PTO/SB/08a (05-07)
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# INFORMATION DISCLOSURE STATEMENT BY APPLICANT

**( Not for submission under 37 CFR 1.99)**

| | |
|---|---|
| Application Number | |
| Filing Date | 2007-08-15 |
| First Named Inventor | Karczewicz et al. |
| Art Unit | |
| Examiner Name | |
| Attorney Docket Number | 982-010567-US (C02) |

**U.S.PATENTS**

| Examiner Initial* | Cite No | Patent Number | Kind Code[1] | Issue Date | Name of Patentee or Applicant of cited Document | Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear |
|---|---|---|---|---|---|---|
| | 1 | 4937666 | | 1990-06-26 | Yang | |
| | 2 | 5452377 | | 1995-09-19 | Igarashi et al. | |
| | 3 | 5488419 | | 1996-01-30 | Hui et al. | |
| | 4 | 5521642 | | 1996-05-28 | Park | |
| | 5 | 5568597 | | 1996-10-22 | Nakayama et al. | |
| | 6 | 5570436 | | 1996-10-29 | Fukushima et al. | |
| | 7 | 5844616 | | 1998-12-01 | Collet et al. | |
| | 8 | 5901248 | | 1999-05-04 | Fandrianto et al. | |

| INFORMATION DISCLOSURE STATEMENT BY APPLICANT ( Not for submission under 37 CFR 1.99) | | |
|---|---|---|
| | Application Number | |
| | Filing Date | 2007-08-15 |
| | First Named Inventor | Karczewicz et al. |
| | Art Unit | |
| | Examiner Name | |
| | Attorney Docket Number | 982-010567-US (C02) |

| | | | | | | |
|---|---|---|---|---|---|---|
| | 9 | 6219464 | B1 | 2001-04-17 | Greggain et al. | |
| | 10 | 6252576 | B1 | 2001-06-26 | Nottingham | |

If you wish to add additional U.S. Patent citation information please click the Add button.

**U.S.PATENT APPLICATION PUBLICATIONS**

| Examiner Initial* | Cite No | Publication Number | Kind Code[1] | Publication Date | Name of Patentee or Applicant of cited Document | Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear |
|---|---|---|---|---|---|---|
| | 1 | 20020064229 | | 2002-05-30 | Nakaya | |

If you wish to add additional U.S. Published Application citation information please click the Add button.

**FOREIGN PATENT DOCUMENTS**

| Examiner Initial* | Cite No | Foreign Document Number[3] | Country Code[2] ¡ | Kind Code[4] | Publication Date | Name of Patentee or Applicant of cited Document | Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear | T[5] |
|---|---|---|---|---|---|---|---|---|
| | 1 | 9904574 | WO | | 1999-01-28 | Robert Bosch GMBH | | ☐ |
| | 2 | 0576290 | EP | A2 | 1993-12-29 | Sony Corp. | | ☐ |
| | 3 | 2205707 | GB | | 1988-12-14 | Sony Corp. | | ☐ |

If you wish to add additional Foreign Patent Document citation information please click the Add button

**NON-PATENT LITERATURE DOCUMENTS**

| Examiner Initials* | Cite No | Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc), date, pages(s), volume-issue number(s), publisher, city and/or country where published. | T[5] |
|---|---|---|---|

| INFORMATION DISCLOSURE STATEMENT BY APPLICANT ( Not for submission under 37 CFR 1.99) | | |
|---|---|---|
| | Application Number | |
| | Filing Date | 2007-08-15 |
| | First Named Inventor | Karczewicz et al. |
| | Art Unit | |
| | Examiner Name | |
| | Attorney Docket Number | 982-010567-US (C02) |

| | | | |
|---|---|---|---|
| | 1 | Chao, et a., FPM 21.3, "An Interpolator for HD-MAC Decoder". | ☐ |
| | 2 | Mehran Mashfeghi, "Directional Interpolation for Magnetic Resonance Angiography Data", IEEE Transactions on Medical Imaging, Vol. 12, No. 2, June 1993. | ☐ |
| | 3 | Document Q15-K-59, "H.26L Test Model Long Term Number 5 (TML-5) draft0" ITU, Study Group 16. | ☐ |
| | 4 | Document VCEG-L20, "Complexity Reduced Motion Compensated Prediction with 1/8-pel Displacement Vector Resolution", ITU, Study Group 16. | ☐ |
| | 5 | English translation of Japanese publication No. Hei 6-14739. | ☐ |
| | 6 | Japanese Patent Document No. JP 62-039920. | ☐ |

If you wish to add additional non-patent literature document citation information please click the Add button

**EXAMINER SIGNATURE**

| Examiner Signature | | Date Considered | |
|---|---|---|---|

*EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through a citation if not in conformance and not considered. Include copy of this form with next communication to applicant.

[1] See Kind Codes of USPTO Patent Documents at www.USPTO.GOV or MPEP 901.04. [2] Enter office that issued the document, by the two-letter code (WIPO Standard ST.3). [3] For Japanese patent documents, the indication of the year of the reign of the Emperor must precede the serial number of the patent document. [4] Kind of document by the appropriate symbols as indicated on the document under WIPO Standard ST.16 if possible. [5] Applicant is to place a check mark here if English language translation is attached.

| INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99) | | |
|---|---|---|
| | Application Number | |
| | Filing Date | 2007-08-15 |
| | First Named Inventor | Karczewicz et al. |
| | Art Unit | |
| | Examiner Name | |
| | Attorney Docket Number | 982-010567-US (C02) |

**CERTIFICATION STATEMENT**

Please see 37 CFR 1.97 and 1.98 to make the appropriate selection(s):

☐ That each item of information contained in the information disclosure statement was first cited in any communication from a foreign patent office in a counterpart foreign application not more than three months prior to the filing of the information disclosure statement. See 37 CFR 1.97(e)(1).

**OR**

☐ That no item of information contained in the information disclosure statement was cited in a communication from a foreign patent office in a counterpart foreign application, and, to the knowledge of the person signing the certification after making reasonable inquiry, no item of information contained in the information disclosure statement was known to any individual designated in 37 CFR 1.56(c) more than three months prior to the filing of the information disclosure statement. See 37 CFR 1.97(e)(2).

☐ See attached certification statement.

☐ Fee set forth in 37 CFR 1.17 (p) has been submitted herewith.

☐ None

**SIGNATURE**

A signature of the applicant or representative is required in accordance with CFR 1.33, 10.18. Please see CFR 1.4(d) for the form of the signature.

| Signature | /gcz44004/ | Date (YYYY-MM-DD) | 2007-08-15 |
|---|---|---|---|
| Name/Print | Geza C. Ziegler, Jr. | Registration Number | 44,004 |

This collection of information is required by 37 CFR 1.97 and 1.98. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 1 hour to complete, including gathering, preparing and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

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The Privacy Act of 1974 (P.L. 93-579) requires that you be given certain information in connection with your submission of the attached form related to a patent application or patent. Accordingly, pursuant to the requirements of the Act, please be advised that: (1) the general authority for the collection of this information is 35 U.S.C. 2(b)(2); (2) furnishing of the information solicited is voluntary; and (3) the principal purpose for which the information is used by the U.S. Patent and Trademark Office is to process and/or examine your submission related to a patent application or patent. If you do not furnish the requested information, the U.S. Patent and Trademark Office may not be able to process and/or examine your submission, which may result in termination of proceedings or abandonment of the application or expiration of the patent.

The information provided by you in this form will be subject to the following routine uses:

1. The information on this form will be treated confidentially to the extent allowed under the Freedom of Information Act (5 U.S.C. 552) and the Privacy Act (5 U.S.C. 552a). Records from this system of records may be disclosed to the Department of Justice to determine whether the Freedom of Information Act requires disclosure of these record s.

2. A record from this system of records may be disclosed, as a routine use, in the course of presenting evidence to a court, magistrate, or administrative tribunal, including disclosures to opposing counsel in the course of settlement negotiations.

3. A record in this system of records may be disclosed, as a routine use, to a Member of Congress submitting a request involving an individual, to whom the record pertains, when the individual has requested assistance from the Member with respect to the subject matter of the record.

4. A record in this system of records may be disclosed, as a routine use, to a contractor of the Agency having need for the information in order to perform a contract. Recipients of information shall be required to comply with the requirements of the Privacy Act of 1974, as amended, pursuant to 5 U.S.C. 552a(m).

5. A record related to an International Application filed under the Patent Cooperation Treaty in this system of records may be disclosed, as a routine use, to the International Bureau of the World Intellectual Property Organization, pursuant to the Patent Cooperation Treaty.

6. A record in this system of records may be disclosed, as a routine use, to another federal agency for purposes of National Security review (35 U.S.C. 181) and for review pursuant to the Atomic Energy Act (42 U.S.C. 218(c)).

7. A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (i.e., GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.

8. A record from this system of records may be disclosed, as a routine use, to the public after either publication of the application pursuant to 35 U.S.C. 122(b) or issuance of a patent pursuant to 35 U.S.C. 151. Further, a record may be disclosed, subject to the limitations of 37 CFR 1.14, as a routine use, to the public if the record was filed in an application which became abandoned or in which the proceedings were terminated and which application is referenced by either a published application, an application open to public inspections or an issued patent.

9. A record from this system of records may be disclosed, as a routine use, to a Federal, State, or local law enforcement agency, if the USPTO becomes aware of a violation or potential violation of law or regulation.

# Electronic Patent Application Fee Transmittal

| | |
|---|---|
| **Application Number:** | |
| **Filing Date:** | |
| **Title of Invention:** | METHOD FOR SUB-PIXEL VALUE INTERPOLATION |
| First Named Inventor/Applicant Name: | Marta Karczewicz |
| **Filer:** | GEZA C ZIEGLER JR/Shannon D'Amico |
| **Attorney Docket Number:** | 982-010567-US (C02) |

Filed as Large Entity

**Utility Filing Fees**

| Description | Fee Code | Quantity | Amount | Sub-Total in USD($) |
|---|---|---|---|---|
| **Basic Filing:** | | | | |
| Utility application filing | 1011 | 1 | 300 | 300 |
| Utility Search Fee | 1111 | 1 | 500 | 500 |
| Utility Examination Fee | 1311 | 1 | 200 | 200 |
| **Pages:** | | | | |
| **Claims:** | | | | |
| **Miscellaneous-Filing:** | | | | |
| **Petition:** | | | | |
| **Patent-Appeals-and-Interference:** | | | | |

| Description | Fee Code | Quantity | Amount | Sub-Total in USD($) |
|---|---|---|---|---|
| Post-Allowance-and-Post-Issuance: | | | | |
| **Extension-of-Time:** | | | | |
| **Miscellaneous:** | | | | |
| | | | **Total in USD ($)** | **1000** |

# Electronic Acknowledgement Receipt

| | |
|---|---|
| **EFS ID:** | 2086606 |
| **Application Number:** | 11839205 |
| **International Application Number:** | |
| **Confirmation Number:** | 8091 |
| **Title of Invention:** | METHOD FOR SUB-PIXEL VALUE INTERPOLATION |
| **First Named Inventor/Applicant Name:** | Marta Karczewicz |
| **Customer Number:** | 02512 |
| **Filer:** | GEZA C ZIEGLER JR/Shannon D'Amico |
| **Filer Authorized By:** | GEZA C ZIEGLER JR |
| **Attorney Docket Number:** | 982-010567-US (C02) |
| **Receipt Date:** | 15-AUG-2007 |
| **Filing Date:** | |
| **Time Stamp:** | 15:54:14 |
| **Application Type:** | Utility under 35 USC 111(a) |

## Payment information:

| | |
|---|---|
| Submitted with Payment | yes |
| Payment was successfully received in RAM | $1000 |
| RAM confirmation Number | 1021 |
| Deposit Account | 161350 |
| The Director of the USPTO is hereby authorized to charge indicated fees and credit any overpayment as follows:<br>Charge any Additional Fees required under 37 C.F.R. Section 1.16 and 1.17 | |

## File Listing:

| Document Number | Document Description | File Name | File Size(Bytes) /Message Digest | Multi Part /.zip | Pages (if appl.) |
|---|---|---|---|---|---|
| 1 | Application Data Sheet | AppDataSheet.pdf | 184330<br>08f7075ef834a04906b39d154068d2ed54b74dcf | no | 4 |
| **Warnings:** | | | | | |
| **Information:** | | | | | |
| This is not an USPTO supplied ADS fillable form | | | | | |
| 2 | | Application.pdf | 4030808<br>c70db6898bbc847746e95f4062bc9aaf7ca50b08 | yes | 96 |

**Multipart Description/PDF files in .zip description**

| Document Description | Start | End |
|---|---|---|
| Specification | 1 | 91 |
| Claims | 92 | 95 |
| Abstract | 96 | 96 |

| | | | | | |
|---|---|---|---|---|---|
| **Warnings:** | | | | | |
| **Information:** | | | | | |
| 3 | Drawings | Drawings.pdf | 244032<br>1c996f0dd87289029d81129fbd59a4e8447a5aff | no | 28 |
| **Warnings:** | | | | | |
| **Information:** | | | | | |
| 4 | Oath or Declaration filed | Declaration.pdf | 343765<br>775a74dab6fbcbabd0d0e7626b8c3d24669b8267 | no | 10 |
| **Warnings:** | | | | | |
| **Information:** | | | | | |
| 5 | Information Disclosure Statement (IDS) Filed | IDS.pdf | 224668<br>303c58aace4ea9633733ce29ed5355ba2b9f9ab0 | no | 5 |
| **Warnings:** | | | | | |
| **Information:** | | | | | |
| This is not an USPTO supplied IDS fillable form | | | | | |
| 6 | Fee Worksheet (PTO-06) | fee-info.pdf | 8389<br>6c8b5c03ecb349288a093a3c15914b3b6a814215 | no | 2 |
| **Warnings:** | | | | | |
| **Information:** | | | | | |
| | | **Total Files Size (in bytes):** | 5035992 | | |

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**New Applications Under 35 U.S.C. 111**
**If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.**

**National Stage of an International Application under 35 U.S.C. 371**
**If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.**

**New International Application Filed with the USPTO as a Receiving Office**
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| Application Data Sheet 37 CFR 1.76 | Attorney Docket Number | 982-010567-US (C02) |
|---|---|---|
| | Application Number | |
| Title of Invention | Method For Sub-Pixel Value Interpolation | |

The application data sheet is part of the provisional or nonprovisional application for which it is being submitted. The following form contains the bibliographic data arranged in a format specified by the United States Patent and Trademark Office as outlined in 37 CFR 1.76.
This document may be completed electronically and submitted to the Office in electronic format using the Electronic Filing System (EFS) or the document may be printed and included in a paper filed application.

## Secrecy Order 37 CFR 5.2

☐ Portions or all of the application associated with this Application Data Sheet may fall under a Secrecy Order pursuant to 37 CFR 5.2 (Paper filers only. Applications that fall under Secrecy Order may not be filed electronically.)

## Applicant Information:

**Applicant 1**

**Applicant Authority** ◉ Inventor ○ Legal Representative under 35 U.S.C. 117 ○ Party of Interest under 35 U.S.C. 118

| Prefix | Given Name | Middle Name | Family Name | Suffix |
|---|---|---|---|---|
| | Marta | | Karczewicz | |

**Residence Information (Select One)** ◉ US Residency ○ Non US Residency ○ Active US Military Service

| City | Irving | State/Province | TX | Country of Residence[i] | US |
|---|---|---|---|---|---|

**Citizenship under 37 CFR 1.41(b)[i]** PL

**Mailing Address of Applicant:**

| Address 1 | 1224 Hidden Ridge, #3097 | | |
|---|---|---|---|
| Address 2 | | | |
| City | Irving | State/Province | TX |
| Postal Code | 75038 | Country[i] | US |

**Applicant 2**

**Applicant Authority** ◉ Inventor ○ Legal Representative under 35 U.S.C. 117 ○ Party of Interest under 35 U.S.C. 118

| Prefix | Given Name | Middle Name | Family Name | Suffix |
|---|---|---|---|---|
| | Antti | | Hallapuro | |

**Residence Information (Select One)** ○ US Residency ◉ Non US Residency ○ Active US Military Service

| City | Tampere | Country Of Residence[i] | FI |
|---|---|---|---|

**Citizenship under 37 CFR 1.41(b)[i]** FI

**Mailing Address of Applicant:**

| Address 1 | Insinoorinkatu 60 B 115, FIN-33720 | | |
|---|---|---|---|
| Address 2 | | | |
| City | Tampere | State/Province | FI |
| Postal Code | | Country[i] | |

All Inventors Must Be Listed - Additional Inventor Information blocks may be generated within this form by selecting the **Add** button. Add

## Correspondence Information:

**Enter either Customer Number or complete the Correspondence Information section below.**
**For further information see 37 CFR 1.33(a).**

☐ **An Address is being provided for the correspondence Information of this application.**

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| Application Data Sheet 37 CFR 1.76 | Attorney Docket Number | 982-010567-US (C02) |
|---|---|---|
| | Application Number | |
| Title of Invention | Method For Sub-Pixel Value Interpolation | |

| Customer Number | 02512 | | |
|---|---|---|---|
| Email Address | | Add Email | Remove Email |

## Application Information:

| Title of the Invention | Method For Sub-Pixel Value Interpolation | | |
|---|---|---|---|
| Attorney Docket Number | 982-010567-US (C02) | Small Entity Status Claimed | ☐ |
| Application Type | Nonprovisional | | |
| Subject Matter | Utility | | |
| Suggested Class (if any) | | Sub Class (if any) | |
| Suggested Technology Center (if any) | | | |
| Total Number of Drawing Sheets (if any) | 28 | Suggested Figure for Publication (if any) | |

## Publication Information:

☐ Request Early Publication (Fee required at time of Request 37 CFR 1.219)

☐ **Request Not to Publish.** I hereby request that the attached application not be published under 35 U.S. C. 122(b) and certify that the invention disclosed in the attached application has not been and will not be the subject of an application filed in another country, or under a multilateral agreement, that requires publication at eighteen months after filing.

## Representative Information:

Representative information should be provided for all practitioners having a power of attorney in the application. Providing this information in the Application Data Sheet does not constitute a power of attorney in the application (see 37 CFR 1.32).
Enter either Customer Number or complete the Representative Name section below. If both sections are completed the Customer Number will be used for the Representative Information during processing.

| Please Select One: | ◉ Customer Number | ○ US Patent Practitioner | ○ US Representative (37 CFR 11.9) |
|---|---|---|---|
| Customer Number | 02512 | | |

## Domestic Priority Information:

This section allows for the applicant to claim benefit under 35 U.S.C. 119(e), 120, 121, or 365(c). Providing this information in the application data sheet constitutes the specific reference required by 35 U.S.C. 119(e) or 120, and 37 CFR 1.78(a)(2) or CFR 1.78(a)(4), and need not otherwise be made part of the specification.

| Prior Application Status | Pending | | Remove |
|---|---|---|---|
| Application Number | Continuity Type | Prior Application Number | Filing Date (YYYY-MM-DD) |
| | Continuation of | 11090717 | 2005-03-25 |
| Prior Application Status | Patented | | Remove |

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| **Application Data Sheet 37 CFR 1.76** | Attorney Docket Number | 982-010567-US (C02) |
|---|---|---|
| | Application Number | |
| Title of Invention | Method For Sub-Pixel Value Interpolation | |

| Application Number | Continuity Type | Prior Application Number | Filing Date (YYYY-MM-DD) | Patent Number | Issue Date (YYYY-MM-DD) |
|---|---|---|---|---|---|
| | Continuation of | 09954608 | 2001-09-17 | 6950469 | |

Additional Domestic Priority Data may be generated within this form by selecting the **Add** button.

## Foreign Priority Information:

This section allows for the applicant to claim benefit of foreign priority and to identify any prior foreign application for which priority is not claimed. Providing this information in the application data sheet constitutes the claim for priority as required by 35 U.S.C. 119(b) and 37 CFR 1.55(a).

Remove

| Application Number | Country [i] | Parent Filing Date (YYYY-MM-DD) | Priority Claimed |
|---|---|---|---|
| | | | ○ Yes ◉ No |

Additional Foreign Priority Data may be generated within this form by selecting the **Add** button.

## Assignee Information:

Providing this information in the application data sheet does not substitute for compliance with any requirement of part 3 of Title 37 of the CFR to have an assignment recorded in the Office.

**Assignee 1**

If the Assignee is an Organization check here. ☒

| Organization Name | Nokia Corporation | | |
|---|---|---|---|
| **Mailing Address Information:** | | | |
| **Address 1** | Keilalahdentie 4 | | |
| Address 2 | | | |
| **City** | Espoo | **State/Province** | |
| **Country** [i] FI | | Postal Code | 02150 |
| Phone Number | | Fax Number | |
| Email Address | | | |

Additional Assignee Data may be generated within this form by selecting the **Add** button.

## Signature:

A signature of the applicant or representative is required in accordance with 37 CFR 1.33 and 10.18. Please see 37 CFR 1.4(d) for the form of the signature.

| **Signature** | /gcz44004/ | | | Date (YYYY-MM-DD) | 2007-08-15 |
|---|---|---|---|---|---|
| First Name | Geza | Last Name | Ziegler, Jr. | Registration Number | 44004 |

PTO/SB/14 (06-07)
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U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
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| **Application Data Sheet 37 CFR 1.76** | Attorney Docket Number | 982-010567-US (C02) |
|---|---|---|
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# METHOD FOR SUB-PIXEL VALUE INTERPOLATION

## CROSS REFERENCE TO RELATED APPLICATIONS

This application is a continuation of, and claims priority to, co-pending U.S Application Serial No. 11/090,717, filed March 25, 2005, now allowed, which is a continuation of, and claims priority to, U.S. Application Serial No. 09/954,608, filed September 17, 2001, now U.S Patent No. 6,950,469, all of which are incorporated by reference herein in their entirety.

The present invention relates to a method for sub-pixel value interpolation in the encoding and decoding of data. It relates particularly, but not exclusively, to encoding and decoding of digital video.

## Background of the invention

Digital video sequences, like ordinary motion pictures recorded on film, comprise a sequence of still images, the illusion of motion being created by displaying the images one after the other at a relatively fast frame rate, typically 15 to 30 frames per second. Because of the relatively fast frame rate, images in consecutive frames tend to be quite similar and thus contain a considerable amount of redundant information. For example, a typical scene may comprise some stationary elements, such as background scenery, and some moving areas, which may take many different forms, for example the face of a newsreader, moving traffic and so on. Alternatively, the camera recording the scene may itself be moving, in which case all elements of the image have the same kind of motion. In many cases, this means that the overall change between one video frame and the next is rather small. Of course, this depends on the nature of the movement. For example, the faster the movement, the greater the change from one frame to the next. Similarly, if a scene contains a number of moving elements, the change from one frame to the next is likely to be greater than in a scene where only one element is moving.

It should be appreciated that each frame of a raw, that is uncompressed, digital video sequence comprises a very large amount of image information. Each frame of an uncompressed digital video sequence is formed from an array of image pixels. For example, in a commonly used digital video format, known as the Quarter Common Interchange Format (QCIF), a frame comprises an array of 176 x 144 pixels, in which case each frame has 25,344 pixels. In turn, each pixel is represented by a certain number of bits, which carry information about the luminance and/or colour content of the region of the image corresponding to the pixel. Commonly, a so-called YUV colour model is used to represent the luminance and chrominance content of the image. The luminance, or Y, component represents the intensity (brightness) of the image, while the colour content of the image is represented by two chrominance components, labelled U and V.

Colour models based on a luminance/chrominance representation of image content provide certain advantages compared with colour models that are based on a representation involving primary colours (that is Red, Green and Blue, RGB). The human visual system is more sensitive to intensity variations than it is to colour variations; YUV colour models exploit this property by using a lower spatial resolution for the chrominance components (U, V) than for the luminance component (Y). In this way the amount of information needed to code the colour information in an image can be reduced with an acceptable reduction in image quality.

The lower spatial resolution of the chrominance components is usually attained by sub-sampling. Typically, a block of 16x16 image pixels is represented by one block of 16x16 pixels comprising luminance information and the corresponding chrominance components are each represented by one block of 8x8 pixels representing an area of the image equivalent to that of the 16x16 pixels of the luminance component. The chrominance components are thus spatially sub-sampled by a factor of 2 in the $x$ and $y$ directions. The resulting assembly of one 16x16 pixel luminance block and two

8x8 pixel chrominance blocks is commonly referred to as a YUV macroblock, or macroblock, for short.

A QCIF image comprises 11x9 macroblocks. If the luminance blocks and chrominance blocks are represented with 8 bit resolution (that is by numbers in the range 0 to 255), the total number of bits required per macroblock is (16x16x8)+2x(8x8x8) = 3072 bits. The number of bits needed to represent a video frame in QCIF format is thus 99x3072 = 304,128 bits. This means that the amount of data required to transmit/record/display a video sequence in QCIF format, represented using a YUV colour model, at a rate of 30 frames per second, is more than 9 Mbps (million bits per second). This is an extremely high data rate and is impractical for use in video recording, transmission and display applications because of the very large storage capacity, transmission channel capacity and hardware performance required.

If video data is to be transmitted in real-time over a fixed line network such as an ISDN (Integrated Services Digital Network) or a conventional PSTN (Public Service Telephone Network), the available data transmission bandwidth is typically of the order of 64kbits/s. In mobile videotelephony, where transmission takes place at least in part over a radio communications link, the available bandwidth can be as low as 20kbits/s. This means that a significant reduction in the amount of information used to represent video data must be achieved in order to enable transmission of digital video sequences over low bandwidth communication networks. For this reason video compression techniques have been developed which reduce the amount of information transmitted while retaining an acceptable image quality.

Video compression methods are based on reducing the redundant and perceptually irrelevant parts of video sequences. The redundancy in video sequences can be categorised into spatial, temporal and spectral redundancy. 'Spatial redundancy' is the term used to describe the correlation between neighbouring pixels within a frame. The term 'temporal redundancy' expresses the fact that the objects appearing

in one frame of a sequence are likely to appear in subsequent frames, while 'spectral redundancy' refers to the correlation between different colour components of the same image.

Sufficiently efficient compression cannot usually be achieved by simply reducing the various forms of redundancy in a given sequence of images. Thus, most current video encoders also reduce the quality of those parts of the video sequence which are subjectively the least important. In addition, the redundancy of the compressed video bit-stream is itself reduced by means of efficient loss-less encoding. Typically, this is achieved using a technique known as 'variable length coding' (VLC).

Modern video compression standards, such as ITU-T recommendations H.261, H.263(+)(++), H.26L and the Motion Picture Experts Group recommendation MPEG-4 make use of 'motion compensated temporal prediction'. This is a form of temporal redundancy reduction in which the content of some (often many) frames in a video sequence is 'predicted' from other frames in the sequence by tracing the motion of objects or regions of an image between frames.

Compressed images which do not make use of temporal redundancy reduction are usually called INTRA-coded or I-frames, whereas temporally predicted images are called INTER-coded or P-frames. In the case of INTER frames, the predicted (motion-compensated) image is rarely precise enough to represent the image content with sufficient quality, and therefore a spatially compressed prediction error (PE) frame is also associated with each INTER frame. Many video compression schemes can also make use of bi-directionally predicted frames, which are commonly referred to as B-pictures or B-frames. B-pictures are inserted between reference or so-called 'anchor' picture pairs (I or P frames) and are predicted from either one or both of the anchor pictures. B-pictures are not themselves used as anchor pictures, that is no other frames are predicted from them, and therefore, they can be discarded from the video sequence without causing deterioration in the quality of future pictures.

The different types of frame that occur in a typical compressed video sequence are illustrated in Figure 3 of the accompanying drawings. As can be seen from the figure, the sequence starts with an INTRA or I frame 30. In Figure 3, arrows 33 denote the 'forward' prediction process by which P-frames (labelled 34) are formed. The bi-directional prediction process by which B-frames (36) are formed is denoted by arrows 31a and 31b, respectively.

A schematic diagram of an example video coding system using motion compensated prediction is shown in Figures 1 and 2. Figure 1 illustrates an encoder 10 employing motion compensation and Figure 2 illustrates a corresponding decoder 20. The encoder 10 shown in Figure 1 comprises a Motion Field Estimation block 11, a Motion Field Coding block 12, a Motion Compensated Prediction block 13, a Prediction Error Coding block 14, a Prediction Error Decoding block 15, a Multiplexing block 16, a Frame Memory 17, and an adder 19. The decoder 20 comprises a Motion Compensated Prediction block 21, a Prediction Error Decoding block 22, a Demultiplexing block 23 and a Frame Memory 24.

The operating principle of video coders using motion compensation is to minimise the amount of information in a prediction error frame $E_n(x,y)$, which is the difference between a current frame $I_n(x,y)$ being coded and a prediction frame $P_n(x,y)$. The prediction error frame is thus:

$$E_n(x,y) = I_n(x,y) - P_n(x,y). \qquad (1)$$

The prediction frame $P_n(x,y)$ is built using pixel values of a reference frame $R_n(x,y)$, which is generally one of the previously coded and transmitted frames, for example the frame immediately preceding the current frame and is available from the Frame Memory 17 of the encoder 10. More specifically, the prediction frame $P_n(x,y)$ is constructed by finding so-called 'prediction pixels' in the reference frame $R_n(x,y)$

which correspond substantially with pixels in the current frame. Motion information, describing the relationship (e.g. relative location, rotation, scale etc.) between pixels in the current frame and their corresponding prediction pixels in the reference frame is derived and the prediction frame is constructed by moving the prediction pixels according to the motion information. In this way, the prediction frame is constructed as an approximate representation of the current frame, using pixel values in the reference frame. The prediction error frame referred to above therefore represents the difference between the approximate representation of the current frame provided by the prediction frame and the current frame itself. The basic advantage provided by video encoders that use motion compensated prediction arises from the fact that a comparatively compact description of the current frame can be obtained by representing it in terms of the motion information required to form its prediction together with the associated prediction error information in the prediction error frame.

However, due to the very large number of pixels in a frame, it is generally not efficient to transmit separate motion information for each pixel to the decoder. Instead, in most video coding schemes, the current frame is divided into larger image segments $S_k$ and motion information relating to the segments is transmitted to the decoder. For example, motion information is typically provided for each macroblock of a frame and the same motion information is then used for all pixels within the macroblock. In some video coding standards, such as H.26L, a macroblock can be divided into smaller blocks, each smaller block being provided with its own motion information.

The motion information usually takes the form of motion vectors $[\Delta x(x,y), \Delta y(x,y)]$. The pair of numbers $\Delta x(x,y)$ and $\Delta y(x,y)$ represents the horizontal and vertical displacements of a pixel at location $(x,y)$ in the current frame $I_n(x,y)$ with respect to a pixel in the reference frame $R_n(x,y)$. The motion vectors $[\Delta x(x,y), \Delta y(x,y)]$ are

calculated in the Motion Field Estimation block 11 and the set of motion vectors of the current frame $[\Delta x(\cdot), \Delta y(\cdot)]$ is referred to as the motion vector field.

Typically, the location of a macroblock in a current video frame is specified by the $(x, y)$ co-ordinate of its upper left-hand corner. Thus, in a video coding scheme in which motion information is associated with each macroblock of a frame, each motion vector describes the horizontal and vertical displacement $\Delta x(x, y)$ and $\Delta y(x, y)$ of a pixel representing the upper left-hand corner of a macroblock in the current frame $I_n(x, y)$ with respect to a pixel in the upper left-hand corner of a substantially corresponding block of prediction pixels in the reference frame $R_n(x, y)$ (as shown in Figure 4b).

Motion estimation is a computationally intensive task. Given a reference frame $R_n(x, y)$ and, for example, a square macroblock comprising N x N pixels in a current frame (as shown in Figure 4a), the objective of motion estimation is to find an N x N pixel block in the reference frame that matches the characteristics of the macroblock in the current picture according to some criterion. This criterion can be, for example, a sum of absolute differences (SAD) between the pixels of the macroblock in the current frame and the block of pixels in the reference frame with which it is compared. This process is known generally as 'block matching'. It should be noted that, in general, the geometry of the block to be matched and that in the reference frame do not have to be the same, as real-world objects can undergo scale changes, as well as rotation and warping. However, in current international video coding standards, only a translational motion model is used (see below) and thus fixed rectangular geometry is sufficient.

Ideally, in order to achieve the best chance of finding a match, the whole of the reference frame should be searched. However, this is impractical as it imposes too high a computational burden on the video encoder. Instead, the search region is

restricted to region $[-p, p]$ around the original location of the macroblock in the current frame, as shown in Figure 4c.

In order to reduce the amount of motion information to be transmitted from the encoder 10 to the decoder 20, the motion vector field is coded in the Motion Field Coding block 12 of the encoder 10, by representing it with a motion model. In this process, the motion vectors of image segments are re-expressed using certain predetermined functions or, in other words, the motion vector field is represented with a model. Almost all currently used motion vector field models are additive motion models, complying with the following general formula:

$$\Delta x(x,y) = \sum_{i=0}^{N-1} a_i f_i(x,y) \qquad (2)$$

$$\Delta y(x,y) = \sum_{i=0}^{M-1} b_i g_i(x,y) \qquad (3)$$

where coefficients $a_i$ and $b_i$ are called motion coefficients. The motion coefficients are transmitted to the decoder 20 (information stream 2 in Figures 1 and 2). Functions $f_i$ and $g_i$ are called motion field basis functions, and are known both to the encoder and decoder. An approximate motion vector field $(\tilde{\Delta}x(x,y), \tilde{\Delta}y(x,y))$ can be constructed using the coefficients and the basis functions. As the basis functions are known to (that is stored in) both the encoder 10 and the decoder 20, only the motion coefficients need to be transmitted to the encoder, thus reducing the amount of information required to represent the motion information of the frame.

The simplest motion model is the translational motion model which requires only two coefficients to describe the motion vectors of each segment. The values of motion vectors are given by:

$$\Delta x(x,y) = a_0$$
$$\Delta y(x,y) = b_0 \qquad (4)$$

This model is widely used in various international standards (ISO MPEG-1, MPEG-2, MPEG-4, ITU-T Recommendations H.261 and H.263) to describe the motion of 16x16 and 8x8 pixel blocks. Systems which use a translational motion model typically perform motion estimation at full pixel resolution or some integer fraction of full pixel resolution, for example at half or one quarter pixel resolution.

The prediction frame $P_n(x,y)$ is constructed in the Motion Compensated Prediction block 13 in the encoder 10, and is given by:

$$P_n(x,y) = R_n\left[x + \tilde{\Delta}x(x,y),\, y + \tilde{\Delta}y(x,y)\right] \qquad (5)$$

In the Prediction Error Coding block 14, the prediction error frame $E_n(x,y)$ is typically compressed by representing it as a finite series (transform) of some 2-dimensional functions. For example, a 2-dimensional Discrete Cosine Transform (DCT) can be used. The transform coefficients are quantised and entropy (for example Huffman) coded before they are transmitted to the decoder (information stream 1 in Figures 1 and 2). Because of the error introduced by quantisation, this operation usually produces some degradation (loss of information) in the prediction error frame $E_n(x,y)$. To compensate for this degradation, the encoder 10 also comprises a Prediction Error Decoding block 15, where a decoded prediction error frame $\tilde{E}_n(x,y)$ is constructed using the transform coefficients. This locally decoded prediction error frame is added to the prediction frame $P_n(x,y)$ in the adder 19 and the resulting decoded current frame $\tilde{I}_n(x,y)$ is stored in the Frame Memory 17 for further use as the next reference frame $R_{n+1}(x,y)$.

The information stream 2 carrying information about the motion vectors is combined with information about the prediction error in multiplexer 16 and an information

stream 3 containing typically at least those two types of information is sent to the decoder 20.

The operation of a corresponding video decoder 20 will now be described.

The Frame Memory 24 of the decoder 20 stores a previously reconstructed reference frame $R_n(x,y)$. The prediction frame $P_n(x,y)$ is constructed in the Motion Compensated Prediction block 21 of the decoder 20 according to equation 5, using received motion coefficient information and pixel values of the previously reconstructed reference frame $R_n(x,y)$ . The transmitted transform coefficients of the prediction error frame $E_n(x,y)$ are used in the Prediction Error Decoding block 22 to construct the decoded prediction error frame $\tilde{E}_n(x,y)$. The pixels of the decoded current frame $\tilde{I}_n(x,y)$ are then reconstructed by adding the prediction frame $P_n(x,y)$ and the decoded prediction error frame $\tilde{E}_n(x,y)$:

$$\tilde{I}_n(x,y) = P_n(x,y) + \tilde{E}_n(x,y) = R_n\left[x + \tilde{\Delta}x(x,y), y + \tilde{\Delta}y(x,y)\right] + \tilde{E}_n(x,y). \qquad (6)$$

This decoded current frame may be stored in the Frame Memory 24 as the next reference frame $R_{n+1}(x,y)$.

In the description of motion compensated encoding and decoding of digital video presented above, the motion vector $[\Delta x(x,y), \Delta y(x,y)]$ describing the motion of a macroblock in the current frame with respect to the reference frame $R_n(x,y)$ can point to any of the pixels in the reference frame. This means that motion between frames of a digital video sequence can only be represented at a resolution which is determined by the image pixels in the frame (so-called full pixel resolution). Real motion, however, has arbitrary precision, and thus the system described above can only provide approximate modelling of the motion between successive frames of a digital video sequence. Typically, modelling of motion between video frames with full

pixel resolution is not sufficiently accurate to allow efficient minimisation of the prediction error (PE) information associated with each macroblock/frame. Therefore, to enable more accurate modelling of real motion and to help reduce the amount of PE information that must be transmitted from encoder to decoder, many video coding standards, such as H.263(+)(++) and H.26L, allow motion vectors to point 'in between' image pixels. In other words, the motion vectors can have 'sub-pixel' resolution. Allowing motion vectors to have sub-pixel resolution adds to the complexity of the encoding and decoding operations that must be performed, so it is still advantageous to limit the degree of spatial resolution a motion vector may have. Thus, video coding standards, such as those previously mentioned, typically only allow motion vectors to have full-, half- or quarter-pixel resolution.

Motion estimation with sub-pixel resolution is usually performed as a two-stage process, as illustrated in Figure 5, for a video coding scheme which allows motion vectors to have full- or half-pixel resolution. In the first step, a motion vector having full-pixel resolution is determined using any appropriate motion estimation scheme, such as the block-matching process described in the foregoing. The resulting motion vector, having full-pixel resolution is shown in Figure 5.

In the second stage, the motion vector determined in the first stage is refined to obtain the desired half-pixel resolution. In the example illustrated in Figure 5, this is done by forming eight new search blocks of 16 x 16 pixels, the location of the top-left corner of each block being marked with an X in Figure 5. These locations are denoted as $[\Delta x + m/2, \Delta y + n/2]$, where m and n can take the values −1, 0 and +1, but cannot be zero at the same time. As only the pixel values of original image pixels are known, the values (for example luminance and/or chrominance values) of the sub-pixels residing at half-pixel locations must be estimated for each of the eight new search blocks, using some form of interpolation scheme.

Having interpolated the values of the sub-pixels at half-pixel resolution, each of the eight search blocks is compared with the macroblock whose motion vector is being

sought. As in the block matching process performed in order to determine the motion vector with full pixel resolution, the macroblock is compared with each of the eight search blocks according to some criterion, for example a SAD. As a result of the comparisons, a minimum SAD value will generally be obtained. Depending on the nature of the motion in the video sequence, this minimum value may correspond to the location specified by the original motion vector (having full-pixel resolution), or it may correspond to a location having a half-pixel resolution. Thus, it is possible to determine whether a motion vector should point to a full-pixel or sub-pixel location and if sub-pixel resolution is appropriate, to determine the correct sub-pixel resolution motion vector. It should also be appreciated that the scheme just described can be extended to other sub-pixel resolutions (for example, one-quarter-pixel resolution) in an entirely analogous fashion.

In practice, the estimation of a sub-pixel value in the reference frame is performed by interpolating the value of the sub-pixel from surrounding pixel values. In general, interpolation of a sub-pixel value *F(x,y)* situated at a non-integer location *(x, y) = (n+Δx, m+Δy)*, can be formulated as a two-dimensional operation, represented mathematically as:

$$F(x,y) = \sum_{k=-K}^{K=1} \sum_{l=-L}^{L=1} f(k+K, l+L) F(n+k, m+l) \qquad (7)$$

where *f(k,l)* are filter coefficients and *n* and *m* are obtained by truncating *x* and *y*, respectively, to integer values. Typically, the filter coefficients are dependent on the *x* and *y* values and the interpolation filters are usually so-called 'separable filters', in which case sub-pixel value *F(x,y)* can be calculated as follows:

$$F(x,y) = \sum_{k=-K}^{K=1} f(k+K) \sum_{l=-K}^{K=1} f(l+K) F(n+k, m+l) \qquad (8)$$

The motion vectors are calculated in the encoder. Once the corresponding motion coefficients are transmitted to the decoder, it is a straightforward matter to interpolate the required sub-pixels using an interpolation method identical to that used in the encoder. In this way, a frame following a reference frame in the Frame Memory 24, can be reconstructed from the reference frame and the motion vectors.

The simplest way of applying sub-pixel value interpolation in a video coder is to interpolate each sub-pixel value every time it is needed. However, this is not an efficient solution in a video encoder, because it is likely that the same sub-pixel value will be required several times and thus calculations to interpolate the same sub-pixel value will be performed multiple times. This results in an unnecessary increase of computational complexity / burden in the encoder.

An alternative approach, which limits the complexity of the encoder, is to pre-calculate and store all sub-pixel values in a memory associated with the encoder. This solution is called interpolation 'before-hand' interpolation hereafter in this document. While limiting complexity, before-hand interpolation has the disadvantage of increasing memory usage by a large margin. For example, if the motion vector accuracy is one quarter pixel in both horizontal and vertical dimensions, storing pre-calculated sub-pixel values for a complete image results in a memory usage that is 16 times that required to store the original, non-interpolated image. In addition, it involves the calculation of some sub-pixels which might not actually be required in calculating motion vectors in the encoder. Before-hand interpolation is also particularly inefficient in a video decoder, as the majority of pre-calculated sub-pixel values will never be required by the decoder. Thus, it is advantageous not to use pre-calculation in the decoder.

So-called 'on-demand' interpolation can be used to reduce memory requirements in the encoder. For example, if the desired pixel precision is quarter pixel resolution, only sub-pixels at one half unit resolution are interpolated before-hand for the whole frame and stored in the memory. Values of one-quarter pixel resolution sub-pixels

are only calculated during the motion estimation / compensation process as and when it is required. In this case memory usage is only 4 times that required to store the original, non-interpolated image.

It should be noted that when before-hand interpolation is used, the interpolation process constitutes only a small fraction of the total encoder computational complexity / burden, since every pixel is interpolated just once. Therefore, in the encoder, the complexity of the interpolation process itself is not very critical when before-hand sub-pixel value interpolation is used. On the other hand, on-demand interpolation poses a much higher computational burden on the encoder, since sub-pixels may be interpolated many times. Hence the complexity of interpolation process, which may be considered in terms of the number of computational operations or operational cycles that must be performed in order to interpolate the sub-pixel values, becomes an important consideration.

In the decoder, the same sub-pixel values are used a few times at most and some are not needed at all. Therefore, in the decoder it is advantageous not to use before-hand interpolation at all, that is, it is advantageous not to pre-calculate any sub-pixel values.

Two interpolation schemes have been developed as part of the work ongoing in the ITU-Telecommunications Standardization Sector, Study Group 16, Video Coding Experts Group (VCEG), Questions 6 and 15. These approaches were proposed for incorporation into ITU-T recommendation H.26L and have been implemented in test models (TML) for the purposes of evaluation and further development. The test model corresponding to Question 15 is referred to as Test Model 5 (TML5), while that resulting from Question 6 is known as Test Model 6 (TML6). The interpolation schemes proposed in both TML5 and TML6 will now be described.

Throughout the description of the sub-pixel value interpolation scheme used in test model TML5, reference will be made to Figure 12a, which defines a notation for

describing pixel and sub-pixel locations specific to TML5. A separate notation, defined in Figure 13a, will be used in the discussion of the sub-pixel value interpolation scheme used in TML6. A still further notation, illustrated in Figure 14a, will be used later in the text in connection with the sub-pixel value interpolation method according to the invention. It should be appreciated that the three different notations used in the text are intended to assist in the understanding of each interpolation method and to help distinguish differences between them. However, in all three figures, the letter A is used to denote original image pixels (full pixel resolution). More specifically, the letter A represents the location of pixels in the image data representing a frame of a video sequence, the pixel values of pixels A being either received as current frame $I_n(x,y)$ from a video source, or reconstructed and stored as a reference frame $R_n(x,y)$ in the Frame Memory 17, 24 of the encoder 10 or the decoder 20. All other letters represent sub-pixel locations, the values of the sub-pixels situated at the sub-pixel locations being obtained by interpolation.

Certain other terms will also be used in a consistent manner throughout the text to identify particular pixel and sub-pixel locations. These are as follows:

The term 'unit horizontal location' is used to describe the location of any sub-pixel that is constructed in a column of the original image data. Sub-pixels c and e in Figures 12a and 13a, as well as sub-pixels b and e in Figure 14a have unit horizontal locations.

The term 'unit vertical location' is used to describe any sub-pixel that is constructed in a row of the original image data. Sub-pixels b and d in Figures 12a and 13a as well as sub-pixels b and d in Figure 14a have unit vertical locations.

By definition, pixels A have unit horizontal and unit vertical locations.

The term 'half horizontal location' is used to describe the location of any sub-pixel that is constructed in a column that lies at half pixel resolution. Sub-pixels b, c, and e shown in Figures 12a and 13a fall into this category, as do sub-pixels b, c and f in Figure 14a. In a similar manner, the term 'half vertical location' is used to describe the location of any sub-pixel that is constructed in a row that lies at half-pixel resolution, such as sub-pixels c and d in Figures 12a and 13a, as well as sub-pixels b, c and g in Figure 14a.

Furthermore, the term 'quarter horizontal location' refers to any sub-pixel that is constructed in a column which lies at quarter-pixel resolution, such as sub-pixels d and e in Figure 12a, sub-pixels d and g in Figure 13a and sub-pixels d, g and h in Figure 14a. Analogously, the term 'quarter vertical location' refers to sub-pixels that are constructed in a row which lies at quarter-pixel resolution. In Figure 12a, sub-pixels e and f fall into this category, as do sub-pixels e, f and g in Figure 13a and sub-pixels e, f and h in Figure 14a.

The definition of each of the terms described above is shown by 'envelopes' drawn on the corresponding figures.

It should further be noted that it is often convenient to denote a particular pixel with a two-dimensional reference. In this case, the appropriate two-dimensional reference can be obtained by examining the intersection of the envelopes in Figures 12a, 13a and 14a. Applying this principle, pixel d in Figure 12a, for example, has a half horizontal and half vertical location and sub-pixel e has a unit horizontal and quarter vertical location. In addition, and for ease of reference, sub-pixels that reside at half unit horizontal and unit vertical locations, unit horizontal and half unit vertical locations as well as half unit horizontal and half unit vertical locations, will be referred to as ½ resolution sub-pixels. Sub-pixels which reside at any quarter unit horizontal and / or quarter unit vertical location will be referred to as ¼ resolution sub-pixels.

It should also be noted that in the descriptions of the two test models and in the detailed description of the invention itself, it will be assumed that pixels have a minimum value of 0 and a maximum value of $2^n-1$ where $n$ is the number of bits reserved for a pixel value. The number of bits is typically 8. After a sub-pixel has been interpolated, if the value of that interpolated sub-pixel exceeds the value of $2^n-1$, it is restricted to the range of $[0, 2^n-1]$, i.e. values lower than the minimum allowed value will become the minimum value ($0$) and values larger than the maximum will the become maximum value ($2^n-1$). This operation is called clipping.

The sub-pixel value interpolation scheme according to TML5 will now be described in detail with reference to Figures 12a, 12b and 12c.

1. The value for the sub-pixel at half unit horizontal and unit vertical location, that is ½ resolution sub-pixel b in Figure 12a, is calculated using a 6-tap filter. The filter interpolates a value for ½ resolution sub-pixel b based upon the values of the 6 pixels ($A_1$ to $A_6$) situated in a row at unit horizontal locations and unit vertical locations symmetrically about b, as shown in Figure 12b, according to the formula $b = (A_1 - 5A_2 + 20A_3 + 20A_4 - 5A_5 + A_6 + 16) / 32$. The operator / denotes division with truncation. The result is clipped to lie in the range $[0, 2^n-1]$.

2. Values for the ½ resolution sub-pixels labelled c are calculated using the same six tap filter as used in step 1 and the six nearest pixels or sub-pixels (A or b) in the vertical direction. Referring now to Figure 12c, the filter interpolates a value for the ½ resolution sub-pixel c located at unit horizontal and half vertical location based upon the values of the 6 pixels ($A_1$ to $A_6$) situated in a column at unit horizontal locations and unit vertical locations symmetrically about c, according to the formula $c = (A_1 - 5A_2 + 20A_3 + 20A_4 - 5A_5 + A_6 + 16) / 32$. Similarly, a value for the ½ resolution sub-pixel c at half horizontal and half vertical location is calculated according to $c = (b_1 - 5b_2 + 20b_3 + 20b_4 - 5b_5 + b_6 + 16) / 32$. Again, the operator / denotes division with truncation. The values calculated for the c sub-pixels are further clipped to lie in the range $[0, 2^n-1]$.

At this point in the interpolation process the values of all ½ resolution sub-pixels have been calculated and the process proceeds to the calculation of ¼ resolution sub-pixel values.

3. Values for the ¼ resolution sub-pixels labelled d are calculated using linear interpolation and the values of the nearest pixels and / or ½ resolution sub-pixels in the horizontal direction. More specifically, values for ¼ resolution sub-pixels d located at quarter horizontal and unit vertical locations, are calculated by taking the average of the immediately neighbouring pixel at unit horizontal and unit vertical location (pixel A) and the immediately neighbouring ½ resolution sub-pixel at half horizontal and unit vertical location (sub-pixel b), i.e. according to d = (A + b) / 2. Values for ¼ resolution sub-pixels d located at quarter horizontal and half vertical locations, are calculated by taking the average of the immediately neighbouring ½ resolution sub-pixels c which lie at unit horizontal and half vertical location and half horizontal and half vertical locations respectively, i.e. according to $d = (c_1 + c_2)/2$. Again operator / indicates division with truncation.

4. Values for the ¼ resolution sub-pixels labelled e are calculated using linear interpolation and the values of the nearest pixels and / or ½ resolution sub-pixels in the vertical direction. In particular, ¼ resolution sub-pixels e at unit horizontal and quarter vertical locations are calculated by taking the average of the immediately neighbouring pixel at unit horizontal and unit vertical location (pixel A) and the immediately neighbouring sub-pixel at unit horizontal and half vertical location (sub-pixel c) according to e = (A + c) / 2. ¼ resolution sub-pixels $e_3$ at half horizontal and quarter vertical locations are calculated by taking the average of the immediately neighbouring sub-pixel at half horizontal and unit vertical location (sub-pixel b) and the immediately neighbouring sub-pixel at half horizontal and half vertical location (sub-pixel c), according to e = (b + c) / 2. Furthermore, ¼ resolution sub-pixels e at quarter horizontal and quarter vertical

locations are calculated by taking the average of the immediately neighbouring sub-pixels at quarter horizontal and unit vertical location and the corresponding sub-pixel at quarter horizontal and half vertical location (sub-pixels d), according to $e = (d_1 + d_2) / 2$. Once more, operator / indicates division with truncation.

5. The value for ¼ resolution sub-pixel f is interpolated by averaging the values of the 4 closest pixels values at unit horizontal and vertical locations, according to $f = (A_1 + A_2 + A_3 + A_4 + 2) / 4$, where pixels $A_1$, $A_2$, $A_3$ and $A_4$ are the four nearest original pixels.

A disadvantage of TML5 is that the decoder is computationally complex. This results from the fact that TML5 uses an approach in which interpolation of ¼ resolution sub-pixel values depends upon the interpolation of ½ resolution sub-pixel values. This means that in order to interpolate the values of the ¼ resolution sub-pixels, the values of the ½ resolution sub-pixels from which they are determined must be calculated first. Furthermore, since the values of some of the ¼ resolution sub-pixels depend upon the interpolated values obtained for other ¼ resolution sub-pixels, truncation of the ¼ resolution sub-pixel values has a deleterious effect on the precision of some of the ¼ resolution sub-pixel values. Specifically, the ¼ resolution sub-pixel values are less precise than they would be if calculated from values that had not been truncated and clipped. Another disadvantage of TML5 is that it is necessary to store the values of the ½ resolution sub-pixels in order to interpolate the ¼ resolution sub-pixel values. Therefore, excess memory is required to store a result which is not ultimately required.

The sub-pixel value interpolation scheme according to TML6, referred to herein as direct interpolation, will now be described. In the encoder the interpolation method according to TML6 works like the previously described TML5 interpolation method, except that maximum precision is retained throughout. This is achieved by using intermediate values which are neither rounded nor clipped. A step-by-step

description of interpolation method according to TML6 as applied in the encoder is given below with reference to Figures 13a, 13b and 13c.

1. The value for the sub-pixel at half unit horizontal and unit vertical location, that is ½ resolution sub-pixel b in Figure 13a, is obtained by first calculating an intermediate value *b* using a six tap filter. The filter calculates *b* based upon the values of the 6 pixels ($A_1$ to $A_6$) situated in a row at unit horizontal locations and unit vertical locations symmetrically about b, as shown in Figure 13b, according to the formula $b = (A_1 - 5A_2 + 20A_3 + 20A_4 - 5A_5 + A_6)$. The final value of b is then calculated as $b = (b + 16) / 32$ and is clipped to lie in the range $[0, 2^n-1]$. As before, the operator / denotes division with truncation.

2. Values for the ½ resolution sub-pixels labelled c are obtained by first calculating intermediate values *c*. Referring to Figure 13c, an intermediate value *c* for the ½ resolution sub-pixel c located at unit horizontal and half vertical location is calculated based upon the values of the 6 pixels ($A_1$ to $A_6$) situated in a column at unit horizontal locations and unit vertical locations symmetrically about c, according to the formula $c = (A_1 - 5A_2 + 20A_3 + 20A_4 - 5A_5 + A_6)$. The final value for the ½ resolution sub-pixel c located at unit horizontal and half vertical location is then calculated according to $c = (c + 16) / 32$. Similarly, an intermediate value *c* for the ½ resolution sub-pixel c at half horizontal and half vertical location is calculated according to $c = (b_1 - 5b_2 + 20b_3 + 20b_4 - 5b_5 + b_6)$. A final value for this ½ resolution sub-pixel is then calculated according to $(c + 512) / 1024$. Again, the operator / denotes division with truncation and the values calculated for ½ resolution sub-pixels c are further clipped to lie in the range $[0, 2^n-1]$.

3. Values for the ¼ resolution sub-pixels labelled d are calculated as follows. Values for ¼ resolution sub-pixels d located at quarter horizontal and unit vertical locations, are calculated from the value of the immediately neighbouring pixel at unit horizontal and unit vertical location (pixel A) and

the intermediate value *b* calculated in step (1) for the immediately neighbouring ½ resolution sub-pixel at half horizontal and unit vertical location (½ resolution sub-pixel b), according to d = (32A + *b* + 32) / 64. Values for ¼ resolution sub-pixels d located at quarter horizontal and half vertical locations, are interpolated using the intermediate values *c* calculated for the immediately neighbouring ½ resolution sub-pixels c which lie at unit horizontal and half vertical location and half horizontal and half vertical locations respectively, according to d = ($32c_1$ + $c_2$ + 1024) / 2048. Again operator / indicates division with truncation and the finally obtained ¼ resolution sub-pixel values d are clipped to lie in the range [0, $2^n$-1].

4. Values for the ¼ resolution sub-pixels labelled e are calculated as follows. Values for ¼ resolution sub-pixels e located at unit horizontal and quarter vertical locations are calculated from the value of the immediately neighbouring pixel at unit horizontal and unit vertical location (pixel A) and the intermediate value *c* calculated in step (2) for the immediately neighbouring ½ resolution sub-pixel at unit horizontal and half vertical location, according to e = (32A + *c*+ 32) / 64. Values for ¼ resolution sub-pixels e located at half horizontal and quarter vertical locations are calculated from the intermediate value *b* calculated in step (1) for the immediately neighbouring ½ resolution sub-pixel at half horizontal and unit vertical location and the intermediate value *c* calculated in step (2) for the immediately neighbouring ½ resolution sub-pixel at half horizontal and half vertical location, according to e = (32*b* + *c* + 1024) / 2048. Once more, operator / indicates division with truncation and the finally obtained ¼ resolution sub-pixel values e are clipped to lie in the range [0, $2^n$-1].

5. Values for ¼ resolution sub-pixels labelled g are computed using the value of the nearest original pixel A and the intermediate values of the three nearest neighbouring ½ resolution sub-pixels, according to g = (1024A + 32*b* + $32c_1$ +

$c_2$ + 2048) / 4096. As before, operator / indicates division with truncation and the finally obtained for ¼ resolution sub-pixel values g are clipped to lie in the range [0, $2^n$-1].

6. The value for ¼ resolution sub-pixel f is interpolated by averaging the values of the 4 closest pixels at unit horizontal and vertical locations, according to f = ($A_1$ + $A_2$ + $A_3$ + $A_4$ + 2) / 4, where the locations of pixels $A_1$, $A_2$, $A_3$ and $A_4$ are the four nearest original pixels.

In the decoder, sub-pixel values can be obtained directly by applying 6-tap filters in horizontal and vertical directions. In the case of ¼ sub-pixel resolution, referring to Figure 13a, the filter coefficients applied to pixels and sub-pixels at unit vertical location are [0, 0, 64, 0, 0, 0] for a set of six pixels A, [1, -5, 52, 20, -5, 1] for a set of six sub-pixels d, [2, -10, 40, 40, -10, 2] for a set of six sub-pixels b, and [1, -5, 20, 52, -5, 1] for a set of six sub-pixels d. These filter coefficients are applied to respective sets of pixels or sub-pixels in the same row as the sub-pixel values being interpolated.

After applying the filters in the horizontal and vertical directions, interpolated value $c$ is normalized according to c = ($c$ + 2048) / 4096 and clipped to lie in the range [0, $2^n$-1]. When a motion vector points to an integer pixel position in either the horizontal or vertical direction, many zero coefficients are used. In a practical implementation of TML6, different branches are used in the software which are optimised for the different sub-pixel cases so that there are no multiplications by zero coefficients.

It should be noted that in TML6, ¼ resolution sub-pixel values are obtained directly using the intermediate values referred to above and are not derived from rounded and clipped values for ½ resolution sub-pixels. Therefore, in obtaining the ¼ resolution sub-pixel values, it is not necessary to calculate final values for any of the ½ resolution sub-pixels. Specifically, it is not necessary to carry out the truncation

and clipping operations associated with the calculation of final values for the ½ resolution sub-pixels. Neither is it necessary to have stored final values for ½ resolution sub-pixels for use in the calculation of the ¼ resolution sub-pixel values. Therefore TML6 is computationally less complex than TML5, as fewer truncating and clipping operations are required. However, a disadvantage of TML6 is that high precision arithmetic is required both in the encoder and in the decoder. High precision interpolation requires more silicon area in ASICs and requires more computations in some CPUs. Furthermore, implementation of direct interpolation as specified in TML6 in an on-demand fashion has a high memory requirement. This is an important factor, particularly in embedded devices.

In view of the previously presented discussion, it should be appreciated that due to the different requirements of the video encoder and decoder with regard to sub-pixel interpolation, there exists a significant problem in developing a method of sub-pixel value interpolation capable of providing satisfactory performance in both the encoder and decoder. Furthermore, neither of the current test models (TML5, TML6) described in the foregoing can provide a solution that is optimum for application in both encoder and decoder.

Summary of the Invention

According to a first aspect of the invention there is provided method of interpolation in video coding in which an image comprising pixels arranged in rows and columns and represented by values having a specified dynamic range, the pixels in the rows residing at unit horizontal locations and the pixels in the columns residing at unit vertical locations, is interpolated to generate values for sub-pixels at fractional horizontal and vertical locations, the fractional horizontal and vertical locations being defined according to $1/2^x$, where x is a positive integer having a maximum value N, the method comprising:

a) when values for sub-pixels at $1/2^{N-1}$ unit horizontal and unit vertical locations, and unit horizontal and $1/2^{N-1}$ unit vertical locations are required, interpolating such

values directly using weighted sums of pixels residing at unit horizontal and unit vertical locations;

b) when values for sub-pixels at $1/2^{N-1}$ unit horizontal and $1/2^{N-1}$ unit vertical locations are required, interpolating such values directly using a choice of a first weighted sum of values for sub-pixels residing at $1/2^{N-1}$ unit horizontal and unit vertical locations and a second weighted sum of values for sub-pixels residing at unit horizontal and $1/2^{N-1}$ unit vertical locations, the first and second weighted sums of values being calculated according to step (a); and

c) when a value for a sub-pixel situated at a $1/2^{N}$ unit horizontal and $1/2^{N}$ unit vertical location is required, interpolating such a value by taking a weighted average of the value of a first sub-pixel or pixel situated at a $1/2^{N-m}$ unit horizontal and $1/2^{N-n}$ unit vertical location and the value of a second sub-pixel or pixel located at a $1/2^{N-p}$ unit horizontal and $1/2^{N-q}$ unit vertical location, variables m, n, p and q taking integer values in the range 1 to N such that the first and second sub-pixels or pixels are located diagonally with respect to the sub-pixel at $1/2^{N}$ unit horizontal and $1/2^{N}$ vertical location.

Preferably a first and a second weight are used in the weighted average referred to in (c), the relative magnitudes of the weights being inversely proportional to the (straight-line diagonal) proximity of the first and the second sub-pixel or pixel to the sub-pixel at $1/2^{N}$ unit horizontal and $1/2^{N}$ vertical location.

In a situation where the first and the second sub-pixel or pixel are symmetrically located with respect to (equidistant from) the sub-pixel at $1/2^{N}$ unit horizontal and $1/2^{N}$ vertical location, the first and second weights may have equal values.

The first weighted sum of values for sub-pixels residing at $1/2^{N-1}$ unit horizontal and unit vertical locations in step b) may be used when a sub-pixel at $1/2^{N-1}$ unit horizontal and $1/2^{N}$ unit vertical location is required.

The second weighted sum of values for sub-pixels residing at unit horizontal and $1/2^{N-1}$ unit vertical locations in step b) may be used when a sub-pixel at $1/2^{N}$ unit horizontal and $1/2^{N-1}$ unit vertical location is required.

In one embodiment, when values for sub-pixels at $1/2^{N}$ unit horizontal and unit vertical locations, and $1/2^{N}$ horizontal and $1/2^{N-1}$ vertical locations are required, such values are interpolated by taking the average of the values of a first pixel or sub-pixel located at a vertical location corresponding to that of the sub-pixel being calculated and unit horizontal location and a second pixel or sub-pixel located at a vertical location corresponding to that of the sub-pixel being calculated and $1/2^{N-1}$ unit horizontal location.

When values for sub-pixels at unit horizontal and $1/2^{N}$ unit vertical locations, and $1/2^{N-1}$ unit horizontal and $1/2^{N}$ unit vertical locations are required, they may be interpolated by taking the average of the values of a first pixel or sub-pixel located at a horizontal location corresponding to that of the sub-pixel being calculated and unit vertical location and a second pixel or sub-pixel located at a horizontal location corresponding to that of the sub-pixel being calculated and $1/2^{N-1}$ unit vertical location.

Values for sub-pixels at $1/2^{N}$ unit horizontal and $1/2^{N}$ unit vertical locations may be interpolated by taking the average of values of a pixel located at a unit horizontal and unit vertical location, and a sub-pixel located at a $1/2^{N-1}$ unit horizontal and $1/2^{N-1}$ unit vertical location.

Values for sub-pixels at $1/2^{N}$ unit horizontal and $1/2^{N}$ unit vertical locations may be interpolated by taking the average of values of a sub-pixel located at a $1/2^{N-1}$ unit horizontal and unit vertical location, and a sub-pixel located at a unit horizontal and $1/2^{N-1}$ unit vertical location.

Values for half of the sub-pixels at $1/2^N$ unit horizontal and $1/2^N$ unit vertical locations may be interpolated by taking the average of a first pair of values of a sub-pixel located at a $1/2^{N-1}$ unit horizontal and unit vertical location, and a sub-pixel located at a unit horizontal and $1/2^{N-1}$ unit vertical location and values for the other half of the sub-pixels at $1/2^N$ unit horizontal and $1/2^N$ unit vertical locations are interpolated by taking the average of a second pair of values of a pixel located at a unit horizontal and unit vertical location, and a sub-pixel located at a $1/2^{N-1}$ unit horizontal and $1/2^{N-1}$ unit vertical location.

Values for sub-pixels at $1/2^N$ unit horizontal and $1/2^N$ unit vertical locations are alternately interpolated for one such sub-pixel by taking the average of a first pair of values of a sub-pixel located at a $1/2^{N-1}$ unit horizontal and unit vertical location, and a sub-pixel located at a unit horizontal and $1/2^{N-1}$ unit vertical location and values and for a neighbouring such sub-pixel by taking the average of a second pair of values of a pixel located at a unit horizontal and unit vertical location, and a sub-pixel located at a $1/2^{N-1}$ unit horizontal and $1/2^{N-1}$ unit vertical location.

The sub-pixels at $1/2^N$ unit horizontal and $1/2^N$ unit vertical locations may be alternately interpolated in a horizontal direction.

The sub-pixels at $1/2^N$ unit horizontal and $1/2^N$ unit vertical locations may be alternately interpolated in a horizontal direction.

When values for some sub-pixels at $1/2^N$ unit horizontal and $1/2^N$ unit vertical locations are required, such values may be interpolated by taking the average of a plurality of nearest neighbouring pixels.

At least one of step a) and step b) interpolating sub-pixel values directly using weighted sums may involve the calculation of an intermediate value for the sub-pixel values having a dynamic range greater than the specified dynamic range.

The intermediate value for a sub-pixel having $1/2^{N-1}$ sub-pixel resolution may be used the calculation of a sub-pixel value having $1/2^{N}$ sub-pixel resolution.

According to a second aspect of the invention, there is provided a method of interpolation in video coding in which an image comprising pixels arranged in rows and columns and represented by values having a specified dynamic range, the pixels in the rows residing at unit horizontal locations and the pixels in the columns residing at unit vertical locations, is interpolated to generate values for sub-pixels at fractional horizontal and vertical locations, the method comprising:

a) when values for sub-pixels at half unit horizontal and unit vertical locations, and unit horizontal and half unit vertical locations are required, interpolating such values directly using weighted sums of pixels residing at unit horizontal and unit vertical locations;

b) when values for sub-pixels at half unit horizontal and half unit vertical locations are required, interpolating such values directly using a weighted sum of values for sub-pixels residing at half unit horizontal and unit vertical locations calculated according to step (a); and

c) when values for sub-pixels at quarter unit horizontal and quarter unit vertical locations are required, interpolating such values by taking the average of at least one pair of a first pair of values of a sub-pixel located at a half unit horizontal and unit vertical location, and a sub-pixel located at a unit horizontal and half unit vertical location and a second pair of values of a pixel located at a unit horizontal and unit vertical location, and a sub-pixel located at a half unit horizontal and half unit vertical location.

According to a third aspect of the invention, there is provided a method of interpolation in video coding in which an image comprising pixels arranged in rows and columns and represented by values having a specified dynamic range, the pixels in the rows residing at unit horizontal locations and the pixels in the columns residing at unit vertical locations, is interpolated to generate values for sub-pixels at fractional horizontal and vertical locations, the fractional horizontal and vertical

locations being defined according to $1/2^x$ where x is a positive integer having a maximum value N, the method comprising:

a) when values for sub-pixels at $1/2^{N-1}$ unit horizontal and unit vertical locations, and unit horizontal and $1/2^{N-1}$ unit vertical locations are required, interpolating such values directly using weighted sums of pixels residing at unit horizontal and unit vertical locations;

b) when a value for a sub-pixel at a sub-pixel horizontal and sub-pixel vertical location is required, interpolating such a value directly using a choice of a first weighted sum of values for sub-pixels located at a vertical location corresponding to that of the sub-pixel being calculated and a second weighted sum of values for sub-pixels located at a horizontal location corresponding to that of the sub-pixel being calculated.

The sub-pixels used in the first weighted sum may be sub-pixels residing at $1/2^{N-1}$ unit horizontal and unit vertical locations and the first weighted sum may be used to interpolate a value for a sub-pixel at $1/2^{N-1}$ unit horizontal and $1/2^N$ unit vertical location.

The sub-pixels used in the second weighted sum may be sub-pixels residing at unit horizontal and $1/2^{N-1}$ unit vertical locations and the second weighted sum may be used to interpolate a value for a sub-pixel at $1/2^N$ unit horizontal and $1/2^{N-1}$ unit vertical location.

When values for sub-pixels at $1/2^N$ unit horizontal and $1/2^N$ unit vertical locations are required, they may be interpolated by taking the average of at least one pair of a first pair of values of a sub-pixel located at a $1/2^{N-1}$ unit horizontal and unit vertical location, and a sub-pixel located at a unit horizontal and $1/2^{N-1}$ unit vertical location and a second pair of values of a pixel located at a unit horizontal and unit vertical location, and a sub-pixel located at a $1/2^{N-1}$ unit horizontal and $1/2^{N-1}$ unit vertical location.

In the foregoing, N may be equal an integer selected from a list consisting of the values 2, 3, and 4.

Sub-pixels at quarter unit horizontal location are to be interpreted as being sub-pixels having as their left-hand nearest neighbour a pixel at unit horizontal location and as their right-hand nearest neighbour a sub-pixel at half unit horizontal location as well as sub-pixels having as their left-hand nearest neighbour a sub-pixel at half unit horizontal location and as their right-hand nearest neighbour a pixel at unit horizontal location. Correspondingly, sub-pixels at quarter unit vertical location are to be interpreted as being sub-pixels having as their upper nearest neighbour a pixel at unit vertical location and as their lower nearest neighbour a sub-pixel at half unit vertical location as well as sub-pixels having as their upper nearest neighbour a sub-pixel at half unit vertical location and as their lower nearest neighbour a pixel at unit vertical location.

The term dynamic range, refers to the range of values which the sub-pixel values and the weighted sums can take.

Preferably changing the dynamic range, whether by extending it or reducing it, means changing the number of bits which are used to represent the dynamic range.

In an embodiment of the invention, the method is applied to an image that is sub-divided into a number of image blocks. Preferably each image block comprises four corners, each corner being defined by a pixel located at a unit horizontal and unit vertical location. Preferably the method is applied to each image block as the block becomes available for sub-pixel value interpolation. Alternatively, sub-pixel value interpolation according to the method of the invention is performed once all image blocks of an image have become available for sub-pixel value interpolation.

Preferably the method is used in video encoding. Preferably the method is used in video decoding.

In one embodiment of the invention, when used in encoding, the method is carried out as before-hand interpolation, in which values for all sub-pixels at half unit locations and values for all sub-pixels at quarter unit locations are calculated and stored before being subsequently used in the determination of a prediction frame during motion predictive coding. In alternative embodiments, the method is carried out as a combination of before-hand and on-demand interpolation. In this case, a certain proportion or category of sub-pixel values is calculated and stored before being used in the determination of a prediction frame and certain other sub-pixel values are calculated only when required during motion predictive coding.

Preferably, when the method is used in decoding, sub-pixels are only interpolated when their need is indicated by a motion vector.

According to a fourth aspect of the invention, there is provided a video coder for coding an image comprising pixels arranged in rows and columns and represented by values having a specified dynamic range, the pixels in the rows residing at unit horizontal locations and the pixels in the columns residing at unit vertical locations, the video coder comprising an interpolator adapted to generate values for sub-pixels at fractional horizontal and vertical locations, the fractional horizontal and vertical locations being defined according to $1/2^x$, where x is a positive integer having a maximum value N, the interpolator being adapted to:

a) interpolate values for sub-pixels at $1/2^{N-1}$ unit horizontal and unit vertical locations, and unit horizontal and $1/2^{N-1}$ unit vertical locations directly using weighted sums of pixels residing at unit horizontal and unit vertical locations;

b) interpolate values for sub-pixels at $1/2^{N-1}$ unit horizontal and $1/2^{N-1}$ unit vertical locations directly using a choice of a first weighted sum of values for sub-pixels residing at $1/2^{N-1}$ unit horizontal and unit vertical locations and a second weighted sum of values for sub-pixels residing at unit horizontal and $1/2^{N-1}$ unit vertical locations, the first and second weighted sums of values being calculated according to step (a); and

c) interpolate a value for a sub-pixel situated at a $1/2^N$ unit horizontal and $1/2^N$ unit vertical location by taking a weighted average of the value of a first sub-pixel or pixel situated at a $1/2^{N-m}$ unit horizontal and $1/2^{N-n}$ unit vertical location and the value of a second sub-pixel or pixel located at a $1/2^{N-p}$ unit horizontal and $1/2^{N-q}$ unit vertical location, variables m, n, p and q taking integer values in the range 1 to N such that the first and second sub-pixels or pixels are located diagonally with respect to the sub-pixel at $1/2^N$ unit horizontal and $1/2^N$ vertical location.

The video coder may comprise a video encoder. It may comprise a video decoder. There may be a codec comprising both the video encoder and the video decoder.

According to a fifth aspect of the invention, there is provided a communications terminal comprising a video coder for coding an image comprising pixels arranged in rows and columns and represented by values having a specified dynamic range, the pixels in the rows residing at unit horizontal locations and the pixels in the columns residing at unit vertical locations, the video coder comprising an interpolator adapted to generate values for sub-pixels at fractional horizontal and vertical locations, the fractional horizontal and vertical locations being defined according to $1/2^x$, where x is a positive integer having a maximum value N, the interpolator being adapted to:

a) interpolate values for sub-pixels at $1/2^{N-1}$ unit horizontal and unit vertical locations, and unit horizontal and $1/2^{N-1}$ unit vertical locations directly using weighted sums of pixels residing at unit horizontal and unit vertical locations;

b) interpolate values for sub-pixels at $1/2^{N-1}$ unit horizontal and $1/2^{N-1}$ unit vertical locations directly using a choice of a first weighted sum of values for sub-pixels residing at $1/2^{N-1}$ unit horizontal and unit vertical locations and a second weighted sum of values for sub-pixels residing at unit horizontal and $1/2^{N-1}$ unit vertical locations, the first and second weighted sums of values being calculated according to step (a); and

c) interpolate a value for a sub-pixel situated at a $1/2^N$ unit horizontal and $1/2^N$ unit vertical location by taking a weighted average of the value of a first sub-pixel or pixel situated at a $1/2^{N-m}$ unit horizontal and $1/2^{N-n}$ unit vertical location and the value of a

second sub-pixel or pixel located at a $1/2^{N-p}$ unit horizontal and $1/2^{N-q}$ unit vertical location, variables m, n, p and q taking integer values in the range 1 to N such that the first and second sub-pixels or pixels are located diagonally with respect to the sub-pixel at $1/2^N$ unit horizontal and $1/2^N$ vertical location.

The communications terminal may comprise a video encoder. It may comprise a video decoder. Preferably, it comprises a video codec comprising a video encoder and a video decoder.

Preferably the communications terminal comprising a user interface, a processor and at least one of a transmitting block and a receiving block, and a video coder according to at least one of the third and fourth aspects of the invention. Preferably the processor controls the operation of the transmitting block and/or the receiving block and the video coder.

According to a sixth aspect of the invention, there is provided a telecommunications system comprising a communications terminal and a network, the telecommunications network and the communications terminal being connected by a communications link over which coded video can be transmitted, the communications terminal comprising a video coder for coding for coding an image comprising pixels arranged in rows and columns and represented by values having a specified dynamic range, the pixels in the rows residing at unit horizontal locations and the pixels in the columns residing at unit vertical locations, the video coder comprising an interpolator adapted to generate values for sub-pixels at fractional horizontal and vertical locations, the fractional horizontal and vertical locations being defined according to $1/2^x$, where x is a positive integer having a maximum value N, the interpolator being adapted to:

a) interpolate values for sub-pixels at $1/2^{N-1}$ unit horizontal and unit vertical locations, and unit horizontal and $1/2^{N-1}$ unit vertical locations directly using weighted sums of pixels residing at unit horizontal and unit vertical locations;

b) interpolate values for sub-pixels at $1/2^{N-1}$ unit horizontal and $1/2^{N-1}$ unit vertical locations directly using a choice of a first weighted sum of values for sub-pixels residing at $1/2^{N-1}$ unit horizontal and unit vertical locations and a second weighted sum of values for sub-pixels residing at unit horizontal and $1/2^{N-1}$ unit vertical locations, the first and second weighted sums of values being calculated according to step (a); and

c) interpolate a value for a sub-pixel situated at a $1/2^{N}$ unit horizontal and $1/2^{N}$ unit vertical location by taking a weighted average of the value of a first sub-pixel or pixel situated at a $1/2^{N-m}$ unit horizontal and $1/2^{N-n}$ unit vertical location and the value of a second sub-pixel or pixel located at a $1/2^{N-p}$ unit horizontal and $1/2^{N-q}$ unit vertical location, variables m, n, p and q taking integer values in the range 1 to N such that the first and second sub-pixels or pixels are located diagonally with respect to the sub-pixel at $1/2^{N}$ unit horizontal and $1/2^{N}$ vertical location.

Preferably the telecommunications system is a mobile telecommunications system comprising a mobile communications terminal and a wireless network, the connection between the mobile communications terminal and the wireless network being formed by a radio link. Preferably the network enables the communications terminal to communicate with other communications terminals connected to the network over communications links between the other communications terminals and the network.

According to a seventh aspect of the invention, there is provided a telecommunications system comprising a communications terminal and a network, the telecommunications network and the communications terminal being connected by a communications link over which coded video can be transmitted, the network comprising a video coder for coding for coding an image comprising pixels arranged in rows and columns and represented by values having a specified dynamic range, the pixels in the rows residing at unit horizontal locations and the pixels in the columns residing at unit vertical locations, the video coder comprising an interpolator adapted to generate values for sub-pixels at fractional horizontal and vertical

locations, the fractional horizontal and vertical locations being defined according to $1/2^x$, where x is a positive integer having a maximum value N, the interpolator being adapted to:

a) interpolate values for sub-pixels at $1/2^{N-1}$ unit horizontal and unit vertical locations, and unit horizontal and $1/2^{N-1}$ unit vertical locations directly using weighted sums of pixels residing at unit horizontal and unit vertical locations;

b) interpolate values for sub-pixels at $1/2^{N-1}$ unit horizontal and $1/2^{N-1}$ unit vertical locations directly using a choice of a first weighted sum of values for sub-pixels residing at $1/2^{N-1}$ unit horizontal and unit vertical locations and a second weighted sum of values for sub-pixels residing at unit horizontal and $1/2^{N-1}$ unit vertical locations, the first and second weighted sums of values being calculated according to step (a); and

c) interpolate a value for a sub-pixel situated at a $1/2^N$ unit horizontal and $1/2^N$ unit vertical location by taking a weighted average of the value of a first sub-pixel or pixel situated at a $1/2^{N-m}$ unit horizontal and $1/2^{N-n}$ unit vertical location and the value of a second sub-pixel or pixel located at a $1/2^{N-p}$ unit horizontal and $1/2^{N-q}$ unit vertical location, variables m, n, p and q taking integer values in the range 1 to N such that the first and second sub-pixels or pixels are located diagonally with respect to the sub-pixel at $1/2^N$ unit horizontal and $1/2^N$ vertical location.

According to an eighth aspect of the invention there is provided a video coder for coding an image comprising pixels arranged in rows and columns and represented by values having a specified dynamic range, the pixels in the rows residing at unit horizontal locations and the pixels in the columns residing at unit vertical locations, the coder comprising an interpolator adapted to generate values for sub-pixels at fractional horizontal and vertical locations, the resolution of the sub-pixels being determined by a positive integer N, the interpolator being adapted to:

a) interpolate values for sub-pixels at $1/2^{N-1}$ unit horizontal and unit vertical locations, and unit horizontal and $1/2^{N-1}$ unit vertical locations directly using weighted sums of pixels residing at unit horizontal and unit vertical locations;

b) interpolate a value for a sub-pixel at a sub-pixel horizontal and sub-pixel vertical location is required directly using a choice of a first weighted sum of values for sub-pixels located at a vertical location corresponding to that of the sub-pixel being calculated and a second weighted sum of values for sub-pixels located at a horizontal location corresponding to that of the sub-pixel being calculated.

The interpolator may be further adapted to form the first weighted sum using the values of sub-pixels residing at $1/2^{N-1}$ unit horizontal and unit vertical locations and to use the first weighted sum to interpolate a value for a sub-pixel at $1/2^{N-1}$ unit horizontal and $1/2^{N}$ unit vertical location.

The interpolator may be further adapted to form the second weighted sum using the values of sub-pixels residing at unit horizontal and $1/2^{N-1}$ unit vertical locations and to use the second weighted sum to interpolate a value for a sub-pixel at $1/2^{N}$ unit horizontal and $1/2^{N-1}$ unit vertical location.

The interpolator may be further adapted to interpolate values for sub-pixels at $1/2^{N}$ unit horizontal and $1/2^{N}$ unit vertical locations by taking the average of at least one pair of a first pair of values of a sub-pixel located at a $1/2^{N-1}$ unit horizontal and unit vertical location, and a sub-pixel located at a unit horizontal and $1/2^{N-1}$ unit vertical location and a second pair of values of a pixel located at a unit horizontal and unit vertical location, and a sub-pixel located at a $1/2^{N-1}$ unit horizontal and $1/2^{N-1}$ unit vertical location.

According to a ninth aspect of the invention there is provided a communications terminal comprising a video coder for coding an image comprising pixels arranged in rows and columns and represented by values having a specified dynamic range, the pixels in the rows residing at unit horizontal locations and the pixels in the columns residing at unit vertical locations, the coder comprising an interpolator adapted to generate values for sub-pixels at fractional horizontal and vertical locations, the

resolution of the sub-pixels being determined by a positive integer N, the interpolator being adapted to:

a) interpolate values for sub-pixels at $1/2^{N-1}$ unit horizontal and unit vertical locations, and unit horizontal and $1/2^{N-1}$ unit vertical locations directly using weighted sums of pixels residing at unit horizontal and unit vertical locations;

b) interpolate a value for a sub-pixel at a sub-pixel horizontal and sub-pixel vertical location is required directly using a choice of a first weighted sum of values for sub-pixels located at a vertical location corresponding to that of the sub-pixel being calculated and a second weighted sum of values for sub-pixels located at a horizontal location corresponding to that of the sub-pixel being calculated.

According to a tenth aspect of the invention there is provided a telecommunications system comprising a communications terminal and a network, the telecommunications network and the communications terminal being connected by a communications link over which coded video can be transmitted, the communications terminal comprising a video coder for coding an image comprising pixels arranged in rows and columns and represented by values having a specified dynamic range, the pixels in the rows residing at unit horizontal locations and the pixels in the columns residing at unit vertical locations, the coder comprising an interpolator adapted to generate values for sub-pixels at fractional horizontal and vertical locations, the resolution of the sub-pixels being determined by a positive integer N, the interpolator being adapted to:

a) interpolate values for sub-pixels at $1/2^{N-1}$ unit horizontal and unit vertical locations, and unit horizontal and $1/2^{N-1}$ unit vertical locations directly using weighted sums of pixels residing at unit horizontal and unit vertical locations;

b) interpolate a value for a sub-pixel at a sub-pixel horizontal and sub-pixel vertical location is required directly using a choice of a first weighted sum of values for sub-pixels located at a vertical location corresponding to that of the sub-pixel being calculated and a second weighted sum of values for sub-pixels located at a horizontal location corresponding to that of the sub-pixel being calculated.

According to an eleventh aspect of the invention there is provided a telecommunications system comprising a communications terminal and a network, the telecommunications network and the communications terminal being connected by a communications link over which coded video can be transmitted, the network comprising a video coder for coding for coding an image comprising pixels arranged in rows and columns and represented by values having a specified dynamic range, the pixels in the rows residing at unit horizontal locations and the pixels in the columns residing at unit vertical locations, the coder comprising an interpolator adapted to generate values for sub-pixels at fractional horizontal and vertical locations, the resolution of the sub-pixels being determined by a positive integer N, the interpolator being adapted to:

a) interpolate values for sub-pixels at $1/2^{N-1}$ unit horizontal and unit vertical locations, and unit horizontal and $1/2^{N-1}$ unit vertical locations directly using weighted sums of pixels residing at unit horizontal and unit vertical locations;

b) interpolate a value for a sub-pixel at a sub-pixel horizontal and sub-pixel vertical location is required directly using a choice of a first weighted sum of values for sub-pixels located at a vertical location corresponding to that of the sub-pixel being calculated and a second weighted sum of values for sub-pixels located at a horizontal location corresponding to that of the sub-pixel being calculated.

According to the twelfth aspect of the invention, the disclosed embodiments are directed to a method for sub-pixel value interpolation to determine values for sub-pixels situated within a rectangular bounded region defined by four corner pixels with no intermediate pixels between the corners, the pixels and sub-pixels being arranged in rows and columns, the pixel and sub-pixel locations being representable mathematically within the rectangular bounded region using the co-ordinate notation $K/2^N$, $L/2^N$, K and L being positive integers having respective values between zero and $2^N$, N being a positive integer greater than one and representing a particular degree of sub-pixel value interpolation, the method comprising:

(a) interpolating a sub-pixel value for a sub-pixel having co-ordinates with odd values of both K and L, according to a predetermined choice of a weighted average of the value of a nearest-neighbouring pixel and the value of the sub-pixel situated at co-ordinates 1/2, 1/2, and a weighted average of the values of a pair of diagonally-opposed sub-pixels having co-ordinates with even values of both K and L, including zero, situated within a quadrant of the rectangular bounded region defined by corner pixels having co-ordinates 1/2, 1/2 and the nearest neighbouring pixel;

(b) interpolating sub-pixel values for sub-pixels having co-ordinates with K equal to an even value and L equal zero and sub-pixels having co-ordinates with K equal to zero and L equal to an even value, used in the interpolation of the sub-pixels having co-ordinates with odd values of both K and L, using weighted sums of the values of pixels located in rows and columns respectively; and

(c) interpolating sub-pixel values for sub-pixels having co-ordinates with even values of both K and L, used in the interpolation of sub-pixel values for the sub-pixels having co-ordinates with odd values of both K and L, using a predetermined choice of either a weighted sum of the values of sub-pixels having co-ordinates with K equal to an even value and L equal to zero and the values of sub-pixels having corresponding co-ordinates in immediately adjacent rectangular bounded regions, or a weighted sum of the values of sub-pixels having co-ordinates with K equal to zero and L equal to an even value and the values of sub-pixels having corresponding co-ordinates in immediately adjacent bounded rectangular regions.

According to the thirteenth aspect of the invention, the disclosed embodiments are directed to a method for quarter resolution sub-pixel value interpolation to determine values for sub-pixels situated within a rectangular bounded region defined by four corner pixels with no intermediate pixels between the corners, the pixels and sub-pixels being arranged in rows and columns, the pixel and sub-pixel locations being

representable mathematically within the rectangular bounded region using the co-ordinate notation K/4, L/4, K and L being positive integers having respective values between zero and 4, the method comprising:

(a) interpolating a sub-pixel value for a sub-pixel having co-ordinates with both K and L equal to 1 or 3, according to a predetermined choice of a weighted average of the value of a nearest-neighbouring pixel and the value of the sub-pixel situated at co-ordinates 2/4, 2/4, and a weighted average of the values of a pair of diagonally-opposed sub-pixels having co-ordinates with both K and L equal to zero, 2 or 4, situated within a quadrant of the rectangular bounded region defined by corner pixels having co-ordinates 2/4, 2/4 and the nearest neighbouring pixel;

(b) interpolating sub-pixel values for sub-pixels having co-ordinates with K equal to 2 and L equal zero and sub-pixels having co-ordinates with K equal to zero and L equal to 2, used in the interpolation of the sub-pixels having co-ordinates with both K and L equal to 1 or 3, using weighted sums of the values of pixels located in rows and columns respectively; and

(c) interpolating a sub-pixel value for the sub-pixel having co-ordinates with both K and L equal to 2, used in the interpolation of sub-pixel values for the sub-pixels having co-ordinates with both K and L equal to 1 or 3, using a predetermined choice of either a weighted sum of the values of the sub-pixel having co-ordinates with K equal to 2 and L equal to zero and the values of sub-pixels having corresponding co-ordinates in immediately adjacent rectangular bounded regions, or a weighted sum of the value of the sub-pixel having co-ordinates with K equal to zero and L equal to 2 and the values of sub-pixels having corresponding co-ordinates in immediately adjacent rectangular bounded regions.

According to the fourteenth aspect of the invention, the disclosed embodiments are direct to a method for eighth resolution sub-pixel value interpolation to determine values for sub-pixels situated within a rectangular bounded region defined by four corner pixels with no intermediate pixels between the corners, the pixels and sub-pixels being arranged in rows and columns, the pixel and sub-pixel locations being representable mathematically with the rectangular bounded region using the co-ordinate notation K/8, L/8, K and L being positive integers having respective values between zero and 8, the method comprising:

(a) interpolating a sub-pixel value for a sub-pixel having co-ordinates with both K and L equal to 1, 3, 5 or 7, according to a predetermined choice of a weighted average of the value of a nearest-neighbouring pixel and the value of the sub-pixel situated at co-ordinates 4/8, 4/8, and a weighted average of the values of a pair of diagonally-opposed sub-pixels having co-ordinates with both K and L equal to zero, 2, 4, 6 or 8, situated within a quadrant of the rectangular bounded region defined by corner pixels having co-ordinates 4/8, 4/8 and the nearest neighbouring pixel;

(b) interpolating sub-pixel values for sub-pixels having co-ordinates with K equal to 2, 4 or 6 and L equal zero and sub-pixels having co-ordinates with K equal to zero and L equal to 2, 4 or 6, used in the interpolation of the sub-pixels having co-ordinates with both K and L equal to 1, 3, 5 or 7, using weighted sums of the values of pixels located in rows and columns respectively; and

(c) interpolating sub-pixel values for sub-pixels having co-ordinates with both K and L equal to 2, 4 or 6, used in the interpolation of sub-pixel values for the sub-pixels having co-ordinates with both K and L equal to 1, 3, 5 or 7, using a predetermined choice of either a weighted sum of the values of sub-pixels having co-ordinates with K equal to 2, 4 or 6 and L equal to zero and the values of sub-pixels having corresponding co-ordinates in immediately adjacent rectangular bounded regions or a weighted sum of the values of sub-pixels having co-ordinates with K equal to zero and L equal to 2, 4 or 6 and the values of sub-

pixels having corresponding co-ordinates in immediately adjacent rectangular bounded regions.

According to the fifteenth aspect of the invention, the disclosed embodiments are directed to an apparatus for sub-pixel value interpolation, the apparatus being operable to determine values for sub-pixels situated within a rectangular bounded region defined by four corner pixels with no intermediate pixels between the corners, the pixels and sub-pixels being arranged in rows and columns, the pixel and sub-pixel locations being representable mathematically within the rectangular bounded region using the co-ordinate notation $K/2^N$, $L/2^N$, K and L being positive integers having respective values between zero and $2^N$, N being a positive integer greater than one and representing a particular degree of sub-pixel value interpolation, the apparatus comprising:

(a) circuitry operable to interpolate a sub-pixel value for a sub-pixel having co-ordinates with odd values of both K and L, according to a predetermined choice of a weighted average of the value of a nearest-neighbouring pixel and the value of the sub-pixel situated at co-ordinates 1/2, 1/2, and a weighted average of the values of a pair of diagonally-opposed sub-pixels having co-ordinates with even values of both K and L, including zero, situated within a quadrant of the rectangular bounded region defined by corner pixels having co-ordinates 1/2, 1/2 and the nearest neighbouring pixel;

(b) circuitry operable to interpolate sub-pixel values for sub-pixels having co-ordinates with K equal to an even value and L equal zero and sub-pixels having co-ordinates with K equal to zero and L equal to an even value, used in the interpolation of the sub-pixels having co-ordinates with odd values of both K and L, using weighted sums of the values of pixels located in rows and columns respectively; and

(c) circuitry operable to interpolate sub-pixel values for sub-pixels having co-ordinates with even values of both K and L, used in the interpolation of sub-pixel values for the sub-pixels having co-ordinates with odd values of both K and L, using a predetermined choice of either a weighted sum of the values of sub-pixels having co-ordinates with K equal to an even value and L equal to zero and the values of sub-pixels having corresponding co-ordinates in immediately adjacent rectangular bounded regions, or a weighted sum of the values of sub-pixels having co-ordinates with K equal to zero and L equal to an even value and the values of sub-pixels having corresponding co-ordinates in immediately adjacent bounded rectangular regions.

In one embodiment the method includes comprising using a first and a second weight in the weighted average chosen to interpolate the sub-pixel value for a sub-pixel having co-ordinates with odd values of both K and L, wherein when the chosen weighted average is that involving the value of a nearest neighbouring pixel and the value of the sub-pixel situated at co-ordinates 1/2, 1/2, selecting the relative magnitudes of the first and second weights to be inversely proportional to the respective straight-line diagonal distances of the nearest-neighbouring pixel and the sub-pixel situated at co-ordinates 1/2, 1/2 to the sub-pixel having co-ordinates with odd values of both K and L whose value is being interpolated.

In one embodiment the method includes comprising using a first and a second weight in the weighted average chosen to interpolate the sub-pixel value for a sub-pixel having co-ordinates with odd values of both K and L, wherein when the chosen weighted average is that involving the values of a pair of diagonally-opposed sub-pixels having co-ordinates with even values of both K and L, selecting the relative magnitudes of the first and second weights to be inversely proportional to the respective straight-line diagonal distances of the sub-pixels having co-ordinates with even values of both K and L to the sub-pixel having co-ordinates with odd values of both K and L whose value is being interpolated.

In one embodiment the method includes comprising using first and second weights with equal values when the nearest-neighbouring pixel and sub-pixel situated at co-ordinates 1/2, 1/2 are equidistant from the sub-pixel having co-ordinates with odd values of both K and L whose value is being interpolated.

In one embodiment the method includes comprising using first and second weights with equal values when the sub-pixels having co-ordinates with even values of both K and L are equidistant from the sub-pixel having co-ordinates with odd values of both K and L whose value is being interpolated.

In one embodiment the method includes interpolating sub-pixel values for sub-pixels having co-ordinates with even values of both K and L, used in interpolation of sub-pixel values for the sub-pixels having co-ordinates with odd values of both K and L, using a weighted sum of the values of sub-pixels having co-ordinates with K equal to an even value and L equal to zero and the values of sub-pixels having corresponding co-ordinates in immediately adjacent rectangular bounded regions when the value of a sub-pixel having co-ordinates with K equal to an even value and L equal to an odd value is also required.

In one embodiment the method includes comprising interpolating sub-pixel values for sub-pixels having co-ordinates with even values of both K and L, used in interpolation of sub-pixel values for the sub-pixels having co-ordinates with odd values of both K and L, using a weighted sum of the values of sub-pixels having co-ordinates with K equal to zero and L equal to an even value and the values of sub-pixels having corresponding co-ordinates in immediately adjacent rectangular bounded regions when the value of a sub-pixel having co-ordinates with K equal to an odd value and L equal to an even value is also required.

In one embodiment the method includes comprising interpolating sub-pixel values for sub-pixels having co-ordinates with K equal to an odd value O and L equal to an even value E, not including zero or $2^N$, by taking an average of the value of a first sub-pixel having co-ordinates with K equal to the even value O - 1 and L equal to E and a second sub-pixel having co-ordinates with K equal to the even value O + 1 and L equal to E.

In one embodiment the method includes comprising interpolating a sub-pixel value for a sub-pixel having co-ordinates with K equal to 1 and L equal to zero, by taking an average of the value of a pixel having co-ordinates with K equal to zero and L equal to zero, and a sub-pixel having co-ordinates with K equal to 2 and L equal to zero.

In one embodiment the method includes comprising interpolating a sub-pixel value for a sub-pixel having co-ordinates with K equal to $2^N$ - 1 and L equal to zero, by taking an average of the value of a pixel having co-ordinates with K equal to $2^N$ and L equal to zero, and a sub-pixel having co-ordinates with K equal to $2^N$ - 2 and L equal to zero.

In one embodiment the method includes comprising interpolating a sub-pixel value for a sub-pixel having co-ordinates with K equal to 1 and L equal to $2^N$, by taking an average of the value of a pixel having co-ordinates with K equal to zero and L equal to $2^N$, and a sub-pixel having co-ordinates with K equal to 2 and L equal to $2^N$.

In one embodiment the method includes comprising interpolating a sub-pixel value for a sub-pixel having co-ordinates with K equal to $2^N$ - 1 and L equal to $2^N$, by taking an average of the value of a pixel having co-ordinates with K equal to $2^N$ and

L equal to $2^N$, and a sub-pixel having co-ordinates with K equal to $2^N$ - 2 and L equal to $2^N$.

In one embodiment the method includes comprising interpolating sub-pixel values for sub-pixels having co-ordinates with K equal to an even value E, not including zero or $2^N$, and L equal to an odd value O, by taking an average of the value of a first sub-pixel having co-ordinates with K equal to E and L equal to the even value O - 1 and a second sub-pixel having co-ordinates with K equal to E and L equal to the even value O + 1.

In one embodiment the method includes comprising interpolating a sub-pixel value for a sub-pixel having co-ordinates with K equal to zero and L equal to 1, by taking an average of the value of a pixel having co-ordinates with K equal to zero and L equal to zero, and a sub-pixel having co-ordinates with K equal to zero and L equal to 2.

In one embodiment the method includes comprising interpolating a sub-pixel value for a sub-pixel having co-ordinates with K equal to $2^N$ and L equal to 1, by taking an average of the value of a pixel having co-ordinates with K equal to $2^N$ and L equal to zero, and a sub-pixel having co-ordinates with K equal to zero and L equal to 2.

In one embodiment the method includes comprising interpolating a sub-pixel value for a sub-pixel having co-ordinates with K equal to 0 and L equal to $2^N$ - 1, by taking an average of the value of a pixel having co-ordinates with K equal to zero and L equal to $2^N$, and a sub-pixel having co-ordinates with K equal to zero and L equal to $2^N$ - 2.

In one embodiment the method includes comprising interpolating a sub-pixel value for a sub-pixel having co-ordinates with K equal to $2^N$ and L equal to $2^N$ - 1, by taking an average of the value of a pixel having co-ordinates with K equal to $2^N$ and L equal to $2^N$, and a sub-pixel having co-ordinates with K equal to $2^N$ and L equal to $2^N$ - 2.

In one embodiment the method includes comprising interpolating a sub-pixel value for the sub-pixel having co-ordinates with K equal to $2^N$ - 1 and L equal to $2^N$ - 1, by taking a weighted average of the values of the four corner pixels that define the rectangular bounded region.

In one embodiment the method includes comprising selecting a value for N from a list consisting of the values 2, 3, and 4.

In one embodiment the apparatus is operable to use a first and a second weight in the weighted average chosen to interpolate the sub-pixel value for a sub-pixel having co-ordinates with odd values of both K and L, wherein when the chosen weighted average is that involving the value of a nearest neighbouring pixel and the value of the sub-pixel situated at co-ordinates 1/2, 1/2, the apparatus is operable to select the relative magnitudes of the first and second weights to be inversely proportional to the respective straight-line diagonal distances of the nearest-neighbouring pixel and the sub-pixel situated at co-ordinates 1/2, 1/2 to the sub-pixel having co-ordinates with odd values of both K and L whose value is being interpolated.

In one embodiment the apparatus is operable to use a first and a second weight in the weighted average chosen to interpolate the sub-pixel value for a sub-pixel having co-ordinates with odd values of both K and L, wherein when the chosen

weighted average is that involving the values of a pair of diagonally-opposed sub-pixels having co-ordinates with even values of both K and L, the apparatus is operable to select the relative magnitudes of the first and second weights to be inversely proportional to the respective straight-line diagonal distances of the sub-pixels having co-ordinates with even values of both K and L to the sub-pixel having co-ordinates with odd values of both K and L whose value is being interpolated.

In one embodiment the apparatus is operable to use first and second weights with equal values when the nearest-neighbouring pixel and sub-pixel situated at co-ordinates 1/2, 1/2 are equidistant from the sub-pixel having co-ordinates with odd values of both K and L whose value is being interpolated.

In one embodiment the apparatus is operable to use first and second weights with equal values when the sub-pixels having co-ordinates with even values of both K and L are equidistant from the sub-pixel having co-ordinates with odd values of both K and L whose value is being interpolated.

In one embodiment the apparatus is operable to interpolate sub-pixel values for sub-pixels having co-ordinates with even values of both K and L, used in interpolation of sub-pixel values for the sub-pixels having co-ordinates with odd values of both K and L, using a weighted sum of the values of sub-pixels having co-ordinates with K equal to an even value and L equal to zero and the values of sub-pixels having corresponding co-ordinates in immediately adjacent rectangular bounded regions when the value of a sub-pixel having co-ordinates with K equal to an even value and L equal to an odd value is also required.

In one embodiment the apparatus is operable to interpolate sub-pixel values for sub-pixels having co-ordinates with even values of both K and L, used in interpolation of

sub-pixel values for the sub-pixels having co-ordinates with odd values of both K and L, using a weighted sum of the values of sub-pixels having co-ordinates with K equal to zero and L equal to an even value and the values of sub-pixels having corresponding co-ordinates in immediately adjacent rectangular bounded regions when the value of a sub-pixel having co-ordinates with K equal to an odd value and L equal to an even value is also required.

In one embodiment the apparatus is operable to interpolate sub-pixel values for sub-pixels having co-ordinates with K equal to an odd value O and L equal to an even value E, not including zero or $2^N$, by taking an average of the value of a first sub-pixel having co-ordinates with K equal to the even value O - 1 and L equal to E and a second sub-pixel having co-ordinates with K equal to the even value O + 1 and L equal to E.

In one embodiment the apparatus is operable to interpolate a sub-pixel value for a sub-pixel having co-ordinates with K equal to 1 and L equal to zero, by taking an average of the value of a pixel having co-ordinates with K equal to zero and L equal to zero, and a sub-pixel having co-ordinates with K equal to 2 and L equal to zero.

In one embodiment the apparatus is operable to interpolate a sub-pixel value for a sub-pixel having co-ordinates with K equal to $2^N$ - 1 and L equal to zero, by taking an average of the value of a pixel having co-ordinates with K equal to $2^N$ and L equal to zero, and a sub-pixel having co-ordinates with K equal to $2^N$ - 2 and L equal to zero.

In one embodiment the apparatus is operable to interpolate a sub-pixel value for a sub-pixel having co-ordinates with K equal to 1 and L equal to $2^N$, by taking an average of the value of a pixel having co-ordinates with K equal to zero and L equal to $2^N$, and a sub-pixel having co-ordinates with K equal to 2 and L equal to $2^N$.

In one embodiment the apparatus is operable to interpolate a sub-pixel value for a sub-pixel having co-ordinates with K equal to $2^N - 1$ and L equal to $2^N$, by taking an average of the value of a pixel having co-ordinates with K equal to $2^N$ and L equal to $2^N$, and a sub-pixel having co-ordinates with K equal to $2^N - 2$ and L equal to $2^N$.

In one embodiment the apparatus is operable to interpolate sub-pixel values for sub-pixels having co-ordinates with K equal to an even value E, not including zero or $2^N$, and L equal to an odd value O, by taking an average of the value of a first sub-pixel having co-ordinates with K equal to E and L equal to the even value O - 1 and a second sub-pixel having co-ordinates with K equal to E and L equal to the even value O + 1.

In one embodiment the apparatus is operable to interpolate a sub-pixel value for a sub-pixel having co-ordinates with K equal to zero and L equal to 1, by taking an average of the value of a pixel having co-ordinates with K equal to zero and L equal to zero, and a sub-pixel having co-ordinates with K equal to zero and L equal to 2.

In one embodiment the apparatus is operable to interpolate a sub-pixel value for a sub-pixel having co-ordinates with K equal to $2^N$ and L equal to 1, by taking an average of the value of a pixel having co-ordinates with K equal to $2^N$ and L equal to zero, and a sub-pixel having co-ordinates with K equal to zero and L equal to 2.

In one embodiment the apparatus is operable to interpolate a sub-pixel value for a sub-pixel having co-ordinates with K equal to 0 and L equal to $2^N - 1$, by taking an average of the value of a pixel having co-ordinates with K equal to zero and L equal to $2^N$, and a sub-pixel having co-ordinates with K equal to zero and L equal to $2^N - 2$.

In one embodiment the apparatus is operable to interpolate a sub-pixel value for a sub-pixel having co-ordinates with K equal to $2^N$ and L equal to $2^N$ - 1, by taking an average of the value of a pixel having co-ordinates with K equal to $2^N$ and L equal to $2^N$, and a sub-pixel having co-ordinates with K equal to $2^N$ and L equal to $2^N$ - 2.

In one embodiment the apparatus is operable to interpolate a sub-pixel value for the sub-pixel having co-ordinates with K equal to $2^N$ - 1 and L equal to $2^N$ - 1, by taking a weighted average of the values of the four corner pixels that define the rectangular bounded region.

In one embodiment the apparatus includes N is set equal to 2.

In one embodiment the apparatus includes N is set equal to 3.

In one embodiment the apparatus includes a video encoder comprising an apparatus for sub-pixel value interpolation.

In one embodiment the apparatus includes a still image encoder comprising an apparatus for sub-pixel value interpolation.

In one embodiment the apparatus includes a video decoder comprising an apparatus for sub-pixel value interpolation.

In one embodiment the apparatus includes a still image decoder comprising an apparatus for sub-pixel value interpolation.

In one embodiment the apparatus includes a codec comprising a video encoder and a video decoder.

In one embodiment the apparatus includes a codec comprising a still image encoder and a still image decoder.

In one embodiment the apparatus includes a communications terminal comprising a video encoder.

In one embodiment the apparatus includes a communications terminal comprising a still image encoder.

In one embodiment the apparatus includes a communications terminal comprising a video decoder.

In one embodiment the apparatus includes a communications terminal comprising a still image decoder.

Brief Description of the Figures

An embodiment of the invention will now be described by way of example only with reference to the accompanying drawings in which:
Figure 1 shows a video encoder according to the prior art;
Figure 2 shows a video decoder according to the prior art;
Figure 3 shows the types of frames used in video encoding;
Figures 4a, 4b, and 4c show steps in block-matching;
Figure 5 illustrates the process of motion estimation to sub-pixel resolution;
Figure 6 shows a terminal device comprising video encoding and decoding equipment in which the method of the invention may be implemented;

Figure 7 shows a video encoder according an embodiment of the present invention;

Figure 8 shows a video decoder according to an embodiment of the present invention;

Figures 9 and 10 have not been used and any such figures should be disregarded;

Figure 11 shows a schematic diagram of a mobile telecommunications network according to an embodiment of the present invention;

Figure 12a shows a notation for describing pixel and sub-pixel locations specific to TML5;

Figure 12b shows interpolation of a half resolution sub-pixels;

Figure 12c shows interpolation of a half resolution sub-pixels;

Figure 13a shows a notation for describing pixel and sub-pixel locations specific to TML6;

Figure 13b shows interpolation of a half resolution sub-pixels;

Figure 13c shows interpolation of a half resolution sub-pixels;

Figure 14 shows a notation for describing pixel and sub-pixel locations specific to the invention;

Figure 14b shows interpolation of a half resolution sub-pixels according to the invention;

Figure 14c shows interpolation of a half resolution sub-pixels according to the invention;

Figure 15 shows possible choices of diagonal interpolation for sub-pixels;

Figure 16 shows the half resolution sub-pixel values required to calculate other half resolution sub-pixel values;

Figure 17a shows the half resolution sub-pixel values that must be calculated in order to interpolate values for quarter resolution sub-pixels in an image block using the interpolation method of TML5;

Figure 17b shows the half resolution sub-pixel values that must be calculated in order to interpolate values for quarter resolution sub-pixels in an image block using the interpolation method according to the invention;

Figures 18a shows the numbers of half resolution sub-pixels that must be calculated in order to obtain values for quarter resolution sub-pixels within an image block using the sub-pixel value interpolation method according to TML5;

Figure 18b shows the numbers of half resolution sub-pixels that must be calculated in order to obtain values for quarter resolution sub-pixels within an image block using the sub-pixel value interpolation method according to the invention;

Figure 19 shows a numbering scheme for each of the 15 sub-pixel positions;

Figure 20 shows nomenclature used to describe pixels, half resolution sub-pixels, quarter resolution sub-pixels and eighth resolution sub-pixels

Figure 21a shows the diagonal direction to be used in the interpolation of each eighth resolution sub-pixel in an embodiment of the invention;

Figure 21b shows the diagonal direction to be used in the interpolation of each eighth resolution sub-pixel in another embodiment of the invention; and

Figure 22 shows nomenclature used to describe eighth resolution sub-pixels within an image.

Detailed Description

Figures 1 to 5, 12a, 12b, 12c, 13a, 13b, and 13c have been described in the foregoing.

Figure 6 presents a terminal device comprising video encoding and decoding equipment which may be adapted to operate in accordance with the present invention. More precisely, the figure illustrates a multimedia terminal 60 implemented according to ITU-T recommendation H.324. The terminal can be regarded as a multimedia transceiver device. It includes elements that capture, encode and multiplex multimedia data streams for transmission via a communications network, as well as elements that receive, de-multiplex, decode and display received multimedia content. ITU-T recommendation H.324 defines the overall operation of the terminal and refers to other recommendations that govern the operation of its various constituent parts. This kind of multimedia terminal can

be used in real-time applications such as conversational videotelephony, or non real-time applications such as the retrieval/streaming of video clips, for example from a multimedia content server in the Internet.

In the context of the present invention, it should be appreciated that the H.324 terminal shown in Figure 6 is only one of a number of alternative multimedia terminal implementations suited to application of the inventive method. It should also be noted that a number of alternatives exist relating to the location and implementation of the terminal equipment. As illustrated in Figure 6, the multimedia terminal may be located in communications equipment connected to a fixed line telephone network such as an analogue PSTN (Public Switched Telephone Network). In this case the multimedia terminal is equipped with a modem 71, compliant with ITU-T recommendations V.8, V.34 and optionally V.8bis. Alternatively, the multimedia terminal may be connected to an external modem. The modem enables conversion of the multiplexed digital data and control signals produced by the multimedia terminal into an analogue form suitable for transmission over the PSTN. It further enables the multimedia terminal to receive data and control signals in analogue form from the PSTN and to convert them into a digital data stream that can be demulitplexed and processed in an appropriate manner by the terminal.

An H.324 multimedia terminal may also be implemented in such a way that it can be connected directly to a digital fixed line network, such as an ISDN (Integrated Services Digital Network). In this case the modem 71 is replaced with an ISDN user-network interface. In Figure 6, this ISDN user-network interface is represented by alternative block 72.

H.324 multimedia terminals may also be adapted for use in mobile communication applications. If used with a wireless communication link, the modem 71 can be replaced with any appropriate wireless interface, as represented by alternative block 73 in Figure 6. For example, an H.324/M multimedia terminal can include a radio

transceiver enabling connection to the current 2nd generation GSM mobile telephone network, or the proposed 3rd generation UMTS (Universal Mobile Telephone System).

It should be noted that in multimedia terminals designed for two-way communication, that is for transmission and reception of video data, it is advantageous to provide both a video encoder and video decoder implemented according to the present invention. Such an encoder and decoder pair is often implemented as a single combined functional unit, referred to as a 'codec'.

Because a video encoder according to the invention performs motion compensated video encoding to sub-pixel resolution using a specific interpolation scheme and a particular combination of before-hand and on-demand sub-pixel value interpolation, it is generally necessary for a video decoder of a receiving terminal to be implemented in a manner compatible with the encoder of the transmitting terminal which formed the compressed video data stream. Failure to ensure this compatibility may have an adverse effect on the quality of the motion compensation and the accuracy of reconstructed video frames.

A typical H.324 multimedia terminal will now be described in further detail with reference to Figure 6.

The multimedia terminal 60 includes a variety of elements referred to as 'terminal equipment'. This includes video, audio and telematic devices, denoted generically by reference numbers 61, 62 and 63, respectively. The video equipment 61 may include, for example, a video camera for capturing video images, a monitor for displaying received video content and optional video processing equipment. The audio equipment 62 typically includes a microphone, for example for capturing spoken messages, and a loudspeaker for reproducing received audio content. The audio equipment may also include additional audio processing units. The telematic equipment 63, may include a data terminal, keyboard, electronic whiteboard or a still image transceiver, such as a fax unit.

The video equipment 61 is coupled to a video codec 65. The video codec 65 comprises a video encoder and a corresponding video decoder both implemented according to the invention. Such an encoder and a decoder will be described in the following. The video codec 65 is responsible for encoding captured video data in an appropriate form for further transmission over a communications link and decoding compressed video content received from the communications network. In the example illustrated in Figure 6, the video codec is implemented according to ITU-T recommendation H.263, with appropriate modifications to implement the sub-pixel value interpolation method according to the invention in both the encoder and the decoder of the video codec.

Similarly, the terminal's audio equipment is coupled to an audio codec, denoted in Figure 6 by reference number 66. Like the video codec, the audio codec comprises an encoder/decoder pair. It converts audio data captured by the terminal's audio equipment into a form suitable for transmission over the communications link and transforms encoded audio data received from the network back into a form suitable for reproduction, for example on the terminal's loudspeaker. The output of the audio codec is passed to a delay block 67. This compensates for the delays introduced by the video coding process and thus ensures synchronisation of audio and video content.

The system control block 64 of the multimedia terminal controls end-to-network signalling using an appropriate control protocol (signalling block 68) to establish a common mode of operation between a transmitting and a receiving terminal. The signalling block 68 exchanges information about the encoding and decoding capabilities of the transmitting and receiving terminals and can be used to enable the various coding modes of the video encoder. The system control block 64 also controls the use of data encryption. Information regarding the type of encryption to be used in data transmission is passed from encryption block 69 to the multiplexer/de-multiplexer (MUX/DMUX unit) 70.

During data transmission from the multimedia terminal, the MUX/DMUX unit 70 combines encoded and synchronised video and audio streams with data input from the telematic equipment 63 and possible control data, to form a single bit-stream. Information concerning the type of data encryption (if any) to be applied to the bit-stream, provided by encryption block 69, is used to select an encryption mode. Correspondingly, when a multiplexed and possibly encrypted multimedia bit-stream is being received, MUX/DMUX unit 70 is responsible for decrypting the bit-stream, dividing it into its constituent multimedia components and passing those components to the appropriate codec(s) and/or terminal equipment for decoding and reproduction.

It should be noted that the functional elements of the multimedia terminal, video encoder, decoder and video codec according to the invention can be implemented as software or dedicated hardware, or a combination of the two. The video encoding and decoding methods according to the invention are particularly suited for implementation in the form of a computer program comprising machine-readable instructions for performing the functional steps of the invention. As such, the encoder and decoder according to the invention may be implemented as software code stored on a storage medium and executed in a computer, such as a personal desktop computer, in order to provide that computer with video encoding and/or decoding functionality.

If the multimedia terminal 60 is a mobile terminal, that is if it is equipped with a radio transceiver 73, it will be understood by those skilled in the art that it may also comprise additional elements. In one embodiment it comprises a user interface having a display and a keyboard, which enables operation of the multimedia terminal 60 by a user, together with necessary functional blocks including a central processing unit, such as a microprocessor, which controls the blocks responsible for different functions of the multimedia terminal, a random access memory RAM, a read only memory ROM, and a digital camera. The microprocessor's operating

instructions, that is program code corresponding to the basic functions of the multimedia terminal 60, is stored in the read-only memory ROM and can be executed as required by the microprocessor, for example under control of the user. In accordance with the program code, the microprocessor uses the radio transceiver 73 to form a connection with a mobile communication network, enabling the multimedia terminal 60 to transmit information to and receive information from the mobile communication network over a radio path.

The microprocessor monitors the state of the user interface and controls the digital camera. In response to a user command, the microprocessor instructs the camera to record digital images into the RAM. Once an image is captured, or alternatively during the capturing process, the microprocessor segments the image into image segments (for example macroblocks) and uses the encoder to perform motion compensated encoding for the segments in order to generate a compressed image sequence as explained in the foregoing description. A user may command the multimedia terminal 60 to display the captured images on its display or to send the compressed image sequence using the radio transceiver 73 to another multimedia terminal, a video telephone connected to a fixed line network (PSTN) or some other telecommunications device. In a preferred embodiment, transmission of image data is started as soon as the first segment is encoded so that the recipient can start a corresponding decoding process with a minimum delay.

Figure 11 is a schematic diagram of a mobile telecommunications network according to an embodiment of the invention. Multimedia terminals MS are in communication with base stations BTS by means of a radio link. The base stations BTS are further connected, through a so-called Abis interface, to a base station controller BSC, which controls and manages several base stations.

The entity formed by a number of base stations BTS (typically, by a few tens of base stations) and a single base station controller BSC, controlling the base stations, is called a base station subsystem BSS. Particularly, the base station controller BSC

manages radio communication channels and handovers. The base station controller BSC is also connected, through a so-called A interface, to a mobile services switching centre MSC, which co-ordinates the formation of connections to and from mobile stations. A further connection is made, through the mobile service switching centre MSC, to outside the mobile communications network. Outside the mobile communications network there may further reside other network(s) connected to the mobile communications network by gateway(s) GTW, for example the Internet or a Public Switched Telephone Network (PSTN). In such an external network, or within the telecommunications network, there may be located video decoding or encoding stations, such as computers PC. In an embodiment of the invention, the mobile telecommunications network comprises a video server VSRVR to provide video data to a MS subscribing to such a service. The video data is compressed using the motion compensated video compression method as described in the foregoing. The video server may function as a gateway to an online video source or it may comprise previously recorded video clips. Typical videotelephony applications may involve, for example, two mobile stations or one mobile station MS and a videotelephone connected to the PSTN, a PC connected to the Internet or a H.261 compatible terminal connected either to the Internet or to the PSTN.

Figure 7 shows a video encoder 700 according to an embodiment the invention. Figure 8 shows a video decoder 800 according to an embodiment the invention.

The encoder 700 comprises an input 701 for receiving a video signal from a camera or other video source (not shown). It further comprises a DCT transformer 705, a quantiser 706, an inverse quantiser 709, an inverse DCT transformer 710, combiners 712 and 716, a before-hand sub-pixel interpolation block 730, a frame store 740 and an on-demand sub-pixel interpolation block 750, implemented in combination with motion estimation block 760. The encoder also comprises a motion field coding block 770 and a motion compensated prediction block 780. Switches 702 and 714 are operated co-operatively by a control manager 720 to switch the encoder between an INTRA-mode of video encoding and an INTER-mode of video encoding. The encoder

700 also comprises a multiplexer unit (MUX/DMUX) 790 to form a single bit-stream from the various types of information produced by the encoder 700 for further transmission to a remote receiving terminal, or for example for storage on a mass storage medium such as a computer hard drive (not shown).

It should be noted that the presence and implementations of before-hand sub-pixel interpolation block 730 and on-demand sub-pixel value interpolation block 750 in the encoder architecture depend on the way in which the sub-pixel interpolation method according to the invention is applied. In embodiments of the invention in which before-hand sub-pixel value interpolation is not performed, encoder 700 does not comprise before-hand sub-pixel value interpolation block 730. In other embodiments of the invention, only before-hand sub-pixel interpolation is performed and thus the encoder does not include on-demand sub-pixel value interpolation block 750. In embodiments in which both before-hand and on-demand sub-pixel value interpolation are performed, both blocks 730 and 750 are present in the encoder 700.

Operation of the encoder 700 according to the invention will now be described in detail. In the description, it will be assumed that each frame of uncompressed video, received from the video source at the input 701, is received and processed on a macroblock-by-macroblock basis, preferably in raster-scan order. It will further be assumed that when the encoding of a new video sequence starts, the first frame of the sequence is encoded in INTRA-mode. Subsequently, the encoder is programmed to code each frame in INTER-format, unless one of the following conditions is met: 1) it is judged that the current frame being coded is so dissimilar from the reference frame used in its prediction that excessive prediction error information is produced; 2) a predefined INTRA frame repetition interval has expired; or 3) feedback is received from a receiving terminal indicating a request for a frame to be coded in INTRA format.

The occurrence of condition 1) is detected by monitoring the output of the combiner 716. The combiner 716 forms a difference between the current macroblock of the frame being coded and its prediction, produced in the motion compensated prediction block 780. If a measure of this difference (for example a sum of absolute differences of pixel values) exceeds a predetermined threshold, the combiner 716 informs the control manager 720 via a control line 717 and the control manager 720 operates the switches 702 and 714 so as to switch the encoder 700 into INTRA coding mode. Occurrence of condition 2) is monitored by means of a timer or frame counter implemented in the control manager 720, in such a way that if the timer expires, or the frame counter reaches a predetermined number of frames, the control manager 720 operates the switches 702 and 714 to switch the encoder into INTRA coding mode. Condition 3) is triggered if the control manager 720 receives a feedback signal from, for example, a receiving terminal, via control line 718 indicating that an INTRA frame refresh is required by the receiving terminal. Such a condition might arise, for example, if a previously transmitted frame were badly corrupted by interference during its transmission, rendering it impossible to decode at the receiver. In this situation, the receiver would issue a request for the next frame to be encoded in INTRA format, thus re-initialising the coding sequence.

It will further be assumed that the encoder and decoder are implemented in such a way as to allow the determination of motion vectors with a spatial resolution of up to quarter-pixel resolution. As will be seen in the following, finer levels of resolution are also possible.

Operation of the encoder 700 in INTRA coding mode will now be described. In INTRA-mode, the control manager 720 operates the switch 702 to accept video input from input line 719. The video signal input is received macroblock by macroblock from input 701 via the input line 719 and each macroblock of original image pixels is transformed into DCT coefficients by the DCT transformer 705. The DCT coefficients are then passed to the quantiser 706, where they are quantised using a quantisation parameter QP. Selection of the quantisation parameter QP is controlled by the

control manager 720 via control line 722. Each DCT transformed and quantised macroblock that makes up the INTRA coded image information 723 of the frame is passed from the quantiser 706 to the MUX/DMUX 790. The MUX/DMUX 790 combines the INTRA coded image information with possible control information (for example header data, quantisation parameter information, error correction data etc.) to form a single bit-stream of coded image information 725. Variable length coding (VLC) is used to reduce redundancy of the compressed video bit-stream, as is known to those skilled in the art.

A locally decoded picture is formed in the encoder 700 by passing the data output by the quantiser 706 through inverse quantiser 709 and applying an inverse DCT transform 710 to the inverse-quantised data. The resulting data is then input to the combiner 712. In INTRA mode, switch 714 is set so that the input to the combiner 712 via the switch 714 is set to zero. In this way, the operation performed by the combiner 712 is equivalent to passing the decoded image data formed by the inverse quantiser 709 and the inverse DCT transform 710 unaltered.

In embodiments of the invention in which before-hand sub-pixel value interpolation is performed, the output from combiner 712 is applied to before-hand sub-pixel interpolation block 730. The input to the before-hand sub-pixel value interpolation block 730 takes the form of decoded image blocks. In the before-hand sub-pixel value interpolation block 730, each decoded macroblock is subjected to sub-pixel interpolation in such a way that a predetermined sub-set of sub-pixel resolution sub-pixel values is calculated according to the interpolation method of the invention and is stored together with the decoded pixel values in frame store 740.

In embodiments in which before-hand sub-pixel interpolation is not performed, before-hand sub-pixel interpolation block is not present in the encoder architecture and the output from combiner 712, comprising decoded image blocks, is applied directly to frame store 740.

As subsequent macroblocks of the current frame are received and undergo the previously described coding and decoding steps in blocks 705, 706, 709, 710, 712, a decoded version of the INTRA frameis built up in the frame store 740. When the last macroblock of the current frame has been INTRA coded and subsequently decoded, the frame store 740 contains a completely decoded frame, available for use as a prediction reference frame in coding a subsequently received video frame in INTER format. In embodiments of the invention in which before-hand sub-pixel value interpolation is performed, the reference frame held in frame store 740 is at least partially interpolated to sub-pixel resolution.

Operation of the encoder 700 in INTER coding mode will now be described. In INTER coding mode, the control manager 720 operates switch 702 to receive its input from line 721, which comprises the output of the combiner 716. The combiner 716 forms prediction error information representing the difference between the current macroblock of the frame being coded and its prediction, produced in the motion compensated prediction block 780. The prediction error information is DCT transformed in block 705 and quantised in block 706 to form a macroblock of DCT transformed and quantised prediction error information. Each macroblock of DCT transformed and quantised prediction error information is passed from the quantiser 706 to the MUX/DMUX unit 790. The MUX/DMUX unit 790 combines the prediction error information 723 with motion coefficients 724 (described in the following) and control information (for example header data, quantisation parameter information, error correction data etc.) to form a single bit-stream of coded image information, 725.

Locally decoded prediction error information for the each macroblock of the INTER coded frame is then formed in the encoder 700 by passing the encoded prediction error information 723 output by the quantiser 706 through the inverse quantiser 709 and applying an inverse DCT transform in block 710. The resulting locally decoded macroblock of prediction error information is then input to combiner 712. In INTER-mode, switch 714 is set so that the combiner 712 also receives motion predicted

macroblocks for the current INTER frame, produced in the motion compensated prediction block 780. The combiner 712 combines these two pieces of information to produce reconstructed image blocks for the current INTER frame.

As described above when considering INTRA coded frames, in embodiments of the invention in which before-hand sub-pixel value interpolation is performed, the output from combiner 712 is applied to the before-hand sub-pixel interpolation block 730. Thus, the input to the before-hand sub-pixel value interpolation block 730 in INTER coding mode also takes the form of decoded image blocks. In the before-hand sub-pixel value interpolation block 730, each decoded macroblock is subjected to sub-pixel interpolation in such a way that a predetermined sub-set of sub-pixel values is calculated according to the interpolation method of the invention and is stored together with the decoded pixel values in frame store 740. In embodiments in which before-hand sub-pixel interpolation is not performed, before-hand sub-pixel interpolation block is not present in the encoder architecture and the output from combiner 712, comprising decoded image blocks, is applied directly to frame store 740.

As subsequent macroblocks of the video signal are received from the video source and undergo the previously described coding and decoding steps in blocks 705, 706, 709, 710, 712, a decoded version of the INTER frame is built up in the frame store 740. When the last macroblock of the frame has been INTER coded and subsequently decoded, the frame store 740 contains a completely decoded frame, available for use as a prediction reference frame in encoding a subsequently received video frame in INTER format. In embodiments of the invention in which before-hand sub-pixel value interpolation is performed, the reference frame held in frame store 740 is at least partially interpolated to sub-pixel resolution.

Formation of a prediction for a macroblock of the current frame will now be described.

Any frame encoded in INTER format requires a reference frame for motion compensated prediction. This means, inter alia, that when encoding a video sequence, the first frame to be encoded, whether it is the first frame in the sequence, or some other frame, must be encoded in INTRA format. This, in turn, means that when the video encoder 700 is switched into INTER coding mode by control manager 720, a complete reference frame, formed by locally decoding a previously encoded frame, is already available in the frame store 740 of the encoder. In general, the reference frame is formed by locally decoding either an INTRA coded frame or an INTER coded frame.

The first step in forming a prediction for a macroblock of the current frame is performed by motion estimation block 760. The motion estimation block 760 receives the current macroblock of the frame being coded via line 727 and performs a block matching operation in order to identify a region in the reference frame which corresponds substantially with the current macroblock. According to the invention, the block-matching process is performed to sub-pixel resolution in a manner that depends on the implementation of the encoder 700 and the degree of before-hand sub-pixel interpolation performed. However, the basic principle behind the block-matching process is similar in all cases. Specifically, motion estimation block 760 performs block-matching by calculating difference values (e.g. sums of absolute differences) representing the difference in pixel values between the macroblock of the current frame under examination and candidate best-matching regions of pixels / sub-pixels in the reference frame. A difference value is produced for all possible offsets (e.g. quarter- or one eighth sub-pixel precision x, y displacements) between the macroblock of the current frame and candidate test region within a predefined search region of the reference frame and motion estimation block 760 determines the smallest calculated difference value. The offset between the macroblock in the current frame and the candidate test region of pixel values / sub-pixel values in the reference frame that yields the smallest difference value defines the motion vector for the macroblock in question. In certain embodiments of the invention, an initial

estimate for the motion vector having unit pixel precision is first determined and then refined to a finer level of sub-pixel precision, as described in the foregoing.

In embodiments of the encoder in which before-hand sub-pixel value interpolation is not performed, all sub-pixel values required in the block matching process are calculated in on-demand sub-pixel value interpolation block 750. Motion estimation block 760 controls on-demand sub-pixel value interpolation block 750 to calculate each sub-pixel value needed in the block-matching process in an on-demand fashion, as and when it is required. In this case, motion estimation block 760 may be implemented so as to perform block-matching as a one-step process, in which case a motion vector with the desired sub-pixel resolution is sought directly, or it may be implemented so as to perform block-matching as a two step process. If the two-step process is adopted, the first step may comprise a search for e.g. a full or half-pixel resolution motion vector and the second step is performed in order to refine the the motion vector to the desired sub-pixel resolution. As block matching is an exhaustive process, in which blocks of n x m pixels in the current frame are compared one-by-one with blocks of n x m pixels or sub-pixels in the interpolated reference frame, it should be appreciated that a sub-pixel calculated in an on-demand fashion by the on-demand pixel interpolation block 750 may need to be calculated multiple times as successive difference values are determined. In a video encoder, this approach is not the most efficient possible in terms of computational complexity / burden.

In embodiments of the encoder which use only before-hand sub-pixel value interpolation, block-matching may be performed as a one step process, as all sub-pixel values of the reference frame required to determine a motion vector with the desired sub-pixel resolution are calculated before-hand in block 730 and stored in frame store 740. Thus, they are directly available for use in the block-matching process and can be retrieved as required from frame store 740 by motion estimation block 760. However, even in the case where all sub-pixel values are available from frame store 740, it is still more computationally efficient to perform block-matching as a two-step process, as fewer difference calculations are required. It should be

appreciated that while full before-hand sub-pixel value interpolation reduces computational complexity in the encoder, it is not the most efficient approach in terms of memory consumption.

In embodiments of the encoder in which both before-hand and on-demand sub-pixel value interpolation are used, motion estimation block 760 is implemented in such a way that it can retrieve sub-pixel values previously calculated in before-hand sub-pixel value interpolation block 730 and stored in frame store 740 and further control on-demand sub-pixel value interpolation block 750 to calculate any additional sub-pixel values that may be required. The block-matching process may be performed as a one-step or a two-step process. If a two-step implementation is used, before-hand calculated sub-pixel values retrieved from frame store 740 may be used in the first step of the process and the second step may be implemented so as to use sub-pixel values calculated by on-demand sub-pixel value interpolation block 750. In this case, certain sub-pixel values used in the second step of the block matching process may need to be calculated multiple times as successive comparisons are made, but the number of such duplicate calculations is significantly less than if before-hand sub-pixel value calculation is not used. Furthermore, memory consumption is reduced with respect to embodiments in which only before-hand sub-pixel value interpolation is used.

Once the motion estimation block 760 has produced a motion vector for the macroblock of the current frame under examination, it outputs the motion vector to the motion field coding block 770. Motion field coding block 770 then approximates the motion vector received from motion estimation block 760 using a motion model. The motion model generally comprises a set of basis functions. More specifically, the motion field coding block 770 represents the motion vector as a set of coefficient values (known as motion coefficients) which, when multiplied by the basis functions, form an approximation of the motion vector. The motion coefficients 724 are passed from motion field coding block 770 to motion compensated prediction block 780. Motion compensated prediction block 780 also receives the pixel / sub-pixel values of

the best-matching candidate test region of the reference frame identified by motion estimation block 760. In Figure 7, these values are shown to be passed via line 729 from on-demand sub-pixel interpolation block 750. In alternative embodiments of the invention, the pixel values in question are provided from the motion estimation block 760 itself.

Using the approximate representation of the motion vector generated by motion field coding block 770 and the pixel / sub-pixel values of the best-matching candidate test region, motion compensated prediction block 780 produces a macroblock of predicted pixel values. The macroblock of predicted pixel values represents a prediction for the pixel values of the current macroblock generated from the interpolated reference frame. The macroblock of predicted pixel values is passed to the combiner 716 where it is subtracted from the new current frame in order to produce prediction error information 723 for the macroblock, as described in the foregoing.

The motion coefficients 724 formed by motion field coding block are also passed to the MUX/DMUX unit 790, where they are combined with prediction error information 723 for the macroblock in question and possible control information from control manager 720 to form an encoded video stream 725 for transmission to a receiving terminal.

Operation of a video decoder 800 according to the invention will now be described. Referring to Figure 8, the decoder 800 comprises a demultiplexing unit (MUX/DMUX) 810, which receives the encoded video stream 725 from the encoder 700 and demultiplexes it, an inverse quantiser 820, an inverse DCT transformer 830, a motion compensated prediction block 840, a frame store 850, a combiner 860, a control manager 870, an output 880, before-hand sub-pixel value interpolation block 845 and on-demand sub-pixel interpolation block 890 associated with the motion compensated prediction block 840. In practice the control manager 870 of the decoder 800 and the control manager 720 of the encoder 700 may be the same

processor. This may be the case if the encoder 700 and decoder 800 are part of the same video codec.

Figure 8 shows an embodiment in which a combination of before-hand and on-demand sub-pixel value interpolation is used in the decoder. In other embodiments, only before-hand sub-pixel value interpolation is used, in which case decoder 800 does not include on-demand sub-pixel value interpolation block 890. In a preferred embodiment of the invention, no before-hand sub-pixel value interpolation is used in the decoder and therefore before-hand sub-pixel value interpolation block 845 is omitted from the decoder architecture. If both before-hand and on-demand sub-pixel value interpolation are performed, the decoder comprises both blocks 845 and 890.

The control manager 870 controls the operation of the decoder 800 in response to whether an INTRA or an INTER frame is being decoded. An INTRA / INTER trigger control signal, which causes the decoder to switch between decoding modes is derived, for example, from picture type information provided in the header portion of each compressed video frame received from the encoder. The INTRA / INTER trigger control signal is passed to control manager 870 via control line 815, together with other video codec control signals demultiplexed from the encoded video stream 725 by the MUX/DMUX unit 810.

When an INTRA frame is decoded, the encoded video stream 725 is demultiplexed into INTRA coded macroblocks and control information. No motion vectors are included in the encoded video stream 725 for an INTRA coded frame. The decoding process is performed macroblock-by-macroblock. When the encoded information 723 for a macroblock is extracted from video stream 725 by MUX/DMUX unit 810, it is passed to inverse quantiser 820. The control manager controls inverse quantiser 820 to apply a suitable level of inverse quantisation to the macroblock of encoded information, according to control information provided in video stream 725. The inverse quantised macroblock is then inversely transformed in the inverse DCT

transformer 830 to form a decoded block of image information. Control manager 870 controls combiner 860 to prevent any reference information being used in the decoding of the INTRA coded macroblock. The decoded block of image information is passed to the video output 880 of the decoder.

In embodiments of the decoder which employ before-hand sub-pixel value interpolation, the decoded block of image information (i.e. pixel values) produced as a result of the inverse quantisation and inverse transform operations performed in blocks 820 and 830 is passed to before-hand sub-pixel value interpolation block 845. Here, sub-pixel value interpolation is performed according to the method of the invention, the degree of before-hand sub-pixel value interpolation applied being determined by the details of the decoder implementation. In embodiments of the invention in which on-demand sub-pixel value interpolation is not performed, before-hand sub-pixel value interpolation block 845 interpolates all sub-pixelvalues. In embodiments that use a combination of before-hand and on-demand sub-pixel value interpolation, before-hand sub-pixel value interpolation block 845 interpolates a certain sub-set of sub-pixel values. This may comprise, for example, all sub-pixels at half-pixel locations, or a combination of sub-pixels at half-pixel and one quarter-pixel locations. In any case, after before-hand sub-pixel value interpolation, the interpolated sub-pixel values are stored in frame store 850, together with the original decoded pixel values. As subsequent macroblocks are decoded, before-hand interpolated and stored, a decoded frame, at least partially interpolated to sub-pixel resolution is progressively assembled in the frame store 850 and becomes available for use as a reference frame for motion compensated prediction.

In embodiments of the decoder which do not employ before-hand sub-pixel value interpolation, the decoded block of image information (i.e. pixel values) produced as a result of the inverse quantisation and inverse transform operations performed on the macroblock in blocks 820 and 830 is passed directly to frame store 850. As subsequent macroblocks are decoded and stored, a decoded frame, having unit pixel

resolution is progressively assembled in the frame store 850 and becomes available for use as a reference frame for motion compensated prediction.

When an INTER frame is decoded, the encoded video stream 725 is demultiplexed into encoded prediction error information 723 for each macroblock of the frame, associated motion coefficients 724 and control information. Again, the decoding process is performed macroblock-by-macroblock. When the encoded prediction error information 723 for a macroblock is extracted from the video stream 725 by MUX/DMUX unit 810, it is passed to inverse quantiser 820. Control manager 870 controls inverse quantiser 820 to apply a suitable level of inverse quantisation to the macroblock of encoded prediction error information, according to control information received in video stream 725. The inverse quantised macroblock of prediction error information is then inversely transformed in the inverse DCT transformer 830 to yield decoded prediction error information for the macroblock.

The motion coefficients 724 associated with the macroblock in question are extracted from the video stream 725 by MUX/DMUX unit 810 and passed to motion compensated prediction block 840, which reconstructs a motion vector for the macroblock using the same motion model as that used to encode the INTER-coded macroblock in encoder 700. The reconstructed motion vector approximates the motion vector originally determined by motion estimation block 760 of the encoder. The motion compensated prediction block 840 of the decoder uses the reconstructed motion vector to identify the location of a block of pixel / sub-pixel values in a prediction reference frame stored in frame store 850. The reference frame may be, for example, a previously decoded INTRA frame, or a previously decoded INTER frame. In either case, the block of pixel / sub-pixel values indicated by the reconstructed motion vector, represents the prediction of the macroblock in question.

The reconstructed motion vector may point to any pixel or sub-pixel. If the motion vector indicates that the prediction for the current macroblock is formed from pixel

values (i.e. the values of pixels at unit pixel locations), these can simply be retrieved from frame store 850, as the values in question are obtained directly during the decoding of each frame. If the motion vector indicates that the prediction for the current macroblock is formed from sub-pixel values, these must either be retrieved from frame store 850, or calculated in on-demand sub-pixel interpolation block 890. Whether sub-pixel values must be calculated, or can simply be retrieved from the frame store, depends on the degree of before-hand sub-pixel value interpolation used in the decoder.

In embodiments of the decoder that do not employ before-hand sub-pixel value interpolation, the required sub-pixel values are all calculated in on-demand sub-pixel value interpolation block 890. On the other hand, in embodiments in which all sub-pixel values are interpolated before-hand, motion compensated prediction block 840 can retrieve the required sub-pixel values directly from the frame store 850. In embodiments that use a combination before-hand and on-demand sub-pixel value interpolation, the action required in order to obtain the required sub-pixel values depends on which sub-pixel values are interpolated before-hand. Taking as an example an embodiment in which all sub-pixel values at half-pixel locations are calculated before-hand, it is evident that if a reconstructed motion vector for a macroblock points to a pixel at unit location or a sub-pixel at half-pixel location, all the pixel or sub-pixel values required to form the prediction for the macroblock are present in the frame store 850 and can be retrieved from there by motion compensated prediction block 840. If, however, the motion vector indicates a sub-pixel at a quarter-pixel location, the sub-pixels required to form the prediction for the macroblock are not present in frame store 850 and are therefore calculated in on-demand sub-pixel value interpolation block 890. In this case, on-demand sub-pixel value interpolation block 890 retrieves any pixel or sub-pixel required to perform the interpolation from frame store 850 and applies the interpolation method described below. Sub-pixel values calculated in on-demand sub-pixel value interpolation block 890 are passed to motion compensated prediction block 840.

Once a prediction for a macroblock has been obtained, the prediction (that is, a macroblock of predicted pixel values) is passed from motion compensated prediction block 840 to combiner 860 where it combined with the decoded prediction error information for the macroblock to form a reconstructed image block which, in turn, is passed to the video output 880 of the decoder.

It should be appreciated that in practical implementations of encoder 700 and decoder 800, the extent to which frames are before-hand sub-pixel interpolated, and thus the amount of on-demand sub-pixel value interpolation that is performed, can be chosen according to, or dictated by, the hardware implementation of the video encoder 700, or the environment in which it is intended to be used. For example, if the memory available to the video encoder is limited, or memory must be reserved for other functions, it is appropriate to limit the amount of before-hand sub-pixel value interpolation that is performed. In other cases, where the microprocessor performing the video encoding operation has limited processing capacity, e.g. the number of operations per second that can be executed is comparatively low, it is more appropriate to restrict the amount of on-demand sub-pixel value interpolation that is performed. In a mobile communications environment, for example, when video encoding and decoding functionality is incorporated in a mobile telephone or similar wireless terminal for communication with a mobile telephone network, both memory and processing power may be limited. In this case a combination of before-hand and on-demand sub-pixel value interpolation may be the best choice to obtain an efficient implementation in the video encoder. In video decoder 800, use of before-hand sub-pixel value is generally not preferred, as it typically results in the calculation of many sub-pixel values that are not actually used in the decoding process. However, it should be appreciated that although different amounts of before-hand and on-demand interpolation can be used in the encoder and decoder in order to optimise the operation of each, both encoder and decoder can be implemented so as to use the same division between before-hand and on-demand sub-pixel value interpolation.

Although the foregoing description does not describe the construction of bi-directionally predicted frames (B-frames) in the encoder 700 and the decoder 800, it should be understood that in embodiments of the invention, such a capability may be provided. Provision of such capability is considered within the ability of one skilled in the art.

An encoder 700 or a decoder 800 according to the invention can be realised using hardware or software, or using a suitable combination of both. An encoder or decoder implemented in software may be, for example, a separate program or a software building block that can be used by various programs. In the above description and in the drawings, the functional blocks are represented as separate units, but the functionality of these blocks can be implemented, for example, in one software program unit.

The encoder 700 and decoder 800 can further be combined in order to form a video codec having both encoding and decoding functionality. In addition to being implemented in a multimedia terminal, such a codec may also be implemented in a network. A codec according to the invention may be a computer program or a computer program element, or it may be implemented at least partly using hardware.

The sub-pixel interpolation method used in the encoder 700 and decoder 800 according to the invention now be described in detail. The method will first be introduced at a general conceptual level and then two preferred embodiments will be described. In the first preferred embodiment, sub-pixel value interpolation is performed to ¼ pixel resolution and in the second the method is extended to $\frac{1}{8}$ pixel resolution.

It should be noted that interpolation must produce identical values in the encoder and the decoder, but its implementation should be optimized for both entities separately. For example, in an encoder according to the first embodiment of the

invention in which sub-pixel value interpolation is preformed to ¼ pixel resolution, it is most efficient to calculate ½ resolution pixels before-hand and to calculate values for ¼ resolution sub-pixels in an on-demand fashion, only when they are needed during motion estimation. This has the effect of limiting memory usage while keeping the computational complexity / burden at an acceptable level. In the decoder, on the other hand, it is advantageous not to pre-calculate any of the sub-pixels. Therefore, it should be appreciated that a preferred embodiment of the decoder does not include before-hand sub-pixel value interpolation block 845 and all sub-pixel value interpolation is performed in on-demand sub-pixel value interpolation block 890.

In the description of the interpolation method provided below, references are made to the pixel positions depicted in Figure 14a. In this figure pixels labelled A represent original pixels (that is, pixels residing at unit horizontal and vertical locations). Pixels labelled with other letters represent sub-pixels that are to be interpolated. The description that follows will adhere to the previously introduced conventions regarding the description of pixel and sub-pixel locations.

Next, the steps required to interpolate all sub-pixel positions are described:

Values for the ½ resolution sub-pixels labelled b are obtained by first calculating an intermediate value *b* using a Kth order filter, according to:

$$b = \sum_{i=1}^{K} \mathbf{x}_i \, \mathbf{A}_i \qquad (9)$$

where $\mathbf{x}_i$ is a vector of filter coefficients, $\mathbf{A}_i$ is a corresponding vector of original pixel values A situated at unit horizontal and unit vertical locations, and K is an integer which defines the order of the filter. Thus, equation 9 can be re-expressed as:

$$b = x_1 A_1 + x_2 A_2 + x_3 A_3 + .... + x_{K-1} A_{K-1} + x_K A_K \qquad (10)$$

The values of the filter coefficients $x_i$ and the order of the filter K may vary from embodiment to embodiment. Equally, different coefficient values may be used in the calculation of different sub-pixels within an embodiment. In other embodiments, the values of filter coefficients $x_i$ and the order of the filter may depend on which of the ½ resolution b sub-pixels is being interpolated. Pixels $A_i$ are disposed symmetrically with respect to the ½ resolution sub-pixel b being interpolated and are the closest neighbours of that sub-pixel. In the case of the ½ resolution sub-pixel b situated at half horizontal and unit vertical location, pixels $A_i$ are disposed horizontally with respect to b (as shown in Figure 14b). If the ½ resolution sub-pixel b situated at unit horizontal and half vertical location is being interpolated, pixels $A_i$ are disposed vertically with respect to b (as shown in Figure 14c).

A final value for ½ resolution sub-pixel b is calculated by dividing intermediate value $b$ by a constant $scale_1$, truncating it to obtain an integer number and clipping the result to lie in the range $[0, 2^n-1]$. In alternative embodiments of the invention rounding may be performed instead of truncation. Preferably, constant $scale_1$ is chosen to be equal to the sum of filter coefficients $x_i$.

A value for the ½ resolution sub-pixel labelled c is also obtained by first calculating an intermediate value $c$ using an Mth order filter, according to:

$$c = \sum_{i=1}^{M} \mathbf{y}_i \boldsymbol{b}_i \qquad (11)$$

where $\mathbf{y}_i$ is a vector of filter coefficients, $\boldsymbol{b}_i$ is a corresponding vector of intermediate values $b_i$ in the horizontal or vertical direction. i.e.:

$$c = y_1 b_1 + y_2 b_2 + y_3 b_3 + .... + y_{M-1} b_{M-1} + y_M b_M \qquad (12)$$

The values of the filter coefficients $y_i$ and the order of the filter M may vary from embodiment to embodiment. Equally, different coefficient values may be used in the

calculation of different sub-pixels within an embodiment. Preferably, the *b* values are intermediate values for ½ resolution sub-pixels b which are disposed symmetrically with respect to ½ resolution sub-pixel c and are the closest neighbours of sub-pixel c. In an embodiment of the invention, the ½ resolution sub-pixels b are disposed horizontally with respect to sub-pixel c, in an alternative embodiment they are disposed vertically with respect to sub-pixel c.

A final value of ½ resolution sub-pixel c is computed by dividing intermediate value *c* by a constant $scale_2$, truncating it to obtain an integer number and clipping the result to lie in the range $[0, 2^n-1]$. In alternative embodiments of the invention rounding may be performed instead of truncation. Preferably, constant $scale_2$ is equal to $scale_1$ * $scale_1$.

It should be noted that the use of intermediate values *b* in the horizontal direction leads to the same result as using intermediate values *b* in the vertical direction.

There are two alternatives for interpolating values for the ¼ resolution sub-pixels labelled h. Both involve linear interpolation along a diagonal line linking ½ resolution sub-pixels neighbouring the ¼ resolution sub-pixel h being interpolated. In a first embodiment, a value for sub-pixel h is calculated by averaging the values of the two ½ resolution sub-pixels b closest to sub-pixel h. In a second embodiment, a value for sub-pixel h is calculated by averaging the values of the closest pixel A and the closest ½ resolution sub-pixel c. It should be appreciated that this provides the possibility of using different combinations of diagonal interpolations to determine the values for sub-pixels h within the confines of different groups of 4 image pixels A. However, it should also be realised that the same combination should be used in both the encoder and the decoder in order to produce identical interpolation results. Figure 15 depicts 4 possible choices of diagonal interpolation for sub-pixels h in adjacent groups of 4 pixels within an image. Simulations in the TML environment have verified that both embodiments result in similar compression efficiency. The second embodiment has higher complexity, since calculation of sub-pixel c requires

calculation of several intermediate values. Therefore the first embodiment is preferred.

Values for ¼ resolution sub-pixels labelled d and g are calculated from the values of their nearest horizontal neighbours using linear interpolation. In other words, a value for ¼ resolution sub-pixel d is obtained by averaging values of its nearest horizontal neighbours, original image pixel A and ½ resolution sub-pixel b. Similarly, a value for ¼ resolution sub-pixel g is obtained by taking the average of its two nearest horizontal neighbours, ½ resolution sub-pixels b and c.

Values for ¼ resolution sub-pixels labelled e, f and i are calculated from the values of their nearest neighbours in the vertical direction using linear interpolation. More specifically, a value for ¼ resolution sub-pixel e is obtained by averaging the values of its two nearest vertical neighbours, original image pixel A and ½ resolution sub-pixel b. Similarly, a value for ¼ resolution sub-pixel f is obtained by taking the average of its two nearest vertical neighbours, ½ resolution sub-pixels b and c. In an embodiment of the invention, a value for ¼ resolution sub-pixel i is obtained in manner identical to that just described in connection with ¼ resolution sub-pixel f. However, in an alternative embodiment of the invention, and in common with the H.26 test models TML5 and TML6 previously described, ¼ resolution sub-pixel i is determined using the values of the four closest original image pixels, according to $(A_1+A_2+A_3+A_4+2) / 4$.

It should also be noted that in all cases where an average involving pixel and / or sub-pixel values is determined, the average may be formed in any appropriate manner. For example, the value for ¼ resolution sub-pixel d can be defined as $d = (A + b) / 2$ or as $d = (A + b + 1) / 2$. The addition of 1 to the sum of values for pixel A and ½ resolution sub-pixel b has the effect of causing any rounding or truncation operation subsequently applied to round or truncate the value for d to the next highest integer value. This is true for any sum of integer values and may be applied

to any of the averaging operations performed according to the method of the invention in order to control rounding or truncation effects.

It should be noted that the sub-pixel value interpolation method according to the invention provides advantages over each of TML5 and TML6.

In contrast to TML5, in which the values of some of the ¼ resolution sub-pixels depend on previously interpolated values obtained for other ¼ resolution sub-pixels, in the method according to the invention, all ¼ resolution sub-pixels are calculated from original image pixels or ½ resolution sub-pixel positions using linear interpolation. Thus, the reduction in precision of those ¼ resolution sub-pixel values which occurs in TML5 due to the intermediate truncation and clipping of the other ¼ resolution sub-pixels from which they are calculated, does not take place in the method according to the invention. In particular, referring to Figure 14a, ¼ resolution sub-pixels h (and sub-pixel i in one embodiment of the invention) are interpolated diagonally in order to reduce dependency on other ¼-pixels. Furthermore, in the method according to the invention, the number of calculations (and therefore the number of processor cycles) required to obtain a value for those ¼ resolution sub-pixels in the decoder is reduced compared with TML5. Additionally, the calculation of any ¼ resolution sub-pixel value requires a number of calculations which is substantially similar to the number of calculations required to determine any other ¼ resolution sub-pixel value. More specifically, in a situation where the required ½ resolution sub-pixel values are already available, e.g. they have been calculated before-hand, the number of calculations required to interpolate a ¼ resolution sub-pixel value from the pre-calculated ½ resolution sub-pixel values is the same as the number of calculations required to calculate any other ¼ resolution sub-pixel value from the available ½ resolution sub-pixel values.

In comparison with TML6, the method according to the invention does not require high precision arithmetic to be used in the calculation of all sub-pixels. Specifically, as all of the ¼ resolution sub-pixel values are calculated from original image pixels

or ½ resolution sub-pixel values using linear interpolation, lower precision arithmetic can be used in their interpolation. Consequently, in hardware implementations of the inventive method, for example in an ASIC (Application Specific Integrated Circuit), the use of lower precision arithmetic reduces the number of components (e.g. gates) that must be devoted to the calculation of ¼ resolution sub-pixel values. This, in turn, reduces the overall area of silicon that must be dedicated to the interpolation function. As the majority of sub-pixels are, in fact, ¼ resolution sub-pixels (12 out of the 15 sub-pixels illustrated in Figure 14a), the advantage provided by the invention in this respect is particularly significant. In software implementations, where sub-pixel interpolation is performed using the standard instruction set of a general purpose CPU (Central Processor Unit) or using a DSP (Digital Signal Processor), a reduction in the precision of the arithmetic required generally leads to an increase in the speed at which the calculations can be performed. This is particularly advantageous in 'low cost' implementations, in which it is desirable to use a general purpose CPU rather than any form of ASIC.

The method according to the invention provides still further advantages compared with TML5. As mentioned previously, in the decoder only 1 out of the 15 sub-pixel positions is required at any given time, namely that which is indicated by received motion vector information. Therefore, it is advantageous if the value of a sub-pixel in any sub-pixel location can be calculated with the minimum number of steps that result in a correctly interpolated value. The method according to the invention provides this capability. As mentioned in the detailed description provided above, ½ resolution sub-pixel c can be interpolated by filtering in either the vertical or the horizontal direction, the same value being obtained for c regardless of whether horizontal or vertical filtering is used. The decoder can therefore take advantage of this property when calculating values for ¼ resolution sub-pixels f and g in such a way as to minimise the number of operations required in order to obtain the required values. For example, if the decoder requires a value for ¼ resolution sub-pixel f, ½ resolution sub-pixel c should interpolated in the vertical direction. If a value is required for ¼ resolution sub-pixel g, it is advantageous to interpolate a

value for c in the horizontal direction. Thus, in general, it can be said that the method according to the invention provides flexibility in the way in which values are derived for certain ¼ resolution sub-pixels. No such flexibility is provided in TML5.

Two specific embodiments will now be described in detail. The first represents a preferred embodiment for calculating sub-pixels with up to ¼ pixel resolution, while in the second, the method according to the invention is extended to the calculation of values for sub-pixels having up to ⅛ pixel resolution. For both embodiments a comparison is provided between the computational complexity / burden resulting from use of the method according to the invention and that which would result from use of the interpolation methods according to TML5 and TML6 in equivalent circumstances.

The preferred embodiment for interpolating sub-pixels at ¼ pixel resolution will be described with reference to Figures 14a, 14b and 14c. In the following, it will be assumed that all image pixels and final interpolated values for sub-pixels are represented with 8-bits.

Calculation of ½ resolution sub-pixels at i) half unit horizontal and unit vertical locations and ii) unit horizontal and half unit vertical locations.

1. A value for the sub-pixel at half unit horizontal and unit vertical location, that is ½ resolution sub-pixel b in Figure 14a, is obtained by first calculating intermediate value $b = (A_1 - 5A_2 + 20A_3 + 20A_4 - 5A_5 + A_6)$ using the values of the six pixels ($A_1$ to $A_6$) which are situated at unit horizontal and unit vertical locations in either the row or the column of pixels containing b and which are disposed symmetrically about b, as shown in Figures 14b and 14c. A final value for ½ resolution sub-pixel b is calculated as $(b + 16) / 32$ where the operator / denotes division with truncation. The result is clipped to lie in the range [0, 255].

Calculation of ½ resolution sub-pixels at half unit horizontal and half unit vertical locations.

2. A value for the sub-pixel at half unit horizontal and half unit vertical location, that is ½ resolution sub-pixel c in Figure 14a, is calculated as $c = (b_1 - 5b_2 + 20b_3 + 20b_4 - 5b_5 + b_6 + 512) / 1024$ using the intermediate values *b* for the six closest ½ resolution sub-pixels which are situated in either the row or the column of sub-pixels containing c and which are disposed symmetrically about c. Again, operator / denotes division with truncation and the result is clipped to lie in the range [0, 255]. As previously explained, using intermediate values *b* for ½ resolution sub-pixels b in the horizontal direction leads to the same result as using intermediate values *b* for ½ resolution sub-pixels b in the vertical direction. Thus, in an encoder according to the invention, the direction for interpolating ½ resolution sub-pixels b can be chosen according to a preferred mode of implementation. In a decoder according to the invention, the direction for interpolating sub-pixels b is chosen according to which, if any, ¼ resolution sub-pixels will be interpolated using the result obtained for ½ resolution sub-pixel c.

Calculation of ¼ resolution sub-pixels at i) quarter unit horizontal and unit vertical locations; ii) quarter unit horizontal and half unit vertical locations; iii) unit horizontal and quarter unit vertical locations; and iv) half unit horizontal and quarter unit vertical locations.

3. Values for ¼ resolution sub-pixels d, situated at quarter unit horizontal and unit vertical locations are calculated according to d = (A + b) / 2 using the nearest original image pixel A and the closest ½ resolution sub-pixel b in the horizontal direction. Similarly, values for ¼ resolution sub-pixels g, situated at quarter unit horizontal and half unit vertical locations are calculated according to g = (b + c) / 2 using the two nearest ½ resolution sub-pixels in the horizontal direction. In a similar manner, values for ¼ resolution sub-pixels e, situated at unit horizontal and quarter unit vertical locations, are calculated according e = (A + b) / 2 using the nearest original image pixel A and the closest ½ resolution sub-pixel b in the vertical direction. Values for ¼ resolution sub-pixels f, situated at half unit horizontal and quarter unit vertical locations, are determined from f = (b + c) / 2

using the two nearest ½ resolution sub-pixel in the vertical direction. In all cases, operator / denotes division with truncation.

Calculation of ¼ resolution sub-pixels at quarter unit horizontal and quarter unit vertical locations.

4. Values for ¼ resolution sub-pixels h, situated at quarter unit horizontal and quarter unit vertical locations are calculated according to $h = (b_1 + b_2) / 2$, using the two nearest ½ resolution sub-pixels b in the diagonal direction. Again, operator / denotes division with truncation.

5. A value for the ¼ resolution sub-pixel labeled i is computed from $i = (A_1 + A_2 + A_3 + A_4 + 2) / 4$ using the four nearest original pixels A. Once more, operator / denotes division with truncation.

An analysis of the computational complexity of the first preferred embodiment of the invention will now be presented.

In the encoder, it is likely that the same sub-pixel values will be calculated multiple times. Therefore, and as previously explained, the complexity of the encoder can be reduced by pre-calculating all sub-pixel values and storing them in memory. However, this solution increases memory usage by a large margin. In the preferred embodiment of the invention, in which motion vector accuracy is ¼ pixel resolution in both the horizontal and vertical dimensions, storing pre-calculated sub-pixel values for the whole image requires 16 times the memory required to store the original, non-interpolated image. To reduce memory usage, all ½ resolution sub-pixels can be interpolated before-hand and ¼ resolution sub-pixels can be calculated on-demand, that is, only when they are needed. According to the method of the invention, on-demand interpolation of values for ¼ resolution sub-pixels only requires linear interpolation from ½ resolution sub-pixels. Four times the original picture memory is required to store the pre-calculated ½ resolution sub-pixels since only 8 bits are necessary to represent them.

However, if the same strategy of pre-calculating all ½ resolution sub-pixels using before-hand interpolation is used in conjunction with the direct interpolation scheme of TML6, the memory requirements increase to 9 times the memory required to store the original non-interpolated image. This results from the fact that a larger number of bits is required to store the high precision intermediate values associated with each ½ resolution sub-pixel in TML6. In addition, the complexity of sub-pixel interpolation during motion estimation is higher in TML6, since scaling and clipping has to be performed for every ½ and ¼ sub-pixel location.

In the following, the complexity of the sub-pixel value interpolation method according to the invention, when applied in a video decoder, is compared with that of the interpolation schemes used in TML5 and TML6. Throughout the analysis which follows, it is assumed that in each method the interpolation of any sub-pixel value is performed using only the minimum number of steps required to obtain a correctly interpolated value. It is further assumed that each method is implemented in a block based manner, that is, intermediate values common for all the sub-pixels to be interpolated in a particular N x M block are calculated only once. An illustrative example is provided in Figure 16. Referring to Figure 16, it can be seen that in order to calculate a 4 x 4 block of ½ resolution sub-pixels c, a 9 x 4 block of ½ resolution sub-pixels b is first calculated.

Compared with the sub-pixel value interpolation method used in TML5, the method according to the invention has a lower computational complexity for the following reasons:

1. Unlike the sub-pixel value interpolation scheme used in TML5, according to the method of the invention, a value for ½ resolution sub-pixel c can be obtained by filtering in either the vertical or the horizontal direction. Thus, in order to reduce the number of operations, ½ resolution sub-pixel c can be interpolated in the vertical direction if a value for ¼ resolution sub-pixel f is required and in the

horizontal direction if a value for ¼ resolution sub-pixel pixel g is required. As an example, Figure 17 shows all the ½ resolution sub-pixel values that must be calculated in order to interpolate values for ¼ resolution sub-pixels g in an image block defined by 4 x 4 original image pixels using the interpolation method of TML5 (Figure 17a) and using the method according to the invention (Figure 17b). In this example, the sub-pixel value interpolation method according to TML5 requires a total of 88 ½ resolution sub-pixels to be interpolated, while the method according to the invention requires the calculation of 72 ½ resolution sub-pixels. As can be seen from Figure 17b, according to the invention, ½ resolution sub-pixels c are interpolated in the horizontal direction in order to reduce the number of calculations required.

2. According to the method of the invention, ¼ resolution sub-pixel h is calculated by linear interpolation from its two closest neighbouring ½ resolution sub-pixels in the diagonal direction. The respective numbers of ½ resolution sub-pixels that must be calculated in order to obtain values for ¼ resolution sub-pixels h within a 4 x 4 block of original image pixels using the sub-pixel value interpolation method according to TML5 and the method according to the invention are shown in Figures 18(a) and 18(b), respectively. Using the method according to TML5 it is necessary to interpolate a total of 56 ½ resolution sub-pixels, while according to the method of the invention it is necessary to interpolate 40 ½ resolution sub-pixels.

Table 1 summarizes the decoder complexities of the three sub-pixel value interpolation methods considered here, that according to TML5, the direct interpolation method used in TML6 and the method according to the invention. Complexity is measured in terms of the number of 6-tap filtering and linear interpolation operations performed. It is assumed that Interpolation of ¼ resolution sub-pixel i is calculated according to $i = (A_1 + A_2 + A_3 + A_4 + 2) / 4$ which is bilinear interpolation and effectively comprises two linear interpolation operations. The operations needed to interpolate sub-pixel values with one 4 x 4 block of original

image pixels are listed for each of the 15 sub-pixel positions which, for convenience of reference, are numbered according to the scheme shown in Figure 19. Referring to Figure 19, location 1 is the location of an original image pixel A and locations 2 to16 are sub-pixel locations. Location 16 is the location of ¼ resolution sub-pixel i. In order to compute the average number of operations it has been assumed that the probability of a motion vector pointing to each sub-pixel position is the same. The average complexity is therefore the average of the 15 sums calculated for each sub-pixel location and the single full-pixel location.

| | TML5 | | TML6 | | Inventive Method | |
|---|---|---|---|---|---|---|
| Location | linear. | 6-tap | linear. | 6-tap | linear. | 6-tap |
| 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| 3,9 | 0 | 16 | 0 | 16 | 0 | 16 |
| 2,4,5,13 | 16 | 16 | 0 | 16 | 16 | 16 |
| 11 | 0 | 52 | 0 | 52 | 0 | 52 |
| 7,15 | 16 | 52 | 0 | 52 | 16 | 52 |
| 10,12 | 16 | 68 | 0 | 52 | 16 | 52 |
| 6,8,14 | 48 | 68 | 0 | 52 | 16 | 32 |
| 16 | 32 | 0 | 32 | 0 | 32 | 0 |
| **Average** | **19** | **37** | **2** | **32** | **13** | **28.25** |

Table 1: Complexity of ¼ resolution sub-pixel interpolation in TML5, TML6 and the method according to the invention.

It can be seen from Table 1 that the method according to the invention requires fewer 6-tap filter operations than the sub-pixel value interpolation method according to TML6 and only a few additional linear interpolation operations. Since 6-tap filter operations are much more complex than linear interpolation operations the complexity of the two methods is similar. The sub-pixel value interpolation method according to TML5 has a considerably higher complexity.

The preferred embodiment for interpolating sub-pixels with up to ⅛ pixel resolution will now be described with reference to Figures 20, 21 and 22.

Figure 20 presents the nomenclature used to describe pixels, ½ resolution sub-pixels, ¼ resolution sub-pixels and ⅛ resolution sub-pixels in this extended application of the method according to the invention.

1. Values for the ½ resolution and ¼ resolution sub-pixels labelled $b^1$, $b^2$ and $b^3$ in Figure 20 are obtained by first calculating intermediate values $b^1 = (-3A_1 + 12A_2 - 37A_3 + 229A_4 + 71A_5 - 21A_6 + 6A_7 - A_8)$; $b^2 = (-3A_1 + 12A_2 - 39A_3 + 158A_4 + 158A_5 - 39A_6 + 12A_7 - 3A_8)$; and $b^3 = (-A_1 + 6A_2 - 21A_3 + 71A_4 + 229A_5 - 37A_6 + 13A_7 - 3A_8)$ using the values of the eight nearest image pixels ($A_1$ to $A_8$) situated at unit horizontal and unit vertical locations in either the row or the column containing $b^1$, $b^2$ and $b^3$ and disposed symmetrically about ½ resolution sub-pixel $b^2$. The asymmetries in the filter coefficients used to obtain intermediate values $b^1$ and $b^3$ account for the fact that pixels $A_1$ to $A_8$ are not symmetrically located with respect to ¼ resolution sub-pixels $b^1$ and $b^3$. Final values for sub-pixels $b^i$, i=1, 2, 3 are calculated according to $b^i = (b^i + 128) / 256$ where the operator / denotes division with truncation. The result is clipped to lie in the range [0, 255].

2. Values for the ½ resolution and ¼ resolution sub-pixels labelled $c^{ij}$, i, j = 1, 2, 3, are calculated according to $c^{1j} = (-3b_1^j + 12b_2^j - 37b_3^j + 229b_4^j + 71b_5^j - 21b_6^j + 6b_7^j - b_8^j + 32768) / 65536$, $c^{2j} = (-3b_1^j + 12b_2^j - 39b_3^j + 158b_4^j + 158b_5^j - 39b_6^j + 12b_7^j - 3b_8^j + 32768) / 65536$ and $c^{3j} = (-b_1^j + 6b_2^j - 21b_3^j + 71b_4^j + 229b_5^j - 37b_6^j + 13b_7^j - 3b_8^j + 32768) / 65536$ using the intermediate values $b^1$, $b^2$ and $b^3$ calculated for the eight closest sub-pixels ($b_1^j$ to $b_8^j$) in the vertical direction, sub-pixels $b^j$ being situated in the column comprising the ½ resolution and ¼ resolution sub-pixels $c^{ij}$ being interpolated and disposed symmetrically about the ½ resolution sub-pixel $c^{2j}$. The asymmetries in the filter coefficients used to obtain values for sub-pixels $c^{1j}$ and $c^{3j}$ account for the fact that sub-pixels $b_1^j$ to $b_8^j$ are not symmetrically located with respect to ¼ resolution sub-pixels $c^{1j}$ and $c^{3j}$. Once more, operator / denotes division with truncation. Before the interpolated values for sub-pixels $c^{ij}$ are stored in the frame memory they are clipped to lie in the range [0, 255]. In an alternative embodiment of the

invention, ½ resolution and ¼ resolution sub-pixels $c^{ij}$ are calculated using in an analogous manner using intermediate values $b^1$, $b^2$ and $b^3$ in the horizontal direction.

3. Values for ⅛ resolution sub-pixels labelled d are calculated using linear interpolation from the values of their closest neighbouring image pixel, ½ resolution or ¼ resolution sub-pixels in the horizontal or vertical direction. For example, upper leftmost ⅛ resolution sub-pixel d is calculated according to $d = (A + b^1 + 1) / 2$. As before, operator / indicates division with truncation.

4. Values for ⅛ resolution sub-pixels labelled e and f are calculated using linear interpolation from the values of image pixels, ½ resolution or ¼ resolution sub-pixels in the diagonal direction. For example, referring to Figure 20, upper leftmost pixel ⅛ resolution sub-pixel e is calculated according to $e = (b^1 + b^1 + 1) / 2$. The diagonal direction to be used in the interpolation of each ⅛ resolution sub-pixel in a first preferred embodiment of the invention, hereinafter referred to as 'preferred method 1', is indicated in Figure 21(a). Values for ⅛ resolution sub-pixels labelled g are calculated according to $g = (A + 3c^{22} + 3) / 4$. As always, operator / denotes division with truncation. In an alternative embodiment of the invention, hereinafter referred to as 'preferred method 2', computational complexity is further reduced by interpolating ⅛ resolution sub-pixels f using linear interpolation from ½ resolution sub-pixels $b^2$, that is, according to the relationship $f = (3b^2 + b^2 + 2) / 4$. The $b^2$ sub-pixel which is closer to f is multiplied by 3. The diagonal interpolation scheme used in this alternative embodiment of the invention is depicted in Figure 21(b). In further alternative embodiments, different diagonal interpolation schemes can be envisaged.

It should be noted that in all cases where an average involving pixel and / or sub-pixel values is used in the determination of ⅛ resolution sub-pixels, the average may be formed in any appropriate manner. The addition of 1 to the sum of values

used in calculating such an average has the effect of causing any rounding or truncation operation subsequently applied to round or truncate the average in question to the next highest integer value. In alternative embodiments of the invention, the addition of 1 is not used.

As in the case of sub-pixel value interpolation to ¼ pixel resolution previously described, memory requirements in the encoder can be reduced by pre-calculating only a part of the sub-pixel values to be interpolated. In the case of sub-pixel value interpolation to ⅛ pixel resolution, it is advantageous to calculate all ½ resolution and ¼ resolution sub-pixels before-hand and to compute values for ⅛ resolution sub-pixels in an on-demand fashion, only when they are required. When this approach is taken, both the interpolation method according to TML5 and that according to the invention require 16 times the original picture memory to store the ½ resolution and ¼ resolution sub-pixel values. However, if the direct interpolation method according to TML6 is used in the same way, intermediate values for the ½ resolution and ¼ pixel resolution sub-pixels must be stored. These intermediate values are represented with 32-bit precision and this results in a memory requirement 64 times that for the original, non-interpolated image.

In the following, the complexity of the sub-pixel value interpolation method according to the invention, when applied in a video decoder to calculate values for sub-pixels at up to ⅛ pixel resolution, is compared with that of the interpolation schemes used in TML5 and TML6. As in the equivalent analysis for ¼ pixel resolution sub-pixel value interpolation described above, it is assumed that in each method the interpolation of any sub-pixel value is performed using only the minimum number of steps required to obtain a correctly interpolated value. It is also assumed that each method is implemented in a block based manner, such that intermediate values common for all the sub-pixels to be interpolated in a particular N x M block are calculated only once.

Table 2 summarizes complexities of the three interpolation methods. Complexity is measured in terms of the number of 8-tap filter and linear interpolation operations performed in each method. The table presents the number of operations required to interpolate each of the 63 $\frac{1}{8}$ resolution sub-pixels within one 4 x 4 block of original image pixels, each sub-pixel location being identified with a corresponding number, as illustrated in Figure 22. In Figure 22, location 1 is the location of an original image pixel and locations 2 to 64 are sub-pixel locations. When computing the average number of operations, it has been assumed that the probability of a motion vector pointing to each sub-pixel position is the same. The average complexity is thus the average of the 63 sums calculated for each sub-pixel location and the single full-pixel location.

| | TML5 | | TML6 | | Preferred Method 1 | | Preferred Method 2 | |
|---|---|---|---|---|---|---|---|---|
| Location | linear. | 8-tap | linear. | 8-tap | linera. | 8-tap | linear. | 8-tap |
| 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 3,5,7,17,33,49 | 0 | 16 | 0 | 16 | 0 | 16 | 0 | 16 |
| 19,21,23,35,37,39, 51,53,55 | 0 | 60 | 0 | 60 | 0 | 60 | 0 | 60 |
| 2,8,9,57 | 16 | 16 | 0 | 16 | 16 | 16 | 16 | 16 |
| 4,6,25,41 | 16 | 32 | 0 | 16 | 16 | 32 | 16 | 32 |
| 10,16,58,64 | 32 | 76 | 0 | 60 | 16 | 32 | 16 | 32 |
| 11,13,15,59,61,63 | 16 | 60 | 0 | 60 | 16 | 60 | 16 | 60 |
| 18,24,34,40,50,56 | 16 | 76 | 0 | 60 | 16 | 60 | 16 | 60 |
| 12,14,60,62 | 32 | 120 | 0 | 60 | 16 | 32 | 16 | 32 |
| 26,32,42,48 | 32 | 108 | 0 | 60 | 16 | 32 | 16 | 32 |
| 20,22,36,38,52,54 | 16 | 120 | 0 | 60 | 16 | 76 | 16 | 76 |
| 27,29,31,43,45,47 | 16 | 76 | 0 | 60 | 16 | 76 | 16 | 76 |
| 28,30,44,46 | 32 | 152 | 0 | 60 | 16 | 60 | 16 | 60 |
| **Average** | **64** | **290.25** | **0** | **197.75** | **48** | **214.75** | **48** | **192.75** |

Table 2: Complexity of ⅛ resolution sub-pixel interpolation in TML5, TML6 and the method according to the invention. (Results shown separately for Preferred Method 1 and Preferred Method 2).

As can be seen from Table 2, the number of 8-tap filtering operations performed according to preferred methods 1 and 2 are, respectively, 26% and 34% lower than the number of 8-tap filtering operation performed in the sub-pixel value interpolation method of TML5. The number of linear operations is 25% lower, in both preferred method 1 and preferred method 2, compared with TML5, but this improvement is of lesser importance compared to the reduction in 8-tap filtering operations. It can further be seen that the direct interpolation method used in TML6 has a complexity comparable that of both preferred methods 1 and 2 when used to interpolate values for ⅛ resolution sub-pixels.

In view of the foregoing description it will be evident to a person skilled in the art that various modifications may be made within the scope of the invention. While a number of preferred embodiments of the invention have been described in detail, it should be apparent that many modifications and variations thereto are possible, all of which fall within the true spirit and scope of the invention.

CLAIMS

1. A method for sub-pixel value interpolation to determine values for sub-pixels situated within a rectangular bounded region defined by four corner pixels with no intermediate pixels between the corners, the pixels and sub-pixels being arranged in rows and columns, the pixel and sub-pixel locations being representable mathematically within the rectangular bounded region using the co-ordinate notation $K/2^N$, $L/2^N$, K and L being positive integers having respective values between zero and $2^N$, N being a positive integer greater than one and representing a particular degree of sub-pixel value interpolation, the method comprising:

interpolating a sub-pixel value for a sub-pixel having co-ordinates with odd values of both K and L, according to a predetermined choice of a weighted average of the value of a nearest-neighbouring pixel and the value of the sub-pixel situated at co-ordinates 1/2, 1/2, and a weighted average of the values of a pair of diagonally-opposed sub-pixels having co-ordinates with even values of both K and L, including zero, situated within a quadrant of the rectangular bounded region defined by corner pixels having co-ordinates 1/2, 1/2 and the nearest neighbouring pixel;

interpolating sub-pixel values for sub-pixels having co-ordinates with K equal to an even value and L equal zero and sub-pixels having co-ordinates with K equal to zero and L equal to an even value, used in the interpolation of the sub-pixels having co-ordinates with odd values of both K and L, using weighted sums of the values of pixels located in rows and columns respectively; and

interpolating sub-pixel values for sub-pixels having co-ordinates with even values of both K and L, used in the interpolation of sub-pixel values for the sub-pixels having co-ordinates with odd values of both K and L, using a predetermined choice of either a weighted sum of the values of sub-pixels

having co-ordinates with K equal to an even value and L equal to zero and the values of sub-pixels having corresponding co-ordinates in immediately adjacent rectangular bounded regions, or a weighted sum of the values of sub-pixels having co-ordinates with K equal to zero and L equal to an even value and the values of sub-pixels having corresponding co-ordinates in immediately adjacent bounded rectangular regions.

2. A method for quarter resolution sub-pixel value interpolation to determine values for sub-pixels situated within a rectangular bounded region defined by four corner pixels with no intermediate pixels between the corners, the pixels and sub-pixels being arranged in rows and columns, the pixel and sub-pixel locations being representable mathematically within the rectangular bounded region using the co-ordinate notation K/4, L/4, K and L being positive integers having respective values between zero and 4, the method comprising:

interpolating a sub-pixel value for a sub-pixel having co-ordinates with both K and L equal to 1 or 3, according to a predetermined choice of a weighted average of the value of a nearest-neighbouring pixel and the value of the sub-pixel situated at co-ordinates 2/4, 2/4, and a weighted average of the values of a pair of diagonally-opposed sub-pixels having co-ordinates with both K and L equal to zero, 2 or 4, situated within a quadrant of the rectangular bounded region defined by corner pixels having co-ordinates 2/4, 2/4 and the nearest neighbouring pixel;

interpolating sub-pixel values for sub-pixels having co-ordinates with K equal to 2 and L equal zero and sub-pixels having co-ordinates with K equal to zero and L equal to 2, used in the interpolation of the sub-pixels having co-ordinates with both K and L equal to 1 or 3, using weighted sums of the values of pixels located in rows and columns respectively; and

interpolating a sub-pixel value for the sub-pixel having co-ordinates with both K and L equal to 2, used in the interpolation of sub-pixel values for the sub-pixels having co-ordinates with both K and L equal to 1 or 3, using a predetermined choice of either a weighted sum of the values of the sub-pixel having co-ordinates with K equal to 2 and L equal to zero and the values of sub-pixels having corresponding co-ordinates in immediately adjacent rectangular bounded regions, or a weighted sum of the value of the sub-pixel having co-ordinates with K equal to zero and L equal to 2 and the values of sub-pixels having corresponding co-ordinates in immediately adjacent rectangular bounded regions.

3. A method for eighth resolution sub-pixel value interpolation to determine values for sub-pixels situated within a rectangular bounded region defined by four corner pixels with no intermediate pixels between the corners, the pixels and sub-pixels being arranged in rows and columns, the pixel and sub-pixel locations being representable mathematically with the rectangular bounded region using the co-ordinate notation K/8, L/8, K and L being positive integers having respective values between zero and 8, the method comprising:

interpolating a sub-pixel value for a sub-pixel having co-ordinates with both K and L equal to 1, 3, 5 or 7, according to a predetermined choice of a weighted average of the value of a nearest-neighbouring pixel and the value of the sub-pixel situated at co-ordinates 4/8, 4/8, and a weighted average of the values of a pair of diagonally-opposed sub-pixels having co-ordinates with both K and L equal to zero, 2, 4, 6 or 8, situated within a quadrant of the rectangular bounded region defined by corner pixels having co-ordinates 4/8, 4/8 and the nearest neighbouring pixel;

interpolating sub-pixel values for sub-pixels having co-ordinates with K equal to 2, 4 or 6 and L equal zero and sub-pixels having co-ordinates with K equal to zero and L equal to 2, 4 or 6, used in the interpolation of the sub-pixels

having co-ordinates with both K and L equal to 1, 3, 5 or 7, using weighted sums of the values of pixels located in rows and columns respectively; and

interpolating sub-pixel values for sub-pixels having co-ordinates with both K and L equal to 2, 4 or 6, used in the interpolation of sub-pixel values for the sub-pixels having co-ordinates with both K and L equal to 1, 3, 5 or 7, using a predetermined choice of either a weighted sum of the values of sub-pixels having co-ordinates with K equal to 2, 4 or 6 and L equal to zero and the values of sub-pixels having corresponding co-ordinates in immediately adjacent rectangular bounded regions or a weighted sum of the values of sub-pixels having co-ordinates with K equal to zero and L equal to 2, 4 or 6 and the values of sub-pixels having corresponding co-ordinates in immediately adjacent rectangular bounded regions.

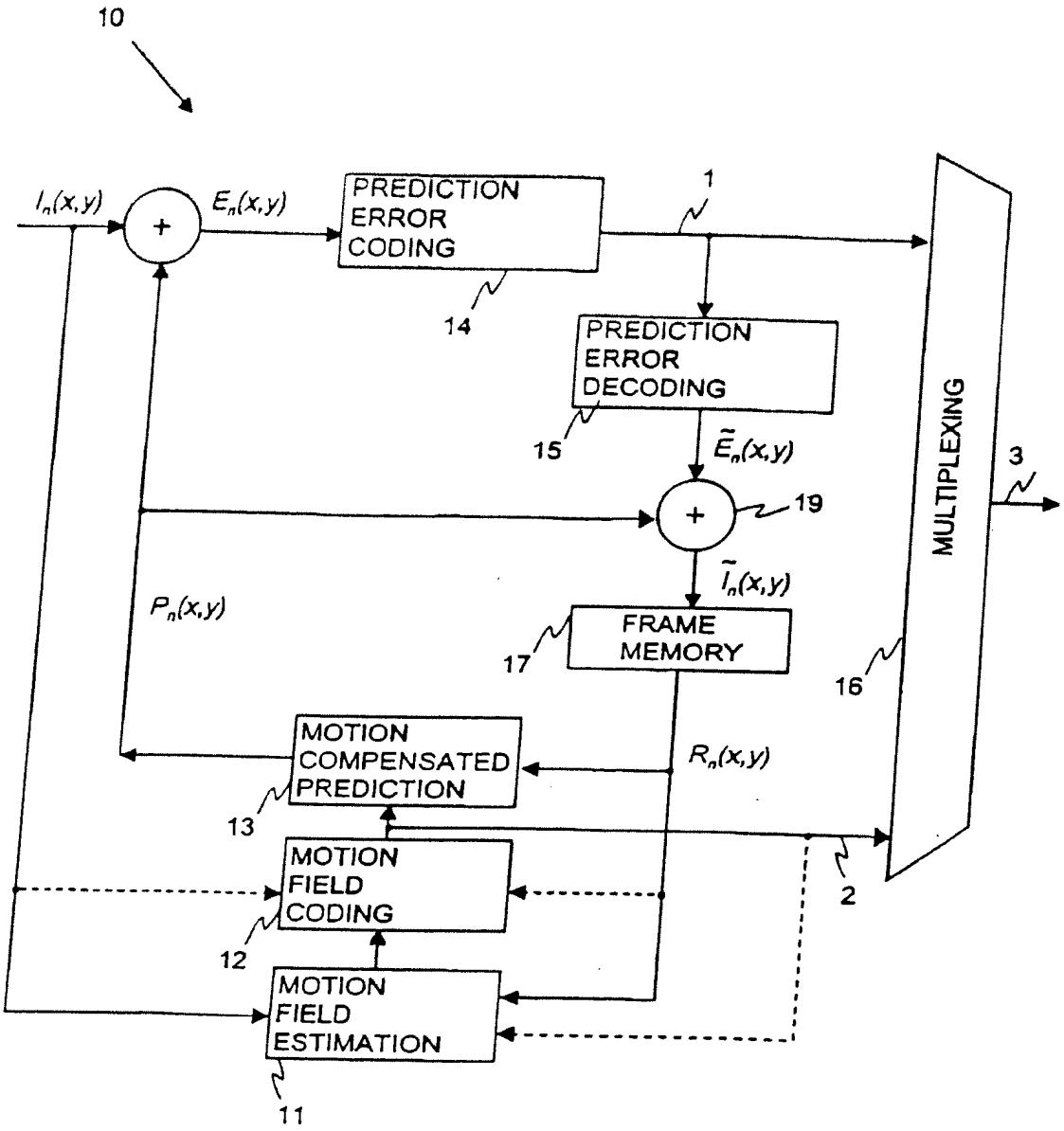
ABSTRACT

A method of interpolation in video coding in which an image comprising pixels arranged in rows and columns and represented by values having a specified dynamic range, the pixels in the rows residing at unit horizontal locations and the pixels in the columns residing at unit vertical locations, is interpolated to generate values for sub-pixels at fractional horizontal and vertical locations, the method comprising:

a) when values for sub-pixels at half unit horizontal and unit vertical locations, and unit horizontal and half unit vertical locations are required, interpolating such values directly using weighted sums of pixels residing at unit horizontal and unit vertical locations;

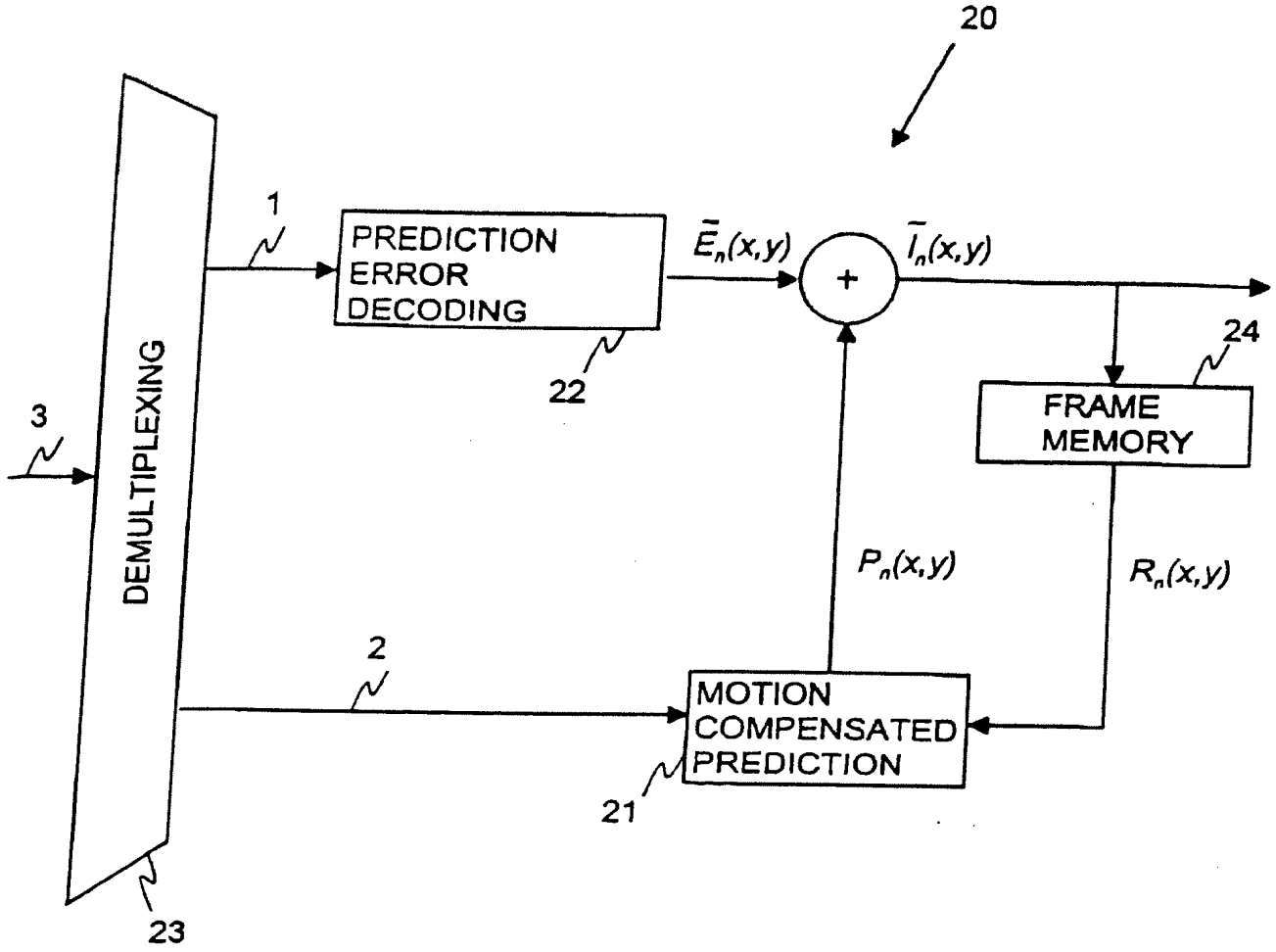
b) when values for sub-pixels at half unit horizontal and half unit vertical locations are required, interpolating such values directly using a weighted sum of values for sub-pixels residing at half unit horizontal and unit vertical locations calculated according to step (a); and

c) when values for sub-pixels at quarter unit horizontal and quarter unit vertical locations are required, interpolating such values by taking the average of at least one pair of a first pair of values of a sub-pixel located at a half unit horizontal and unit vertical location, and a sub-pixel located at a unit horizontal and half unit vertical location and a second pair of values of a pixel located at a unit horizontal and unit vertical location, and a sub-pixel located at a half unit horizontal and half unit vertical location.




PRIOR ART

Fig. 1




PRIOR ART

Fig. 2

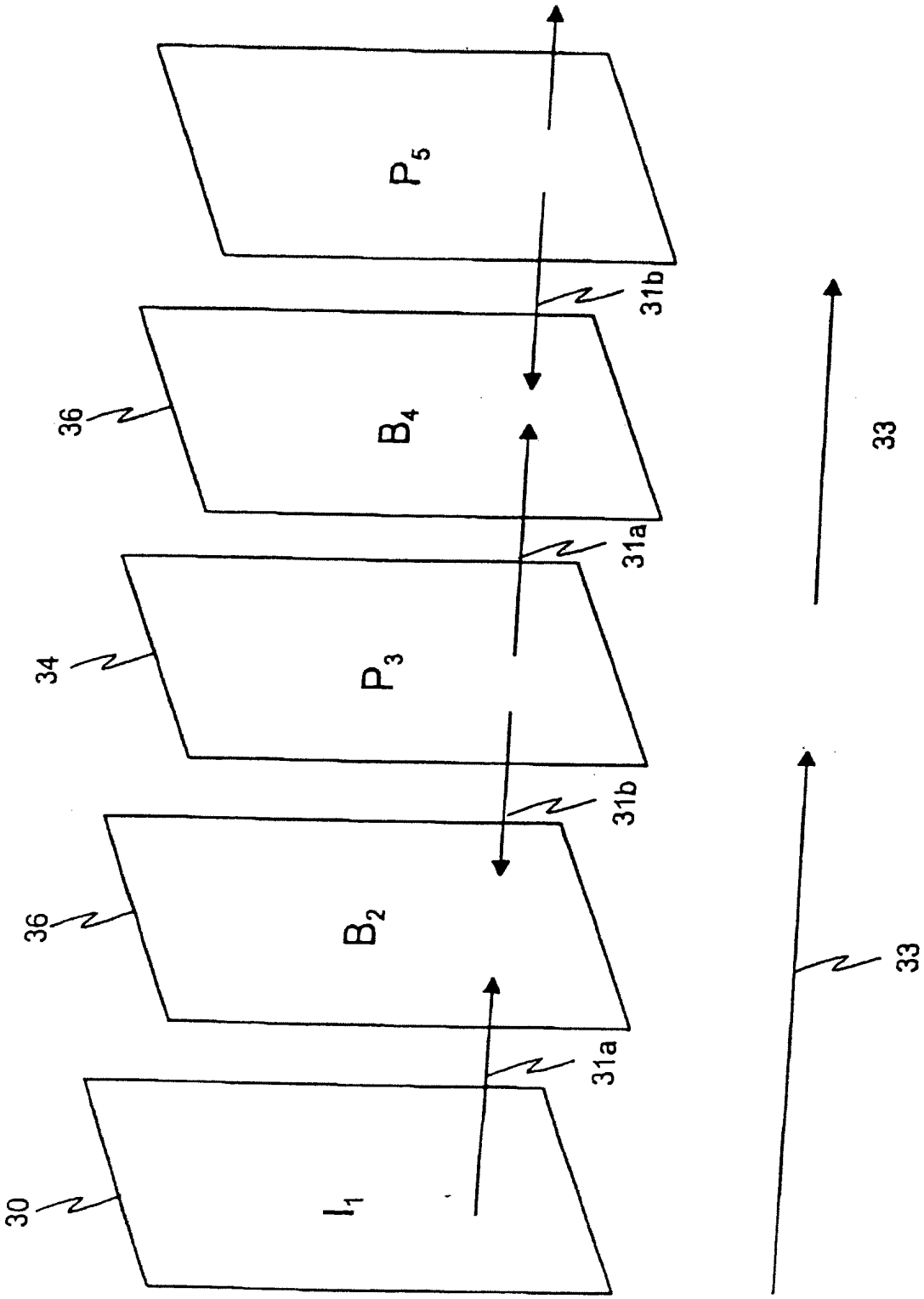
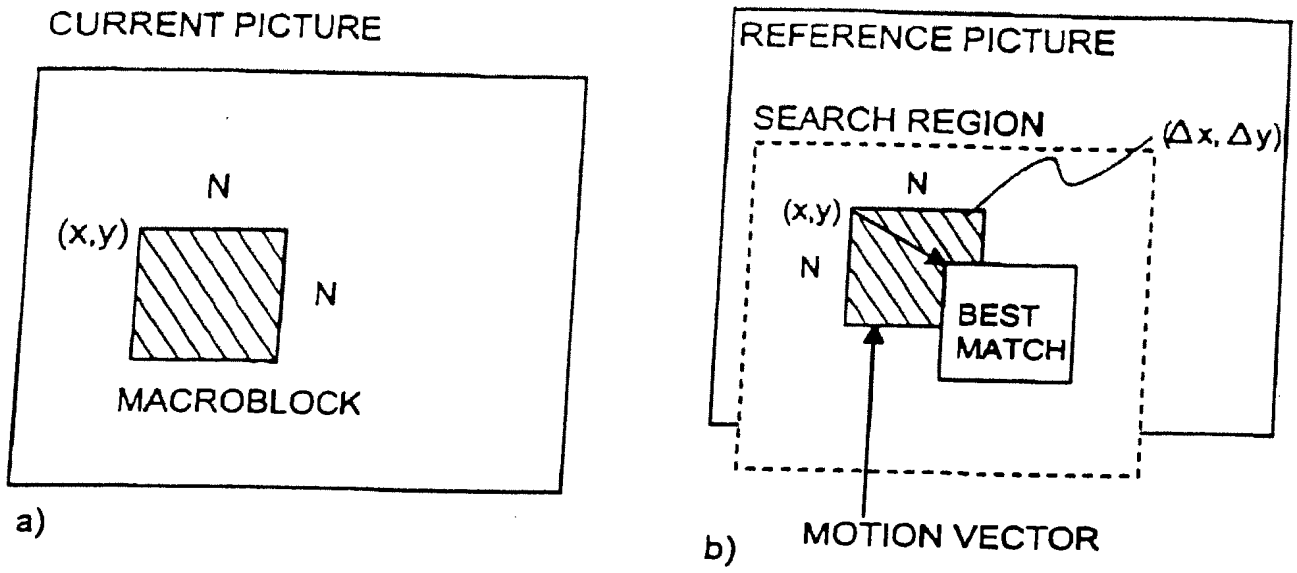
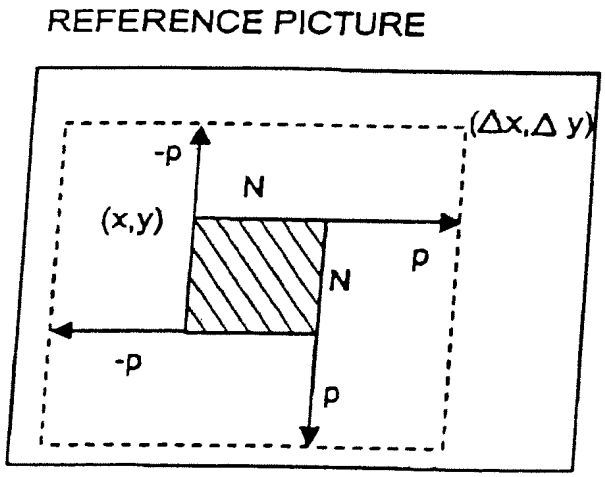



Fig. 3




c) [-p,p] SEARCH REGION

Fig. 4

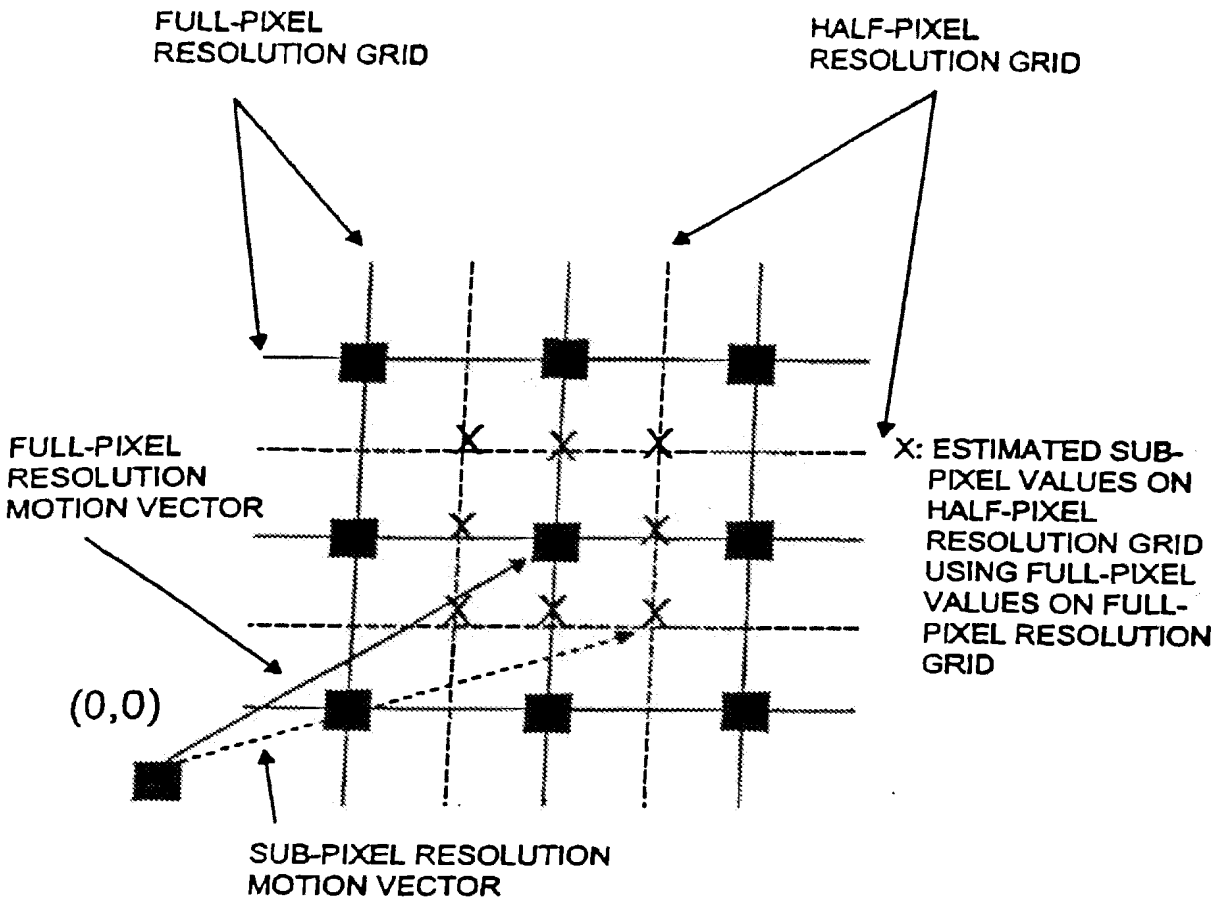

FULL-PIXEL RESOLUTION GRID
HALF-PIXEL RESOLUTION GRID
FULL-PIXEL RESOLUTION MOTION VECTOR
X: ESTIMATED SUB-PIXEL VALUES ON HALF-PIXEL RESOLUTION GRID USING FULL-PIXEL VALUES ON FULL-PIXEL RESOLUTION GRID
(0,0)
SUB-PIXEL RESOLUTION MOTION VECTOR

Fig. 5

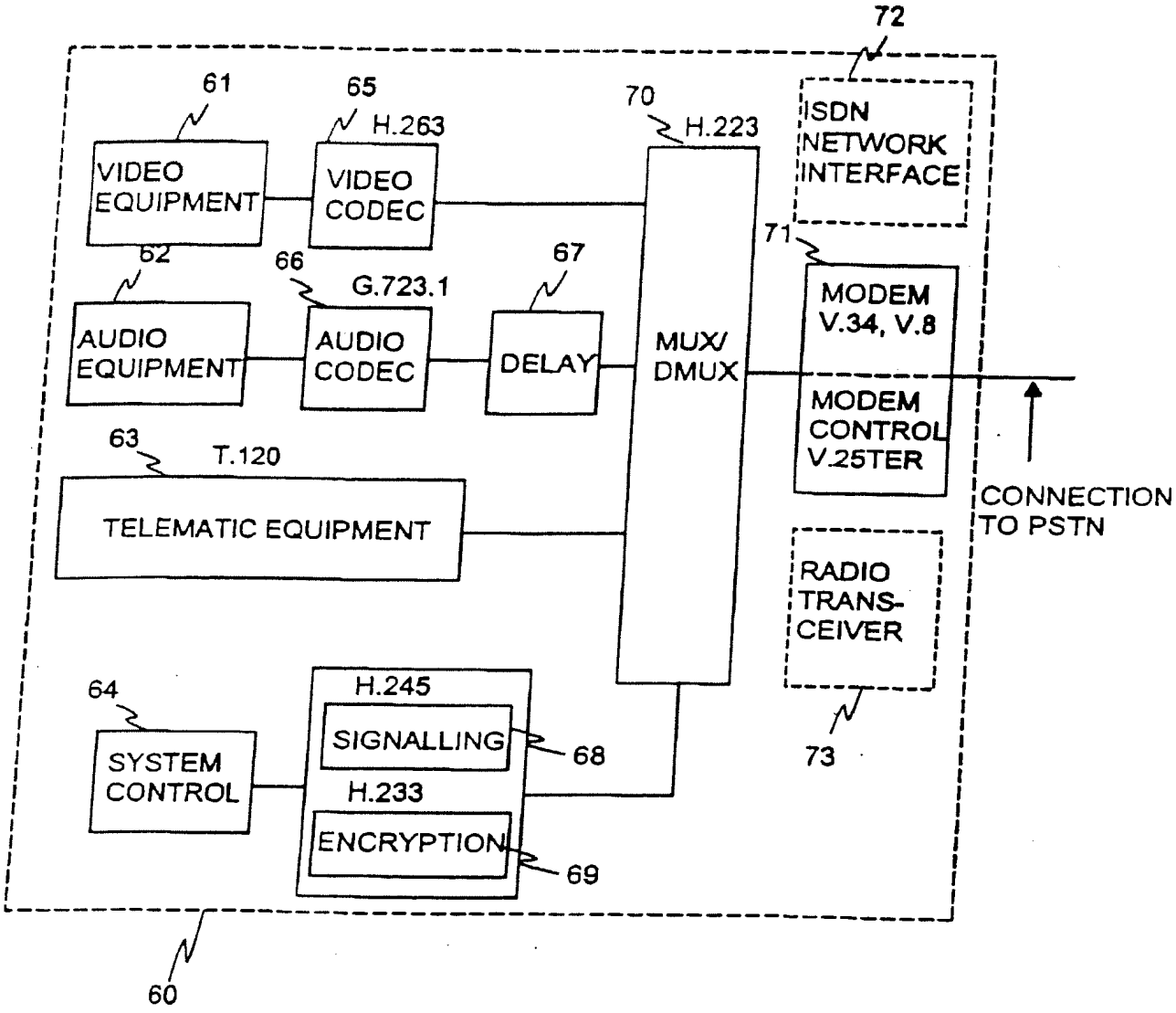

72
61
65
H.263
70
H.223
ISDN
NETWORK
INTERFACE
VIDEO
EQUIPMENT
VIDEO
CODEC
71
62
66
G.723.1
67
MODEM
V.34, V.8
AUDIO
EQUIPMENT
AUDIO
CODEC
DELAY
MUX/
DMUX
MODEM
CONTROL
V.25TER
63
T.120
CONNECTION
TO PSTN
TELEMATIC EQUIPMENT
RADIO
TRANS-
CEIVER
64
H.245
SIGNALLING
68
SYSTEM
CONTROL
H.233
ENCRYPTION
69
73
60

Fig. 6

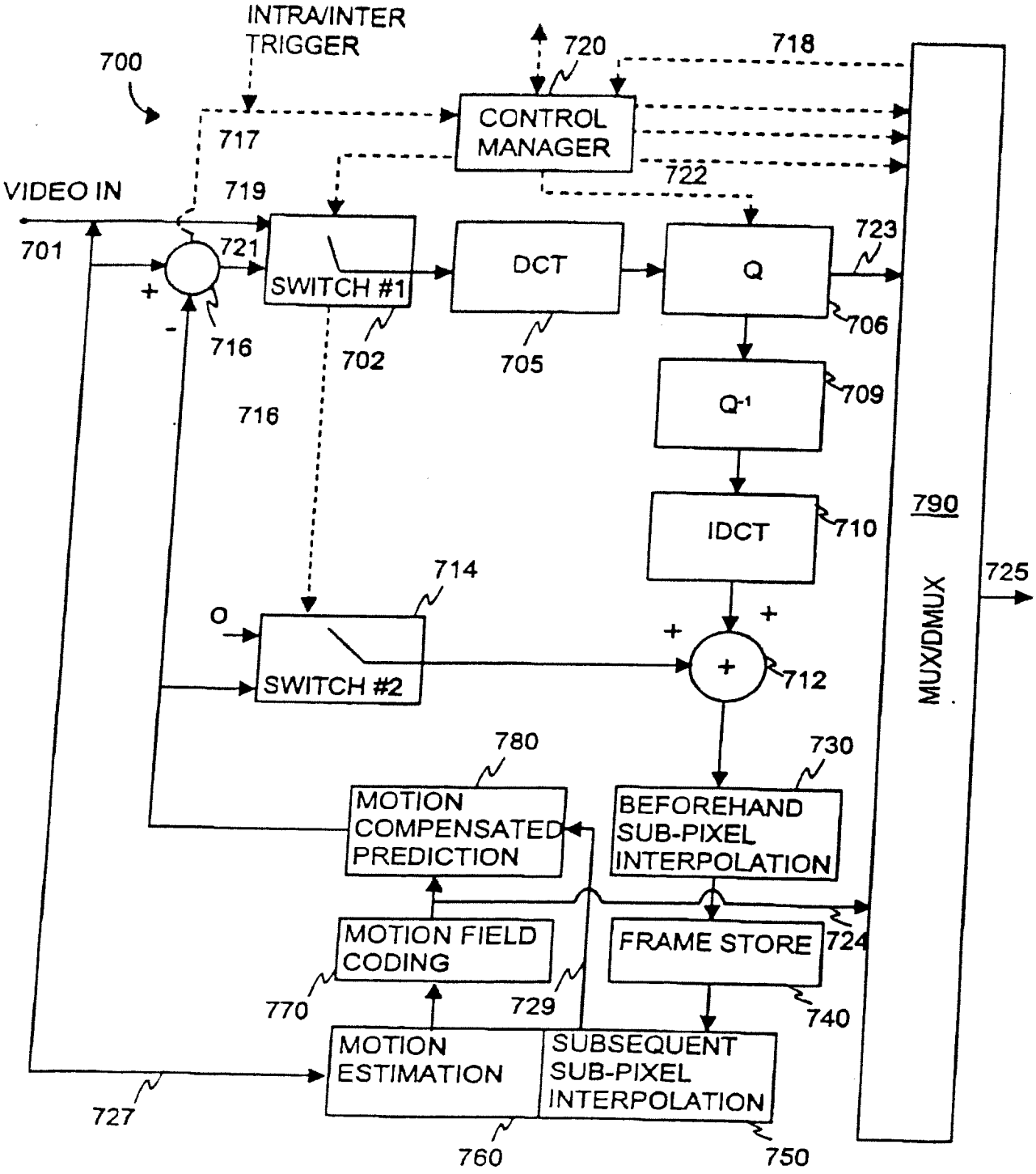

INTRA/INTER
TRIGGER
700
720
718
CONTROL
MANAGER
717
722
VIDEO IN
719
701
721
SWITCH #1
DCT
Q
723
706
716
702
705
716
Q-1
709
IDCT
710
790
MUX/DMUX
725
714
0
SWITCH #2
712
780
730
MOTION
COMPENSATED
PREDICTION
BEFOREHAND
SUB-PIXEL
INTERPOLATION
MOTION FIELD
CODING
FRAME STORE
724
770
729
740
MOTION
ESTIMATION
SUBSEQUENT
SUB-PIXEL
INTERPOLATION
727
760
750

Fig. 7

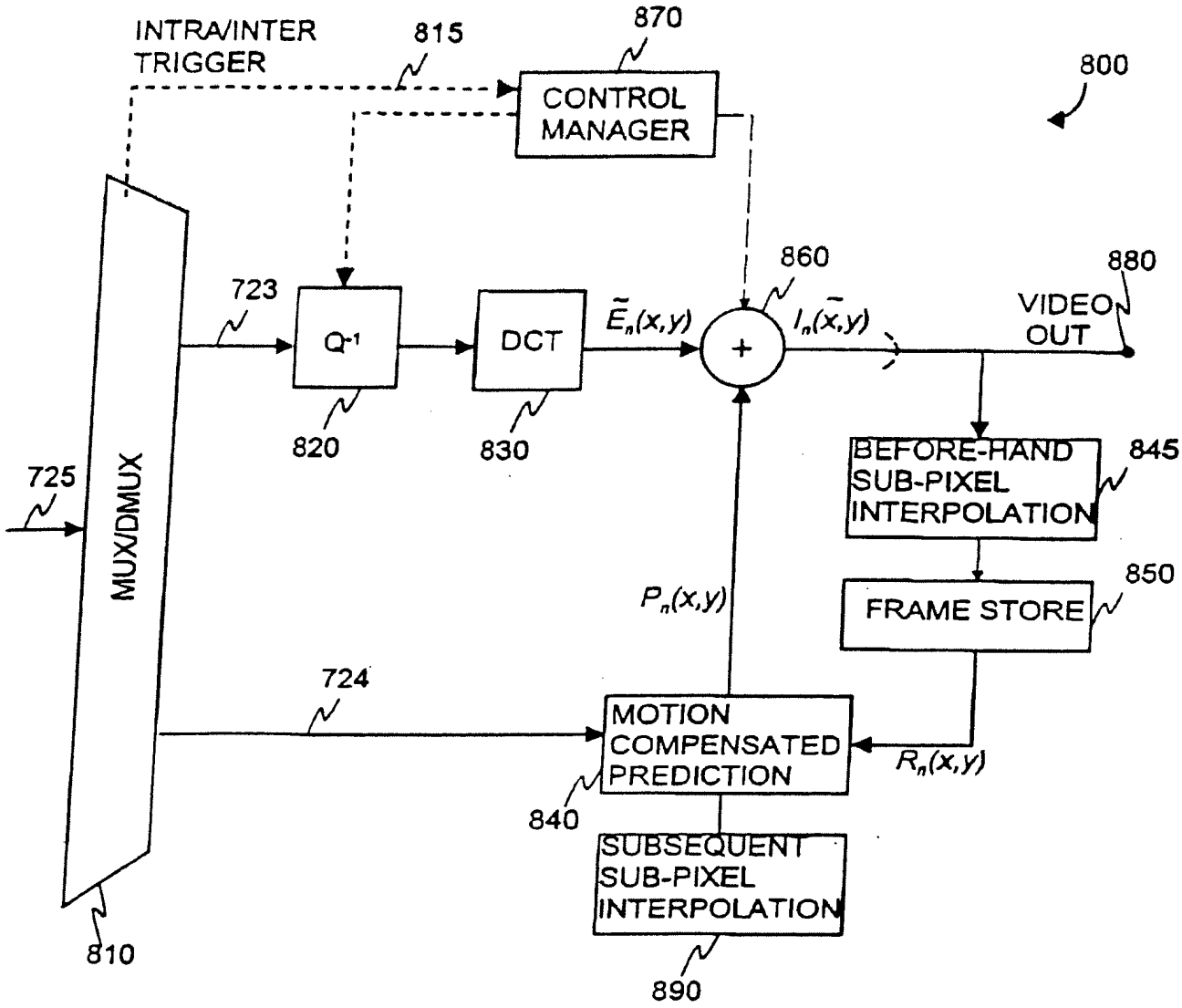

INTRA/INTER
TRIGGER
815
870
CONTROL
MANAGER
800
860
880
723
VIDEO
OUT
Q-1
DCT
820
830
725
MUX/DMUX
BEFORE-HAND
SUB-PIXEL
INTERPOLATION
845
850
FRAME STORE
724
MOTION
COMPENSATED
PREDICTION
840
SUBSEQUENT
SUB-PIXEL
INTERPOLATION
890
810

Fig. 8

Figure Intentionally Omitted

Fig. 9

Figure Intentionally Omitted

Fig. 10

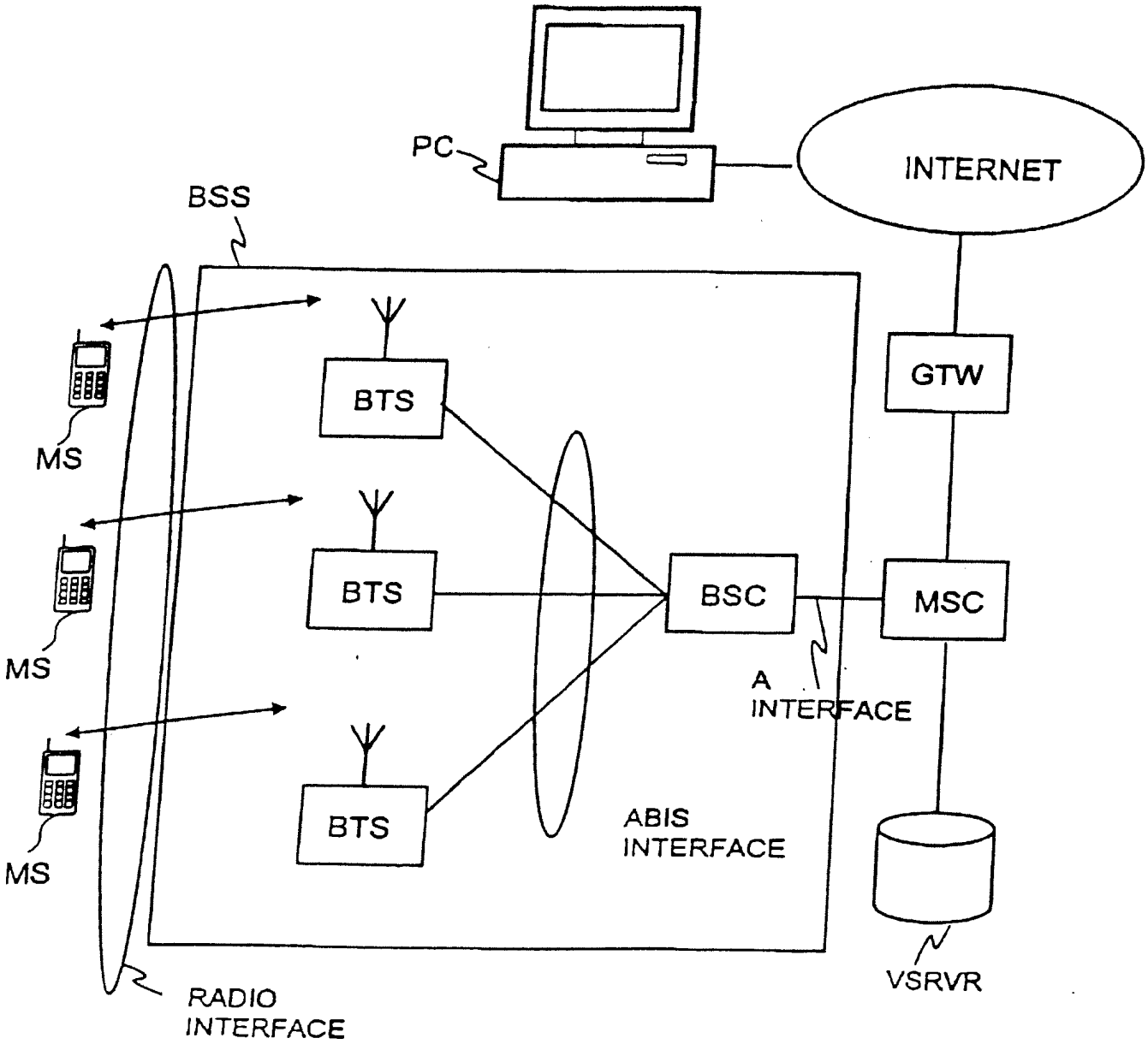

PC
INTERNET
BSS
GTW
BTS
MS
BTS
BSC
MSC
MS
A
INTERFACE
BTS
ABIS
INTERFACE
MS
VSRVR
RADIO
INTERFACE

Fig. 11

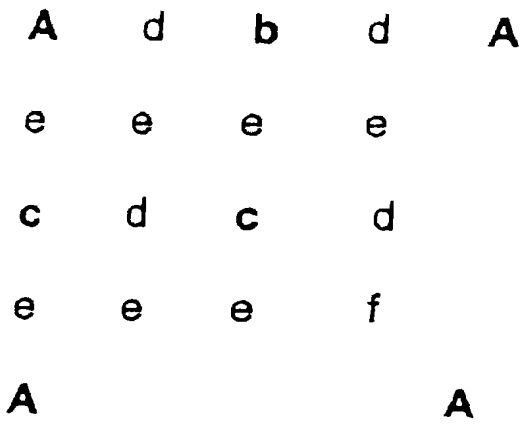



Fig. 12(a)

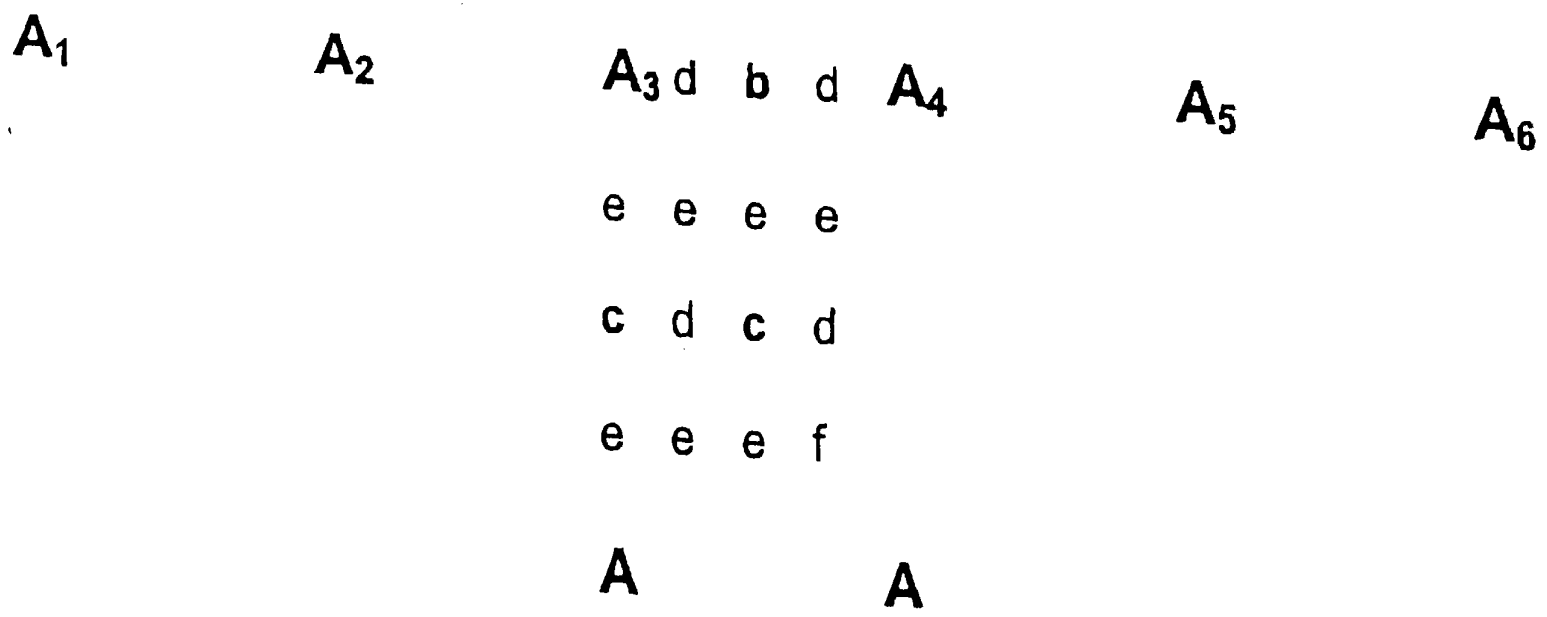



Figure12(b)

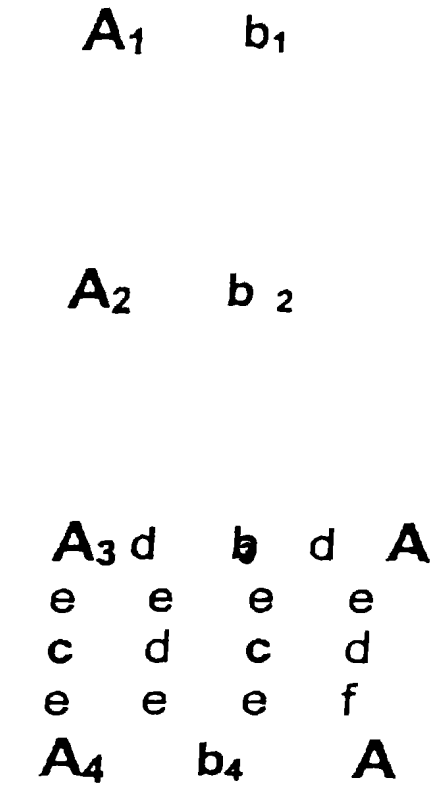



Figure 12(c)

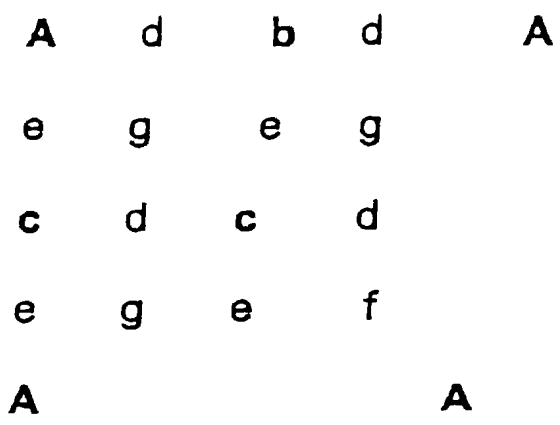



Fig. 13(a)

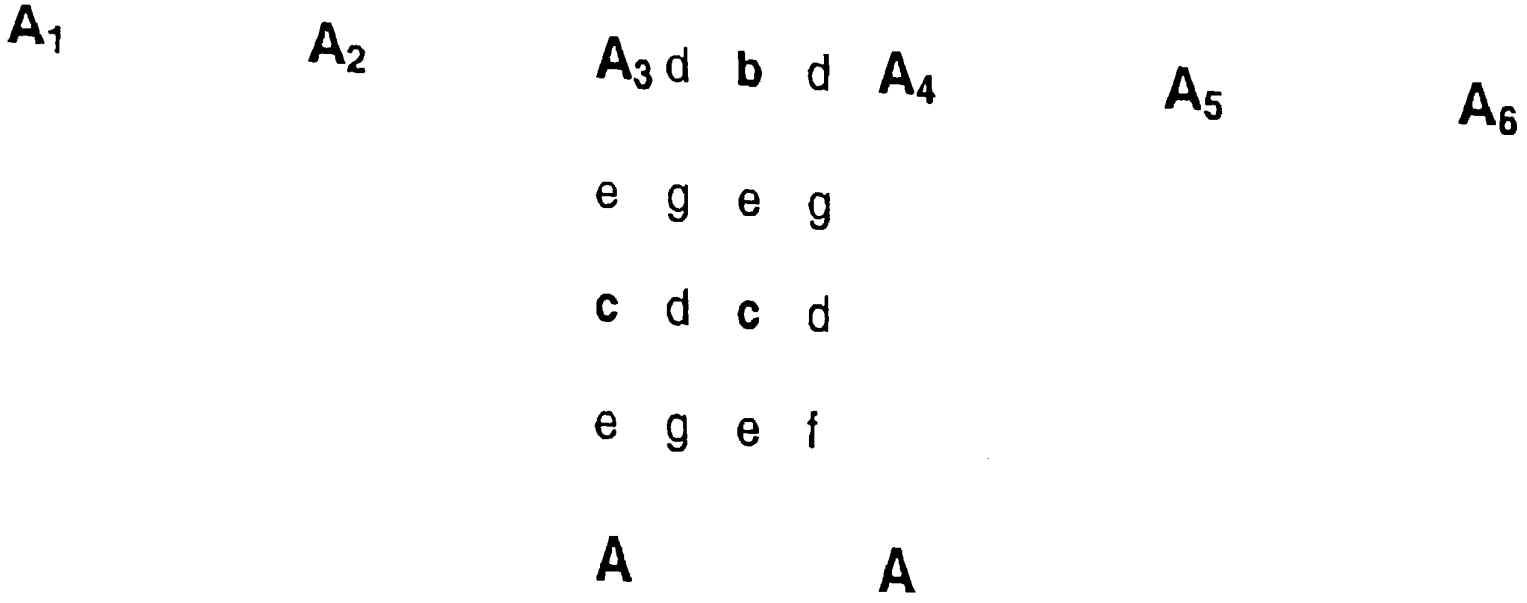



Figure13(b)

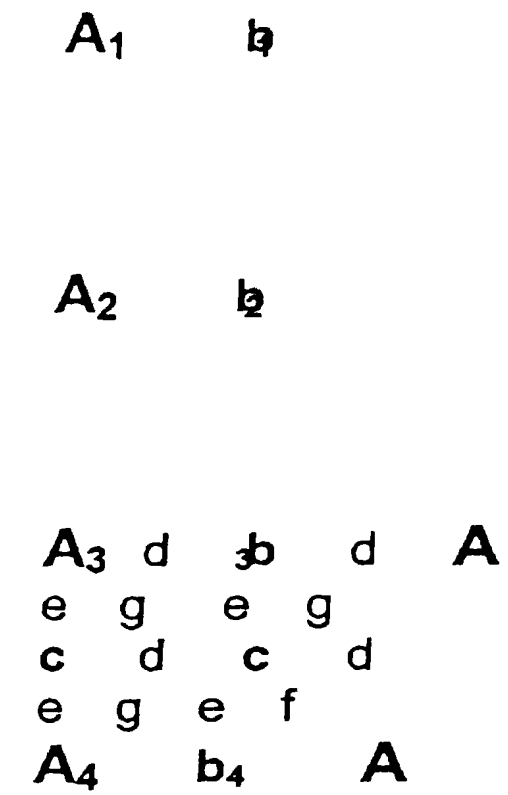



Figure 13(c)

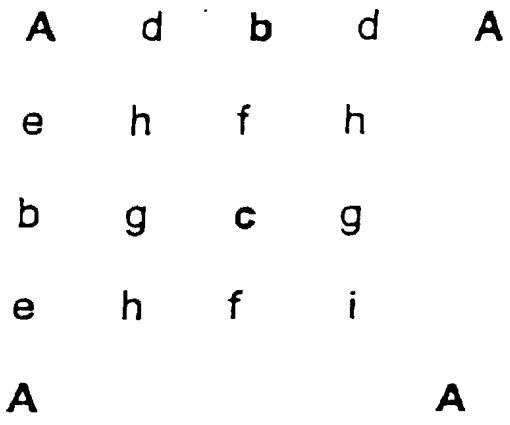



Fig. 14(a)

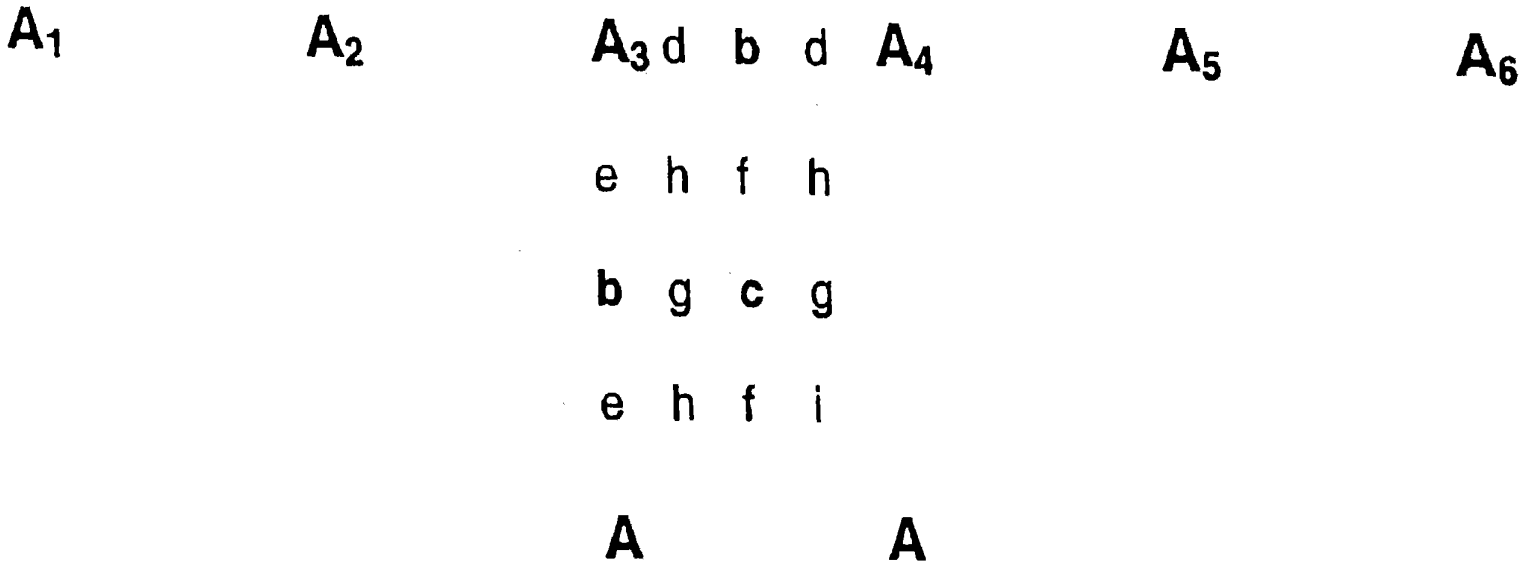



Figure14(b)

$A_1$

$A_2$

$A_3$ d b d A
e h f h
b g c g
e h f i

$A_4$ A

$A_5$

$A_6$

Figure 14(c)

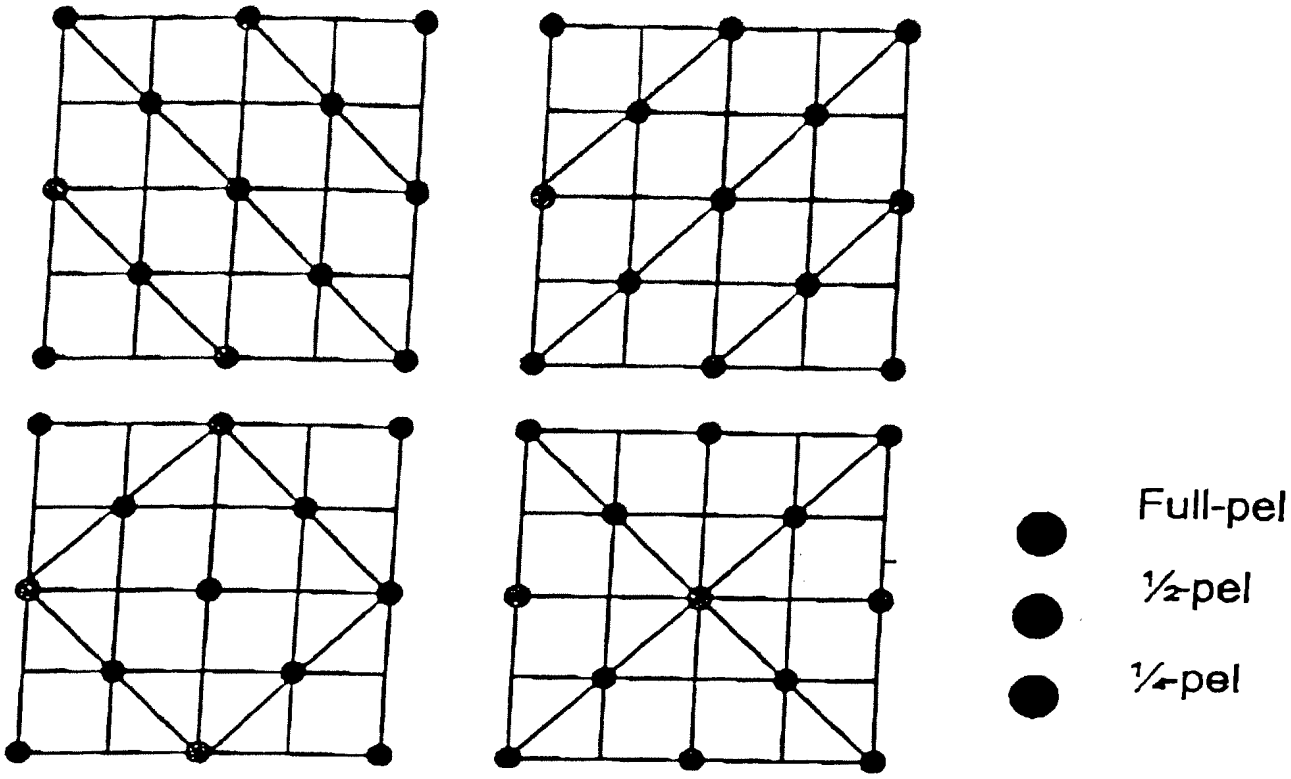
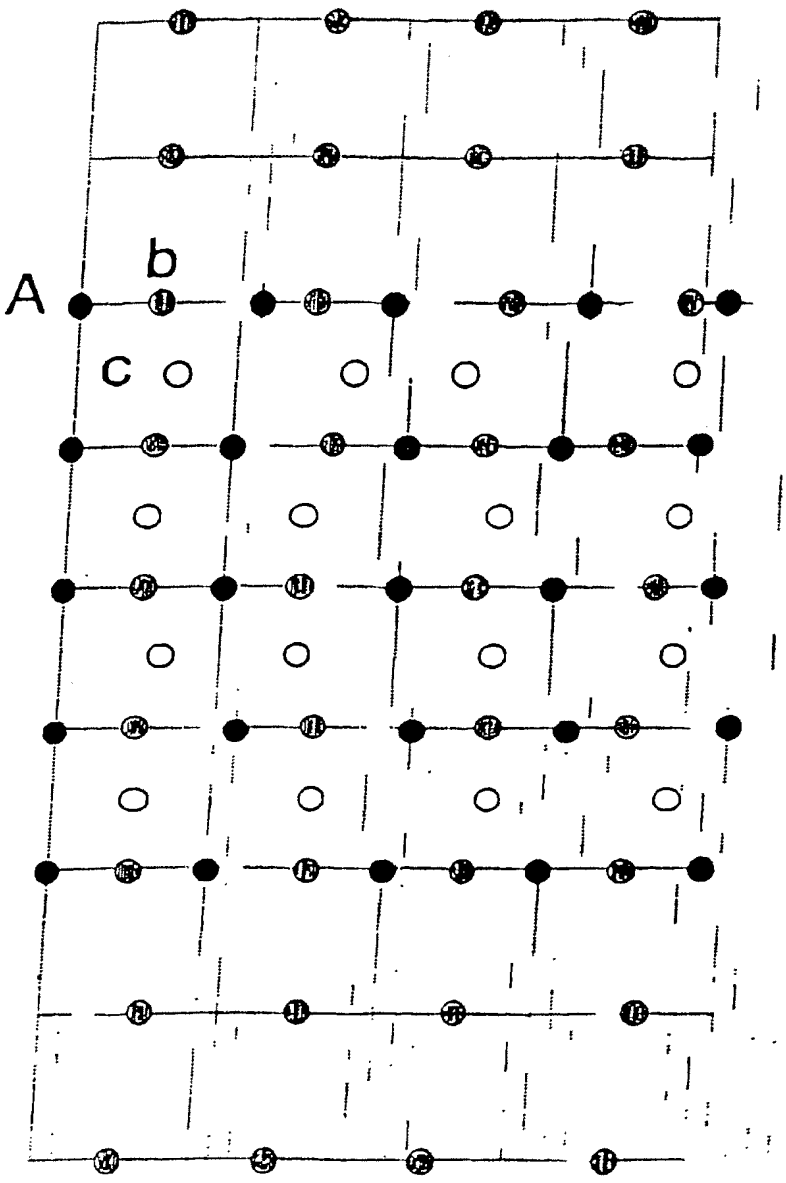



Fig. 15



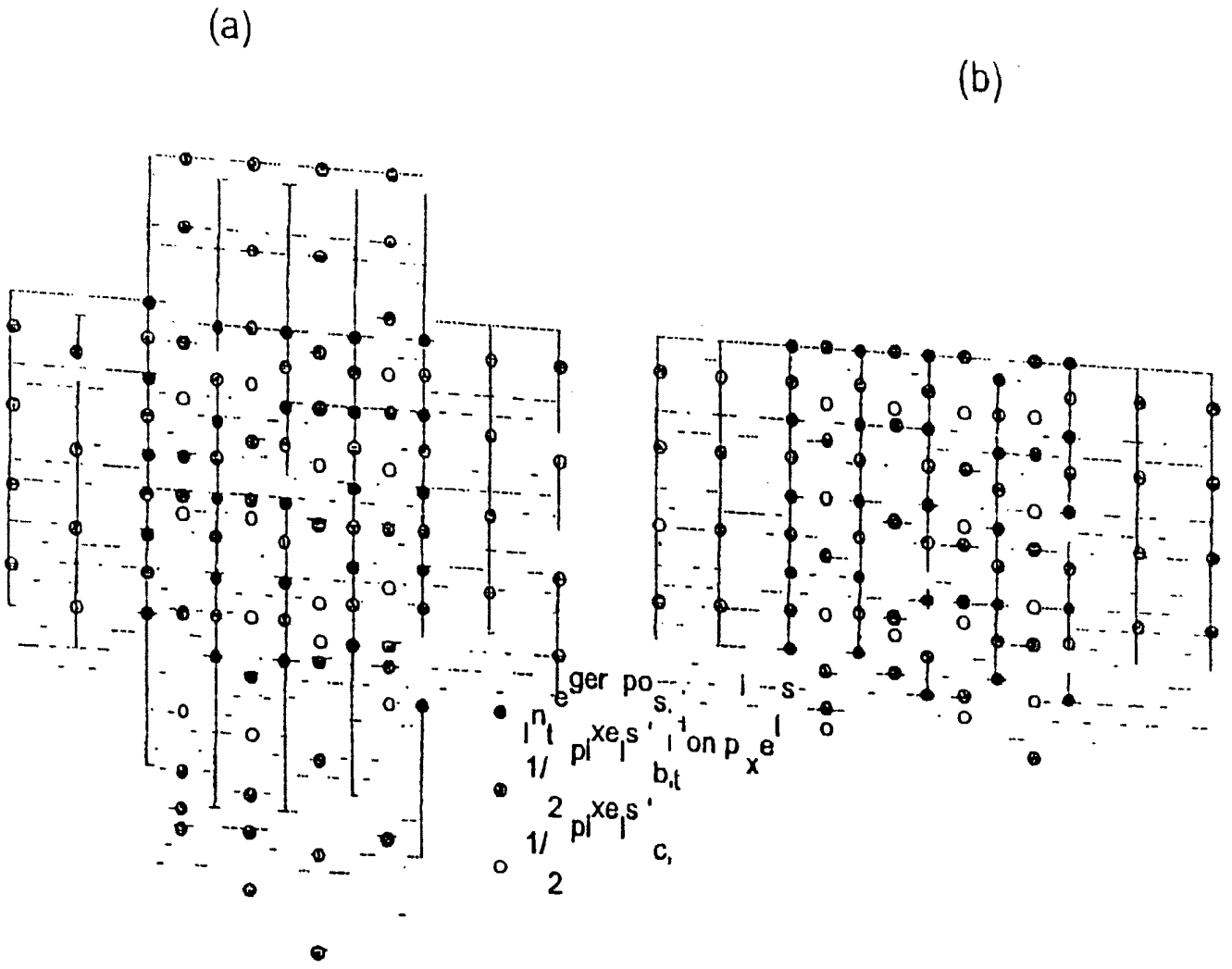

l s

● lgnet re
ops' i t ipò n i x e

1 / 2p' exs' l b

○ 1 / 2xp i é l's

F'g . 1 6



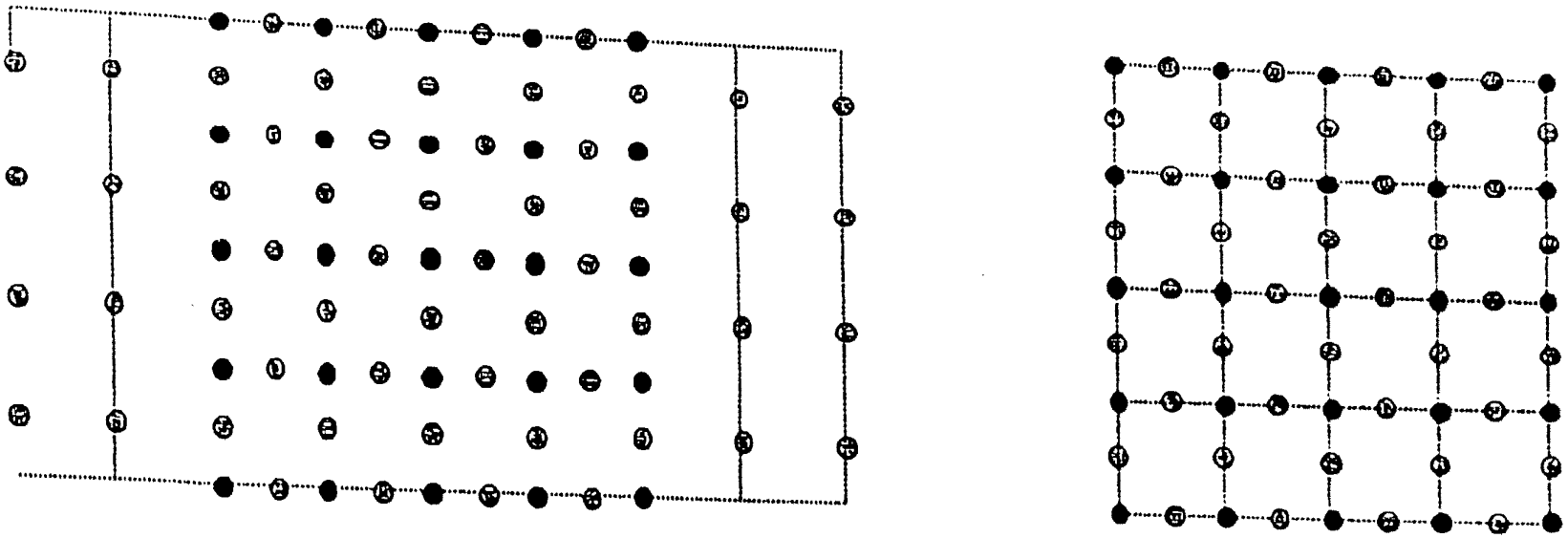

F

ig. 7

1

(a)

(b)



● Integer position pixels

1/2 pixels 'b'

Fig. 18

| | | | |
|---|---|---|---|
| 1 | 2 | 3 | 4 |
| 5 | 6 | 7 | 8 |
| 9 | 10 | 11 | 12 |
| 13 | 14 | 15 | 16 |

Fig. 19

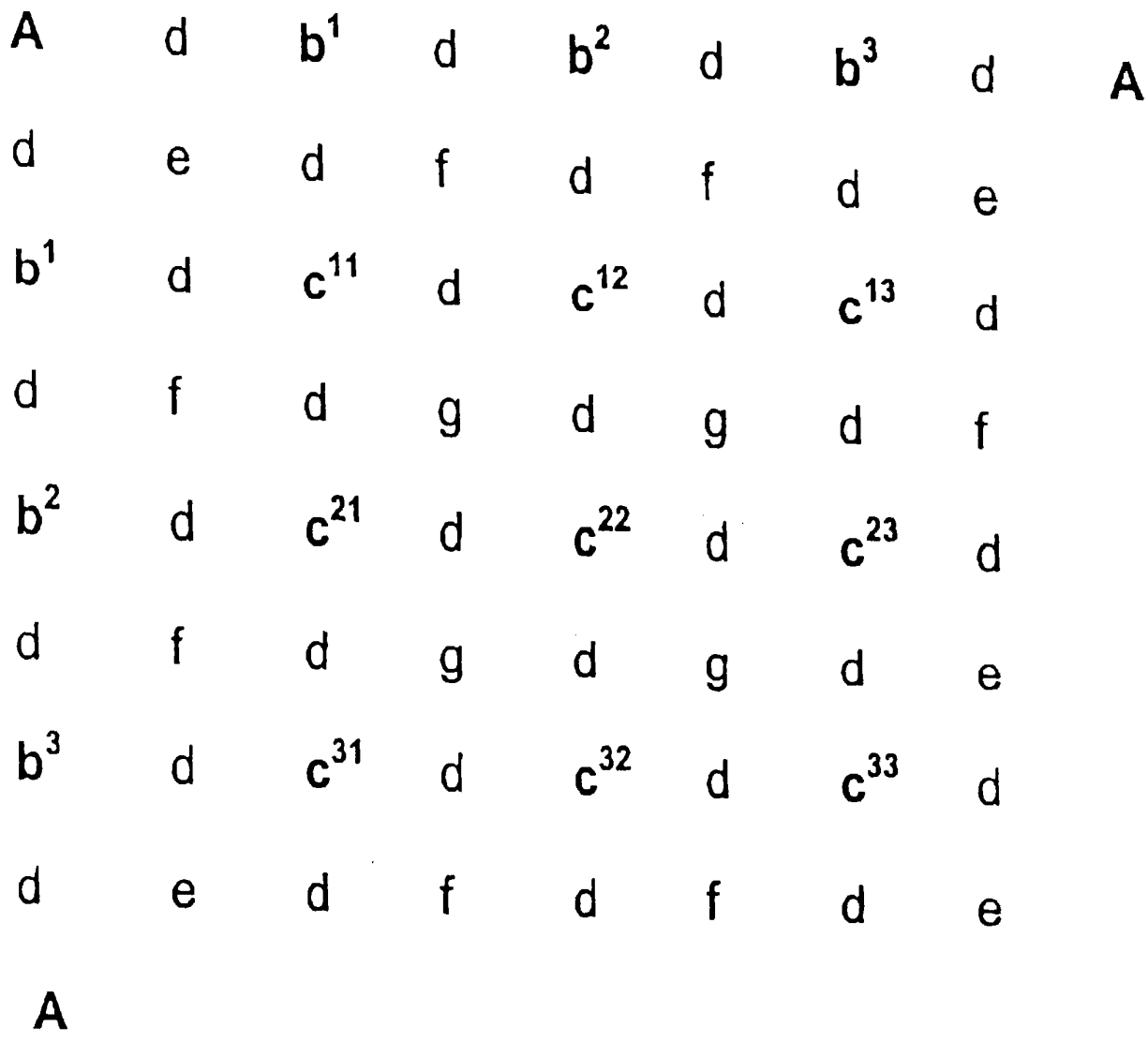

A d b1 d b2 d b3 d A
d e d f d f d e
b1 d c11 d c12 d c13 d
d f d g d g d f
b2 d c21 d c22 d c23 d
d f d g d g d e
b3 d c31 d c32 d c33 d
d e d f d f d e
A

Figure 20

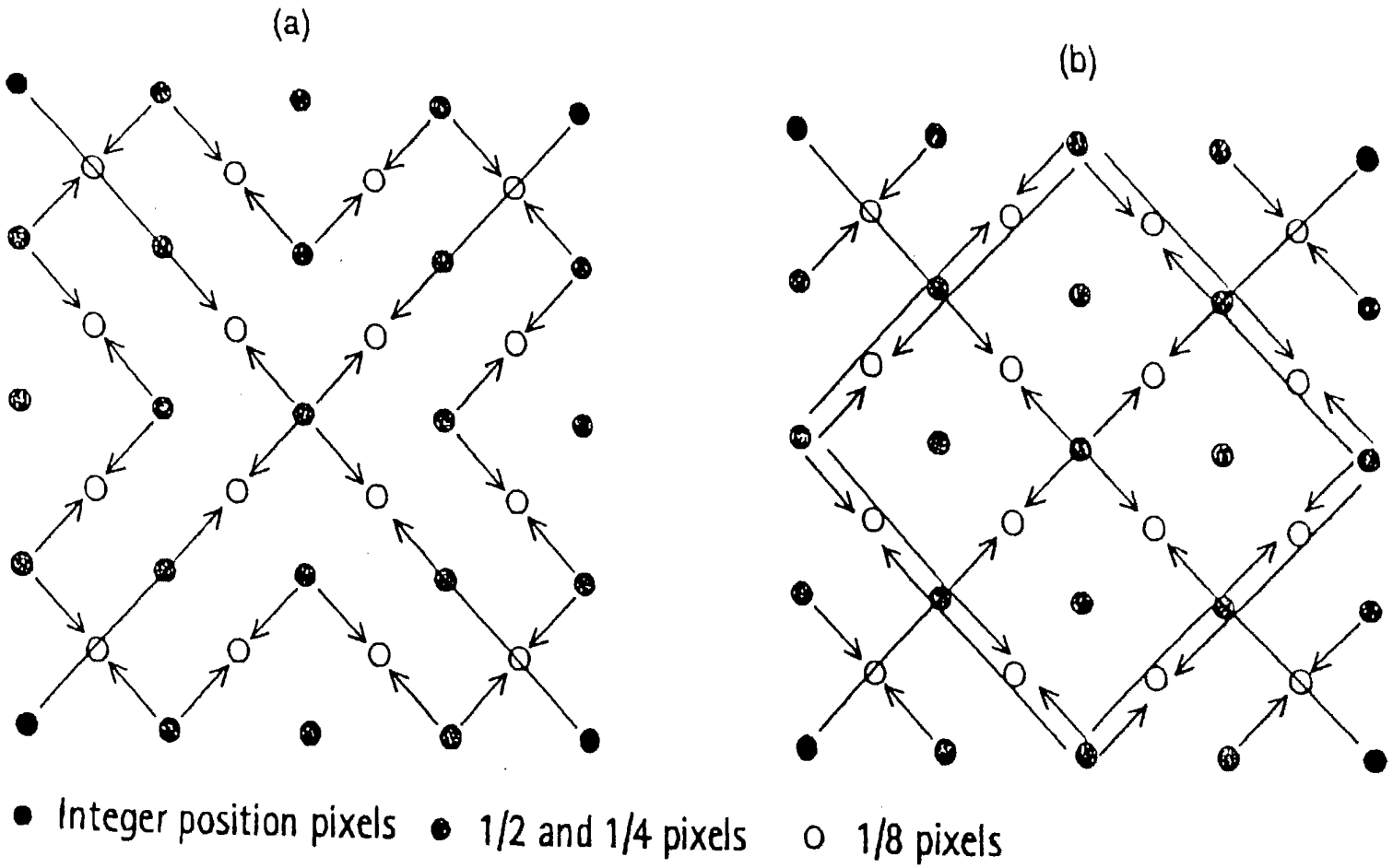



Fig. 21

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
| 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 |
| 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 |
| 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 |
| 33 | 34 | 35 | 36 | 37 | 38 | 39 | 40 |
| 41 | 42 | 43 | 44 | 45 | 46 | 47 | 48 |
| 49 | 50 | 51 | 52 | 53 | 54 | 55 | 56 |
| 57 | 58 | 59 | 60 | 61 | 62 | 63 | 64 |

Fig. 22

Attorney's Docket No. _____ PATENT

COMBINED DECLARATION AND POWER OF ATTORNEY

(ORIGINAL, DESIGN, NATIONAL STAGE OF PCT, SUPPLEMENTAL, DIVISIONAL, CONTINUATION OR C-I-P)

As a below named inventor, I hereby declare that:

## TYPE OF DECLARATION

This declaration is of the following type: (check one applicable item below)

- ☒ original
- ☐ design
- ☐ supplemental

*NOTE: If the declaration is for an International Application being filed as a divisional, continuation or continuation-in-part application, do not check next item; check appropriate one of last three items.*

- ☐ national stage of PCT

*NOTE: if one of the following 3 items apply, then complete and also attach ADDED PAGES FOR DIVISIONAL, CONTINUATION OR C-I-P.*

- ☐ divisional
- ☐ continuation
- ☐ continuation-in-part (C-I-P)

## INVENTORSHIP IDENTIFICATION

WARNING: If the inventors are each not the inventors of all the claims, an explanation of the facts, including the ownership of all the claims at the time the last claimed invention was made, should be submitted.

My residence, post office address and citizenship are as stated below next to my name.
I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled:

## TITLE OF INVENTION

**Method for sub-pixel value interpolation**

## SPECIFICATION IDENTIFICATION

the specification of which: (complete (a), (b) or (c))

(a) ☐ is attached hereto.
(b) ☒ was filed on 17 Sep. 2001 as ☒ Serial No. 09/954,608
or ☐ Express Mail No., as Serial No. not yet known _____
and was amended on _____(if applicable)

NOTE: Amendments file. .er the original papers are deposited with the PTO .ch contain new matter are not accorded a filing date by being referred to in the declaration. Accordingly, the amendments involved are those filed with the application papers or, in the case of a supplemental declaration, are those amendments claiming matter not encompassed in the original statement of invention or claims. See 37 CFR 1.67.

(c) ☐ was described and claimed in PCT International Application No. _____ filed on _____ and as amended under PCT Article 19 on _____(*if any*).

## ACKNOWLEDGEMENT OF REVIEW OF PAPERS AND DUTY OF CANDOR

I hereby state that I have reviewed and understand the contents of the above identified specification, including the claims, as amended by any amendment referred to above.

I acknowledge the duty to disclose information

☒ which is material to patentability as defined in 37, Code of Federal Regulations, § 1.56

(also check the following items, if desired)

☒ and which is material to the examination of this application, namely, information where there is a substantial likelihood that a reasonable examiner would consider it important in deciding whether to allow the application to issue as a patent, and

☐ In compliance with this duty there is attached an information disclosure statement in accordance with 37 CFR 1.98.

## PRIORITY CLAIM (35 U.S.C. § 119)

I hereby claim foreign priority benefits under Title 35, United States Code, § 119 of any foreign application(s) for patent or inventor's certificate or of any PCT International application(s) designating at least one country other than the United States of America listed below and have also identified below any foreign application(s) for patent or inventor's certificate or any PCT International application(s) designating at least one country other than the United States of America filed by me on the same subject matter having a filing date before that of the application(s) of which priority is claimed.

(complete (d) or (e))

(d) ☒ no such applications have been filed.

(e) ☐ such applications have been filed as follows.

*NOTE: Where item (c) is entered above and the International Application which designated the U.S. itself claimed priority check item (e), enter the details below and make the priority claim.*



## A. PRIOR FOREIGN/PCT APPLICATION(S) FILED WITHIN 12 MONTHS (6 MONTHS FOR DESIGN) PRIOR TO THIS APPLICATION

AND ANY PRIORITY CLAIMS UNDER 35 U.S.C. § 119

| COUNTRY (OR INDICATE IF PCT) | APPLICATION NUMBER | DATE OF FILING (day, **month**, year) | PRIORITY CLAIMED UNDER 37 USC 119 |
|---|---|---|---|
| | | | ☐ YES NO☐ |
| | | | ☐ YES NO☐ |
| | | | ☐ YES NO☐ |
| | | | ☐ YES NO☐ |
| | | | ☐ YES NO☐ |

ALL FOREIGN APPLICATION(S), IF ANY FILED MORE THAN 12 MONTHS (6) MONTHS FOR DESIGN PRIOR TO THIS U.S. APPLICATION

_____

_____

_____

*NOTE: If the application filed more than 12 months from the filing date of this application is a PCT filing forming the basis for this application entering the United States as (1) the national stage, or (2) a continuation, divisional, or continuation-in-part, then also complete ADDED PAGES TO COMBINED DECLARATION AND POWER OF ATTORNEY FOR DIVISIONAL, CONTINUATION OR C-I-P APPLICATION for benefit of the prior U.S. or PCT application(s) under 35 U.S.C. § 120.*

## POWER OF ATTORNEY

I hereby appoint the following attorney(s) and/or agent(s) to prosecute this application and transact all business in the Patent and Trademark Office connected therewith. *(List name and registration number)*

Clarence A. Green (24,622)
Mark F. Harrington (31,686)
Janik Marcovici (42,841)

*(check the following item, if applicable)*

☐ Attached as part of this declaration and power of attorney is the authorization of the above named attorney(s) to accept and follow instructions from my representative(s).



SEND CORRESPONDENCE TO

Perman & Green
425 Post Road

DIRECT TELEPHONE CALLS TO:
*(Name and telephone number)*
Mark F. Harrington

## DECLARATION

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code, and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

## SIGNATURE(S)

*NOTE: Carefully indicate the family (or last) name as it should appear on the filing receipt and all other documents.*

Full name of sole or first inventor

Marta (GIVEN NAME) ____ (MIDDLE INITIAL OR NAME) Karczewicz (FAMILY (OR LAST NAME)

Inventor's signature Karczewicz

Date 02/10/2001 Country of Citizenship Poland

Residence Irving, Texas, U.S.A.

Post Office Address 1224 Hidden Ridge, #3097 Irving, TX 75038, U.S.A.

Full name of second joint inventor, if any

Antti (GIVEN NAME) ____ (MIDDLE INITIAL OR NAME) Hallapuro (FAMILY (OR LAST NAME)

Inventor's signature _____

Date _____ Country of Citizenship Finland

Residence Tampere, Finland

Post Office Address Insinöörinkatu 60 B 115, FIN-33720 Tampere, Finland

Full name of third joint inventor, if any

_____ _____ _____
(GIVEN NAME) (MIDDLE INITIAL OR NAME) FAMILY (OR LAST NAME)

Inventor's signature _____
Date _____ Country of Citizenship _____
Residence _____
Post Office Address _____

CHECK PROPER BOX(ES) FOR ANY OF THE FOLLOWING ADDED PAGE(S) WHICH FORM A PART OF THIS DECLARATION

☐ Signature for fourth and subsequent joint inventors. *Number of pages added* _____

. . .

☐ Signature by administrator(trix), executor(trix) or legal representative for deceased or incapacitated inventor. *Number of pages added* _____

. . .

☐ Signature for inventor who refuses to sign or cannot be reached by person authorised under 37 CFR 1.47. *Number of pages added* _____

. . .

☐ Added page for signature by one joint inventor on behalf of deceased inventor(s) where legal representative cannot be appointed in time (37 CFR 1.47).

. . .

☐ Added pages to combined declaration and power of attorney for divisional, continuation, or continuation-in-part (C-I-P) application. *Number of pages added* _____

. . .

☐ Authorization of attorney(s) to accept and follow instructions from representative.

. . .

*(If no further pages form a part of this Declaration, then end this Declaration with this page and check the following item:)*

☒ This declaration ends with this page.

**Attorney's Docket No. _____** **PATENT**

COMBINED DECLARATION AND POWER OF ATTORNEY

(ORIGINAL, DESIGN, NATIONAL STAGE OF PCT, SUPPLEMENTAL, DIVISIONAL, CONTINUATION OR C-I-P)

As a below named inventor, I hereby declare that:

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- ☐ continuation
- ☐ continuation-in-part (C-I-P)

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the specification of which: (complete (a), (b) or (c))

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(b) ☒ was filed on 17 Sep. 2001 as ☒ Serial No. 09/954,608
or ☐ Express Mail No., as Serial No. not yet known _____
and was amended on _____(if applicable)

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(also check the following items, if desired)

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(complete (d) or (e))

(d) ☒ no such applications have been filed.

(e) ☐ such applications have been filed as follows.

*NOTE: Where item (c) is entered above and the International Application which designated the U.S. itself claimed priority check item (e), enter the details below and make the priority claim.*

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| COUNTRY (OR INDICATE IF PCT) | APPLICATION NUMBER | DATE OF FILING (day, **month**, year) | PRIORITY CLAIMED UNDER 37 USC 119 |
|---|---|---|---|
| | | | ☐ **YES** **NO**☐ |
| | | | ☐ **YES** **NO**☐ |
| | | | ☐ **YES** **NO**☐ |
| | | | ☐ **YES** **NO**☐ |
| | | | ☐ **YES** **NO**☐ |

**ALL FOREIGN APPLICATION(S), IF ANY FILED MORE THAN 12 MONTHS (6) MONTHS FOR DESIGN PRIOR TO THIS U.S. APPLICATION**

_____

_____

_____

*NOTE: If the application filed more than 12 months from the filing date of this application is a PCT filing forming the basis for this application entering the United States as (1) the national stage, or (2) a continuation, divisional, or continuation-in-part, then also complete ADDED PAGES TO COMBINED DECLARATION AND POWER OF ATTORNEY FOR DIVISIONAL, CONTINUATION OR C-I-P APPLICATION for benefit of the prior U.S. or PCT application(s) under 35 U.S.C. § 120.*

**POWER OF ATTORNEY**

I hereby appoint the following attorney(s) and/or agent(s) to prosecute this application and transact all business in the Patent and Trademark Office connected therewith. *(List name and registration number)*

Clarence A. Green (24,622)
Mark F. Harrington (31,686)
Janik Marcovici (42,841)

*(check the following item, if applicable)*

☐ Attached as part of this declaration and power of attorney is the authorization of the above named attorney(s) to accept and follow instructions from my representative(s).

| SEND CORRESPONDENCE TO | DIRECT TELEPHONE CALLS TO: *(Name and telephone number)* |
|---|---|
| Perman & Green<br>425 Post Road<br>Fairfield, CT 06430-6232 | Mark F. Harrington<br><br>(203) 259-1800 |

## DECLARATION

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code, and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

## SIGNATURE(S)

***NOTE: Carefully indicate the family (or last) name as it should appear on the filing receipt and all other documents.***

Full name of sole or first inventor

| Marta | _____ | Karczewicz |
|---|---|---|
| (GIVEN NAME) | (MIDDLE INITIAL OR NAME) | FAMILY (OR LAST NAME) |

Inventor's signature _____
Date _____ Country of Citizenship Poland
Residence Irving, Texas, U.S.A.
Post Office Address 1224 Hidden Ridge, #3097 Irving, TX 75038, U.S.A.

Full name of second joint inventor, if any

| Antti | Olli | Hallapuro |
|---|---|---|
| (GIVEN NAME) | (MIDDLE INITIAL OR NAME) | FAMILY (OR LAST NAME) |

Inventor's signature Antti Hallapuro
Date 15.10.2001 Country of Citizenship Finland
Residence Tampere, Finland
Post Office Address Insinöörinkatu 60 B 115, FIN-33720 Tampere, Finland

Full name of third joint inventor, if any

(GIVEN NAME) (MIDDLE INITIAL OR NAME) FAMILY (OR LAST NAME)

Inventor's signature _____
Date _____ Country of Citizenship _____
Residence _____
Post Office Address _____

CHECK PROPER BOX(ES) FOR ANY OF THE FOLLOWING ADDED PAGE(S) WHICH FORM A PART OF THIS DECLARATION

☐ Signature for fourth and subsequent joint inventors. *Number of pages added* ___

. . .

☐ Signature by administrator(trix), executor(trix) or legal representative for deceased or incapacitated inventor. *Number of pages added* _____

. . .

☐ Signature for inventor who refuses to sign or cannot be reached by person authorised under 37 CFR 1.47. *Number of pages added* _____

. . .

☐ Added page for signature by one joint inventor on behalf of deceased inventor(s) where legal representative cannot be appointed in time (37 CFR 1.47).

. . .

☐ Added pages to combined declaration and power of attorney for divisional, continuation, or continuation-in-part (C-I-P) application. *Number of pages added* _____

. . .

☐ Authorization of attorney(s) to accept and follow instructions from representative.

. . .

*(If no further pages form a part of this Declaration, then end this Declaration with this page and check the following item:)*

☒ This declaration ends with this page.

8/15/07

PTO/SB/06 (12-04)
Approved for use through 7/31/2006. OMB 0651-0032
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE

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**PATENT APPLICATION FEE DETERMINATION RECORD**
Substitute for Form PTO-875

11/839,205

## APPLICATION AS FILED – PART I

| | (Column 1) | (Column 2) | SMALL ENTITY | | | OTHER THAN SMALL ENTITY | |
|---|---|---|---|---|---|---|---|
| FOR | NUMBER FILED | NUMBER EXTRA | RATE ($) | FEE ($) | | RATE ($) | FEE ($) |
| BASIC FEE (37 CFR 1.16(a), (b), or (c)) | | | | | | | 300 |
| SEARCH FEE (37 CFR 1.16(k), (i), or (m)) | | | | | | | 500 |
| EXAMINATION FEE (37 CFR 1.16(o), (p), or (q)) | | | | | | | 200 |
| TOTAL CLAIMS (37 CFR 1.16(i)) | 3 minus 20 = | | X 25= | | OR | X 50= | |
| INDEPENDENT CLAIMS (37 CFR 1.16(h)) | 3 minus 3 = | | X 100= | | | X 200= | |
| APPLICATION SIZE FEE (37 CFR 1.16(s)) | If the specification and drawings exceed 100 sheets of paper, the application size fee due is $250 ($125 for small entity) for each additional 50 sheets or fraction thereof. See 35 U.S.C. 41(a)(1)(G) and 37 CFR 1.16(s). | | | | | | |
| MULTIPLE DEPENDENT CLAIM PRESENT (37 CFR 1.16(j)) | | | N/A | | | N/A | |
| * If the difference in column 1 is less than zero, enter "0" in column 2. | | | TOTAL | | | TOTAL | 1000 |

## APPLICATION AS AMENDED – PART II

AMENDMENT A

| | (Column 1) | | (Column 2) | (Column 3) | SMALL ENTITY | | OR | OTHER THAN SMALL ENTITY | |
|---|---|---|---|---|---|---|---|---|---|
| | CLAIMS REMAINING AFTER AMENDMENT | | HIGHEST NUMBER PREVIOUSLY PAID FOR | PRESENT EXTRA | RATE ($) | ADDI-TIONAL FEE ($) | | RATE ($) | ADDI-TIONAL FEE ($) |
| Total (37 CFR 1.16(i)) | * | Minus | ** | = | X = | | OR | X = | |
| Independent (37 CFR 1.16(h)) | * | Minus | *** | = | X = | | OR | X = | |
| Application Size Fee (37 CFR 1.16(s)) | | | | | | | | | |
| FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j)) | | | | | N/A | | OR | N/A | |
| | | | | | TOTAL ADD'T FEE | | OR | TOTAL ADD'T FEE | |

AMENDMENT B

| | (Column 1) | | (Column 2) | (Column 3) | | | OR | | |
|---|---|---|---|---|---|---|---|---|---|
| | CLAIMS REMAINING AFTER AMENDMENT | | HIGHEST NUMBER PREVIOUSLY PAID FOR | PRESENT EXTRA | RATE ($) | ADDI-TIONAL FEE ($) | | RATE ($) | ADDI-TIONAL FEE ($) |
| Total (37 CFR 1.16(i)) | * | Minus | ** | = | X = | | OR | X = | |
| Independent (37 CFR 1.16(h)) | * | Minus | *** | = | X = | | OR | X = | |
| Application Size Fee (37 CFR 1.16(s)) | | | | | | | | | |
| FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j)) | | | | | N/A | | OR | N/A | |
| | | | | | TOTAL ADD'T FEE | | OR | TOTAL ADD'T FEE | |

* If the entry in column 1 is less than the entry in column 2, write "0" in column 3.
** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 20, enter "20".
*** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 3, enter "3".
The "Highest Number Previously Paid For" (Total or Independent) is the highest number found in the appropriate box in column 1.

This collection of information is required by 37 CFR 1.16. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 12 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

*If you need assistance in completing the form, call 1-800-PTO-9199 and select option 2.*

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

| APPLICATION NUMBER | FILING or 371(c) DATE | GRP ART UNIT | FIL FEE REC'D | ATTY.DOCKET.NO | TOT CLAIMS | IND CLAIMS |
|---|---|---|---|---|---|---|
| 11/839,205 | 08/15/2007 | 2621 | 1000 | 982-010567-US (C02) | 3 | 3 |

**CONFIRMATION NO. 8091**

2512
PERMAN & GREEN
425 POST ROAD
FAIRFIELD, CT06824

**FILING RECEIPT**

Date Mailed: 08/22/2007

Receipt is acknowledged of this non-provisional patent application. The application will be taken up for examination in due course. Applicant will be notified as to the results of the examination. Any correspondence concerning the application must include the following identification information: the U.S. APPLICATION NUMBER, FILING DATE, NAME OF APPLICANT, and TITLE OF INVENTION. Fees transmitted by check or draft are subject to collection. Please verify the accuracy of the data presented on this receipt. **If an error is noted on this Filing Receipt, please write to the Office of Initial Patent Examination's Filing Receipt Corrections. Please provide a copy of this Filing Receipt with the changes noted thereon. If you received a "Notice to File Missing Parts" for this application, please submit any corrections to this Filing Receipt with your reply to the Notice. When the USPTO processes the reply to the Notice, the USPTO will generate another Filing Receipt incorporating the requested corrections**

**Applicant(s)**

Marta Karczewicz, Irving, TX;
Antti Olli Hallapuro, Tampere, FINLAND;

**Assignment For Published Patent Application**

Nokia Corporation, Espoo, FINLAND

**Power of Attorney:**
Clarence Green--24622
Mark Harrington--31686
Janik Marcovici--42841

**Domestic Priority data as claimed by applicant**

This application is a CON of 11/090,717 03/25/2005
which is a CON of 09/954,608 09/17/2001 PAT 6,950,469

**Foreign Applications**

**If Required, Foreign Filing License Granted:** 08/22/2007

The country code and number of your priority application, to be used for filing abroad under the Paris Convention, is **US11/839,205**

**Projected Publication Date:** To Be Determined - pending completion of Corrected Papers

**Non-Publication Request:** No

**Early Publication Request:** No

**Title**

METHOD FOR SUB-PIXEL VALUE INTERPOLATION

**Preliminary Class**

375

## PROTECTING YOUR INVENTION OUTSIDE THE UNITED STATES

Since the rights granted by a U.S. patent extend only throughout the territory of the United States and have no effect in a foreign country, an inventor who wishes patent protection in another country must apply for a patent in a specific country or in regional patent offices. Applicants may wish to consider the filing of an international application under the Patent Cooperation Treaty (PCT). An international (PCT) application generally has the same effect as a regular national patent application in each PCT-member country. The PCT process **simplifies** the filing of patent applications on the same invention in member countries, but **does not result** in a grant of "an international patent" and does not eliminate the need of applicants to file additional documents and fees in countries where patent protection is desired.

Almost every country has its own patent law, and a person desiring a patent in a particular country must make an application for patent in that country in accordance with its particular laws. Since the laws of many countries differ in various respects from the patent law of the United States, applicants are advised to seek guidance from specific foreign countries to ensure that patent rights are not lost prematurely.

Applicants also are advised that in the case of inventions made in the United States, the Director of the USPTO must issue a license before applicants can apply for a patent in a foreign country. The filing of a U.S. patent application serves as a request for a foreign filing license. The application's filing receipt contains further information and guidance as to the status of applicant's license for foreign filing.

Applicants may wish to consult the USPTO booklet, "General Information Concerning Patents" (specifically, the section entitled "Treaties and Foreign Patents") for more information on timeframes and deadlines for filing foreign patent applications. The guide is available either by contacting the USPTO Contact Center at 800-786-9199, or it can be viewed on the USPTO website at http://www.uspto.gov/web/offices/pac/doc/general/index.html.

For information on preventing theft of your intellectual property (patents, trademarks and copyrights), you may wish to consult the U.S. Government website, http://www.stopfakes.gov. Part of a Department of Commerce initiative, this website includes self-help "toolkits" giving innovators guidance on how to protect intellectual property in specific countries such as China, Korea and Mexico. For questions regarding patent enforcement issues, applicants may call the U.S. Government hotline at 1-866-999-HALT (1-866-999-4158).

---

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## Title 35, United States Code, Section 184

## Title 37, Code of Federal Regulations, 5.11 & 5.15

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This license is to be retained by the licensee and may be used at any time on or after the effective date thereof unless it is revoked. This license is automatically transferred to any related applications(s) filed under 37 CFR 1.53(d). This license is not retroactive.

The grant of a license does not in any way lessen the responsibility of a licensee for the security of the subject matter as imposed by any Government contract or the provisions of existing laws relating to espionage and the national security or the export of technical data. Licensees should apprise themselves of current regulations especially with respect to certain countries, of other agencies, particularly the Office of Defense Trade Controls, Department of State (with respect to Arms, Munitions and Implements of War (22 CFR 121-128)); the Bureau of Industry and Security, Department of Commerce (15 CFR parts 730-774); the Office of Foreign AssetsControl, Department of Treasury (31 CFR Parts 500+) and the Department of Energy.

**NOT GRANTED**

No license under 35 U.S.C. 184 has been granted at this time, if the phrase "IF REQUIRED, FOREIGN FILING LICENSE GRANTED" DOES NOT appear on this form. Applicant may still petition for a license under 37 CFR 5.12, if a license is desired before the expiration of 6 months from the filing date of the application. If 6 months has lapsed from the filing date of this application and the licensee has not received any indication of a secrecy order under 35 U.S.C. 181, the licensee may foreign file the application pursuant to 37 CFR 5.15(b).

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UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
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Alexandria, Virginia 22313-1450
www.uspto.gov

| APPLICATION NUMBER | FILING OR 371 (c) DATE | FIRST NAMED APPLICANT | ATTORNEY DOCKET NUMBER |
|---|---|---|---|
| 11/839,205 | 08/15/2007 | Marta Karczewicz | 982-010567-US (C02) |

**CONFIRMATION NO. 8091**

2512
PERMAN & GREEN
425 POST ROAD
FAIRFIELD, CT 06824

**FORMALITIES LETTER**

Date Mailed: 08/22/2007

## NOTICE TO FILE CORRECTED APPLICATION PAPERS

### *Filing Date Granted*

An application number and filing date have been accorded to this application. The application is informal since it does not comply with the regulations for the reason(s) indicated below. Applicant is given TWO MONTHS from the date of this Notice within which to correct the informalities indicated below. Extensions of time may be obtained by filing a petition accompanied by the extension fee under the provisions of 37 CFR 1.136(a).

The required item(s) identified below must be timely submitted to avoid abandonment:

- Replacement drawings in compliance with 37 CFR 1.84 and 37 CFR 1.121(d) are required. The drawings submitted are not acceptable because:
  - The drawings have a line quality that is too light to be reproduced (weight of all lines and letters must be heavy enough to permit adequate reproduction) or text that is illegible (reference characters, sheet numbers, and view numbers must be plain and legible) see 37 CFR 1.84(l) and (p)(1)); See Figure(s) 16,17,18A.

Applicant is cautioned that correction of the above items may cause the specification and drawings page count to exceed 100 pages. If the specification and drawings exceed 100 pages, applicant will need to submit the required application size fee.

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T.K

Office of Initial Patent Examination (571) 272-4000, or 1-800-PTO-9199

PART 3 - OFFICE COPY

| Response To Notice To File Missing Parts Of Application Filing Date Granted (PTO-1533)(Large Entity) | Docket No. 982-010567-US (C02) |
|---|---|

In Re Application Of: **Karczewicz**

| Application No. | Filing Date | Examiner | Customer No. | Group Art Unit | Confirmation No. |
|---|---|---|---|---|---|
| **11/839,205** | **8/15/2007** | | **2512** | **2621** | **8091** |

Invention: **METHOD FOR SUB-PIXEL VALUE INTERPOLATION**

Mail Stop Missing Parts

COMMISSIONER FOR PATENTS:

This is a response to the Notice to File Missing Parts of Application - Filing Date Granted (PTO-1533) mailed on

**08/22/2007**
*Date*

Enclosed herewith for filing are the following:

☒ A copy of the Notice to File Missing Parts of Application - Filing Date Granted (PTO-1533). **(REQUIRED)**

☐ An oath or declaration in compliance with 37 CFR 1.63, including residence information and identifying the application by the above Application Number and Filing Date.

☐ A properly signed oath or declaration in compliance with 37 CFR 1.63.

☐ An oath or declaration in compliance with 37 CFR 1.63 listing the names of all inventors and signed by the omitted inventor(s), identifying this application by the above Application Number and Filing Date.

☐ A verified English translation of the non-English language application papers as originally filed. It is requested that this translation be used as the copy for examination purposes in the United States Patent and Trademark Office.

☒ Other (list):

**Replacement Drawings**

| Response To Notice To File Missing Parts Of Application Filing Date Granted (PTO-1533)(Large Entity) | Docket No. 982-010567-US (C02) |
|---|---|

In Re Application Of: **Karczewicz**

| Application No. | Filing Date | Examiner | Customer No. | Group Art Unit | Confirmation No. |
|---|---|---|---|---|---|
| **11/839,205** | **8/15/2007** | | **2512** | **2621** | **8091** |

Invention: **METHOD FOR SUB-PIXEL VALUE INTERPOLATION**

TO THE COMMISSIONER FOR PATENTS:

Mail Stop Missing Parts

☐ Completion of application fees as calculated below:

| | |
|---|---|
| ☐ Utility application basic fee | |
| ☐ Design application basic fee | |
| ☐ Search Fee | |
| ☐ Examination Fee | |
| ☐ Total number of independent claims = _____ | |
| ☐ Total number of claims = _____ | |
| ☐ Multiple dependent claims | |
| ☐ Surcharge for late payment of filing fee and/or late filing of original declaration or oath | |
| ☐ Petition and fee for filing by other than all the inventors or a person not the inventor | |
| ☐ Fee for processing an application filed with a non-English language specification | |
| ☐ Fee for processing and retention of application | |
| Total completion of application fees | |

This is a request under the provisions of 37 CFR 1.136(a) to extend the period for filing a response to the above-identified Notice to File Missing Parts of Application. The requested extension is as follows (check time period desired). If an additional time extension is required, please consider this a petition therefor.

☐ One month ☒ Two months ☐ Three months ☐ Four months ☐ Five months

from: **10/22/2007** *Date* until: **12/22/2007** *Date*

| | |
|---|---|
| Total time extension fees | **$460.00** |
| Total fees due | **$460.00** |

| Response To Notice To File Missing Parts Of Application Filing Date Granted (PTO-1533) (Large Entity) | Docket No. 982-010567-US (C02) |
|---|---|

In Re Application Of: **Karczewicz**

| Application No. | Filing Date | Examiner | Customer No. | Group Art Unit | Confirmation No. |
|---|---|---|---|---|---|
| 11/839,205 | 8/15/2007 | | 2512 | 2621 | 8091 |

Invention: **METHOD FOR SUB-PIXEL VALUE INTERPOLATION**

TO THE COMMISSIONER FOR PATENTS:

Mail Stop Missing Parts

The fee of **$460.00** is to be paid as follows:

- ☐ A check in the amount of the fee is enclosed.
- ☒ The Director is hereby authorized to charge any fees which may be required, or credit any overpayment, to Deposit Account No. **16-1350**
- ☒ If an additional extension of time is required, please consider this a petition therefor and charge any additional fees which may be required to Deposit Account No.
- ☐ Payment by credit card. Form PTO-2038 is attached.

**WARNING: Information on this form may become public. Credit card information should not be included on this form. Provide credit card information and authorization on PTO-2038.**

*Signature*

Dated: **26 November 2007**

**Geza C. Ziegler, Jr.**
**Reg. No. 44,004**
**PERMAN & GREEN, LLP**
**425 Post Road**
**Fairfield, CT 06824**
**(203) 259-1800**

I hereby certify that this correspondence is being deposited with the United States Postal Service with sufficient postage as first class mail in an envelope addressed to "Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450" [37 CFR 1.8(a)] on

_____.
*(Date)*

*Signature of Person Mailing Correspondence*

*Typed or Printed Name of Person Mailing Correspondence*

cc:

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UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
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Alexandria, Virginia 22313-1450
www.uspto.gov

| APPLICATION NUMBER | FILING OR 371 (c) DATE | FIRST NAMED APPLICANT | ATTORNEY DOCKET NUMBER |
|---|---|---|---|
| 11/839,205 | 08/15/2007 | Marta Karczewicz | 982-010567-US (C02) |

**CONFIRMATION NO. 8091**

2512 GC2
PERMAN & GREEN
425 POST ROAD
FAIRFIELD, CT 06824

**FORMALITIES LETTER**

US ACTION
DUE DATE 10-22-2007
PAPER DATED 8-22-2007
OA _____ FINAL _____
MSG PT _____ DWG _____
APPEAL _____ ISSUE FEE _____
OTHER Corrected application

Date Mailed: 08/22/2007

RECEIVED
AUG 27 2007
PERMAN & GREEN, LLP

## NOTICE TO FILE CORRECTED APPLICATION PAPERS

### *Filing Date Granted*

An application number and filing date have been accorded to this application. The application is informal since it does not comply with the regulations for the reason(s) indicated below. Applicant is given TWO MONTHS from the date of this Notice within which to correct the informalities indicated below. Extensions of time may be obtained by filing a petition accompanied by the extension fee under the provisions of 37 CFR 1.136(a).

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  - The drawings have a line quality that is too light to be reproduced (weight of all lines and letters must be heavy enough to permit adequate reproduction) or text that is illegible (reference characters, sheet numbers, and view numbers must be plain and legible) see 37 CFR 1.84(l) and (p)(1)); See Figure(s) 16,17,18A.

Applicant is cautioned that correction of the above items may cause the specification and drawings page count to exceed 100 pages. If the specification and drawings exceed 100 pages, applicant will need to submit the required application size fee.

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Office of Initial Patent Examination (571) 272-4000, or 1-800-PTO-9199
PART 1 - ATTORNEY/APPLICANT COPY

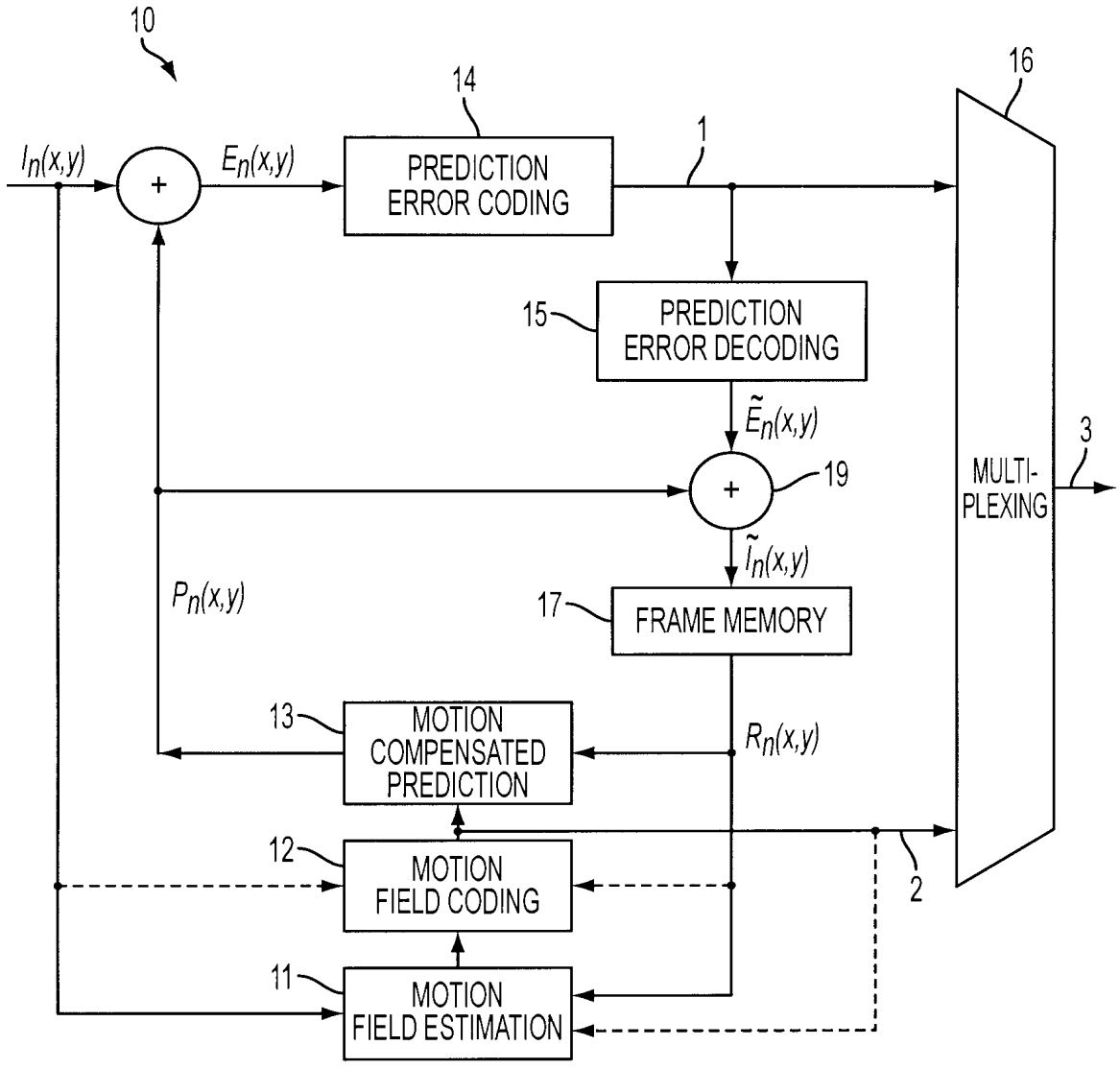



FIG. 1
PRIOR ART

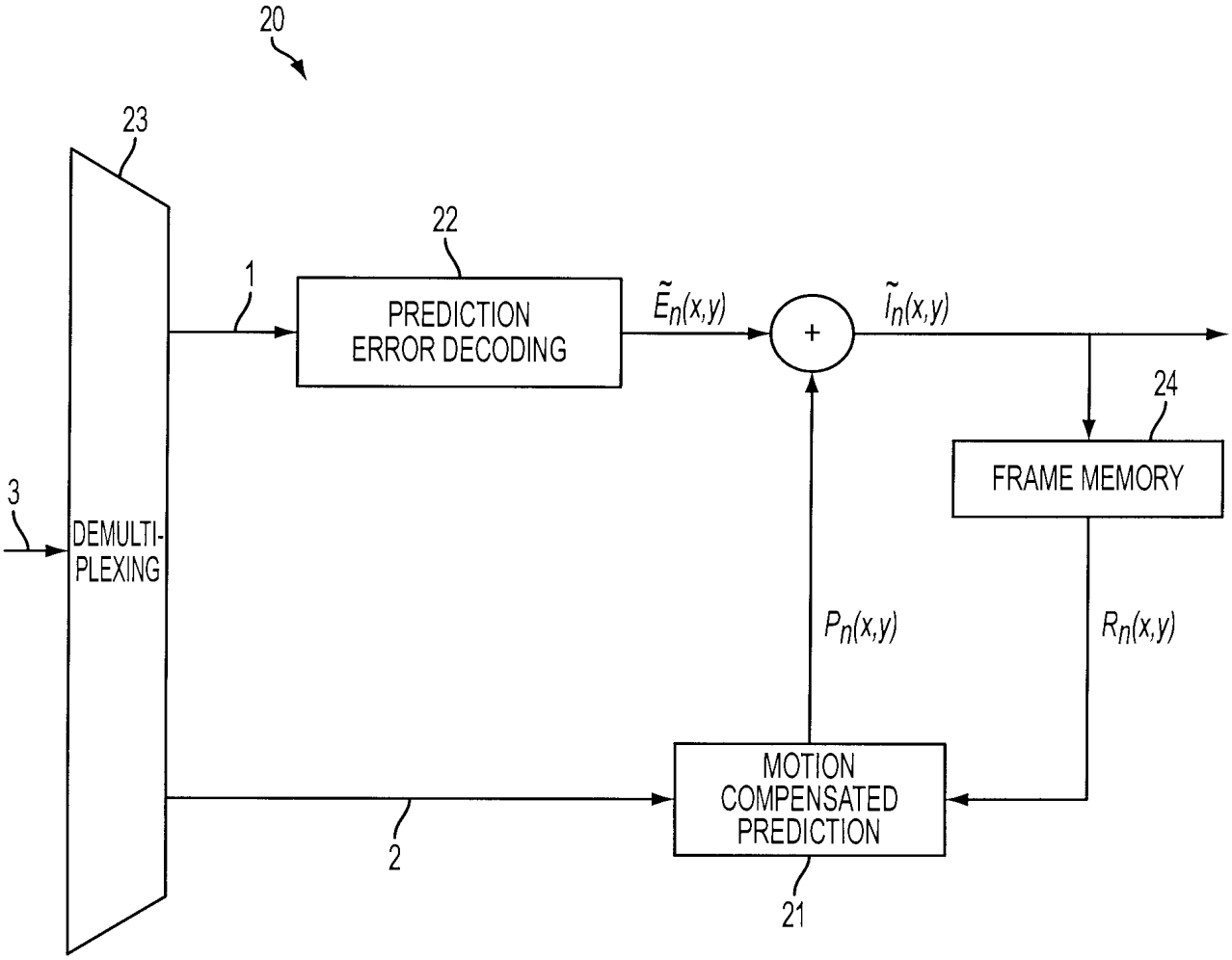



FIG. 2
PRIOR ART

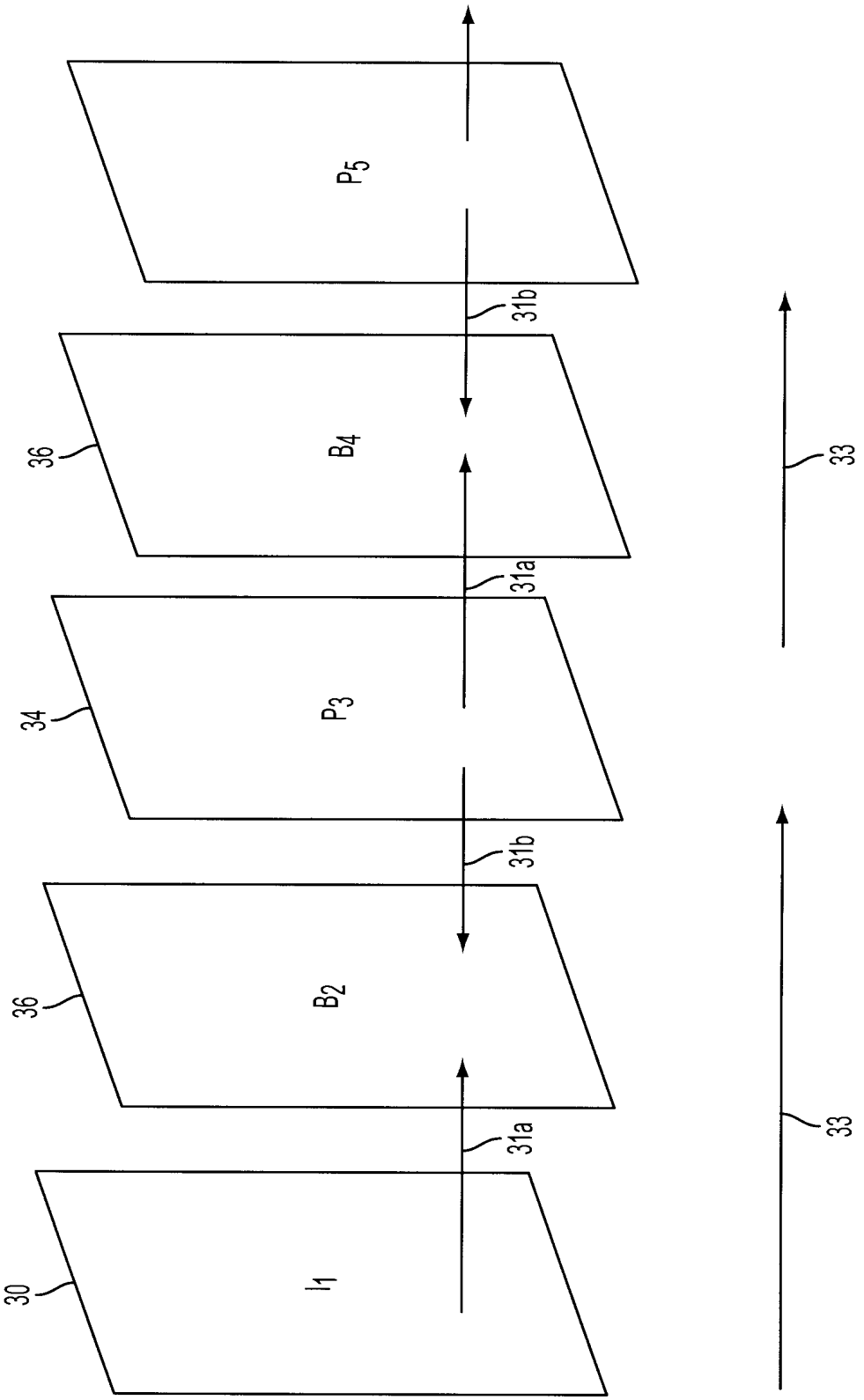



FIG. 3

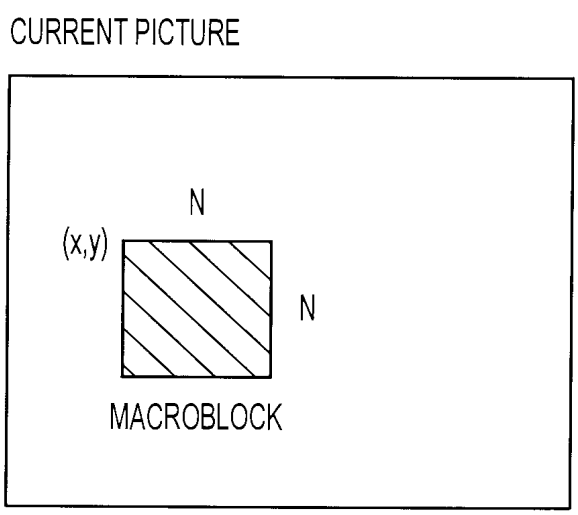



FIG. 4a

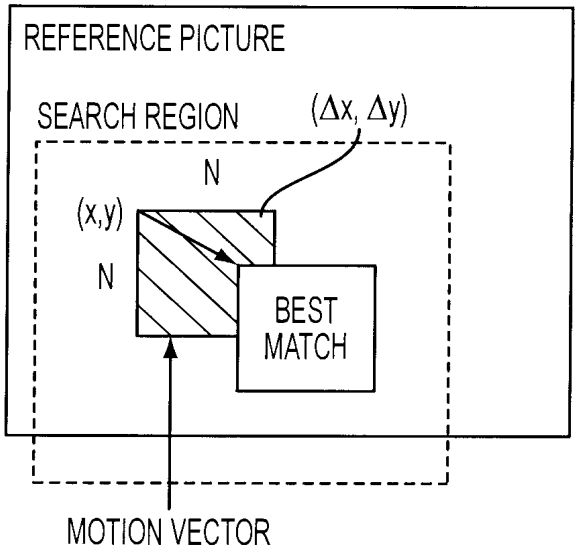



FIG. 4b

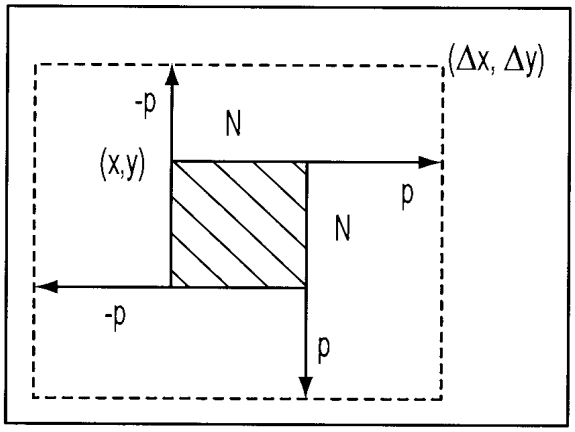



FIG. 4c

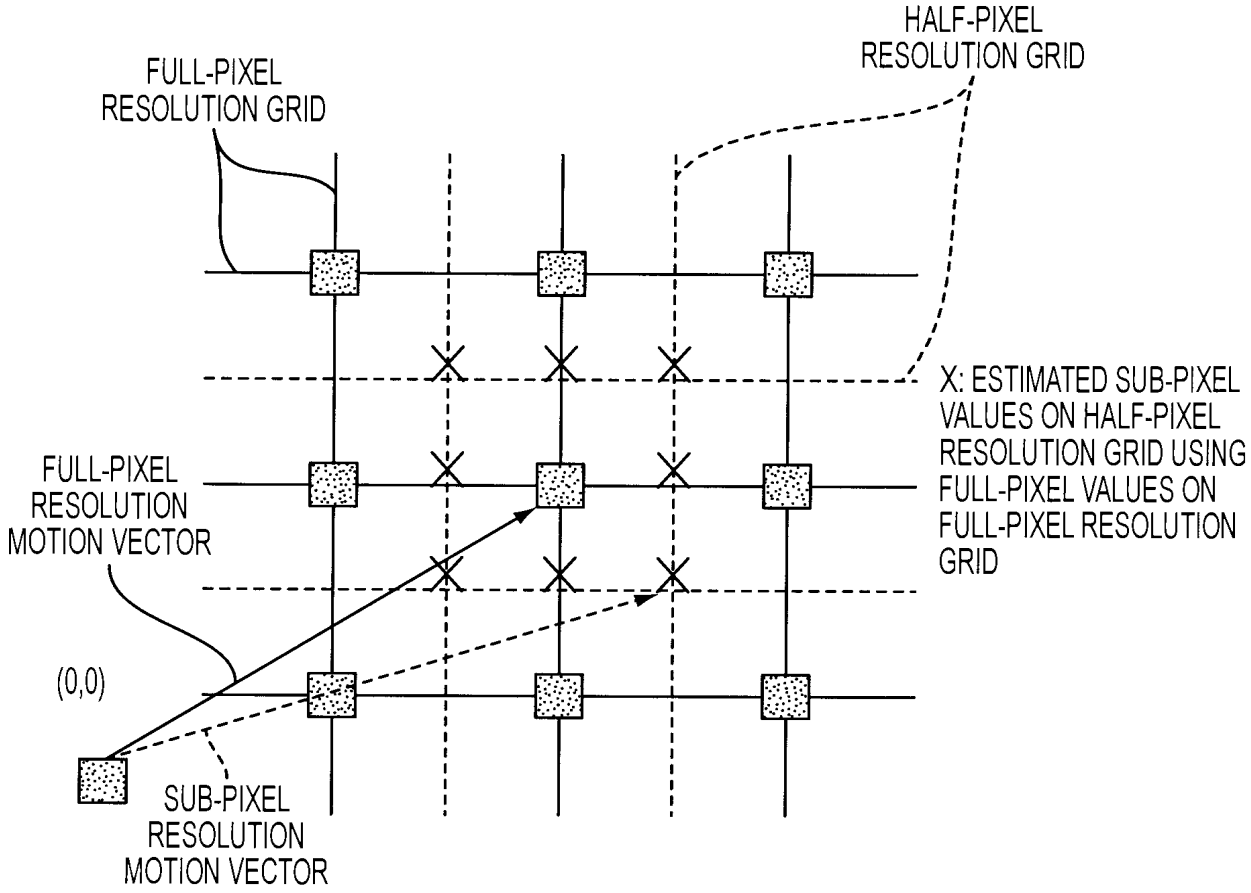

HALF-PIXEL
RESOLUTION GRID
FULL-PIXEL
RESOLUTION GRID
X: ESTIMATED SUB-PIXEL
VALUES ON HALF-PIXEL
RESOLUTION GRID USING
FULL-PIXEL VALUES ON
FULL-PIXEL RESOLUTION
GRID
FULL-PIXEL
RESOLUTION
MOTION VECTOR
(0,0)
SUB-PIXEL
RESOLUTION
MOTION VECTOR

FIG. 5

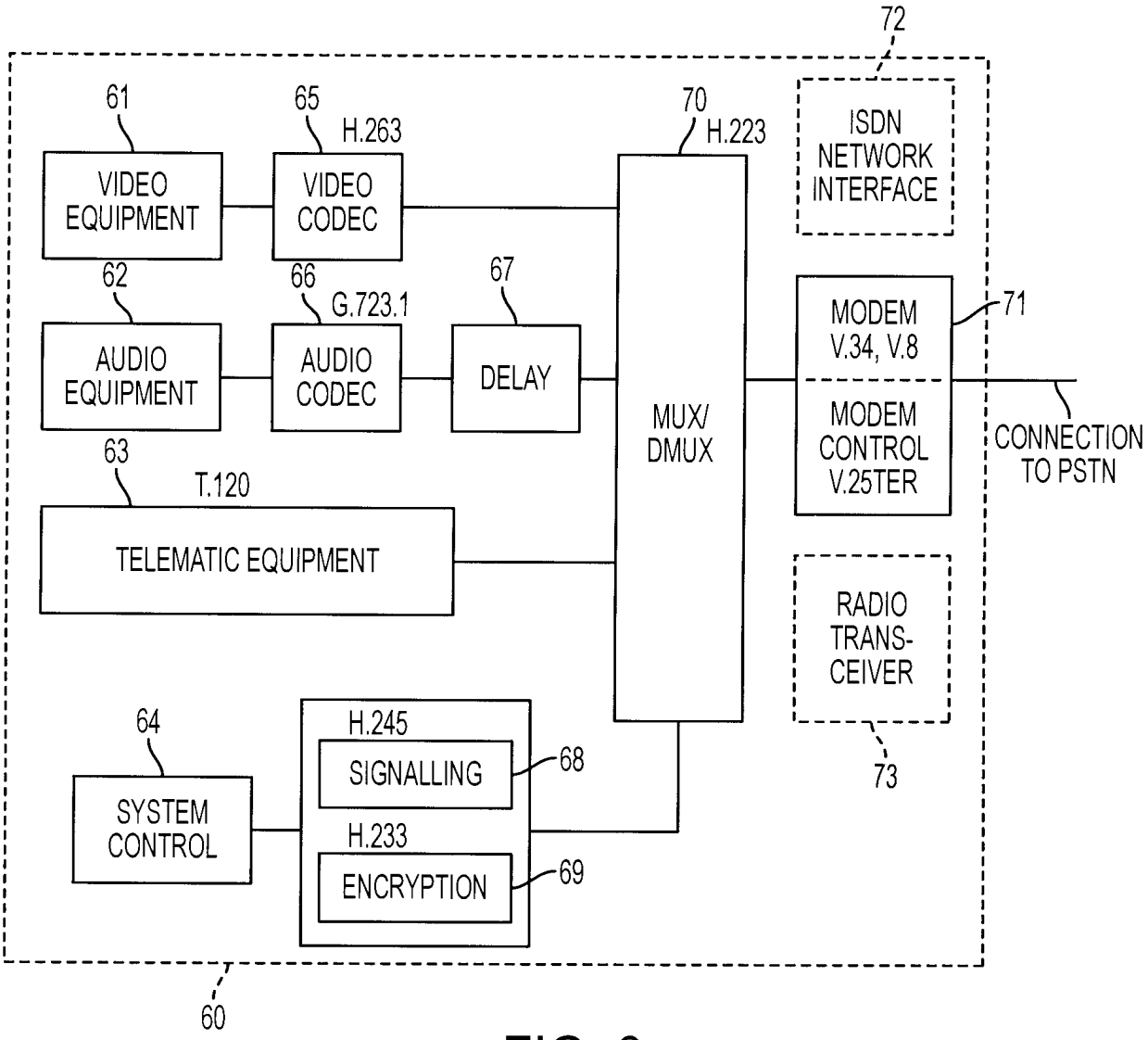

72
61
65
H.263
70
H.223
ISDN
NETWORK
INTERFACE
VIDEO
EQUIPMENT
VIDEO
CODEC
62
66
G.723.1
67
MODEM
V.34, V.8
71
AUDIO
EQUIPMENT
AUDIO
CODEC
DELAY
MUX/
DMUX
MODEM
CONTROL
V.25TER
CONNECTION
TO PSTN
63
T.120
TELEMATIC EQUIPMENT
RADIO
TRANS-
CEIVER
64
H.245
SIGNALLING
68
SYSTEM
CONTROL
H.233
ENCRYPTION
69
73
60

FIG. 6

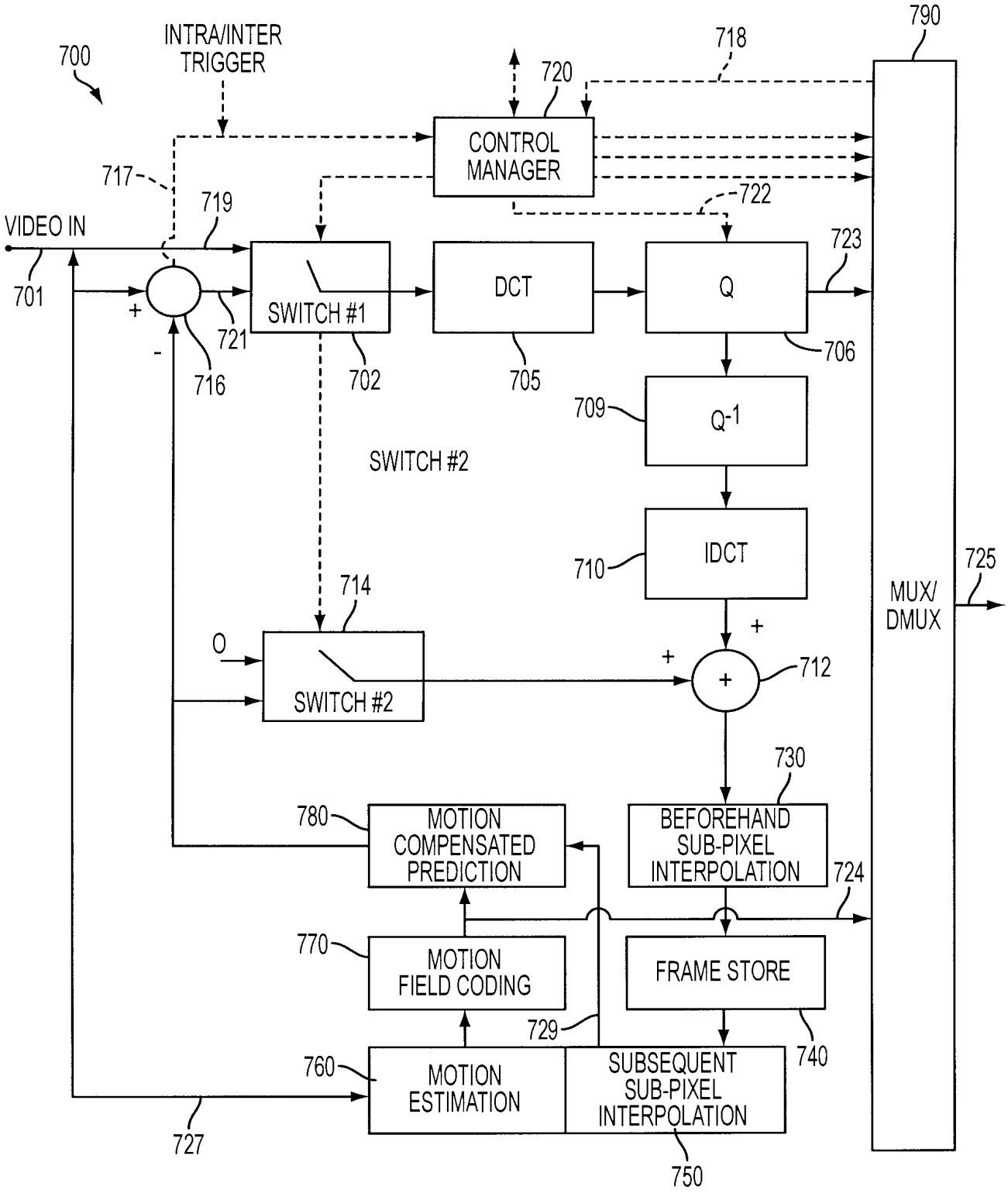

700
INTRA/INTER TRIGGER
790
718
720
CONTROL MANAGER
717
719
722
VIDEO IN
723
701
+
-
721
716
SWITCH #1
702
DCT
705
Q
706
709
Q-1
SWITCH #2
IDCT
710
725
MUX/ DMUX
714
0
SWITCH #2
+
+
712
730
780
MOTION COMPENSATED PREDICTION
BEFOREHAND SUB-PIXEL INTERPOLATION
724
770
MOTION FIELD CODING
FRAME STORE
729
740
760
MOTION ESTIMATION
SUBSEQUENT SUB-PIXEL INTERPOLATION
727
750

FIG. 7

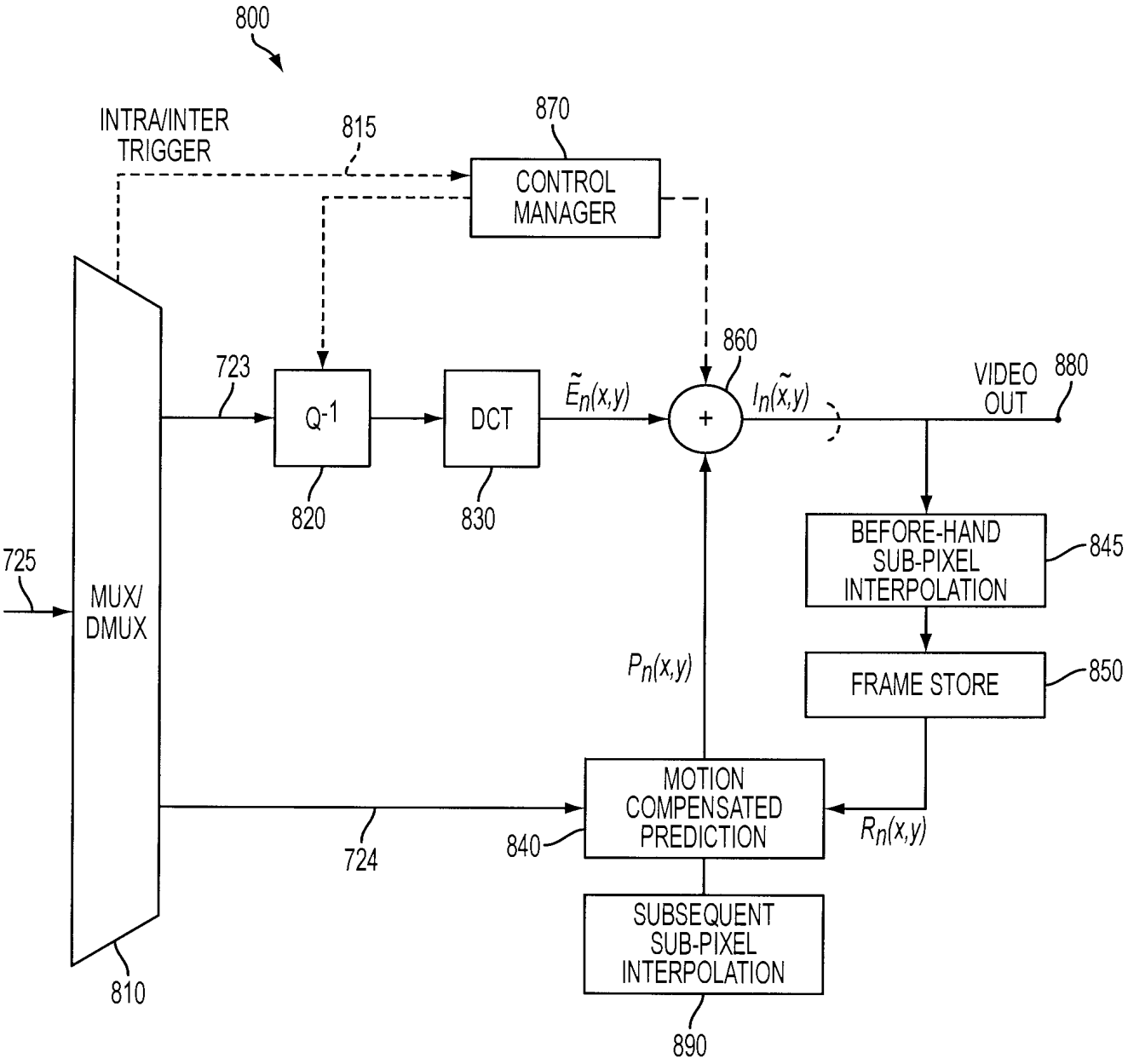

800
INTRA/INTER TRIGGER
815
870
CONTROL MANAGER
723
Q-1
DCT
$\tilde{E}_n(x,y)$
860
+
$I_n(\tilde{x},y)$
VIDEO OUT
880
820
830
BEFORE-HAND SUB-PIXEL INTERPOLATION
845
725
MUX/ DMUX
$P_n(x,y)$
FRAME STORE
850
MOTION COMPENSATED PREDICTION
$R_n(x,y)$
724
840
SUBSEQUENT SUB-PIXEL INTERPOLATION
810
890

FIG. 8

FIGURE INTENTIONALLY OMITTED

FIG. 9

FIGURE INTENTIONALLY OMITTED

FIG. 10

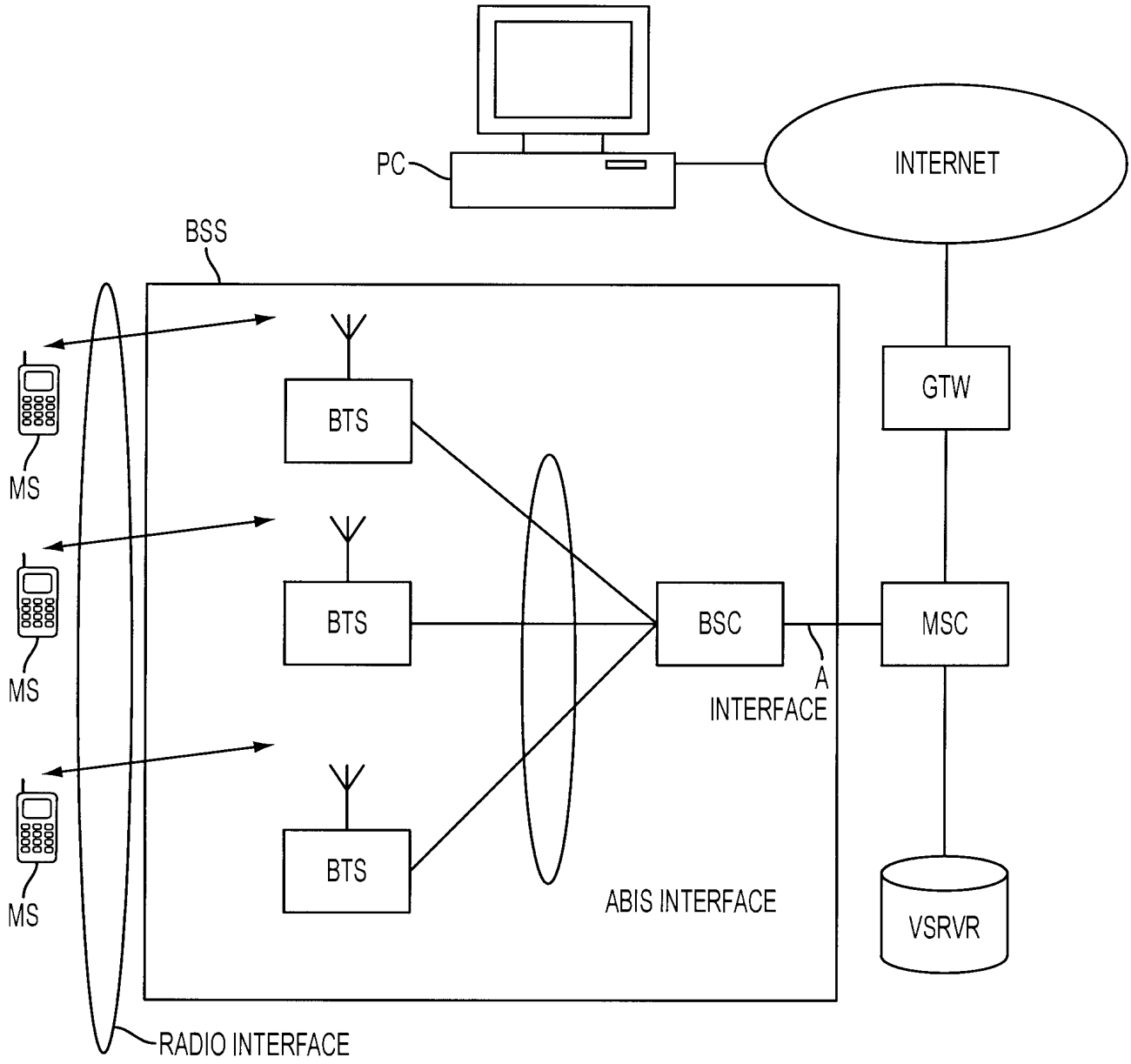

PC
INTERNET
BSS
GTW
BTS
BTS
BTS
MS
MS
MS
BSC
MSC
A
INTERFACE
ABIS INTERFACE
VSRVR
RADIO INTERFACE

FIG. 11

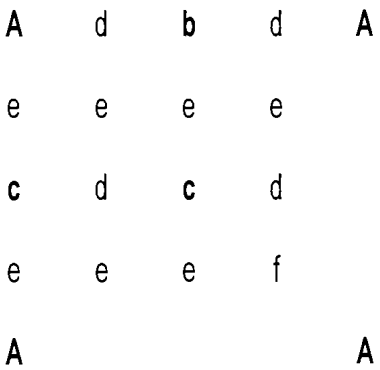



FIG. 12a

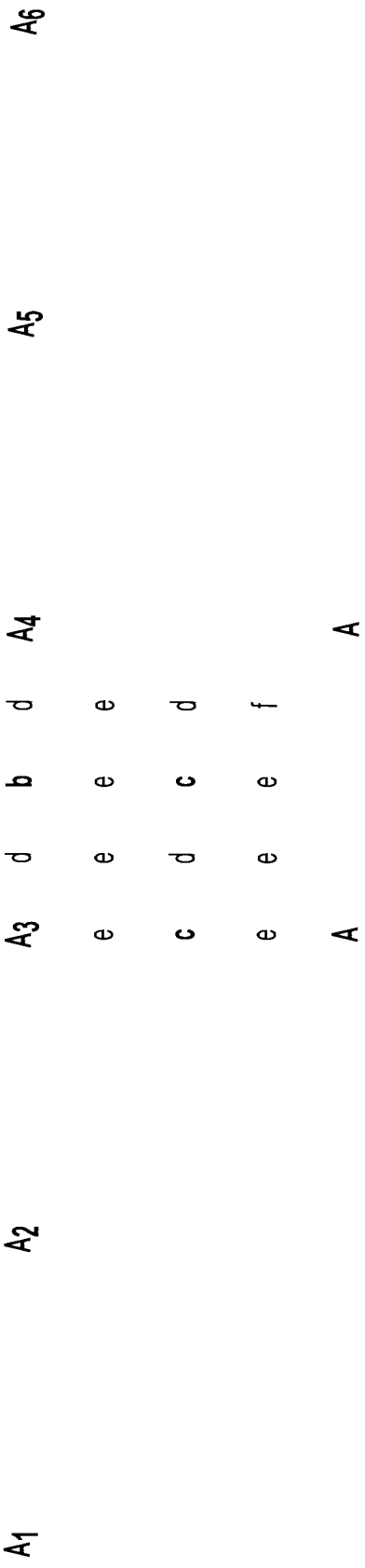



FIG. 12b

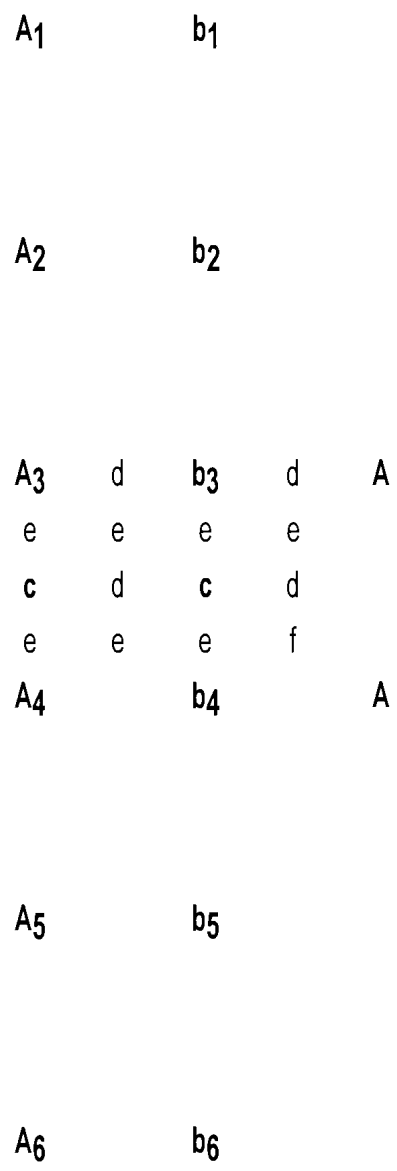



FIG. 12c

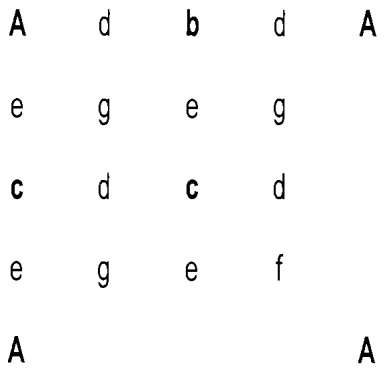



FIG. 13a

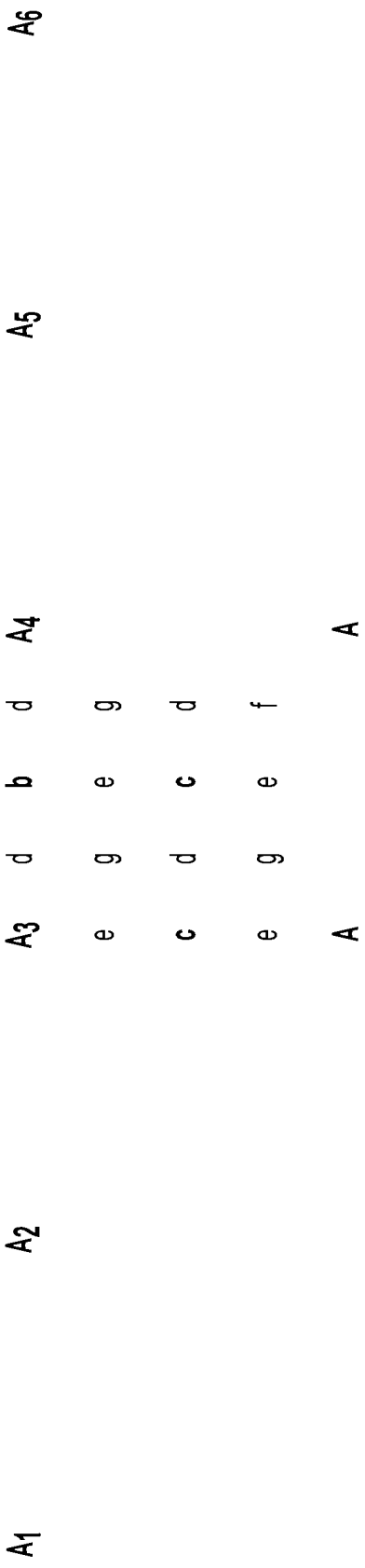



FIG. 13b

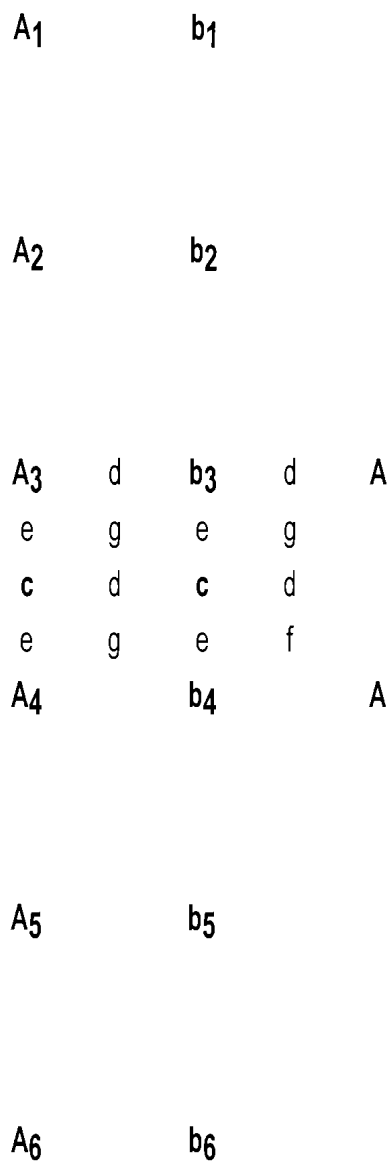



FIG. 13c

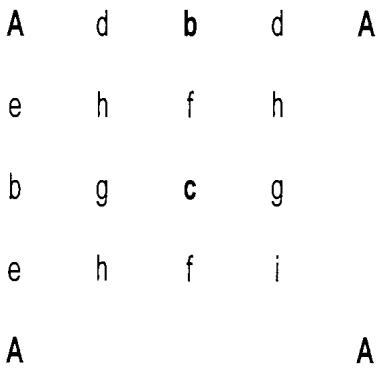



FIG. 14a

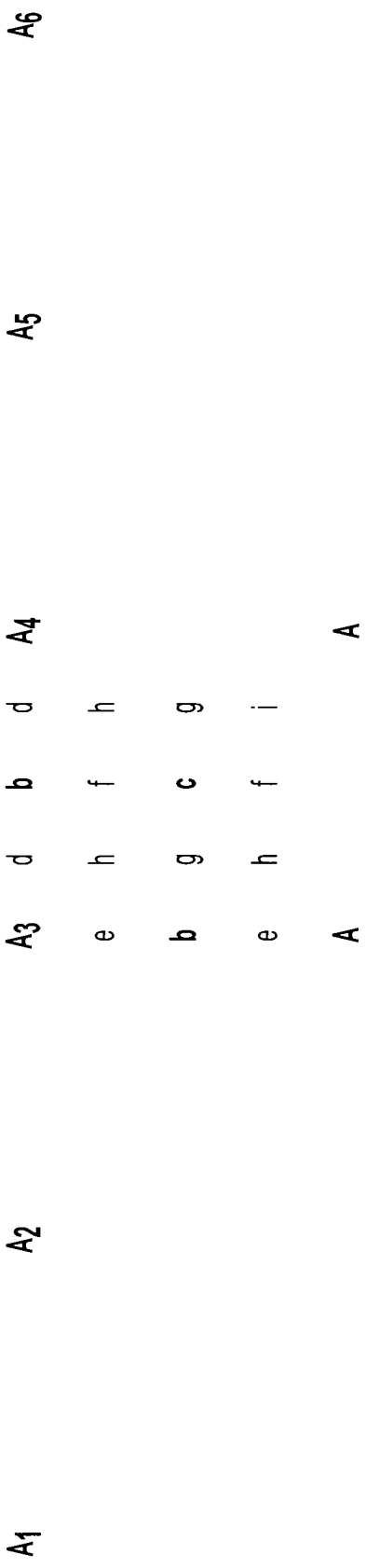



FIG. 14b

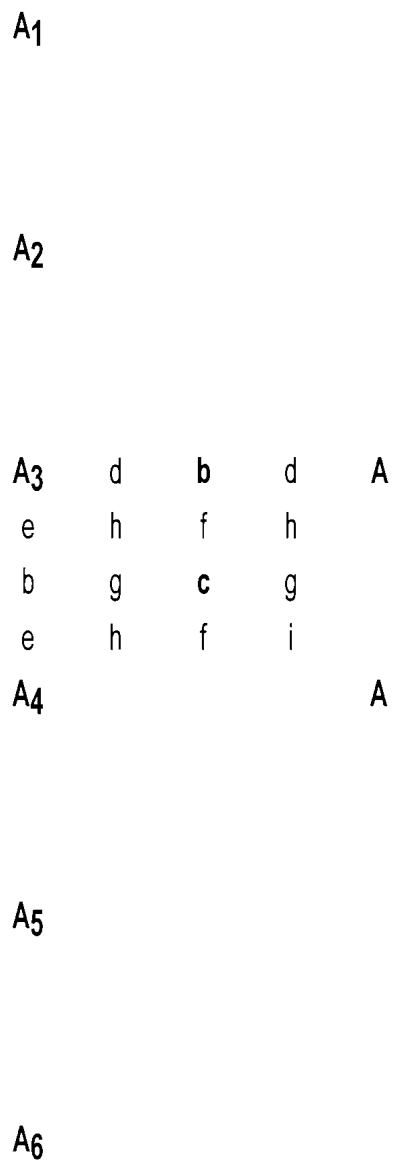



FIG. 14c

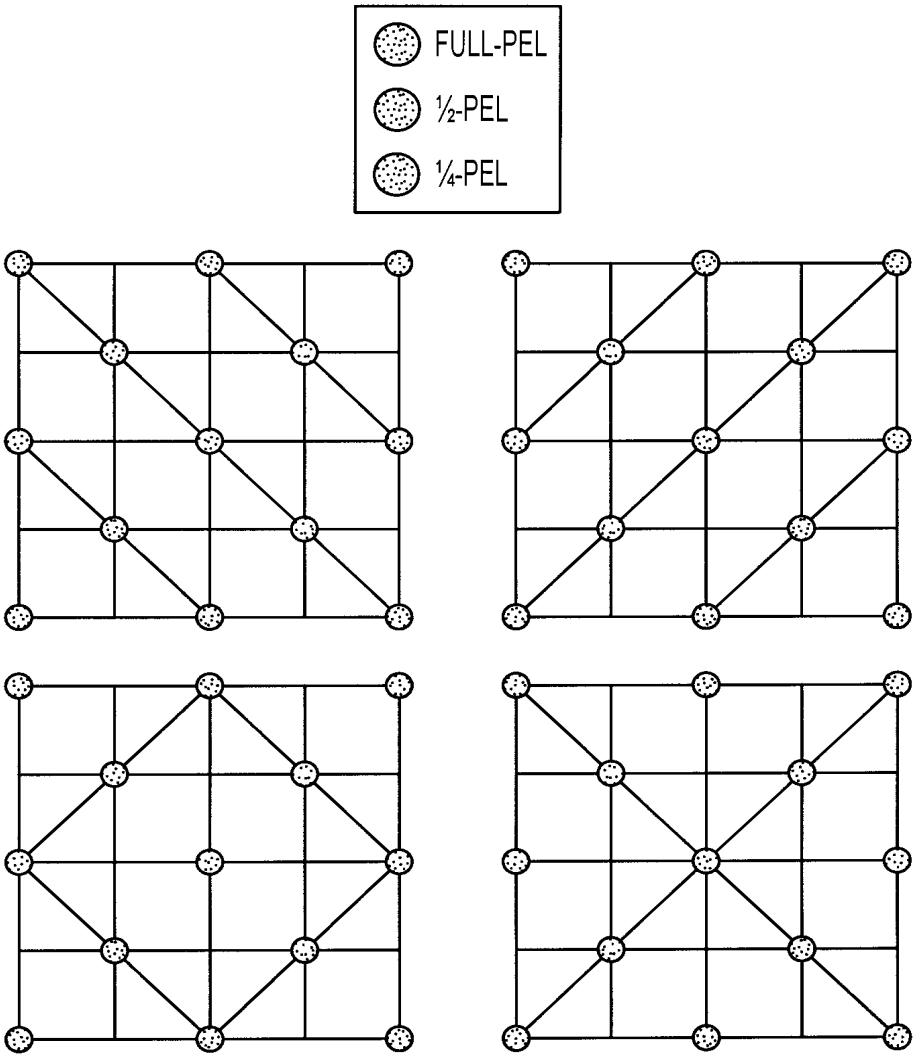



FIG. 15

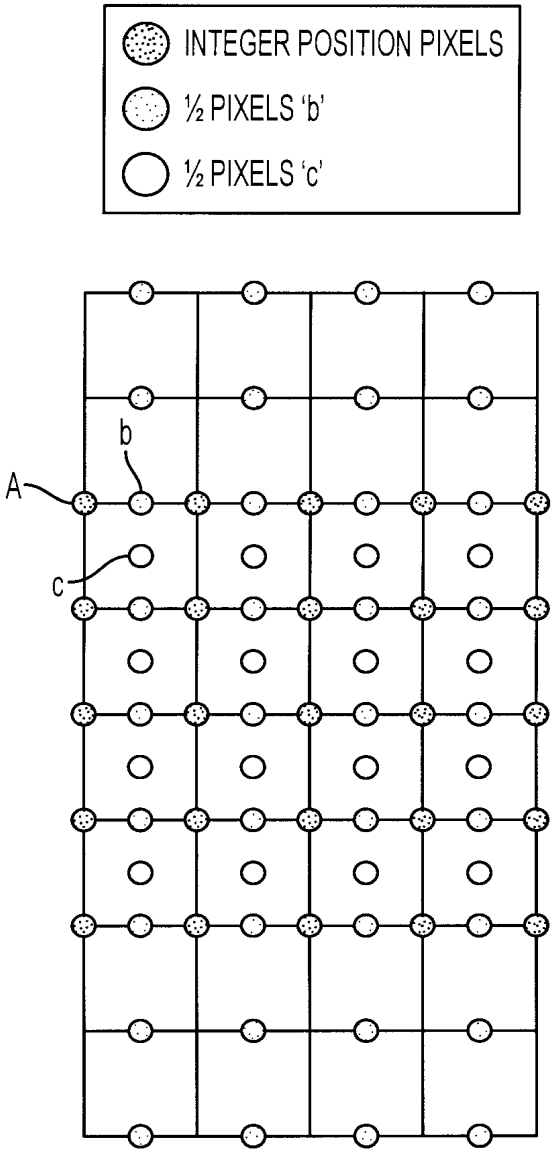



FIG. 16

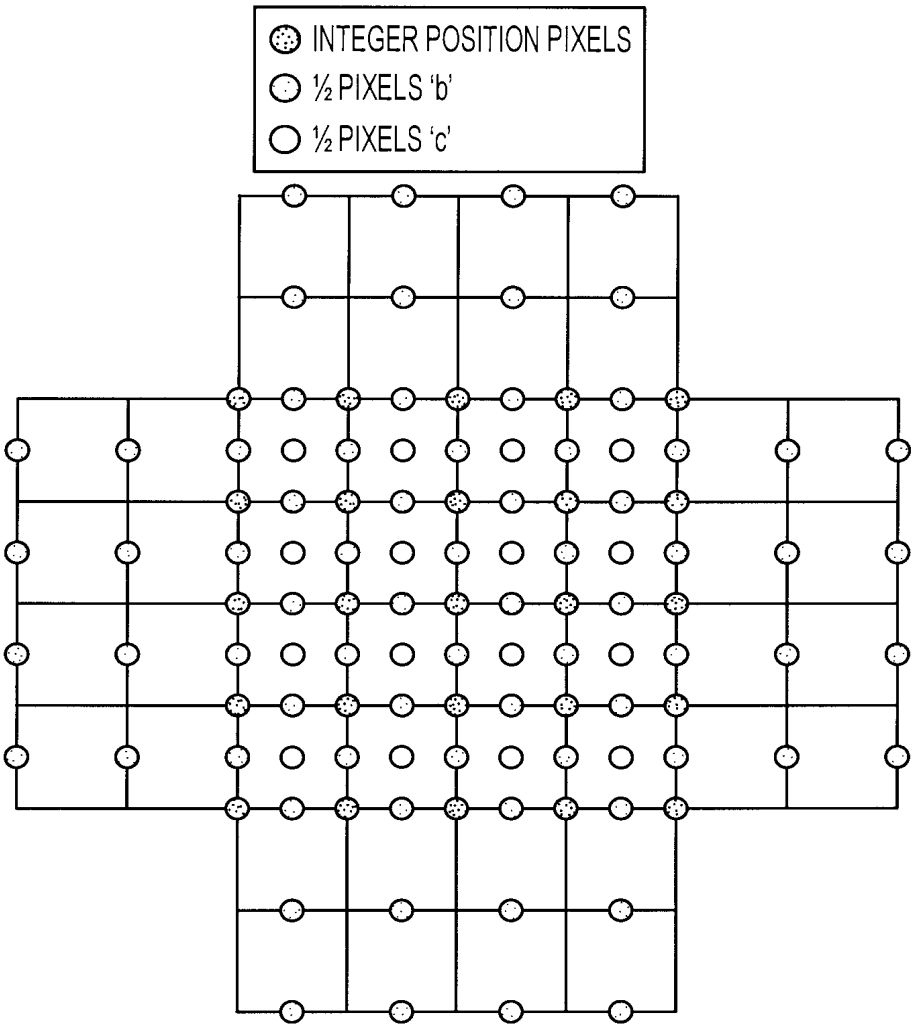



FIG. 17a

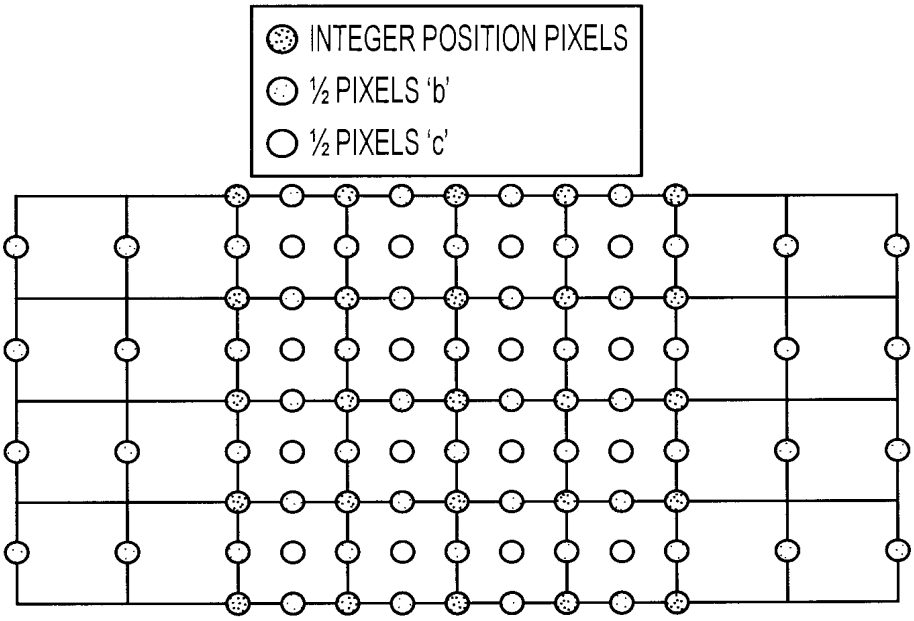



FIG. 17b

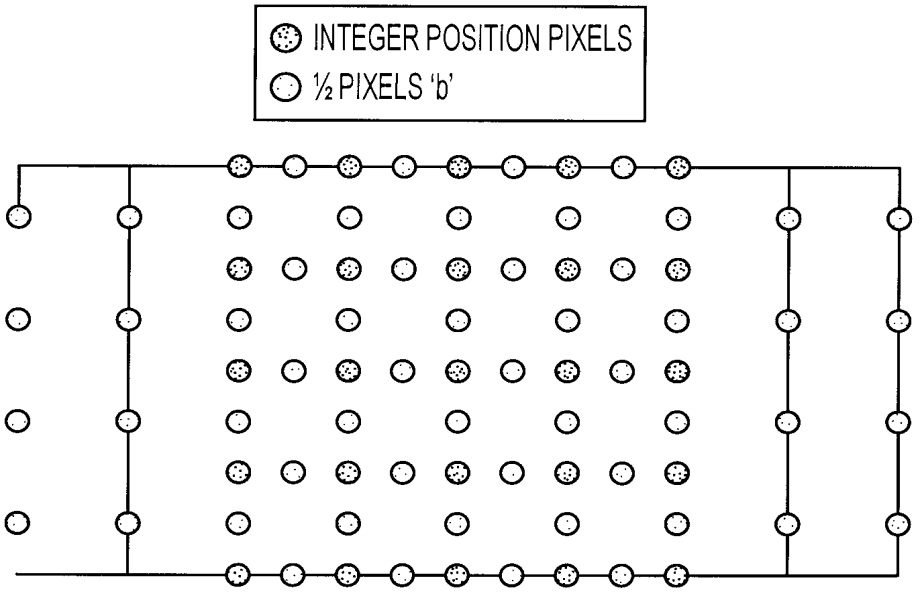



FIG. 18a

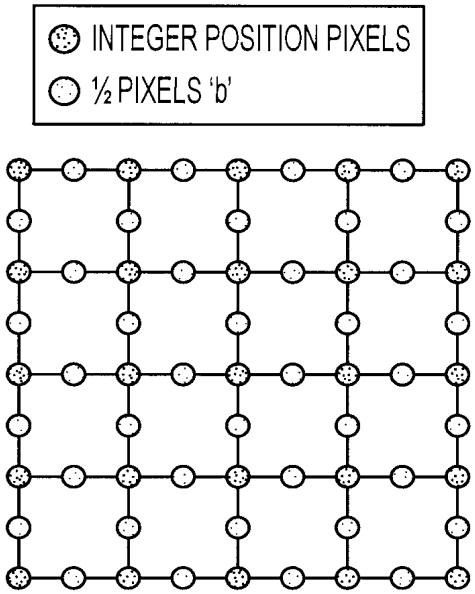



FIG. 18b

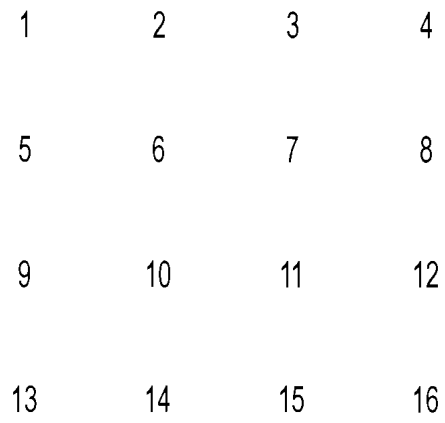



FIG. 19

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| A | d | $b^1$ | d | $b^2$ | d | $b^3$ | d | A |
| d | e | d | f | d | f | d | e | |
| $b^1$ | d | $c^{11}$ | d | $c^{12}$ | d | $c^{13}$ | d | |
| d | f | d | g | d | g | d | f | |
| $b^2$ | d | $c^{21}$ | d | $c^{22}$ | d | $c^{23}$ | d | |
| d | f | d | g | d | g | d | e | |
| $b^3$ | d | $c^{31}$ | d | $c^{32}$ | d | $c^{33}$ | d | |
| d | e | d | f | d | f | d | e | |
| A | | | | | | | | |

FIG. 20

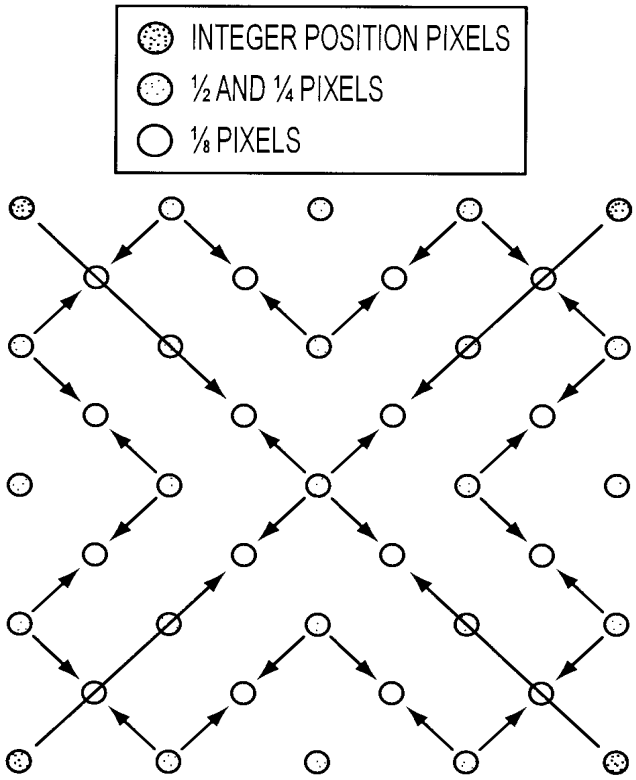



FIG. 21a

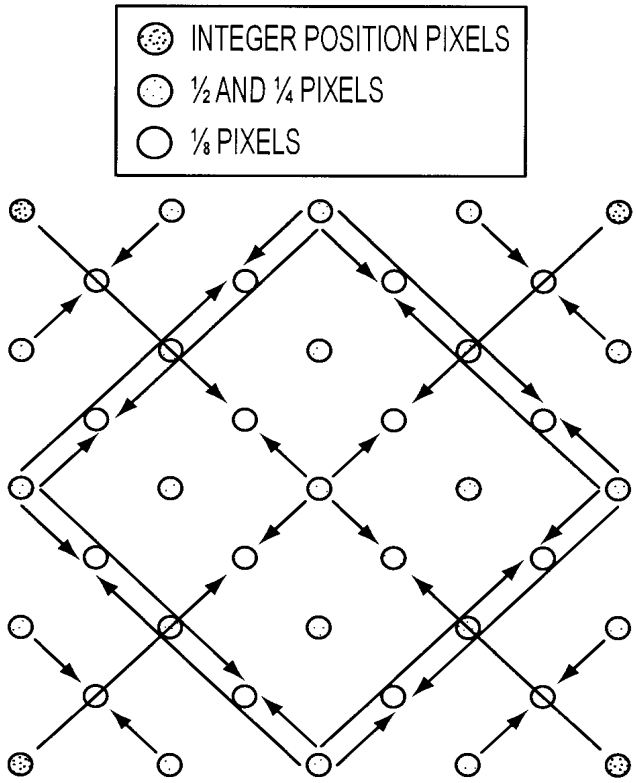



FIG. 21b

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
| 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 |
| 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 |
| 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 |
| 33 | 34 | 35 | 36 | 37 | 38 | 39 | 40 |
| 41 | 42 | 43 | 44 | 45 | 46 | 47 | 48 |
| 49 | 50 | 51 | 52 | 53 | 54 | 55 | 56 |
| 57 | 58 | 59 | 60 | 61 | 62 | 63 | 64 |

FIG. 22

# Electronic Patent Application Fee Transmittal

| | |
|---|---|
| **Application Number:** | 11839205 |
| **Filing Date:** | 15-Aug-2007 |
| **Title of Invention:** | METHOD FOR SUB-PIXEL VALUE INTERPOLATION |
| First Named Inventor/Applicant Name: | Marta Karczewicz |
| **Filer:** | GEZA C ZIEGLER JR/Shannon D'Amico |
| **Attorney Docket Number:** | 982-010567-US (C02) |

Filed as Large Entity

**Utility Filing Fees**

| Description | Fee Code | Quantity | Amount | Sub-Total in USD($) |
|---|---|---|---|---|
| **Basic Filing:** | | | | |
| **Pages:** | | | | |
| **Claims:** | | | | |
| **Miscellaneous-Filing:** | | | | |
| **Petition:** | | | | |
| **Patent-Appeals-and-Interference:** | | | | |
| Post-Allowance-and-Post-Issuance: | | | | |
| **Extension-of-Time:** | | | | |
| Extension - 2 months with $0 paid | 1252 | 1 | 460 | 460 |

| Description | Fee Code | Quantity | Amount | Sub-Total in USD($) |
|---|---|---|---|---|
| **Miscellaneous:** | | | | |
| | | | **Total in USD ($)** | **460** |

# Electronic Acknowledgement Receipt

| | |
|---|---|
| **EFS ID:** | 2507828 |
| **Application Number:** | 11839205 |
| **International Application Number:** | |
| **Confirmation Number:** | 8091 |
| **Title of Invention:** | METHOD FOR SUB-PIXEL VALUE INTERPOLATION |
| **First Named Inventor/Applicant Name:** | Marta Karczewicz |
| **Customer Number:** | 2512 |
| **Filer:** | GEZA C ZIEGLER JR/Shannon D'Amico |
| **Filer Authorized By:** | GEZA C ZIEGLER JR |
| **Attorney Docket Number:** | 982-010567-US (C02) |
| **Receipt Date:** | 26-NOV-2007 |
| **Filing Date:** | 15-AUG-2007 |
| **Time Stamp:** | 16:20:42 |
| **Application Type:** | Utility under 35 USC 111(a) |

## Payment information:

| | |
|---|---|
| Submitted with Payment | yes |
| Payment Type | Deposit Account |
| Payment was successfully received in RAM | $460 |
| RAM confirmation Number | 1361 |
| Deposit Account | 161350 |
| Authorized User | |

## File Listing:

| Document Number | Document Description | File Name | File Size(Bytes) /Message Digest | Multi Part /.zip | Pages (if appl.) |
|---|---|---|---|---|---|

| | | | | | |
|---|---|---|---|---|---|
| 1 | Miscellaneous Incoming Letter | ResponseToMissingParts.pdf | 105235<br>237b1ab90427536716ba2bb322d006387331af9c | no | 3 |
| **Warnings:** | | | | | |
| **Information:** | | | | | |
| 2 | Miscellaneous Incoming Letter | NoticeToFileCorAppPapers.pdf | 60444<br>f8f132a8d7580c18180a7d65f91fdbf8ecc7da57 | no | 2 |
| **Warnings:** | | | | | |
| **Information:** | | | | | |
| 3 | Drawings-only black and white line drawings | FormalDrawings.pdf | 692536<br>3f66d7628646c3f1419aa8a57779ffc1f0b97df4 | no | 28 |
| **Warnings:** | | | | | |
| **Information:** | | | | | |
| 4 | Fee Worksheet (PTO-06) | fee-info.pdf | 8176<br>269fb1db91415953326a438e45b2497caf0a2ff0 | no | 2 |
| **Warnings:** | | | | | |
| **Information:** | | | | | |
| | | | **Total Files Size (in bytes):** | 866391 | |

**This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.**

**New Applications Under 35 U.S.C. 111**
**If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.**

**National Stage of an International Application under 35 U.S.C. 371**
**If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.**

**New International Application Filed with the USPTO as a Receiving Office**
**If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.**

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www.uspto.gov

| APPLICATION NUMBER | FILING OR 371(c) DATE | FIRST NAMED APPLICANT | ATTY. DOCKET NO./TITLE |
|---|---|---|---|
| 11/839,205 | 08/15/2007 | Marta Karczewicz | 982-010567-US (C02) |

**CONFIRMATION NO. 8091**

2512
PERMAN & GREEN
425 POST ROAD
FAIRFIELD, CT06824

Date Mailed. 11/29/2007

## NOTICE OF NEW OR REVISED PROJECTED PUBLICATION DATE

The above-identified application has a new or revised projected publication date. The current projected publication date for this application is 03/06/2008. If this is a new projected publication date (there was no previous projected publication date), the application has been cleared by Licensing & Review or a secrecy order has been rescinded and the application is now in the publication queue.

If this is a revised projected publication date (one that is different from a previously communicated projected publication date), the publication date has been revised due to processing delays in the USPTO or the abandonment and subsequent revival of an application. The application is anticipated to be published on a date that is more than six weeks different from the originally-projected publication date.

More detailed publication information is available through the private side of Patent Application Information Retrieval (PAIR) System. The direct link to access PAIR is currently http://pair.uspto.gov. Further assistance in electronically accessing the publication, or about PAIR, is available by calling the Patent Electronic Business Center at 1-866-217-9197.

Questions relating to this Notice should be directed to the Office of Patent Publication at 1-888-786-0101.

PART 1 - ATTORNEY/APPLICANT COPY

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| APPLICATION NUMBER | FILING or 371(c) DATE | GRP ART UNIT | FIL FEE REC'D | ATTY.DOCKET.NO | TOT CLAIMS | IND CLAIMS |
|---|---|---|---|---|---|---|
| 11/839,205 | 08/15/2007 | 2621 | 1000 | 982-010567-US (C02) | 3 | 3 |

**CONFIRMATION NO. 8091**

**UPDATED FILING RECEIPT**

2512
PERMAN & GREEN
425 POST ROAD
FAIRFIELD, CT 06824

*OC000000026945975*

Date Mailed: 11/30/2007

Receipt is acknowledged of this non-provisional patent application. The application will be taken up for examination in due course. Applicant will be notified as to the results of the examination. Any correspondence concerning the application must include the following identification information: the U.S. APPLICATION NUMBER, FILING DATE, NAME OF APPLICANT, and TITLE OF INVENTION. Fees transmitted by check or draft are subject to collection. Please verify the accuracy of the data presented on this receipt. **If an error is noted on this Filing Receipt, please write to the Office of Initial Patent Examination's Filing Receipt Corrections. Please provide a copy of this Filing Receipt with the changes noted thereon. If you received a "Notice to File Missing Parts" for this application, please submit any corrections to this Filing Receipt with your reply to the Notice. When the USPTO processes the reply to the Notice, the USPTO will generate another Filing Receipt incorporating the requested corrections**

**Applicant(s)**

Marta Karczewicz, Irving, TX;
Antti Olli Hallapuro, Tampere, FINLAND;

**Assignment For Published Patent Application**

Nokia Corporation, Espoo, FINLAND

**Power of Attorney:**

Clarence Green--24622
Mark Harrington--31686
Janik Marcovici--42841

**Domestic Priority data as claimed by applicant**

This application is a CON of 11/090,717 03/25/2005 PAT 7,280,599
which is a CON of 09/954,608 09/17/2001 PAT 6,950,469

**Foreign Applications**

**If Required, Foreign Filing License Granted:** 08/22/2007

The country code and number of your priority application, to be used for filing abroad under the Paris Convention, is **US 11/839,205**

**Projected Publication Date:** 03/06/2008

**Non-Publication Request:** No

**Early Publication Request:** No

**Title**

METHOD FOR SUB-PIXEL VALUE INTERPOLATION

**Preliminary Class**

375

## PROTECTING YOUR INVENTION OUTSIDE THE UNITED STATES

Since the rights granted by a U.S. patent extend only throughout the territory of the United States and have no effect in a foreign country, an inventor who wishes patent protection in another country must apply for a patent in a specific country or in regional patent offices. Applicants may wish to consider the filing of an international application under the Patent Cooperation Treaty (PCT). An international (PCT) application generally has the same effect as a regular national patent application in each PCT-member country. The PCT process **simplifies** the filing of patent applications on the same invention in member countries, but **does not result** in a grant of "an international patent" and does not eliminate the need of applicants to file additional documents and fees in countries where patent protection is desired.

Almost every country has its own patent law, and a person desiring a patent in a particular country must make an application for patent in that country in accordance with its particular laws. Since the laws of many countries differ in various respects from the patent law of the United States, applicants are advised to seek guidance from specific foreign countries to ensure that patent rights are not lost prematurely.

Applicants also are advised that in the case of inventions made in the United States, the Director of the USPTO must issue a license before applicants can apply for a patent in a foreign country. The filing of a U.S. patent application serves as a request for a foreign filing license. The application's filing receipt contains further information and guidance as to the status of applicant's license for foreign filing.

Applicants may wish to consult the USPTO booklet, "General Information Concerning Patents" (specifically, the section entitled "Treaties and Foreign Patents") for more information on timeframes and deadlines for filing foreign patent applications. The guide is available either by contacting the USPTO Contact Center at 800-786-9199, or it can be viewed on the USPTO website at http://www.uspto.gov/web/offices/pac/doc/general/index.html.

For information on preventing theft of your intellectual property (patents, trademarks and copyrights), you may wish to consult the U.S. Government website, http://www.stopfakes.gov. Part of a Department of Commerce initiative, this website includes self-help "toolkits" giving innovators guidance on how to protect intellectual property in specific countries such as China, Korea and Mexico. For questions regarding patent enforcement issues, applicants may call the U.S. Government hotline at 1-866-999-HALT (1-866-999-4158).

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## Title 37, Code of Federal Regulations, 5.11 & 5.15

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|---|---|---|---|
| 11/839,205 | 08/15/2007 | Marta Karczewicz | 982-010567-US (C02) |

**CONFIRMATION NO. 8091**

2512
PERMAN & GREEN
425 POST ROAD
FAIRFIELD, CT06824

**Title:** METHOD FOR SUB-PIXEL VALUE INTERPOLATION

**Publication No.** US-2008-0069203-A1
**Publication Date:** 03/20/2008

## NOTICE OF PUBLICATION OF APPLICATION

The above-identified application will be electronically published as a patent application publication pursuant to 37 CFR 1.211, et seq. The patent application publication number and publication date are set forth above.

The publication may be accessed through the USPTO's publically available Searchable Databases via the Internet at www.uspto.gov. The direct link to access the publication is currently http://www.uspto.gov/patft/.

The publication process established by the Office does not provide for mailing a copy of the publication to applicant. A copy of the publication may be obtained from the Office upon payment of the appropriate fee set forth in 37 CFR 1.19(a)(1). Orders for copies of patent application publications are handled by the USPTO's Office of Public Records. The Office of Public Records can be reached by telephone at (703) 308-9726 or (800) 972-6382, by facsimile at (703) 305-8759, by mail addressed to the United States Patent and Trademark Office, Office of Public Records, Alexandria, VA 22313-1450 or via the Internet.

In addition, information on the status of the application, including the mailing date of Office actions and the dates of receipt of correspondence filed in the Office, may also be accessed via the Internet through the Patent Electronic Business Center at www.uspto.gov using the public side of the Patent Application Information and Retrieval (PAIR) system. The direct link to access this status information is currently http://pair.uspto.gov/. Prior to publication, such status information is confidential and may only be obtained by applicant using the private side of PAIR.

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Pre-Grant Publication Division, 703-605-4283

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| APPLICATION NO. | FILING DATE | FIRST NAMED INVENTOR | ATTORNEY DOCKET NO. | CONFIRMATION NO. |
|---|---|---|---|---|
| 11/839,205 | 08/15/2007 | Marta Karczewicz | 982-010567-US (C02) | 8091 |

2512 7590 06/30/2008

PERMAN & GREEN
425 POST ROAD
FAIRFIELD, CT 06824

| EXAMINER | |
|---|---|
| AN, SHAWN S | |

| ART UNIT | PAPER NUMBER |
|---|---|
| 2621 | |

| MAIL DATE | DELIVERY MODE |
|---|---|
| 06/30/2008 | PAPER |

**Please find below and/or attached an Office communication concerning this application or proceeding.**

The time period for reply, if any, is set in the attached communication.

| Office Action Summary | Application No. | Applicant(s) | |
|---|---|---|---|
| | 11/839,205 | KARCZEWICZ ET AL. | |
| | Examiner | Art Unit | |
| | SHAWN AN | 2621 | |

*-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --*

**Period for Reply**

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE *3* MONTH(S) OR THIRTY (30) DAYS, WHICHEVER IS LONGER, FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133). Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

**Status**

1)☐ Responsive to communication(s) filed on _____.

2a)☐ This action is **FINAL**. 2b)☒ This action is non-final.

3)☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

**Disposition of Claims**

4)☒ Claim(s) *1-3* is/are pending in the application.

4a) Of the above claim(s) _____ is/are withdrawn from consideration.

5)☐ Claim(s) _____ is/are allowed.

6)☒ Claim(s) *1-3* is/are rejected.

7)☐ Claim(s) _____ is/are objected to.

8)☐ Claim(s) _____ are subject to restriction and/or election requirement.

**Application Papers**

9)☐ The specification is objected to by the Examiner.

10)☒ The drawing(s) filed on *15 August 2007* is/are: a)☒ accepted or b)☐ objected to by the Examiner.

Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).

Replacement drawing sheet(s) including the correction is required if the drawing(s) is objected to. See 37 CFR 1.121(d).

11)☐ The oath or declaration is objected to by the Examiner. Note the attached Office Action or form PTO-152.

**Priority under 35 U.S.C. § 119**

12)☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

a)☐ All b)☐ Some * c)☐ None of:

1.☐ Certified copies of the priority documents have been received.

2.☐ Certified copies of the priority documents have been received in Application No. _____.

3.☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

* See the attached detailed Office action for a list of the certified copies not received.

**Attachment(s)**

1) ☒ Notice of References Cited (PTO-892)
2) ☐ Notice of Draftsperson's Patent Drawing Review (PTO-948)
3) ☒ Information Disclosure Statement(s) (PTO/SB/08) Paper No(s)/Mail Date *8/15/07*.
4) ☐ Interview Summary (PTO-413) Paper No(s)/Mail Date. _____ .
5) ☐ Notice of Informal Patent Application
6) ☐ Other: _____.

## DETAILED ACTION

### *Double Patenting*

**1.** The nonstatutory double patenting rejection is based on a judicially created doctrine grounded in public policy (a policy reflected in the statute) so as to prevent the unjustified or improper timewise extension of the "right to exclude" granted by a patent and to prevent possible harassment by multiple assignees. See *In re Goodman*, 11 F.3d 1046, 29 USPQ2d 2010 (Fed. Cir. 1993); *In re Longi*, 759 F.2d 887, 225 USPQ 645 (Fed. Cir. 1985); *In re Van Ornum*, 686 F.2d 937, 214 USPQ 761 (CCPA 1982); *In re Vogel*, 422 F.2d 438, 164 USPQ 619 (CCPA 1970); and, *In re Thorington*, 418 F.2d 528, 163 USPQ 644 (CCPA 1969).

A timely filed terminal disclaimer in compliance with 37 CFR 1.321© may be used to overcome an actual or provisional rejection based on a nonstatutory double patenting ground provided the conflicting application or patent is shown to be commonly owned with this application. See 37 CFR 1.130(b).

Effective January 1, 1994, a registered attorney or agent of record may sign a terminal disclaimer. A terminal disclaimer signed by the assignee must fully comply with 37 CFR 3.73(b).

**2.** Claims 1, 2, and 3 are rejected under the judicially created doctrine of double patenting over claims 1, 20, and 21 of U. S. Patent No. 7,280,599 B2, respectively, since the claims, if allowed, would improperly extend the "right to exclude" already granted in the patent.

The subject matter claimed in the instant application is fully disclosed in the patent and is covered by the patent since the patent and the application are claiming common subject matter, as follows:

**Claims 1, 2, and 3** recite all of the subject matter as recited in the patented claims 1, 20, and 21, respectively. Therefore, claims 1-3 have been rejected in view of double patenting.

Furthermore, there is no apparent reason why applicant was prevented from presenting claims corresponding to those of the instant application during prosecution of the application, which matured into a patent. See In re Schneller, 397 F.2d 350, 158 USPQ 210 (CCPA 1968). See also MPEP § 804.

***Conclusion***

**3.** The prior art made of record is considered pertinent to Applicant's disclosure.

A. Yang (4,937,666), Block matching algorithm with fractional precision.

**4.** Any inquiry concerning this communication or earlier communications from the Examiner should be directed to *Shawn An* whose telephone number is (571) 272-7324.

**5.** The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300.

**6.** Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see http://pair-direct.uspto.gov. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free). If you would like assistance from a USPTO Customer Service Representative or access to the automated information system, call 800-786-9199 (IN USA OR CANADA) or 571-272-1000.

/SHAWN AN/
Primary Examiner, Art Unit 2621
6/25/08

| Notice of References Cited | Application/Control No. 11/839,205 | Applicant(s)/Patent Under Reexamination KARCZEWICZ ET AL. | |
|---|---|---|---|
| | Examiner SHAWN AN | Art Unit 2621 | Page 1 of 1 |

**U.S. PATENT DOCUMENTS**

| * | | Document Number Country Code-Number-Kind Code | Date MM-YYYY | Name | Classification |
|---|---|---|---|---|---|
| | A | US-7,280,599 B2 | 10-2007 | Karczewicz et al. | 375/240.17 |
| * | B | US-4,937,666 | 06-1990 | Yang, Kun-Min | 348/413.1 |
| | C | US- | | | |
| | D | US- | | | |
| | E | US- | | | |
| | F | US- | | | |
| | G | US- | | | |
| | H | US- | | | |
| | I | US- | | | |
| | J | US- | | | |
| | K | US- | | | |
| | L | US- | | | |
| | M | US- | | | |

**FOREIGN PATENT DOCUMENTS**

| * | | Document Number Country Code-Number-Kind Code | Date MM-YYYY | Country | Name | Classification |
|---|---|---|---|---|---|---|
| | N | | | | | |
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| | Q | | | | | |
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| | S | | | | | |
| | T | | | | | |

**NON-PATENT DOCUMENTS**

| * | | Include as applicable: Author, Title Date, Publisher, Edition or Volume, Pertinent Pages) |
|---|---|---|
| | U | |
| | V | |
| | W | |
| | X | |

*A copy of this reference is not being furnished with this Office action. (See MPEP § 707.05(a).)
Dates in MM-YYYY format are publication dates. Classifications may be US or foreign.

| Application Number | Application/Control No. | Applicant(s)/Patent under Reexamination | |
|---|---|---|---|
| | 11/839,205 | KARCZEWICZ ET AL. | |
| | Examiner | Art Unit | |
| | SHAWN AN | 2621 | |

## Index of Claims

| Application/Control No. | Applicant(s)/Patent under Reexamination |
|---|---|
| 11/839,205 | KARCZEWICZ ET AL. |
| **Examiner** | **Art Unit** |
| SHAWN AN | 2621 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| √ | Rejected | – | (Through numeral) Cancelled | N | Non-Elected | A | Appeal |
| = | Allowed | ÷ | Restricted | I | Interference | O | Objected |

| Claim | | Date | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Final | Original | 6/25/08 | | | | | | | |
| | 1 | √ | | | | | | | |
| | 2 | √ | | | | | | | |
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| Search Notes | Application/Control No. | Applicant(s)/Patent under Reexamination | |
|---|---|---|---|
| | 11/839,205 | KARCZEWICZ ET AL. | |
| | Examiner | Art Unit | |
| | SHAWN AN | 2621 | |

| SEARCHED | | | |
|---|---|---|---|
| Class | Subclass | Date | Examiner |
| 375 | 240.17 | 6/25/2008 | SA |
| | 240.16 | | SA |
| | 240.12 | | SA |
| 382 | 238 | | SA |
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| SEARCH NOTES (INCLUDING SEARCH STRATEGY) | | |
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| **INFORMATION DISCLOSURE STATEMENT BY APPLICANT** ( **Not for submission under 37 CFR 1.99**) | | |
|---|---|---|
| | Application Number | |
| | Filing Date | 2007-08-15 |
| | First Named Inventor | Karczewicz et al. |
| | Art Unit | |
| | Examiner Name | |
| | Attorney Docket Number | 982-010567-US (C02) |

| **U.S.PATENTS** | | | | | | |
|---|---|---|---|---|---|---|
| Examiner Initial* | Cite No | Patent Number | Kind Code[1] | Issue Date | Name of Patentee or Applicant of cited Document | Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear |
| /S.A./ | 1 | 4937666 | | 1990-06-26 | Yang | |
| /S.A./ | 2 | 5452377 | | 1995-09-19 | Igarashi et al. | |
| /S.A./ | 3 | 5488419 | | 1996-01-30 | Hui et al. | |
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| /S.A./ | 8 | 5901248 | | 1999-05-04 | Fandrianto et al. | |

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|---|---|---|
| | Application Number | |
| | Filing Date | 2007-08-15 |
| | First Named Inventor | Karczewicz et al. |
| | Art Unit | |
| | Examiner Name | |
| | Attorney Docket Number | 982-010567-US (C02) |

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| /S.A./ | 9 | 6219464 | B1 | 2001-04-17 | Greggain et al. | |
| /S.A./ | 10 | 6252576 | B1 | 2001-06-26 | Nottingham | |

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| Examiner Initial* | Cite No | Publication Number | Kind Code[1] | Publication Date | Name of Patentee or Applicant of cited Document | Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear |
|---|---|---|---|---|---|---|
| /S.A./ | 1 | 20020064229 | | 2002-05-30 | Nakaya | |

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| Examiner Initial* | Cite No | Foreign Document Number[3] | Country Code[2] ¡ | Kind Code[4] | Publication Date | Name of Patentee or Applicant of cited Document | Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear | T[5] |
|---|---|---|---|---|---|---|---|---|
| /S.A./ | 1 | 9904574 | WO | | 1999-01-28 | Robert Bosch GMBH | | ☐ |
| /S.A./ | 2 | 0576290 | EP | A2 | 1993-12-29 | Sony Corp. | | ☐ |
| /S.A./ | 3 | 2205707 | GB | | 1988-12-14 | Sony Corp. | | ☐ |

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| INFORMATION DISCLOSURE STATEMENT BY APPLICANT ( Not for submission under 37 CFR 1.99) | | |
|---|---|---|
| | Application Number | |
| | Filing Date | 2007-08-15 |
| | First Named Inventor | Karczewicz et al. |
| | Art Unit | |
| | Examiner Name | |
| | Attorney Docket Number | 982-010567-US (C02) |

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| /S.A./ | 1 | Chao, et a., FPM 21.3, "An Interpolator for HD-MAC Decoder". | ☐ |
| /S.A./ | 2 | Mehran Mashfeghi, "Directional Interpolation for Magnetic Resonance Angiography Data", IEEE Transactions on Medical Imaging, Vol. 12, No. 2, June 1993. | ☐ |
| /S.A./ | 3 | Document Q15-K-59, "H.26L Test Model Long Term Number 5 (TML-5) draft0" ITU, Study Group 16. | ☐ |
| /S.A./ | 4 | Document VCEG-L20, "Complexity Reduced Motion Compensated Prediction with 1/8-pel Displacement Vector Resolution", ITU, Study Group 16. | ☐ |
| /S.A./ | 5 | English translation of Japanese publication No. Hei 6-14739. | ☐ |
| /S.A./ | 6 | Japanese Patent Document No. JP 62-039920. | ☐ |

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| Examiner Signature | /Shawn An/ (06/25/2008) | Date Considered | 06/25/2008 |
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|---|---|---|
| | Application Number | |
| | Filing Date | 2007-08-15 |
| | First Named Inventor | Karczewicz et al. |
| | Art Unit | |
| | Examiner Name | |
| | Attorney Docket Number | 982-010567-US (C02) |

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☐ See attached certification statement.

☐ Fee set forth in 37 CFR 1.17 (p) has been submitted herewith.

☐ None

**SIGNATURE**

A signature of the applicant or representative is required in accordance with CFR 1.33, 10.18. Please see CFR 1.4(d) for the form of the signature.

| Signature | /gcz44004/ | Date (YYYY-MM-DD) | 2007-08-15 |
|---|---|---|---|
| Name/Print | Geza C. Ziegler, Jr. | Registration Number | 44,004 |

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3. A record in this system of records may be disclosed, as a routine use, to a Member of Congress submitting a request involving an individual, to whom the record pertains, when the individual has requested assistance from the Member with respect to the subject matter of the record.

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# INFORMATION DISCLOSURE STATEMENT BY APPLICANT

**( Not for submission under 37 CFR 1.99)**

| | |
|---|---|
| Application Number | 11839205 |
| Filing Date | 2007-08-15 |
| First Named Inventor | Marta Karczewicz |
| Art Unit | 2621 |
| Examiner Name | An, Shawn S. |
| Attorney Docket Number | 982-010567-US (C02) |

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| Examiner Initial* | Cite No | Patent Number | Kind Code[1] | Issue Date | Name of Patentee or Applicant of cited Document | Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear |
|---|---|---|---|---|---|---|
| | 1 | 6219464 | B1 | 2001-04-17 | Greggain et al. | |
| | 2 | 5521642 | A | 1996-05-28 | Park | |
| | 3 | 5337088 | A | 1994-08-09 | Honjo | |
| | 4 | 5570436 | A | 1996-10-29 | Fukushima et al. | |

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|---|---|---|
| | Application Number | 11839205 |
| | Filing Date | 2007-08-15 |
| | First Named Inventor | Marta Karczewicz |
| | Art Unit | 2621 |
| | Examiner Name | An, Shawn S. |
| | Attorney Docket Number | 982-010567-US (C02) |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 1 | 9956247 | WO | | 1999-11-04 | Philips | | ☐ |

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|---|---|---|---|
| | 1 | Two-Dimensional Adaptive Interpolation for Subsampled HDTV Signals; Vol. 12, No. 4, Journal of China Institute of Communications, July 1991; Pages 8-12. | ☐ |
| | 2 | Interpolative Prediction Coding Method for HDTV Signals; Vol. 32, No. 1, Communication Engineering, February 1992; Pages 81-88. | ☐ |

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|---|---|---|
| | Application Number | 11839205 |
| | Filing Date | 2007-08-15 |
| | First Named Inventor | Marta Karczewicz |
| | Art Unit | 2621 |
| | Examiner Name | An, Shawn S. |
| | Attorney Docket Number | 982-010567-US (C02) |

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☐ See attached certification statement.

☒ Fee set forth in 37 CFR 1.17 (p) has been submitted herewith.

☐ None

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| Signature | /gcz44004/ | Date (YYYY-MM-DD) | 2008-09-11 |
|---|---|---|---|
| Name/Print | Geza C. Ziegler, Jr. | Registration Number | 44,004 |

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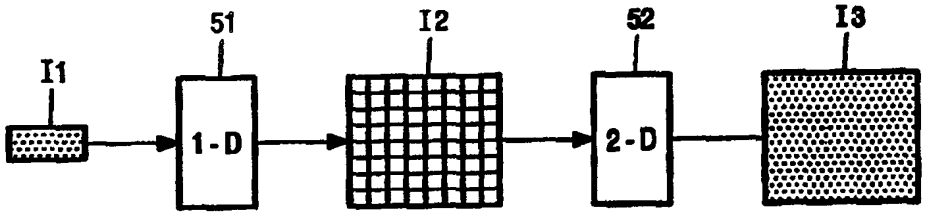
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(54) Title: IMAGE INTERPOLATION

(57) Abstract

In an image interpolation method, interpolated pixels are inserted (51) along horizontal and vertical directions so as to obtain a grid (I2) in which interpolated lines cross themselves in original pixels. In a second step, pixels are interpolated (52) between rows and columns formed by the grid (I2) so as to fill squares delimited by the grid (I2) to obtain an interpolated image (I3).



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Image interpolation.

The invention relates to image interpolation.

In many video and multimedia applications it is necessary to increase image dimensions, preserving the quality of the output images. Linear operators normally used for this purpose - are not suitable to generate high quality interpolated images, because they produce smoothed images and blocking artifacts. Techniques were studied to achieve a sharper reproduction of details, but usually they are excessively complicated and require the explicit detection of the image details and the estimation of their orientation (see e.g. [1]).

Rational filters (RFs), whose input/output relation is expressed as the ratio of two polynomials in the input variables, have already been used with satisfactory results in noise smoothing, contrast enhancement and image interpolation by power-of-two factors [3,4,5].

In [5] an operator was proposed for the interpolation of the DC components of coded images, and it was shown that this algorithm can overcome the theoretical limitations of the linear ones, with respect to the rendering of sharp details in output images; at the same time, this kind of interpolator avoids blocking artifacts which could affect diagonal lines, circles, etc.. That rational interpolator was designed to operate in the two-dimensional domain in a non-separable way and it was able to resize images by repeatedly up-scaling the data by a factor of two.

It is, inter alia, an object of the invention to interpolate images by large and arbitrary factors preserving the sharpness of their contours. To this end, the invention provides an image interpolation method and device, as well as a video display apparatus or a printing apparatus comprising such an image interpolation device, as defined in the independent claims. Advantageous embodiments are defined in the dependent claims.

In a preferred embodiment, the aim of the method presented here is achieved by using a technique based on a nonlinear rational filtering (RF). To allow for up-scaling by arbitrary factors, distances between a pixel to be interpolated and surrounding pixels are preferably taken into account in the rational filtering.

These and other aspects of the invention will be apparent from and elucidated with reference to the embodiments described hereinafter.

In the drawings:

Fig. 1 illustrates the distance between an interpolated pixel and original pixels;

Figs. 2A-2C illustrate row interpolations by a factor 4;

Fig. 3 illustrates original rows and columns interpolations by a factor 4;

Fig. 4 illustrates pixel evaluations within the space delimited by rows and columns;

Fig. 5 shows a conceptual block diagram; and

Fig. 6 shows a two-dimensional operator formula implementation.

Our focus is to study the performance of the RF algorithm as a zooming feature. This feature is a key point in a broad range of multimedia applications. Among these we could list, for instance, photo or video editing and resolution increase for printing pre-processing. However, in many of these applications, it is necessary to cope with high up-scaling factors that are not powers of two. In this description an extension of the interpolator proposed in [5] will be described. It overtakes its limitation thus allowing the use of any value.

The theoretical limitation of linear interpolation is the low-pass filtering implemented by the operators to avoid imaging artifacts in the output image. This operation limits the presence of high frequency components in the output images, corresponding to details and sharp edges in the spatial domain.

For example linear interpolation by an integer L factor is performed by inserting L-1 equidistant zero-valued samples between two consecutive original samples, then a low-pass filtering is performed [2].

The proposed algorithm will be able to reconstruct high frequency components avoiding the blocking artifacts of diagonal edges due to the separability of linear interpolators.

The algorithm works in two steps. The first step is a one-dimensional interpolation of original rows and columns; the second one is the interpolation of the space among interpolated rows and columns.

The first step is the interpolation of the original rows and columns by the required factor. This step is implemented by using a one-dimensional rational interpolator, whose formula is defined by the equation (1). Pixels $S_p$ are calculated between the original

ones $p_2$ and $p_3$ by using the scheme of Fig. 1. The distance between $p_2$ and $p_3$ is equal to 1, while the distance $\delta$ between $S_p(\delta)$ and $p_2$ *is* smaller than or equal to 1 and greater than or equal to 0.

$$Sp(\delta) = \frac{w_{p2}(1-\delta)p_2 + w_{p3}\delta.p_3}{w_{p2}(1-\delta) + w_{p3}\delta} \qquad 1.$$

where $w_{p2} = 1+k((p_2-p_4)^2 + (p_3-p_4)^2)$

and $w_{p3} = 1+k((p_1-p_3)^2 + (p_1-p_2)^2)$

*k* is a parameter related to the non linearity of the algorithm, while the distance $\delta$ is described in Fig. 1. The pixels $p_1$, $p_2$, $p_3$ and $p_4$ are the original input data aligned on the same row or column. The pair $w_{p2}$ and $w_{p3}$ represents an edge sensor that is able to reconstruct luminance transitions sharply.

In Fig. 2 we can see how a one-dimensional edge in an original vector (Fig. 2A) is interpolated by a factor of 4 by using a linear interpolator (Fig. 2B) and a one-dimensional rational interpolator (Fig. 2C). We can see how the rational one-dimensional interpolator of Fig. 2C reconstructs the edge more sharply; indeed the luminance transition produced by using the rational interpolator is shorter than that produced by the linear interpolator of Fig. 2B. This result is achieved by exploiting the sub-pixel information contained in the available data.

The second step of the algorithm is the interpolation of pixels between rows and columns evaluated at the first step (the shadowed square of Fig. 3, in which the bigger circles indicate original pixels and the smaller circles indicate the points interpolated in the first step). The interpolation of a generic point z, located inside the internal square and having the original points (indicated by black dots) as vertexes (see Fig. 4), is performed using the points *a, b, c, d, e, f, g* and *h* interpolated in the first step and indicated by circles. These points are defined once the position of the pixel to be evaluated is fixed; these pixels belong to the 0, 45, 90 and 135 degrees directions and to the interpolated rows and columns. The computation of *z* depends on its "rational" weights and on its distances $(d_a, d_b, \ldots, d_h)$ from points *a, b, ..., h.* This calculation must be done for each of the $(L-1)^2$ points located inside the square. According to the above description, the value of *z* with reference to the Fig. 4, will be:

$$z = \frac{w_{ac}(a\,d_c + c\,d_a) + w_{bd}(b\,d_d + d\,d_b)}{w_{ac} + w_{bd} + w_{eg} + w_{fh}} + \frac{w_{eg}(e\,d_g + g\,d_e) + w_{fh}(f\,d_h + h\,d_f)}{w_{ac} + w_{bd} + w_{eg} + w_{fh}}$$

with

$$d_c = 1 - d_a;\ d_d = 1 - d_b;\ d_e = 1 - d_g;\ d_f = 1 - d_h$$

and

$$w_{ac} = \frac{1}{1 + k(a-c)^2},\ w_{bd} = \frac{1}{1 + k(b-d)^2}$$

and

$$w_{eg} = \frac{1}{1 + k(e-g)^2},\ w_{fh} = \frac{1}{1 + k(f-h)^2}$$

The role of the distances $d_a$, $d_b$, $d_c$, ... $d_h$ is to weigh the contribution of first-step interpolated points taking into account their distances from the pixel to be computed. The weights $w_{ab}$, $w_{bd}$, $w_{eg}$ and $w_{fh}$ are able to determine if there is a dominant direction selected, for example, among 0, 45, 90 and 135 degrees, in the square composed of original and interpolated pixels. These directions are the most reasonable, but the distances could be evaluated also along lines differently oriented. Actually, if a pair of pixels, selected among *(a; c), (b; d), (e; g)* and *(f; h)*, has similar values then the respective weight will be greater and the direction which they belong to will be dominant for the evaluation of pixel *z*. Moreover, there is an average weighting with respect to the distance between the pair of related pixels.

In order to describe more clearly the algorithm let us review the way it works. Starting from an input image whose size is N rows by M columns and using a scale factor SF the 2 steps to be performed for the execution of the processing can be explained as:

1. A mono-dimensional operator (1-D operator) intervention by which interpolated pixel are inserted in between 2 original pixels only along the horizontal and vertical directions in such a way to obtain a grid. In this grid interpolated lines cross themselves in original pixels; in this way we obtain an intermediate image whose nominal dimension is equal to the output image, but, with only N*M +N*M*(SF-1) + M*N*(SF-1) significant pixels; these pixels will be referenced to as grid pixels.
2. An interpolation with a 2-D operator that fills the squares delimited by the grid with new pixels (the size of the squares will be (SF+1) x (SF+1) pixels and the number of pixels to be evaluated for each squares will be (SF-1) x (SF-1)).

The 2 steps can be represented graphically with the block diagram of Fig. 5. An input image I1 having N rows and M columns is applied to a one-dimensional operator 51 to obtain an intermediate image I2 having N*M + N*M*(SF-1) + M*N*(SF-1) significant pixels, viz. the original and interpolated pixels shown in Fig. 3. For the intermediate image I2, the original rows and columns length is increased by the scaling factor SF. The value of the N*(SF-1)*M*(SF-1) located among original interpolated rows and columns is not yet defined. The intermediate image I2 is applied to a two-dimensional operator 52 to obtain an output image I3 having N*SF rows and M*SF columns.

A dedicated hardware could be designed to perform the required operations. The two-dimensional operator, whose behavior is affected by the choice of the "k" parameter (according to our studies a proper value can be selected around 0.1), works on every square defined by the grid pixels. Starting from one of these squares, this operator computes the value of each pixel inside, using the "grid pixels" belonging to the edges of that square and the pixel coordinates referring to the position in the square (see Fig. 3). These relative pixel co-ordinates are expressed by two integer indexes whose values are in the range (1, SF-1). The processing of the 2-D operator can be described with a block diagram as in Fig. 6.

Fig. 6 shows a two-dimensional operator formula implementation. Grid pixels GP and relative pixel coordinates RPC are applied to a grid pixel selector 61. The relative pixel coordinates RPC are also applied to a distance generator 62. An output of the grid pixel selector 61 and the parameter k are applied to a weight generator 63. Outputs of the distance generator 62 and the weight generator 63 are applied to a multiplier generator 64. Outputs of the grid pixel selector 61 and the multiplier generator 64 are applied to a multiplier accumulator 65. Outputs of the weights generator 63 and the multiplier accumulator 65 are applied to a divisor 66 that generates output pixels OP that are displayed on a display D or sent to a printing device P.

A primary aspect of the invention can be summarized as follows. A non-linear technique for image interpolation is presented. Linear techniques produce smoothed images and blocking artifacts at the output. The aim of our method is to interpolate images by large and arbitrary factors preserving the sharpness of their contours. We achieve this goal by using a technique based on the nonlinear rational filter (RF).

The presented algorithm is derived from the one described in Ref. [5]; the algorithm described there is able to perform image interpolations when the scaling factor is

represented by a power of two. That kind of interpolator is important because it applies the method of "rational filters" (RF) to produce interpolated images that preserve the sharpness of the details avoiding at the same time blocking artifacts. The computational load of the algorithm seems not heavier than the one of comparable algorithms that are not based on RF.

In the solution proposed here, the two dimensional interpolation scaling factor advantageously needs no longer be a power of two but can be any number (> 1). A mono-dimensional interpolator based on RF is able to work with arbitrary scaling factor (any real number >1). After a first step during which this operator is used, a two-dimensional operator is applied. Also this operator is based on RF and can work with any interpolation-scaling factor; the proposed structure is intrinsically sensitive to the edge orientation in such a way to produce contours with a high degree of sharpness even if these contours are not horizontal or vertical.

The invention can be used in the zooming of natural images like those obtained from photographic or video cameras.

A primary aspect of the invention thus provides an image interpolation method comprising the steps of inserting interpolated pixels along the horizontal and vertical directions so as to obtain a grid in which interpolated lines cross themselves in original pixels; and interpolating pixels between the rows and columns formed by the grid so as to fill the squares delimited by the grid. An image interpolation device operating in accordance with this method is also provided, as well as a video display apparatus (printing apparatus) comprising such an image interpolation device for supplying an interpolated image, and a display (printing device) for displaying (printing) the interpolated image.

It should be noted that the above-mentioned embodiments illustrate rather than limit the invention, and that those skilled in the art will be able to design many alternative embodiments without departing from the scope of the appended claims. In the claims, any reference signs placed between parentheses shall not be construed as limiting the claim. The word "comprising" does not exclude the presence of other elements or steps than those listed in a claim. The invention can be implemented by means of hardware comprising several distinct elements, and by means of a suitably programmed computer. In the device claim enumerating several means, several of these means can be embodied by one and the same item of hardware.

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[1] K. Jensen and D. Anastassiou, "Subpixel edge localization and the interpolation of still images," *IEEE Trans. on Image Processing,* vol. 4, no. 3, March 1995, pp. 285-295.

[2] S., K., Mitra, "Digital Signal Processing, A Computer-Based Approach," McGraw-Hill Companies, New York, 1998.

[3] G. Ramponi, "The Rational Filter for Image Smoothing," *IEEE Signal Processing Letters,* vol. 3, no. 3, pp. 63-65, March 1996.

[4] G. Ramponi and A. Polesel, "A Rational Unsharp Masking Technique," *Journal of Electronic Imaging*, vol. 7, no. 2, April 1998, pp. 333-338.

[5] G. Ramponi and S. Carrato, "Interpolation of the DC Component of Coded Images Using a Rational Filter," *Proc. Fourth IEEE Intern. Conf. on Image Processing,* ICIP-97, S. Barbara, CA, Oct. 26-29, 1997.

CLAIMS:

1. An image interpolation method, comprising the steps of.

inserting (51) interpolated pixels along horizontal and vertical directions so as to obtain a grid (I2) in which interpolated lines cross themselves in original pixels; and

interpolating (52) pixels between rows and columns formed by the grid (I2) so as to fill squares delimited by the grid (I2).

2. A method as claimed in claim 1, wherein rational filtering is used in said inserting step (51) and/or said interpolating step (52).

3. A method as claimed in claim 3, wherein distances between a pixel to be interpolated and surrounding pixels are taken into account in said rational filtering.

4. An image interpolation device comprising:

means (51) for inserting interpolated pixels along horizontal and vertical directions so as to obtain a grid (I2) in which interpolated lines cross themselves in original pixels; and

means (52) for interpolating pixels between rows and columns formed by the grid (I2) so as to fill squares delimited by the grid (I2) to obtain an interpolated image (I3).

5. A video display apparatus comprising:

an image interpolation device as defined by claim 4 for supplying an interpolated image (I3); and

a display (D) for displaying the interpolated image (I3).

A printing apparatus comprising:

an image interpolation device as defined by claim 4 for supplying an interpolated image (I3); and

a printing device (P) for printing the interpolated image (I3).

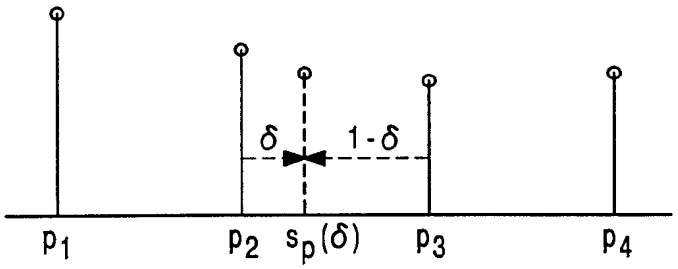



FIG. 1

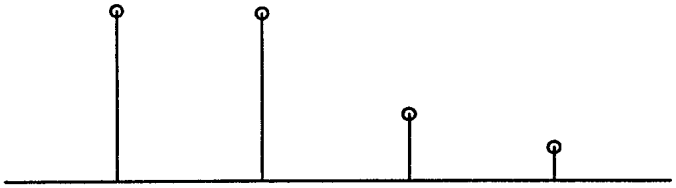


FIG. 2A

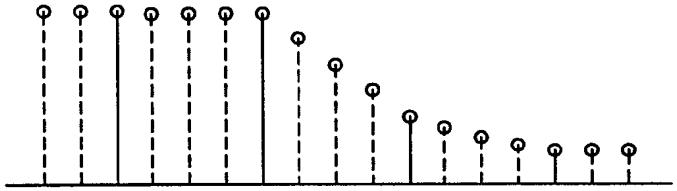


FIG. 2B

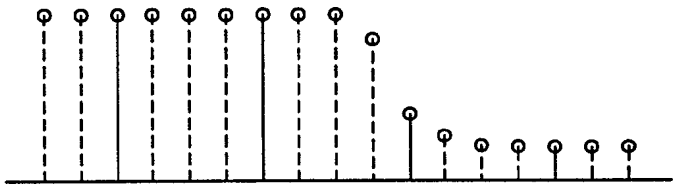


FIG. 2C

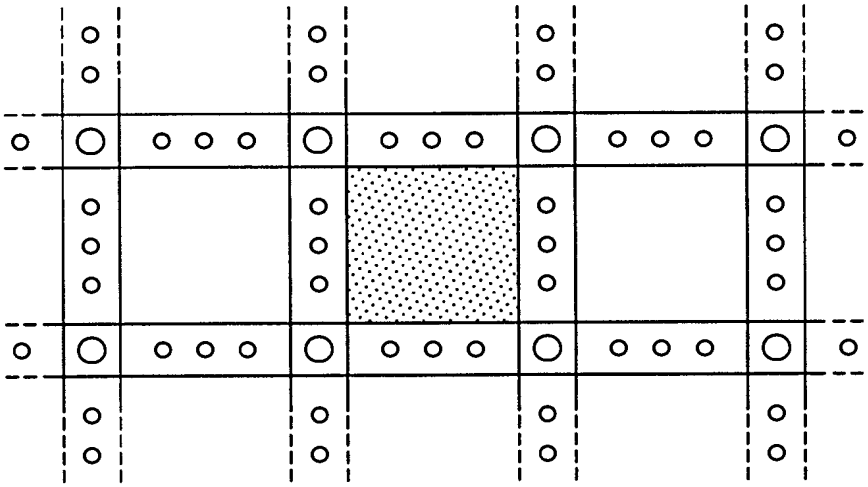


FIG. 3

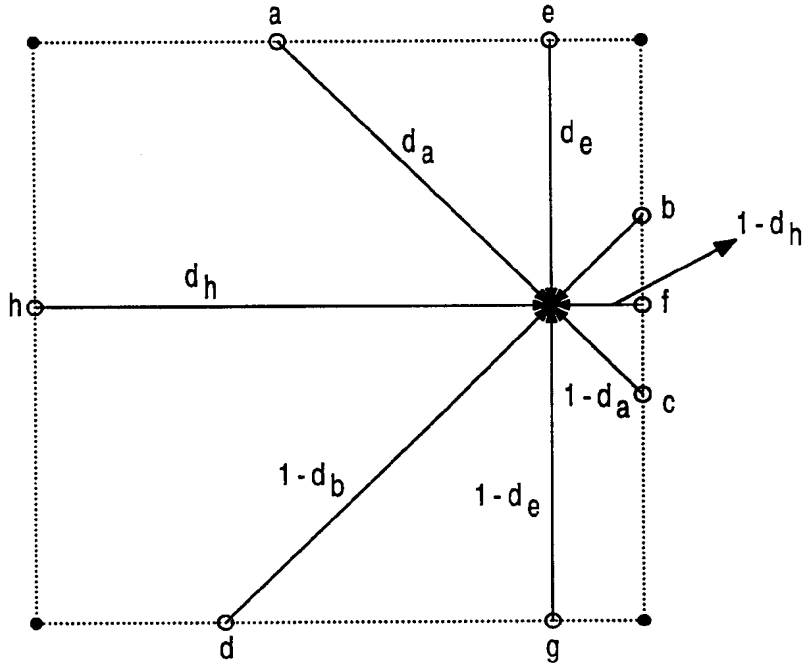



FIG. 4

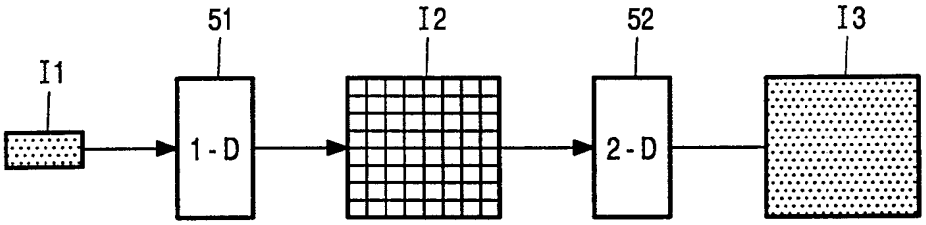



FIG. 5

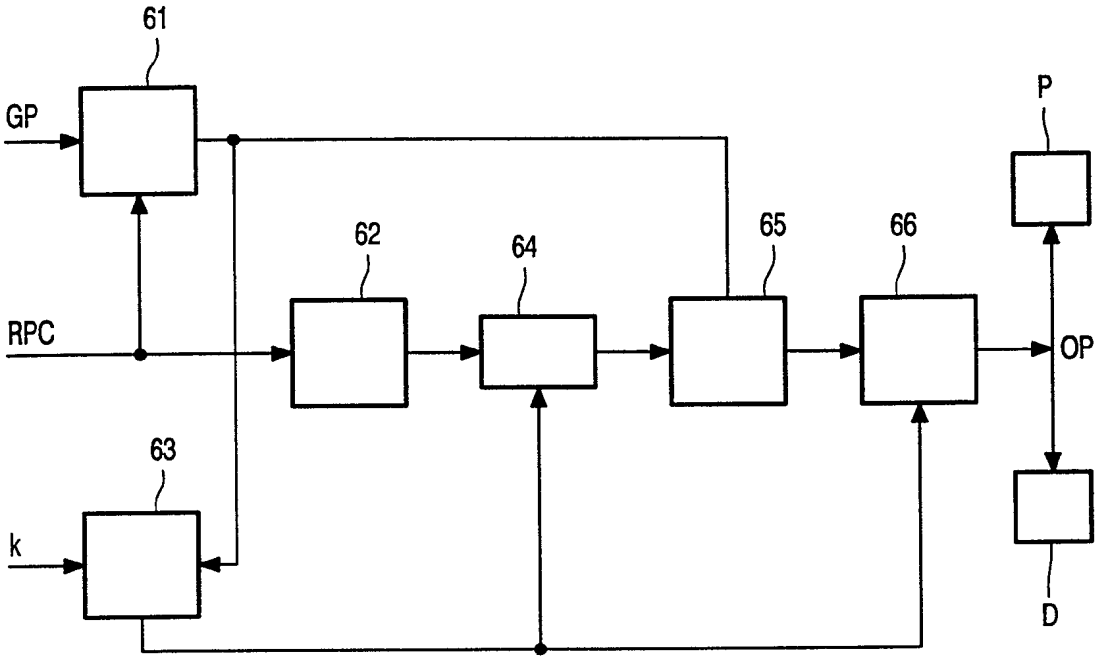



FIG. 6

# INTERNATIONAL SEARCH REPORT

International application No.
PCT/IB 99/00460

A. CLASSIFICATION OF SUBJECT MATTER

IPC6: G06T 5/00, H04N 7/01
According to International Patent Classification (IPC) or to both national classification and IPC

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C. DOCUMENTS CONSIDERED TO BE RELEVANT

| Category* | Citation of document, with indication, where appropriate, of the relevant passages | Relevant to claim No. |
|---|---|---|
| A | JP 9265527 A (FUJI PHOTO FILM CO LTD) 1997-10-07 (abstract) World Oatents Index (online). London, U.K.: Derwent Publications, Ltd. (retrieved on 1999-07-12), Retrieved from: EPO WPI Database. DW9750, Accession No. 97-547270; & JP 9265527 (FUJI PHOTO FILM CO LTD) 1998-01-30 (abstract).(online) (retrieved on 1999-07-12). Retrieved from: EPO PAJ Database<br>-- | 1-6 |
| A | WO 9422100 A1 (B.C.R. J-P DELEAN), 29 Sept 1994 (29.09.94), abstract<br>-- | 1-6 |

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|---|---|
| 22 July 1999 | 04 -08- 1999 |
| Name and mailing address of the ISA/<br>Swedish Patent Office<br>Box 5055, S-102 42 STOCKHOLM<br>Facsimile No. +46 8 666 02 86 | Authorized officer<br>Malin Keijser/AE<br>Telephone No. +46 8 782 25 00 |

Form PCT/ISA/210 (second sheet) (July 1992)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/IB 99/00460

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

| Category* | Citation of document, with indication, where appropriate, of the relevant passages | Relevant to claim No. |
|---|---|---|
| A | EP 0536717 A2 (SALORA OY), 14 April 1993 (14.04.93), abstract<br><br>--<br>-------- | 1-6 |

Form PCT/ISA/210 (continuation of second sheet) (July 1992)

## INTERNATIONAL SEARCH REPORT

Information on patent family members

01/07/99

International application No.
PCT/IB 99/00460

| Patent document cited in search report | Publication date | Patent family member(s) | Publication date |
|---|---|---|---|
| WO 9422100 A1 | 29/09/94 | AT 153460 T | 15/06/97 |
| | | AU 681641 B | 04/09/97 |
| | | AU 690551 B | 30/04/98 |
| | | AU 6403894 A | 11/10/94 |
| | | AU 6697894 A | 11/10/94 |
| | | CA 2158988 A | 29/09/94 |
| | | CN 1124530 A | 12/06/96 |
| | | DE 69403331 D,T | 08/01/98 |
| | | EP 0691010 A,B | 10/01/96 |
| | | EP 0691011 A | 10/01/96 |
| | | FR 2703170 A,B | 30/09/94 |
| | | JP 8510851 T | 12/11/96 |
| | | JP 8511883 T | 10/12/96 |
| | | US 5790708 A | 04/08/98 |
| | | US 5907640 A | 25/05/99 |
| | | WO 9422101 A | 29/09/94 |
| EP 0536717 A2 | 14/04/93 | DE 69219546 D,T | 04/09/97 |
| | | FI 89227 B,C | 14/05/93 |
| | | FI 914781 D | 00/00/00 |

# Electronic Patent Application Fee Transmittal

| | |
|---|---|
| **Application Number:** | 11839205 |
| **Filing Date:** | 15-Aug-2007 |
| **Title of Invention:** | METHOD FOR SUB-PIXEL VALUE INTERPOLATION |
| **First Named Inventor/Applicant Name:** | Marta Karczewicz |
| **Filer:** | GEZA C ZIEGLER JR/Shannon D'Amico |
| **Attorney Docket Number:** | 982-010567-US (C02) |

Filed as Large Entity

## Utility under 35 USC 111(a) Filing Fees

| Description | Fee Code | Quantity | Amount | Sub-Total in USD($) |
|---|---|---|---|---|
| **Basic Filing:** | | | | |
| **Pages:** | | | | |
| **Claims:** | | | | |
| **Miscellaneous-Filing:** | | | | |
| **Petition:** | | | | |
| **Patent-Appeals-and-Interference:** | | | | |
| **Post-Allowance-and-Post-Issuance:** | | | | |
| **Extension-of-Time:** | | | | |

| Description | Fee Code | Quantity | Amount | Sub-Total in USD($) |
|---|---|---|---|---|
| **Miscellaneous:** | | | | |
| Submission- Information Disclosure Stmt | 1806 | 1 | 180 | 180 |
| | | **Total in USD ($)** | | **180** |

# Electronic Acknowledgement Receipt

| | |
|---|---|
| **EFS ID:** | 3925089 |
| **Application Number:** | 11839205 |
| **International Application Number:** | |
| **Confirmation Number:** | 8091 |
| **Title of Invention:** | METHOD FOR SUB-PIXEL VALUE INTERPOLATION |
| **First Named Inventor/Applicant Name:** | Marta Karczewicz |
| **Customer Number:** | 02512 |
| **Filer:** | GEZA C ZIEGLER JR/Shannon D'Amico |
| **Filer Authorized By:** | GEZA C ZIEGLER JR |
| **Attorney Docket Number:** | 982-010567-US (C02) |
| **Receipt Date:** | 11-SEP-2008 |
| **Filing Date:** | 15-AUG-2007 |
| **Time Stamp:** | 13:10:01 |
| **Application Type:** | Utility under 35 USC 111(a) |

## Payment information:

| | |
|---|---|
| Submitted with Payment | yes |
| Payment Type | Deposit Account |
| Payment was successfully received in RAM | $180 |
| RAM confirmation Number | 7448 |
| Deposit Account | 161350 |
| Authorized User | |

## File Listing:

| Document Number | Document Description | File Name | File Size(Bytes)/ Message Digest | Multi Part /.zip | Pages (if appl.) |
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|---|---|---|---|---|---|
| 1 | Information Disclosure Statement (IDS) Filed (SB/08) | US_IDS_Form__SB_08a.pdf | 780708<br>8b501e4e986f44e575f494d1f535240f216e1151 | no | 4 |
| **Warnings:** | | | | | |
| **Information:** | | | | | |
| 2 | Foreign Reference | WO9956247A1.pdf | 583939<br>2b67cc5194d5e788b74b60b3118d685631259754 | no | 16 |
| **Warnings:** | | | | | |
| **Information:** | | | | | |
| 3 | NPL Documents | TwoDimensional.pdf | 405840<br>c5cc5d03aa6f53f109c410dfd72d6b86fb09d780 | no | 6 |
| **Warnings:** | | | | | |
| **Information:** | | | | | |
| 4 | NPL Documents | CodingMethodForHDTV.pdf | 396568<br>1dc9a8efb004e872bb167274d99d54a41ebeb030 | no | 7 |
| **Warnings:** | | | | | |
| **Information:** | | | | | |
| 5 | Fee Worksheet (PTO-06) | fee-info.pdf | 30887<br>89c10661e0264e4034ba2d649a00d6bb2a66d4ea | no | 2 |
| **Warnings:** | | | | | |
| **Information:** | | | | | |
| | | **Total Files Size (in bytes):** | 2197942 | | |

**This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.**

**<u>New Applications Under 35 U.S.C. 111</u>**
**If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.**

**<u>National Stage of an International Application under 35 U.S.C. 371</u>**
**If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.**

**<u>New International Application Filed with the USPTO as a Receiving Office</u>**
**If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.**

| Terminal Disclaimer To Obviate A Double Patenting Rejection Over A Prior Patent | Docket No. 982-010567-US (C02) |
|---|---|

In Re Application Of: **Marta Karczewicz**

| Application No. | Filing Date | Examiner | Customer No. | Group Art Unit | Confirmation No. |
|---|---|---|---|---|---|
| 11/839,205 | 08/15/2007 | An, Shawn S | 2512 | 2621 | 8091 |

Invention: **METHOD FOR SUB-PIXEL VALUE INTERPOLATION**

Owner of Record: **Nokia Corporation**

COMMISSIONER FOR PATENTS:

The above-identified owner of record of a **100%** percent interest in the instant application hereby disclaims, except as provided below, the terminal part of the statutory term of any patent granted on the instant application, which would extend beyond the expiration date of the full statutory term defined in 35 U.S.C. 154 to 156 and 173, as presently shortened by any terminal disclaimer, of prior Patent No. **7,280,599 B2** . The owner hereby agrees that any patent so granted on the instant application shall be enforceable only for and during such period that it and the prior patent are commonly owned. This agreement runs with any patent granted on the instant application and is binding upon the grantee, its successors and/or assigns.

In making the above disclaimer, the owner does not disclaim the terminal part of any patent granted on the instant application that would extend to the expiration date of the full statutory term as defined in 35 U.S.C. 154 to 156 and 173 of the prior patent, as presently shortened by any terminal disclaimer, in the event that it later expires for failure to pay a maintenance fee, is held unenforceable, is found invalid by a court of competent jurisdiction, is statutorily disclaimed in whole or terminally disclaimed under 37 C.F.R. 1.321, has all claims cancelled by a reexamination certificate, is reissued, or is in any manner terminated prior to the expiration of its full statutory term as presently shortened by any terminal disclaimer.

Check either box 1 or 2 below, if appropriate.

1. ☐ For submissions on behalf of an organization (e.g., corporation, partnership, university, government agency, etc.), the undersigned is empowered to act on behalf of the organization.

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

2. ☒ The undersigned is an attorney of record.

*Signature* Dated: **18 December 2008**

**Geza C. Ziegler, Jr. Reg. No. 44,004**

*Typed or Printed Name*

☒ Terminal disclaimer fee under 37 C.F.R. 1.20(d) included.
☒ PTO suggested wording for terminal disclaimer was unchanged.
☐ Certification under 37 C.F.R. 3.73(b) is required if terminal disclaimer is signed by the assignee.

P32/REV03

# Electronic Patent Application Fee Transmittal

| | |
|---|---|
| **Application Number:** | 11839205 |
| **Filing Date:** | 15-Aug-2007 |
| **Title of Invention:** | METHOD FOR SUB-PIXEL VALUE INTERPOLATION |
| **First Named Inventor/Applicant Name:** | Marta Karczewicz |
| **Filer:** | GEZA C ZIEGLER JR/Fran Snow |
| **Attorney Docket Number:** | 982-010567-US (C02) |

Filed as Large Entity

## Utility under 35 USC 111(a) Filing Fees

| Description | Fee Code | Quantity | Amount | Sub-Total in USD($) |
|---|---|---|---|---|
| **Basic Filing:** | | | | |
| **Pages:** | | | | |
| **Claims:** | | | | |
| **Miscellaneous-Filing:** | | | | |
| **Petition:** | | | | |
| **Patent-Appeals-and-Interference:** | | | | |
| **Post-Allowance-and-Post-Issuance:** | | | | |
| **Extension-of-Time:** | | | | |
| Extension - 3 months with $0 paid | 1253 | 1 | 1110 | 1110 |

| Description | Fee Code | Quantity | Amount | Sub-Total in USD($) |
|---|---|---|---|---|
| **Miscellaneous:** | | | | |
| Statutory disclaimer | 1814 | 1 | 140 | 140 |
| | | **Total in USD ($)** | | **1250** |

# Electronic Acknowledgement Receipt

| | |
|---|---|
| **EFS ID:** | 4500697 |
| **Application Number:** | 11839205 |
| **International Application Number:** | |
| **Confirmation Number:** | 8091 |
| **Title of Invention:** | METHOD FOR SUB-PIXEL VALUE INTERPOLATION |
| **First Named Inventor/Applicant Name:** | Marta Karczewicz |
| **Customer Number:** | 02512 |
| **Filer:** | GEZA C ZIEGLER JR/Fran Snow |
| **Filer Authorized By:** | GEZA C ZIEGLER JR |
| **Attorney Docket Number:** | 982-010567-US (C02) |
| **Receipt Date:** | 22-DEC-2008 |
| **Filing Date:** | 15-AUG-2007 |
| **Time Stamp:** | 12:58:34 |
| **Application Type:** | Utility under 35 USC 111(a) |

## Payment information:

| | |
|---|---|
| Submitted with Payment | yes |
| Payment Type | Deposit Account |
| Payment was successfully received in RAM | $1250 |
| RAM confirmation Number | 10740 |
| Deposit Account | 161350 |
| Authorized User | |

## File Listing:

| Document Number | Document Description | File Name | File Size(Bytes)/ Message Digest | Multi Part /.zip | Pages (if appl.) |
|---|---|---|---|---|---|

| | | | | | |
|---|---|---|---|---|---|
| 1 | Statutory disclaimers per MPEP 1490. | TerminalDisclaimer081222.pdf | 56853<br>d5ec9c69dad9565846176752172525 1c4554a24d | no | 1 |
| **Warnings:** | | | | | |
| **Information:** | | | | | |
| 2 | Fee Worksheet (PTO-06) | fee-info.pdf | 32568<br>ba3cabcdc1eb039f3c40b54de1dc04d11710dec1 | no | 2 |
| **Warnings:** | | | | | |
| **Information:** | | | | | |
| | | | **Total Files Size (in bytes):** | 89421 | |

**This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.**

**New Applications Under 35 U.S.C. 111**

**If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.**

**National Stage of an International Application under 35 U.S.C. 371**

**If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.**

**New International Application Filed with the USPTO as a Receiving Office**

**If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.**

| Application Number | Application/Control No. | Applicant(s)/Patent under Reexamination | |
|---|---|---|---|
| | 11/839,205 | KARCZEWICZ ET AL. | |

| Document Code - DISQ | Internal Document – DO NOT MAIL |
|---|---|

| TERMINAL DISCLAIMER | ☐ APPROVED | ☒ DISAPPROVED |
|---|---|---|
| Date Filed : 12/22/08 | This patent is subject to a Terminal Disclaimer | |

| Approved/Disapproved by: |
|---|
| Felicia D. Roberts<br><br>attorney not listed on the POA filed 8/15/07 |

U.S. Patent and Trademark Office

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United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
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Alexandria, Virginia 22313-1450
www.uspto.gov

| APPLICATION NO. | FILING DATE | FIRST NAMED INVENTOR | ATTORNEY DOCKET NO. | CONFIRMATION NO. |
|---|---|---|---|---|
| 11/839,205 | 08/15/2007 | Marta Karczewicz | 982-010567-US (C02) | 8091 |

2512 7590 02/09/2009

PERMAN & GREEN
425 POST ROAD
FAIRFIELD, CT 06824

| EXAMINER | |
|---|---|
| AN, SHAWN S | |

| ART UNIT | PAPER NUMBER |
|---|---|
| 2621 | |

| MAIL DATE | DELIVERY MODE |
|---|---|
| 02/09/2009 | PAPER |

**Please find below and/or attached an Office communication concerning this application or proceeding.**

The time period for reply, if any, is set in the attached communication.

| Office Action Summary | Application No. | Applicant(s) | |
|---|---|---|---|
| | 11/839,205 | KARCZEWICZ ET AL. | |
| | Examiner | Art Unit | |
| | SHAWN AN | 2621 | |

*-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --*

**Period for Reply**

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE *3* MONTH(S) OR THIRTY (30) DAYS, WHICHEVER IS LONGER, FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133). Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

**Status**

1)☒ Responsive to communication(s) filed on *22 December 2008*.

2a)☐ This action is **FINAL**. 2b)☒ This action is non-final.

3)☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

**Disposition of Claims**

4)☒ Claim(s) *1-3* is/are pending in the application.

4a) Of the above claim(s) _____ is/are withdrawn from consideration.

5)☐ Claim(s) _____ is/are allowed.

6)☒ Claim(s) *1-3* is/are rejected.

7)☐ Claim(s) _____ is/are objected to.

8)☐ Claim(s) _____ are subject to restriction and/or election requirement.

**Application Papers**

9)☐ The specification is objected to by the Examiner.

10)☐ The drawing(s) filed on _____ is/are: a)☐ accepted or b)☐ objected to by the Examiner.

Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).

Replacement drawing sheet(s) including the correction is required if the drawing(s) is objected to. See 37 CFR 1.121(d).

11)☐ The oath or declaration is objected to by the Examiner. Note the attached Office Action or form PTO-152.

**Priority under 35 U.S.C. § 119**

12)☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

a)☐ All b)☐ Some * c)☐ None of:

1.☐ Certified copies of the priority documents have been received.

2.☐ Certified copies of the priority documents have been received in Application No. _____.

3.☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

* See the attached detailed Office action for a list of the certified copies not received.

**Attachment(s)**

1) ☐ Notice of References Cited (PTO-892)
2) ☐ Notice of Draftsperson's Patent Drawing Review (PTO-948)
3) ☒ Information Disclosure Statement(s) (PTO/SB/08) Paper No(s)/Mail Date *9/11/08*.
4) ☐ Interview Summary (PTO-413) Paper No(s)/Mail Date. _____ .
5) ☐ Notice of Informal Patent Application
6) ☐ Other: _____.

## DETAILED ACTION

### *Double Patenting I*

**1.** A rejection based on double patenting of the "same invention" type finds its support in the language of 35 U.S.C. 101 which states that "whoever invents or discovers any new and useful process ... may obtain a patent therefor ..." (Emphasis added). Thus, the term "same invention," in this context, means an invention drawn to identical subject matter. See *Miller v. Eagle Mfg. Co.*, 151 U.S. 186 (1894); *In re Ockert*, 245 F.2d 467, 114 USPQ 330 (CCPA 1957); and *In re Vogel*, 422 F.2d 438, 164 USPQ 619 (CCPA 1970).

A statutory type (35 U.S.C. 101) double patenting rejection can be overcome by canceling or amending the conflicting claims so they are no longer coextensive in scope. The filing of a terminal disclaimer cannot overcome a double patenting rejection based upon 35 U.S.C. 101.

**2.** Claims 1-3 are rejected under 35 U.S.C. 101 as claiming the same invention as that of claims 1, 20, and 21 of prior U.S. Patent No. (7,280,599 B2). This is a double patenting rejection.

### *Double Patenting II*

**3.** The nonstatutory double patenting rejection is based on a judicially created doctrine grounded in public policy (a policy reflected in the statute) so as to prevent the unjustified or improper timewise extension of the “right to exclude” granted by a patent and to prevent possible harassment by multiple assignees. A nonstatutory obviousness-type double patenting rejection is appropriate where the conflicting claims are not identical, but at least one examined application claim is not patentably distinct from the reference claim(s) because the examined application claim is either anticipated by, or would have been obvious over, the reference claim(s). See, e.g., *In re Berg*, 140 F.3d 1428, 46 USPQ2d 1226 (Fed. Cir. 1998); *In re Goodman*, 11 F.3d 1046, 29 USPQ2d 2010 (Fed. Cir. 1993); *In re Longi*, 759 F.2d 887, 225 USPQ 645 (Fed. Cir.

1985); *In re Van Ornum*, 686 F.2d 937, 214 USPQ 761 (CCPA 1982); *In re Vogel*, 422 F.2d 438, 164 USPQ 619 (CCPA 1970); and *In re Thorington*, 418 F.2d 528, 163 USPQ 644 (CCPA 1969).

A timely filed terminal disclaimer in compliance with 37 CFR 1.321(c) or 1.321(d) may be used to overcome an actual or provisional rejection based on a nonstatutory double patenting ground provided the conflicting application or patent either is shown to be commonly owned with this application, or claims an invention made as a result of activities undertaken within the scope of a joint research agreement.

Effective January 1, 1994, a registered attorney or agent of record may sign a terminal disclaimer. A terminal disclaimer signed by the assignee must fully comply with 37 CFR 3.73(b).

**4.** Claims 1-3 are rejected on the ground of nonstatutory obviousness-type double patenting as being unpatentable over claims 1, 18-19, and 23 of U.S. Patent No. (6,950, 469 B2).

Although the conflicting claims are not identical, they are not patentably distinct from each other because the novel subject matter(s) of claims 1-3 in the instant/present application is fully disclosed in the above patent and is covered by the above patent, since the above patent and the instant/present application are claiming common subject matter, as follows:

**Claims 1-3** recite substantially all of claimed features **(**with the exceptions of mathematical manipulations**)** as recited in the patented claims 1, 18-19, and 23.

Therefore, it would have been considered obvious to a person of ordinary skill in the relevant art employing the patent reference to mathematically manipulate the method of interpolation such as to derive claims similar to currently pending claims, since the end result does not create unexpected results.

***Claim Rejections - 35 USC § 101***

**5.** 35 U.S.C. 101 reads as follows:

> Whoever invents or discovers any new and useful process, machine, manufacture, or composition of matter, or any new and useful improvement thereof, may obtain a patent therefor, subject to the conditions and requirements of this title.

**6.** Claims 1-3 are rejected under 35 U.S.C. 101 as not falling within one of the four statutory categories of invention.

Claims 1-3 are directed to a method for sub-pixel value interpolation and the bodies of the claims are directed to a series of steps drawn for interpolating a sub-pixel value …, interpolating sub-pixel values for sub-pixels …, and interpolating sub-pixel values for sub-pixels …, having corresponding co-ordinates in immediately adjacent bounded rectangular regions without practical application that produces any useful, tangible, and concrete results. Therefore, claims 1-3 do not fall within the statutory classes set forth in 35 U.S.C. 101.

**7.** Claims 1-3 are rejected under 35 U.S.C. 101 as not falling within one of the four statutory categories of invention.

Supreme Court precedent[1] and recent Federal Circuit decisions[2] indicate that a statutory "process" under 35 U.S.C. 101 must (1) be tied to another statutory category (such as a particular apparatus), or (2) transform underlying subject matter (such as an article or material) to a different state or thing. While the instant claim(s) recite a series of steps or acts to be performed, the claim(s) neither transform underlying subject matter nor positively tie to another statutory category that accomplishes the claimed method steps, and therefore do not qualify as a statutory process. For example, independent claims 1-3 are directed to a method for sub-pixel value interpolation, but the bodies of the claims are directed to a series of steps drawn for interpolating a sub-pixel value …, interpolating sub-pixel values for sub-pixels …, and interpolating sub-

[1] *Diamond v. Diehr*, 450 U.S. 175, 184 (1981); *Parker v. Flook*, 437 U.S. 584, 588 n.9 (1978); *Gottschalk v. Benson*, 409 U.S. 63, 70 (1972); *Cochrane v. Deener*, 94 U.S. 780, 787-88 (1876).

[2] *In re Bilski*, 88 USPQ2d 1385 (Fed. Cir. 2008).

pixel values for sub-pixels …, having corresponding co-ordinates in immediately adjacent bounded rectangular regions without any ties to a *particular* apparatus/structure.

***Conclusion***

**8.** Any inquiry concerning this communication or earlier communications from the Examiner should be directed to *Shawn An* whose telephone number is 571-272-7324.

**9.** The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300.

**10.** Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see http://pair-direct.uspto.gov. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free). If you would like assistance from a USPTO Customer Service Representative or access to the automated information system, call 800-786-9199 (IN USA OR CANADA) or 571-272-1000.

/SHAWN AN/
Primary Examiner, Art Unit 2621
2/04/09

| Application Number | Application/Control No. | Applicant(s)/Patent under Reexamination | |
|---|---|---|---|
| | 11/839,205 | KARCZEWICZ ET AL. | |
| | Examiner | Art Unit | |
| | SHAWN AN | 2621 | |

## Index of Claims

| Application/Control No. | Applicant(s)/Patent under Reexamination |
|---|---|
| 11/839,205 | KARCZEWICZ ET AL. |
| **Examiner** | **Art Unit** |
| SHAWN AN | 2621 |

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|---|---|---|---|---|---|---|---|
| √ | Rejected | – | (Through numeral) Cancelled | N | Non-Elected | A | Appeal |
| = | Allowed | ÷ | Restricted | I | Interference | O | Objected |

| Claim | | Date | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Final | Original | 2/4/09 | | | | | | | |
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PTO/SB/08a (08-08)
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# INFORMATION DISCLOSURE STATEMENT BY APPLICANT

**( Not for submission under 37 CFR 1.99)**

| | |
|---|---|
| Application Number | 11839205 |
| Filing Date | 2007-08-15 |
| First Named Inventor | Marta Karczewicz |
| Art Unit | 2621 |
| Examiner Name | An, Shawn S. |
| Attorney Docket Number | 982-010567-US (C02) |

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|---|---|---|---|---|---|---|
| /S.A./ | 1 | 6219464 | B1 | 2001-04-17 | Greggain et al. | |
| /S.A./ | 2 | 5521642 | A | 1996-05-28 | Park | |
| /S.A./ | 3 | 5337088 | A | 1994-08-09 | Honjo | |
| /S.A./ | 4 | 5570436 | A | 1996-10-29 | Fukushima et al. | |

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|---|---|---|---|---|---|---|---|---|

| INFORMATION DISCLOSURE STATEMENT BY APPLICANT ( Not for submission under 37 CFR 1.99) | | |
|---|---|---|
| | Application Number | 11839205 |
| | Filing Date | 2007-08-15 |
| | First Named Inventor | Marta Karczewicz |
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| | Examiner Name | An, Shawn S. |
| | Attorney Docket Number | 982-010567-US (C02) |

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| /S.A./ | 1 | 9956247 | WO | | 1999-11-04 | Philips | | ☐ |

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|---|---|---|---|
| /S.A./ | 1 | Two-Dimensional Adaptive Interpolation for Subsampled HDTV Signals; Vol. 12, No. 4, Journal of China Institute of Communications, July 1991; Pages 8-12. | ☐ |
| /S.A./ | 2 | Interpolative Prediction Coding Method for HDTV Signals; Vol. 32, No. 1, Communication Engineering, February 1992; Pages 81-88. | ☐ |

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| Examiner Signature | /Shawn An/ (02/04/2009) | Date Considered | 02/04/2009 |
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ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /S.A./ (02/04/2009)

PTO/SB/08a (04-09)
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# INFORMATION DISCLOSURE STATEMENT BY APPLICANT

**( Not for submission under 37 CFR 1.99)**

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| Application Number | 11839205 |
| Filing Date | 2007-08-15 |
| First Named Inventor | Marta Karczewicz |
| Art Unit | 2621 |
| Examiner Name | Shawn S. An |
| Attorney Docket Number | 982-010567-US (C02) |

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| | Application Number | 11839205 |
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| | Art Unit | 2621 |
| | Examiner Name | Shawn S. An |
| | Attorney Docket Number | 982-010567-US (C02) |

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| | 1 | WEDI, Thomas, "Complexity Reduced Motion Compensated Prediction with 1/8-pel Displacement Vector Resolution," ITU-Telecommunications Standardization Sector Study Group 16 Question 6 Video Coding Experts Group (VCEG) Twelfth Meeting: Eibsee, Germany, 9-12 January 2001, [VCEG-L20]. | ☒ |
| | 2 | BJONTEGAARD, Gisle, "H.26L Test Model Long Term Number 6 (TML-6) draft0," ITU-Telecommunications Standardization Sector Study Group 16 Question 6 Video Coding Experts Group (VCEG) 12th meeting: Eibsee, Germany, 9-12 January 2001, [VCEG-L45], p. 15. | ☒ |
| | 3 | WEDI, Thomas, "Direct Interpolation Filters in TML-6," ITU-Telecommunications Standardization Sector Study Group 16 Question 6 Video Coding Experts Group (VCEG) Thirteenth Meeting: Austin, Texas, USA, 2-4 April 2001, [VCEG-M44]. | ☒ |
| | 4 | "Notice of Reasons for Rejection," JP App. No. 2003-529764, mailed 3 March 2009. | ☒ |

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| | Application Number | 11839205 |
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| | First Named Inventor | Marta Karczewicz |
| | Art Unit | 2621 |
| | Examiner Name | Shawn S. An |
| | Attorney Docket Number | 982-010567-US (C02) |

**CERTIFICATION STATEMENT**

Please see 37 CFR 1.97 and 1.98 to make the appropriate selection(s):

☒ That each item of information contained in the information disclosure statement was first cited in any communication from a foreign patent office in a counterpart foreign application not more than three months prior to the filing of the information disclosure statement. See 37 CFR 1.97(e)(1).

**OR**

☐ That no item of information contained in the information disclosure statement was cited in a communication from a foreign patent office in a counterpart foreign application, and, to the knowledge of the person signing the certification after making reasonable inquiry, no item of information contained in the information disclosure statement was known to any individual designated in 37 CFR 1.56(c) more than three months prior to the filing of the information disclosure statement. See 37 CFR 1.97(e)(2).

☐ See attached certification statement.

☐ Fee set forth in 37 CFR 1.17 (p) has been submitted herewith.

☒ None

**SIGNATURE**

A signature of the applicant or representative is required in accordance with CFR 1.33, 10.18. Please see CFR 1.4(d) for the form of the signature.

| Signature | /gcz44004/ | Date (YYYY-MM-DD) | 2009-05-13 |
|---|---|---|---|
| Name/Print | Geza C. Ziegler, Jr. | Registration Number | 44004 |

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# Electronic Acknowledgement Receipt

| | |
|---|---|
| **EFS ID:** | 5326285 |
| **Application Number:** | 11839205 |
| **International Application Number:** | |
| **Confirmation Number:** | 8091 |
| **Title of Invention:** | METHOD FOR SUB-PIXEL VALUE INTERPOLATION |
| **First Named Inventor/Applicant Name:** | Marta Karczewicz |
| **Customer Number:** | 02512 |
| **Filer:** | GEZA C ZIEGLER JR/fran snow |
| **Filer Authorized By:** | GEZA C ZIEGLER JR |
| **Attorney Docket Number:** | 982-010567-US (C02) |
| **Receipt Date:** | 13-MAY-2009 |
| **Filing Date:** | 15-AUG-2007 |
| **Time Stamp:** | 13:16:56 |
| **Application Type:** | Utility under 35 USC 111(a) |

## Payment information:

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| Submitted with Payment | no |

## File Listing:

| Document Number | Document Description | File Name | File Size(Bytes)/ Message Digest | Multi Part /.zip | Pages (if appl.) |
|---|---|---|---|---|---|
| 1 | Information Disclosure Statement (IDS) Filed (SB/08) | US_IDS_Form__SB_08a.pdf | 608911<br>ea515915543922bb55c7d918402fccc927e77fa3 | no | 4 |

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| 2 | NPL Documents | JPOfficeAction_EnglishTranslation.pdf | 122797<br>06237e66ddd5fd7afe50ee46526053c848b186ef | no | 3 |
| **Warnings:** | | | | | |
| **Information:** | | | | | |
| 3 | NPL Documents | NPL_VCEGL20.pdf | 193280<br>e31257c23b23182adcc333239857ca19052dd82e | no | 7 |
| **Warnings:** | | | | | |
| **Information:** | | | | | |
| 4 | NPL Documents | NPL_VCEGL45.pdf | 53109<br>960b0b8c6bf28ced2444960ff695886322c6fdb9 | no | 2 |
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| 5 | NPL Documents | NPL_VCEGM44.pdf | 153593<br>d7ae2c7277f113552bbd5c9d569c83c5f5610f15 | no | 5 |
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**If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.**

**National Stage of an International Application under 35 U.S.C. 371**

**If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.**

**New International Application Filed with the USPTO as a Receiving Office**

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IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

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|---|---|---|---|
| APPLICANT(s): | Marta Karczewicz | CONF. NO.: | 8091 |
| SERIAL NO.: | 11/839,205 | ART UNIT: | 2621 |
| FILING DATE: | 08/15/2007 | EXAMINER: | Shawn S An |
| TITLE: | METHOD FOR SUB-PIXEL VALUE INTERPOLATION | | |
| ATTORNEY DOCKET NO.: | 982-010567-US (C02) | NOKEO/P346 78Uscon2 | |

Mail Stop Amendment
Commissioner of Patents
P.O. Box 1450
Alexandria, VA 22313-1450

**Amendment**

## I. INTRODUCTION

This is in response to the Office Action mailed February 9, 2009, with regard to the above-identified patent application. Reconsideration of the rejection is respectfully solicited in light of the following amendment and remarks.

Please amend the application as follows:

## II. CLAIMS

1. (Currently Amended) A method for sub-pixel value interpolation to determine values for sub-pixels situated within a rectangular bounded region defined by four corner pixels with no intermediate pixels between the corners, the pixels and sub-pixels being ~~arranged~~ configured for display in rows and columns, ~~the~~ pixel and sub-pixel locations in the rows and columns being representable mathematically within the rectangular bounded region using the co-ordinate notation $K/2^N$, $L/2^N$, K and L being positive integers having respective values between zero and $2^N$, N being a positive integer greater than one and representing a particular degree of sub-pixel value interpolation, the method comprising causing an apparatus to:

~~interpolating~~ interpolate a sub-pixel value for a sub-pixel having co-ordinates with odd values of both K and L, according to a predetermined choice of either a weighted average of the value of a nearest-neighbouring pixel and the value of the sub-pixel situated at co-ordinates 1/2, 1/2, ~~and~~ or a weighted average of the values of a pair of diagonally-opposed sub-pixels having co-ordinates with even values of both K and L, including zero, situated within a quadrant of the rectangular bounded region, the quadrant being defined by ~~corner pixels~~the sub-pixel having co-ordinates 1/2, 1/2 and the nearest neighbouring pixel;

~~interpolating~~ interpolate sub-pixel values for sub-pixels having co-ordinates with K equal to an even value and L equal zero and sub-pixels having co-ordinates with K equal to zero and L equal to an even value, used in the interpolation of the sub-pixels having co-ordinates with odd values of both K and L, using weighted sums of the values of pixels located in rows and columns respectively; and

~~interpolating~~ interpolate sub-pixel values for sub-pixels having co-ordinates with even values of both K and L, used in the interpolation of sub-pixel values for the sub-pixels having co-ordinates with odd values of both K and L, using a predetermined choice of either a weighted sum of the values of sub-pixels having co-ordinates with K equal to an even value and L equal to zero and the values of sub-pixels having corresponding co-ordinates in immediately adjacent rectangular bounded regions, or a weighted sum of the values of sub-pixels having co-ordinates with K equal to zero and L equal to an even value and the values of sub-pixels having corresponding co-ordinates in immediately adjacent bounded rectangular regions.

2. (Currently Amended) A method for quarter resolution sub-pixel value interpolation to determine values for sub-pixels situated within a rectangular bounded region defined by four corner pixels with no intermediate pixels between the corners, the pixels and sub-pixels being ~~arranged~~ configured for display in rows and columns, ~~the~~ pixel and sub-pixel locations in the rows and columns being representable mathematically within the rectangular bounded region using the co-ordinate notation K/4, L/4, K and L being positive integers having respective values between zero and 4, the method comprising causing an apparatus to:

~~interpolating~~ interpolate a sub-pixel value for a sub-pixel having co-ordinates with both K and L equal to 1 or 3, according to a predetermined choice of either a weighted average of the value of a nearest-neighbouring pixel and the value of the sub-pixel situated at co-ordinates 2/4, 2/4, ~~and~~ or a weighted average of the values of a pair of diagonally-opposed sub-pixels having co-ordinates with both K and L equal to zero, 2 or 4, situated within a quadrant of the rectangular bounded region, the quadrant being defined by ~~corner pixels~~the sub-pixel having co-ordinates 2/4, 2/4 and the nearest neighbouring pixel;

~~interpolating~~ interpolate sub-pixel values for sub-pixels having co-ordinates with K equal to 2 and L equal zero and sub-pixels having co-ordinates with K equal to zero and L equal to 2, used in the interpolation of the sub-pixels having co-ordinates with both K and L equal to 1 or 3, using weighted sums of the values of pixels located in rows and columns respectively; and

~~interpolating~~ interpolate a sub-pixel value for the sub-pixel having co-ordinates with both K and L equal to 2, used in the interpolation of sub-pixel values for the sub-pixels having co-ordinates with both K and L equal to 1 or 3, using a predetermined choice of either a weighted sum of the values of the sub-pixel having co-ordinates with K equal to 2 and L equal to zero and the values of sub-pixels having corresponding co-ordinates in immediately adjacent rectangular bounded regions, or a weighted sum of the value of the sub-pixel having co-ordinates with K equal to zero and L equal to 2 and the values of sub-pixels having corresponding co-ordinates in immediately adjacent rectangular bounded regions.

3. (Currently Amended) A method for eighth resolution sub-pixel value interpolation to determine values for sub-pixels situated within a rectangular bounded region defined by four corner pixels with no intermediate pixels between the corners, the pixels and sub-pixels being ~~arranged~~ configured for display in rows and columns, ~~the~~ pixel and sub-pixel locations in the rows and columns being representable mathematically with the rectangular bounded region using the co-ordinate notation K/8, L/8, K and L being positive integers having respective values between zero and 8, the method comprising causing an apparatus to:

~~interpolating~~ interpolate a sub-pixel value for a sub-pixel having co-ordinates with both K and L equal to 1, 3, 5 or 7, according to a predetermined choice of either

a weighted average of the value of a nearest-neighbouring pixel and the value of the sub-pixel situated at co-ordinates 4/8, 4/8, ~~and~~ or a weighted average of the values of a pair of diagonally-opposed sub-pixels having co-ordinates with both K and L equal to zero, 2, 4, 6 or 8, situated within a quadrant of the rectangular bounded region, the quadrant being defined by ~~corner pixels~~the sub-pixel having co-ordinates 4/8, 4/8 and the nearest neighbouring pixel;

~~interpolating~~ interpolate sub-pixel values for sub-pixels having co-ordinates with K equal to 2, 4 or 6 and L equal zero and sub-pixels having co-ordinates with K equal to zero and L equal to 2, 4 or 6, used in the interpolation of the sub-pixels having co-ordinates with both K and L equal to 1, 3, 5 or 7, using weighted sums of the values of pixels located in rows and columns respectively; and

~~interpolating~~ interpolate sub-pixel values for sub-pixels having co-ordinates with both K and L equal to 2, 4 or 6, used in the interpolation of sub-pixel values for the sub-pixels having co-ordinates with both K and L equal to 1, 3, 5 or 7, using a predetermined choice of either a weighted sum of the values of sub-pixels having co-ordinates with K equal to 2, 4 or 6 and L equal to zero and the values of sub-pixels having corresponding co-ordinates in immediately adjacent rectangular bounded regions or a weighted sum of the values of sub-pixels having co-ordinates with K equal to zero and L equal to 2, 4 or 6 and the values of sub-pixels having corresponding co-ordinates in immediately adjacent rectangular bounded regions.

4. (New) A method according to claim 1, comprising causing the apparatus to use a first and a second weight in the weighted average chosen to interpolate the sub-pixel value for a sub-pixel having co-ordinates with odd values of both K and L, wherein when the chosen weighted average is that involving the value of a nearest

neighbouring pixel and the value of the sub-pixel situated at co-ordinates 1/2, 1/2, and to select the relative magnitudes of the first and second weights to be inversely proportional to the respective straight-line diagonal distances of the nearest-neighbouring pixel and the sub-pixel situated at co-ordinates 1/2, 1/2 to the sub-pixel having co-ordinates with odd values of both K and L whose value is being interpolated.

5. (New) A method according to claim 1, comprising causing the apparatus to use a first and a second weight in the weighted average chosen to interpolate the sub-pixel value for a sub-pixel having co-ordinates with odd values of both K and L, wherein when the chosen weighted average is that involving the values of a pair of diagonally-opposed sub-pixels having co-ordinates with even values of both K and L, and to select the relative magnitudes of the first and second weights to be inversely proportional to the respective straight-line diagonal distances of the sub-pixels having co-ordinates with even values of both K and L to the sub-pixel having co-ordinates with odd values of both K and L whose value is being interpolated.

6. (New) A method according to claim 4, comprising causing the apparatus to use first and second weights with equal values when the nearest-neighbouring pixel and sub-pixel situated at co-ordinates 1/2, 1/2 are equidistant from the sub-pixel having co-ordinates with odd values of both K and L whose value is being interpolated.

7. (New) A method according to claim 5, comprising causing the apparatus to use first and second weights with equal values when the sub-pixels having co-ordinates with even values of both K and L are equidistant from the sub-pixel having co-ordinates with odd values of both K and L whose value is being interpolated.

8. (New) A method according to claim 1, comprising causing the apparatus to interpolate sub-pixel values for sub-pixels having co-ordinates with even values of both K and L, used in interpolation of sub-pixel values for the sub-pixels having co-ordinates with odd values of both K and L, using a weighted sum of the values of sub-pixels having co-ordinates with K equal to an even value and L equal to zero and the values of sub-pixels having corresponding co-ordinates in immediately adjacent rectangular bounded regions when the value of a sub-pixel having co-ordinates with K equal to an even value and L equal to an odd value is also required.

9. (New) A method according to claim 1, comprising causing the apparatus to interpolate sub-pixel values for sub-pixels having co-ordinates with even values of both K and L, used in interpolation of sub-pixel values for the sub-pixels having co-ordinates with odd values of both K and L, using a weighted sum of the values of sub-pixels having co-ordinates with K equal to zero and L equal to an even value and the values of sub-pixels having corresponding co-ordinates in immediately adjacent rectangular bounded regions when the value of a sub-pixel having co-ordinates with K equal to an odd value and L equal to an even value is also required.

10. (New) A method according to claim 1, comprising causing the apparatus to interpolate sub-pixel values for sub-pixels having co-ordinates with K equal to an odd value O and L equal to an even value E, not including zero or $2^N$, by taking an average of the value of a first sub-pixel having co-ordinates with K equal to the even value O - 1 and L equal to E and a second sub-pixel having co-ordinates with K equal to the even value O + 1 and L equal to E.

11. (New) A method according to claim 1, comprising causing the apparatus to interpolate a sub-pixel value for a sub-pixel having co-ordinates with K equal to 1 and L

equal to zero, by taking an average of the value of a pixel having co-ordinates with K equal to zero and L equal to zero, and a sub-pixel having co-ordinates with K equal to 2 and L equal to zero.

12. (New) A method according to claim 1, comprising causing the apparatus to interpolate a sub-pixel value for a sub-pixel having co-ordinates with K equal to $2^N$ - 1 and L equal to zero, by taking an average of the value of a pixel having co-ordinates with K equal to $2^N$ and L equal to zero, and a sub-pixel having co-ordinates with K equal to $2^N$ - 2 and L equal to zero.

13. (New) A method according to claim 1, comprising causing the apparatus to interpolate a sub-pixel value for a sub-pixel having co-ordinates with K equal to 1 and L equal to $2^N$, by taking an average of the value of a pixel having co-ordinates with K equal to zero and L equal to $2^N$, and a sub-pixel having co-ordinates with K equal to 2 and L equal to $2^N$.

14. (New) A method according to claim 1, comprising causing the apparatus to interpolate a sub-pixel value for a sub-pixel having co-ordinates with K equal to $2^N$ - 1 and L equal to $2^N$, by taking an average of the value of a pixel having co-ordinates with K equal to $2^N$ and L equal to $2^N$, and a sub-pixel having co-ordinates with K equal to $2^N$ - 2 and L equal to $2^N$.

15. (New) A method according to claim 1, comprising causing the apparatus to interpolate sub-pixel values for sub-pixels having co-ordinates with K equal to an even value E, not including zero or $2^N$, and L equal to an odd value O, by taking an average of the value of a first sub-pixel having co-ordinates with K equal to E and L equal to the

even value O - 1 and a second sub-pixel having co-ordinates with K equal to E and L equal to the even value O + 1.

16. (New) A method according to claim 1, comprising causing the apparatus to interpolate a sub-pixel value for a sub-pixel having co-ordinates with K equal to zero and L equal to 1, by taking an average of the value of a pixel having co-ordinates with K equal to zero and L equal to zero, and a sub-pixel having co-ordinates with K equal to zero and L equal to 2.

17. (New) A method according to claim 1, comprising causing the apparatus to interpolate a sub-pixel value for a sub-pixel having co-ordinates with K equal to $2^N$ and L equal to 1, by taking an average of the value of a pixel having co-ordinates with K equal to $2^N$ and L equal to zero, and a sub-pixel having co-ordinates with K equal to zero and L equal to $2^N$.

18. (New) A method according to claim 1, comprising causing the apparatus to interpolate a sub-pixel value for a sub-pixel having co-ordinates with K equal to 0 and L equal to $2^N - 1$, by taking an average of the value of a pixel having co-ordinates with K equal to zero and L equal to $2^N$, and a sub-pixel having co-ordinates with K equal to zero and L equal to $2^N - 2$.

19. (New) A method according to claim 1, comprising causing the apparatus to interpolate a sub-pixel value for a sub-pixel having co-ordinates with K equal to $2^N$ and L equal to $2^N - 1$, by taking an average of the value of a pixel having co-ordinates with K equal to $2^N$ and L equal to $2^N$, and a sub-pixel having co-ordinates with K equal to $2^N$ and L equal to $2^N - 2$.

20. (New) A method according to claim 1, comprising causing the apparatus to interpolate a sub-pixel value for the sub-pixel having co-ordinates with K equal to $2^N$ - 1 and L equal to $2^N$ - 1, by taking a weighted average of the values of the four corner pixels that define the rectangular bounded region.

21. (New) A method according to claim 1, comprising causing the apparatus to select a value for N from a list consisting of the values 2, 3, and 4.

22. (New) An interpolator for sub-pixel value interpolation, the interpolator being configured to determine values for sub-pixels situated within a rectangular bounded region defined by four corner pixels with no intermediate pixels between the corners, the pixels and sub-pixels being configured for display in rows and columns, pixel and sub-pixel locations in the rows and columns being representable mathematically within the rectangular bounded region using the co-ordinate notation $K/2^N$, $L/2^N$, K and L being positive integers having respective values between zero and $2^N$, N being a positive integer greater than one and representing a particular degree of sub-pixel value interpolation, the interpolator being configured to:

interpolate a sub-pixel value for a sub-pixel having co-ordinates with odd values of both K and L, according to a predetermined choice of either a weighted average of the value of a nearest-neighbouring pixel and the value of the sub-pixel situated at co-ordinates 1/2, 1/2, or a weighted average of the values of a pair of diagonally-opposed sub-pixels having co-ordinates with even values of both K and L, including zero, situated within a quadrant of the rectangular bounded region, the quadrant being defined by the sub-pixel having co-ordinates 1/2, 1/2 and the nearest neighbouring pixel;

interpolate sub-pixel values for sub-pixels having co-ordinates with K equal to an even value and L equal zero and sub-pixels having co-ordinates with K equal to zero and L equal to an even value, used in the interpolation of the sub-pixels having co-ordinates with odd values of both K and L, using weighted sums of the values of pixels located in rows and columns respectively; and

interpolate sub-pixel values for sub-pixels having co-ordinates with even values of both K and L, used in the interpolation of sub-pixel values for the sub-pixels having co-ordinates with odd values of both K and L, using a predetermined choice of either a weighted sum of the values of sub-pixels having co-ordinates with K equal to an even value and L equal to zero and the values of sub-pixels having corresponding co-ordinates in immediately adjacent rectangular bounded regions, or a weighted sum of the values of sub-pixels having co-ordinates with K equal to zero and L equal to an even value and the values of sub-pixels having corresponding co-ordinates in immediately adjacent bounded rectangular regions.

23. (New) An interpolator according to claim 22, wherein the interpolator is configured to use a first and a second weight in the weighted average chosen to interpolate the sub-pixel value for a sub-pixel having co-ordinates with odd values of both K and L, wherein when the chosen weighted average is that involving the value of a nearest neighbouring pixel and the value of the sub-pixel situated at co-ordinates 1/2, 1/2, the interpolator is configured to select the relative magnitudes of the first and second weights to be inversely proportional to the respective straight-line diagonal distances of the nearest-neighbouring pixel and the sub-pixel situated at co-ordinates 1/2, 1/2 to the sub-pixel having co-ordinates with odd values of both K and L whose value is being interpolated.

24. (New) An interpolator according to claim 22, wherein the interpolator is configured to use a first and a second weight in the weighted average chosen to interpolate the sub-pixel value for a sub-pixel having co-ordinates with odd values of both K and L, wherein when the chosen weighted average is that involving the values of a pair of diagonally-opposed sub-pixels having co-ordinates with even values of both K and L, the interpolator is configured to select the relative magnitudes of the first and second weights to be inversely proportional to the respective straight-line diagonal distances of the sub-pixels having co-ordinates with even values of both K and L to the sub-pixel having co-ordinates with odd values of both K and L whose value is being interpolated.

25. (New) An interpolator according to claim 23, wherein the interpolator is configured to use first and second weights with equal values when the nearest-neighbouring pixel and sub-pixel situated at co-ordinates 1/2, 1/2 are equidistant from the sub-pixel having co-ordinates with odd values of both K and L whose value is being interpolated.

26. (New) An interpolator according to claim 24, wherein the interpolator is configured to use first and second weights with equal values when the sub-pixels having co-ordinates with even values of both K and L are equidistant from the sub-pixel having co-ordinates with odd values of both K and L whose value is being interpolated.

27. (New) An interpolator according to claim 22, wherein the interpolator is configured to interpolate sub-pixel values for sub-pixels having co-ordinates with even values of both K and L, used in interpolation of sub-pixel values for the sub-pixels having co-ordinates with odd values of both K and L, using a weighted sum of the values of sub-pixels having co-ordinates with K equal to an even value and L equal to

zero and the values of sub-pixels having corresponding co-ordinates in immediately adjacent rectangular bounded regions when the value of a sub-pixel having co-ordinates with K equal to an even value and L equal to an odd value is also required.

28. (New) An interpolator according to claim 22, wherein the interpolator is configured to interpolate sub-pixel values for sub-pixels having co-ordinates with even values of both K and L, used in interpolation of sub-pixel values for the sub-pixels having co-ordinates with odd values of both K and L, using a weighted sum of the values of sub-pixels having co-ordinates with K equal to zero and L equal to an even value and the values of sub-pixels having corresponding co-ordinates in immediately adjacent rectangular bounded regions when the value of a sub-pixel having co-ordinates with K equal to an odd value and L equal to an even value is also required.

29. (New) An interpolator according to claim 22, wherein the interpolator is configured to interpolate sub-pixel values for sub-pixels having co-ordinates with K equal to an odd value O and L equal to an even value E, not including zero or $2^N$, by taking an average of the value of a first sub-pixel having co-ordinates with K equal to the even value O - 1 and L equal to E and a second sub-pixel having co-ordinates with K equal to the even value O + 1 and L equal to E.

30. (New) An interpolator according to claim 22, wherein the interpolator is configured to interpolate a sub-pixel value for a sub-pixel having co-ordinates with K equal to 1 and L equal to zero, by taking an average of the value of a pixel having co-ordinates with K equal to zero and L equal to zero, and a sub-pixel having co-ordinates with K equal to 2 and L equal to zero.

31. (New) An interpolator according to claim 22, wherein the interpolator is configured to interpolate a sub-pixel value for a sub-pixel having co-ordinates with K equal to $2^N$ - 1 and L equal to zero, by taking an average of the value of a pixel having co-ordinates with K equal to $2^N$ and L equal to zero, and a sub-pixel having co-ordinates with K equal to $2^N$ - 2 and L equal to zero.

32. (New) An interpolator according to claim 22, wherein the interpolator is configured to interpolate a sub-pixel value for a sub-pixel having co-ordinates with K equal to 1 and L equal to $2^N$, by taking an average of the value of a pixel having co-ordinates with K equal to zero and L equal to $2^N$, and a sub-pixel having co-ordinates with K equal to 2 and L equal to $2^N$.

33. (New) An interpolator according to claim 22, wherein the interpolator is configured to interpolate a sub-pixel value for a sub-pixel having co-ordinates with K equal to $2^N$ - 1 and L equal to $2^N$, by taking an average of the value of a pixel having co-ordinates with K equal to $2^N$ and L equal to $2^N$, and a sub-pixel having co-ordinates with K equal to $2^N$ - 2 and L equal to $2^N$.

34. (New) An interpolator according to claim 22, wherein the interpolator is configured to interpolate sub-pixel values for sub-pixels having co-ordinates with K equal to an even value E, not including zero or $2^N$, and L equal to an odd value O, by taking an average of the value of a first sub-pixel having co-ordinates with K equal to E and L equal to the even value O - 1 and a second sub-pixel having co-ordinates with K equal to E and L equal to the even value O + 1.

35. (New) An interpolator according to claim 22, wherein the interpolator is configured to interpolate a sub-pixel value for a sub-pixel having co-ordinates with K equal to zero and L equal to 1, by taking an average of the value of a pixel having co-ordinates with K equal to zero and L equal to zero, and a sub-pixel having co-ordinates with K equal to zero and L equal to 2.

36. (New) An interpolator according to claim 22, wherein the interpolator is configured to interpolate a sub-pixel value for a sub-pixel having co-ordinates with K equal to $2^N$ and L equal to 1, by taking an average of the value of a pixel having co-ordinates with K equal to $2^N$ and L equal to zero, and a sub-pixel having co-ordinates with K equal to zero and L equal to $2^N$.

37. (New) An interpolator according to claim 22, wherein the interpolator is configured to interpolate a sub-pixel value for a sub-pixel having co-ordinates with K equal to 0 and L equal to $2^N - 1$, by taking an average of the value of a pixel having co-ordinates with K equal to zero and L equal to $2^N$, and a sub-pixel having co-ordinates with K equal to zero and L equal to $2^N - 2$.

38. (New) An interpolator according to claim 22, wherein the interpolator is configured to interpolate a sub-pixel value for a sub-pixel having co-ordinates with K equal to $2^N$ and L equal to $2^N - 1$, by taking an average of the value of a pixel having co-ordinates with K equal to $2^N$ and L equal to $2^N$, and a sub-pixel having co-ordinates with K equal to $2^N$ and L equal to $2^N - 2$.

39. (New) An interpolator according to claim 22, wherein the interpolator is configured to interpolate a sub-pixel value for the sub-pixel having co-ordinates with K

equal to $2^N$ - 1 and L equal to $2^N$ - 1, by taking a weighted average of the values of the four corner pixels that define the rectangular bounded region.

40. (New) An interpolator according to claim 22, wherein N is set equal to 2.

41. (New) An interpolator according to claim 22, wherein N is set equal to 3.

42. (New) A video encoder comprising an interpolator for sub-pixel value interpolation, the interpolator being configured to determine values for sub-pixels situated within a rectangular bounded region defined by four corner pixels with no intermediate pixels between the corners, the pixels and sub-pixels being configured for display in rows and columns, pixel and sub-pixel locations in the rows and columns being representable mathematically within the rectangular bounded region using the co-ordinate notation $K/2^N$, $L/2^N$, K and L being positive integers having respective values between zero and $2^N$, N being a positive integer greater than one and representing a particular degree of sub-pixel value interpolation, the interpolator being configured to:

interpolate a sub-pixel value for a sub-pixel having co-ordinates with odd values of both K and L, according to a predetermined choice of either a weighted average of the value of a nearest-neighbouring pixel and the value of the sub-pixel situated at co-ordinates 1/2, 1/2, or a weighted average of the values of a pair of diagonally-opposed sub-pixels having co-ordinates with even values of both K and L, including zero, situated within a quadrant of the rectangular bounded region, the quadrant being defined by the sub-pixel having co-ordinates 1/2, 1/2 and the nearest neighbouring pixel;

interpolate sub-pixel values for sub-pixels having co-ordinates with K equal to an even value and L equal zero and sub-pixels having co-ordinates with K equal to zero and L equal to an even value, used in the interpolation of the sub-pixels having co-ordinates with odd values of both K and L, using weighted sums of the values of pixels located in rows and columns respectively; and

interpolate sub-pixel values for sub-pixels having co-ordinates with even values of both K and L, used in the interpolation of sub-pixel values for the sub-pixels having co-ordinates with odd values of both K and L, using a predetermined choice of either a weighted sum of the values of sub-pixels having co-ordinates with K equal to an even value and L equal to zero and the values of sub-pixels having corresponding co-ordinates in immediately adjacent rectangular bounded regions, or a weighted sum of the values of sub-pixels having co-ordinates with K equal to zero and L equal to an even value and the values of sub-pixels having corresponding co-ordinates in immediately adjacent bounded rectangular regions.

43. (New) A still image encoder comprising an interpolator for sub-pixel value interpolation, the interpolator being configured to determine values for sub-pixels situated within a rectangular bounded region defined by four corner pixels with no intermediate pixels between the corners, the pixels and sub-pixels being configured for display in rows and columns, pixel and sub-pixel locations in the rows and columns being representable mathematically within the rectangular bounded region using the co-ordinate notation $K/2^N$, $L/2^N$, K and L being positive integers having respective values between zero and $2^N$, N being a positive integer greater than one and representing a particular degree of sub-pixel value interpolation, the interpolator being configured to:

interpolate a sub-pixel value for a sub-pixel having co-ordinates with odd values of both K and L, according to a predetermined choice of either a weighted average of the value of a nearest-neighbouring pixel and the value of the sub-pixel situated at co-ordinates 1/2, 1/2, or a weighted average of the values of a pair of diagonally-opposed sub-pixels having co-ordinates with even values of both K and L, including zero, situated within a quadrant of the rectangular bounded region, the quadrant being defined by the sub-pixel having co-ordinates 1/2, 1/2 and the nearest neighbouring pixel;

interpolate sub-pixel values for sub-pixels having co-ordinates with K equal to an even value and L equal zero and sub-pixels having co-ordinates with K equal to zero and L equal to an even value, used in the interpolation of the sub-pixels having co-ordinates with odd values of both K and L, using weighted sums of the values of pixels located in rows and columns respectively; and

interpolate sub-pixel values for sub-pixels having co-ordinates with even values of both K and L, used in the interpolation of sub-pixel values for the sub-pixels having co-ordinates with odd values of both K and L, using a predetermined choice of either a weighted sum of the values of sub-pixels having co-ordinates with K equal to an even value and L equal to zero and the values of sub-pixels having corresponding co-ordinates in immediately adjacent rectangular bounded regions, or a weighted sum of the values of sub-pixels having co-ordinates with K equal to zero and L equal to an even value and the values of sub-pixels having corresponding co-ordinates in immediately adjacent bounded rectangular regions.

44. (New) A video decoder comprising an interpolator for sub-pixel value interpolation, the interpolator being configured to determine values for sub-pixels

situated within a rectangular bounded region defined by four corner pixels with no intermediate pixels between the corners, the pixels and sub-pixels being configured for display in rows and columns, pixel and sub-pixel locations in the rows and columns being representable mathematically within the rectangular bounded region using the co-ordinate notation $K/2^N$, $L/2^N$, K and L being positive integers having respective values between zero and $2^N$, N being a positive integer greater than one and representing a particular degree of sub-pixel value interpolation, the interpolator being configured to:

interpolate a sub-pixel value for a sub-pixel having co-ordinates with odd values of both K and L, according to a predetermined choice of a either weighted average of the value of a nearest-neighbouring pixel and the value of the sub-pixel situated at co-ordinates 1/2, 1/2, or a weighted average of the values of a pair of diagonally-opposed sub-pixels having co-ordinates with even values of both K and L, including zero, situated within a quadrant of the rectangular bounded region, the quadrant being defined by the sub-pixel having co-ordinates 1/2, 1/2 and the nearest neighbouring pixel;

interpolate sub-pixel values for sub-pixels having co-ordinates with K equal to an even value and L equal zero and sub-pixels having co-ordinates with K equal to zero and L equal to an even value, used in the interpolation of the sub-pixels having co-ordinates with odd values of both K and L, using weighted sums of the values of pixels located in rows and columns respectively; and

interpolate sub-pixel values for sub-pixels having co-ordinates with even values of both K and L, used in the interpolation of sub-pixel values for the sub-pixels having co-ordinates with odd values of both K and L, using a predetermined choice of either a weighted sum of the values of sub-pixels having co-ordinates with K equal to an even value and L equal to zero and the values of sub-pixels having corresponding co-ordinates in immediately adjacent rectangular bounded

regions, or a weighted sum of the values of sub-pixels having co-ordinates with K equal to zero and L equal to an even value and the values of sub-pixels having corresponding co-ordinates in immediately adjacent bounded rectangular regions.

45. (New) A still image decoder comprising an interpolator for sub-pixel value interpolation, the interpolator being configured to determine values for sub-pixels situated within a rectangular bounded region defined by four corner pixels with no intermediate pixels between the corners, the pixels and sub-pixels being configured for display in rows and columns, pixel and sub-pixel locations in the rows and columns being representable mathematically within the rectangular bounded region using the co-ordinate notation $K/2^N$, $L/2^N$, K and L being positive integers having respective values between zero and $2^N$, N being a positive integer greater than one and representing a particular degree of sub-pixel value interpolation, the interpolator being configured to:

interpolate a sub-pixel value for a sub-pixel having co-ordinates with odd values of both K and L, according to a predetermined choice of either a weighted average of the value of a nearest-neighbouring pixel and the value of the sub-pixel situated at co-ordinates 1/2, 1/2, or a weighted average of the values of a pair of diagonally-opposed sub-pixels having co-ordinates with even values of both K and L, including zero, situated within a quadrant of the rectangular bounded region, the quadrant being defined by the sub-pixel having co-ordinates 1/2, 1/2 and the nearest neighbouring pixel;

interpolate sub-pixel values for sub-pixels having co-ordinates with K equal to an even value and L equal zero and sub-pixels having co-ordinates with K equal to zero and L equal to an even value, used in the interpolation of the sub-pixels

having co-ordinates with odd values of both K and L, using weighted sums of the values of pixels located in rows and columns respectively; and

interpolate sub-pixel values for sub-pixels having co-ordinates with even values of both K and L, used in the interpolation of sub-pixel values for the sub-pixels having co-ordinates with odd values of both K and L, using a predetermined choice of either a weighted sum of the values of sub-pixels having co-ordinates with K equal to an even value and L equal to zero and the values of sub-pixels having corresponding co-ordinates in immediately adjacent rectangular bounded regions, or a weighted sum of the values of sub-pixels having co-ordinates with K equal to zero and L equal to an even value and the values of sub-pixels having corresponding co-ordinates in immediately adjacent bounded rectangular regions.

46. (New) A codec comprising a video encoder according to claim 42 and a video decoder according to claim 44.

47. (New) A codec comprising a still image encoder according to claim 43 and a still image decoder according to claim 45.

48. (New) A communications terminal comprising a video encoder according to claim 42.

49. (New) A communications terminal comprising a still image encoder according to claim 43.

50. (New) A communications terminal comprising a video decoder according to claim 44.

51. (New) A communications terminal comprising a still image decoder according to claim 45.

52. (New) A communications terminal according to claim 48, wherein the communications terminal is a wireless terminal.

53. (New) An interpolator for sub-pixel value interpolation, the interpolator being configured to determine values for sub-pixels situated within a rectangular bounded region defined by four corner pixels with no intermediate pixels between the corners, the pixels and sub-pixels being configured for display in rows and columns, pixel and sub-pixel locations in the rows and columns being representable mathematically within the rectangular bounded region using the co-ordinate notation $K/2^N$, $L/2^N$, K and L being positive integers having respective values between zero and $2^N$, N being a positive integer greater than one and representing a particular degree of sub-pixel value interpolation, the interpolator comprising:

circuitry configured to interpolate a sub-pixel value for a sub-pixel having co-ordinates with odd values of both K and L, according to a predetermined choice of either a weighted average of the value of a nearest-neighbouring pixel and the value of the sub-pixel situated at co-ordinates 1/2, 1/2, and a weighted average of the values of a pair of diagonally-opposed sub-pixels having co-ordinates with even values of both K and L, including zero, situated within a quadrant of the rectangular bounded region, the quadrant being defined by the sub-pixel having co-ordinates 1/2, 1/2 and the nearest neighbouring pixel;

circuitry configured to interpolate sub-pixel values for sub-pixels having co-ordinates with K equal to an even value and L equal zero and sub-pixels having co-ordinates with K equal to zero and L equal to an even value, used in the interpolation of the sub-pixels having co-ordinates with odd values of both K and L, using weighted sums of the values of pixels located in rows and columns respectively; and

circuitry configured to interpolate sub-pixel values for sub-pixels having co-ordinates with even values of both K and L, used in the interpolation of sub-pixel values for the sub-pixels having co-ordinates with odd values of both K and L, using a predetermined choice of either a weighted sum of the values of sub-pixels having co-ordinates with K equal to an even value and L equal to zero and the values of sub-pixels having corresponding co-ordinates in immediately adjacent rectangular bounded regions, or a weighted sum of the values of sub-pixels having co-ordinates with K equal to zero and L equal to an even value and the values of sub-pixels having corresponding co-ordinates in immediately adjacent bounded rectangular regions.

54. (New) An interpolator for quarter resolution sub-pixel value interpolation, the interpolator being configured to determine values for sub-pixels situated within a rectangular bounded region defined by four corner pixels with no intermediate pixels between the corners, the pixels and sub-pixels being configured for display in rows and columns, pixel and sub-pixel locations in the rows and columns being representable mathematically within the rectangular bounded region using the co-ordinate notation K/4, L/4, K and L being positive integers having respective values between zero and 4, the interpolator being configured to:

interpolate a sub-pixel value for a sub-pixel having co-ordinates with both K and L equal to 1 or 3, according to a predetermined choice of either a weighted average of the value of a nearest-neighbouring pixel and the value of the sub-pixel situated at co-ordinates 2/4, 2/4, or a weighted average of the values of a pair of diagonally-opposed sub-pixels having co-ordinates with both K and L equal to zero, 2 or 4, situated within a quadrant of the rectangular bounded region, the quadrant being defined by the sub-pixel having co-ordinates 2/4, 2/4 and the nearest neighbouring pixel;

interpolate sub-pixel values for sub-pixels having co-ordinates with K equal to 2 and L equal zero and sub-pixels having co-ordinates with K equal to zero and L equal to 2, used in the interpolation of the sub-pixels having co-ordinates with both K and L equal to 1 or 3, using weighted sums of the values of pixels located in rows and columns respectively; and

interpolate a sub-pixel value for the sub-pixel having co-ordinates with both K and L equal to 2, used in the interpolation of sub-pixel values for the sub-pixels having co-ordinates with both K and L equal to 1 or 3, using a predetermined choice of either a weighted sum of the values of the sub-pixel having co-ordinates with K equal to 2 and L equal to zero and the values of sub-pixels having corresponding co-ordinates in immediately adjacent rectangular bounded regions, or a weighted sum of the value of the sub-pixel having co-ordinates with K equal to zero and L equal to 2 and the values of sub-pixels having corresponding co-ordinates in immediately adjacent rectangular bounded regions.

55. (New) An interpolator for eighth resolution sub-pixel value interpolation, the interpolator being configured to determine values for sub-pixels situated within a rectangular bounded region defined by four corner pixels with no intermediate pixels

between the corners, the pixels and sub-pixels being configured for display in rows and columns, pixel and sub-pixel locations in the rows and columns being representable mathematically with the rectangular bounded region using the co-ordinate notation K/8, L/8, K and L being positive integers having respective values between zero and 8, the interpolator being configured to:

interpolate a sub-pixel value for a sub-pixel having co-ordinates with both K and L equal to 1, 3, 5 or 7, according to a predetermined choice of either a weighted average of the value of a nearest-neighbouring pixel and the value of the sub-pixel situated at co-ordinates 4/8, 4/8, or a weighted average of the values of a pair of diagonally-opposed sub-pixels having co-ordinates with both K and L equal to zero, 2, 4, 6 or 8, situated within a quadrant of the rectangular bounded region, the quadrant being defined by the sub-pixel having co-ordinates 4/8, 4/8 and the nearest neighbouring pixel;

interpolate sub-pixel values for sub-pixels having co-ordinates with K equal to 2, 4 or 6 and L equal zero and sub-pixels having co-ordinates with K equal to zero and L equal to 2, 4 or 6, used in the interpolation of the sub-pixels having co-ordinates with both K and L equal to 1, 3, 5 or 7, using weighted sums of the values of pixels located in rows and columns respectively; and

interpolate sub-pixel values for sub-pixels having co-ordinates with both K and L equal to 2, 4 or 6, used in the interpolation of sub-pixel values for the sub-pixels having co-ordinates with both K and L equal to 1, 3, 5 or 7, using a predetermined choice of either a weighted sum of the values of sub-pixels having co-ordinates with K equal to 2, 4 or 6 and L equal to zero and the values of sub-pixels having corresponding co-ordinates in immediately adjacent rectangular bounded regions or a weighted sum of the values of sub-pixels having co-ordinates with K equal to zero and L equal to 2, 4 or 6 and the values of sub-

pixels having corresponding co-ordinates in immediately adjacent rectangular bounded regions.

56. (New) A video encoder or still image encoder comprising an interpolator according to claim 54 or 55.

57. (New) A video decoder or still image decoder comprising an interpolator according to claim 54 or 55.

58. (New) A communications terminal comprising a video encoder or still image encoder according to claim 56.

59. (New) A communications terminal comprising a video decoder or still image decoder according to claim 57.

60. (New) A computer program embodied on a computer readable storage medium for sub-pixel value interpolation, the computer program being configured to determine values for sub-pixels situated within a rectangular bounded region defined by four corner pixels with no intermediate pixels between the corners, the pixels and sub-pixels being configured for display in rows and columns, pixel and sub-pixel locations in the rows and columns being representable mathematically within the rectangular bounded region using the co-ordinate notation $K/2^N$, $L/2^N$, K and L being positive integers having respective values between zero and $2^N$, N being a positive integer greater than one and representing a particular degree of sub-pixel value interpolation, the computer program comprising:

computer program code for interpolating a sub-pixel value for a sub-pixel having co-ordinates with odd values of both K and L, according to a predetermined choice of either a weighted average of the value of a nearest-neighbouring pixel and the value of the sub-pixel situated at co-ordinates 1/2, 1/2, or a weighted average of the values of a pair of diagonally-opposed sub-pixels having co-ordinates with even values of both K and L, including zero, situated within a quadrant of the rectangular bounded region, the quadrant being defined by the sub-pixel having co-ordinates 1/2, 1/2 and the nearest neighbouring pixel;

computer program code for interpolating sub-pixel values for sub-pixels having co-ordinates with K equal to an even value and L equal zero and sub-pixels having co-ordinates with K equal to zero and L equal to an even value, used in the interpolation of the sub-pixels having co-ordinates with odd values of both K and L, using weighted sums of the values of pixels located in rows and columns respectively; and

computer program code for interpolating sub-pixel values for sub-pixels having co-ordinates with even values of both K and L, used in the interpolation of sub-pixel values for the sub-pixels having co-ordinates with odd values of both K and L, using a predetermined choice of either a weighted sum of the values of sub-pixels having co-ordinates with K equal to an even value and L equal to zero and the values of sub-pixels having corresponding co-ordinates in immediately adjacent rectangular bounded regions, or a weighted sum of the values of sub-pixels having co-ordinates with K equal to zero and L equal to an even value and the values of sub-pixels having corresponding co-ordinates in immediately adjacent bounded rectangular regions.

61. (New) A network apparatus comprising an interpolator for sub-pixel value interpolation, the interpolator being configured to determine values for sub-pixels situated within a rectangular bounded region defined by four corner pixels with no intermediate pixels between the corners, the pixels and sub-pixels being configured for display in rows and columns, pixel and sub-pixel locations in the rows and columns being representable mathematically within the rectangular bounded region using the co-ordinate notation $K/2^N$, $L/2^N$, K and L being positive integers having respective values between zero and $2^N$, N being a positive integer greater than one and representing a particular degree of sub-pixel value interpolation, the interpolator being configured to:

interpolate a sub-pixel value for a sub-pixel having co-ordinates with odd values of both K and L, according to a predetermined choice of either a weighted average of the value of a nearest-neighbouring pixel and the value of the sub-pixel situated at co-ordinates 1/2, 1/2, or a weighted average of the values of a pair of diagonally-opposed sub-pixels having co-ordinates with even values of both K and L, including zero, situated within a quadrant of the rectangular bounded region, the quadrant being defined by the sub-pixel having co-ordinates 1/2, 1/2 and the nearest neighbouring pixel;

interpolate sub-pixel values for sub-pixels having co-ordinates with K equal to an even value and L equal zero and sub-pixels having co-ordinates with K equal to zero and L equal to an even value, used in the interpolation of the sub-pixels having co-ordinates with odd values of both K and L, using weighted sums of the values of pixels located in rows and columns respectively; and

interpolate sub-pixel values for sub-pixels having co-ordinates with even values of both K and L, used in the interpolation of sub-pixel values for the sub-pixels having co-ordinates with odd values of both K and L, using a predetermined choice of either a weighted sum of the values of sub-pixels having co-ordinates

with K equal to an even value and L equal to zero and the values of sub-pixels having corresponding co-ordinates in immediately adjacent rectangular bounded regions, or a weighted sum of the values of sub-pixels having co-ordinates with K equal to zero and L equal to an even value and the values of sub-pixels having corresponding co-ordinates in immediately adjacent bounded rectangular regions.

## III. REMARKS

1. Claims 1-3 are amended. Claims 4-61 are new and directed to various aspects of the invention. No new subject matter is presented.

2. Claims 1-3 are amended to address the double patenting rejection. It is respectfully submitted that the claims as amended do not claim the same invention as US Patent No. 7,280,599 and the rejection is now moot.

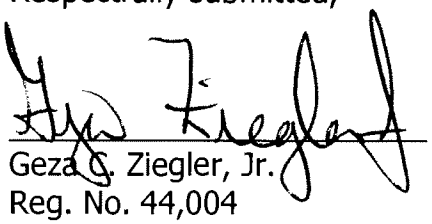
3. A terminal disclaimer over US Patent No. 6,950,469 is being submitted herewith to address the non-statutory obviousness type double patenting rejection.

4. Claims 1-3 are amended to address the rejection under 35 USC §101.

It is respectfully submitted that all of the claims now present in the application are clearly novel and patentable over the prior art of record, and are in proper form for allowance. Accordingly, favorable reconsideration and allowance is respectfully requested. Should any unresolved issues remain, the Examiner is invited to call Applicant's attorney at the telephone number indicated below.

The Commissioner is hereby authorized to charge payment for any fees associated with this communication or credit any overpayment to Deposit Account No. 16-1350.

Respectfully submitted,



Geza C. Ziegler, Jr.
Reg. No. 44,004

10 August 2009
Date

Perman & Green, LLP
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Stratford, CT 06614
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Customer No.: 2512

PTO/SB/26 (07-09)
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| **TERMINAL DISCLAIMER TO OBVIATE A DOUBLE PATENTING REJECTION OVER A "PRIOR" PATENT** | Docket Number (Optional) |
|---|---|

In re Application of: Marta Karczewicz

Application No.: 11/839,205

Filed: 08/15/2007

For: METHOD FOR SUB-PIXEL VALUE INTERPOLATION

The owner*, Nokia Corporation, of 100 percent interest in the instant application hereby disclaims, except as provided below, the terminal part of the statutory term of any patent granted on the instant application which would extend beyond the expiration date of the full statutory term **prior patent** No. 6,950,469 B2 as the term of said prior patent is defined in 35 U.S.C. 154 and 173, and as the term of said **prior patent** is presently shortened by any terminal disclaimer. The owner hereby agrees that any patent so granted on the instant application shall be enforceable only for and during such period that it and the **prior patent** are commonly owned. This agreement runs with any patent granted on the instant application and is binding upon the grantee, its successors or assigns.

In making the above disclaimer, the owner does not disclaim the terminal part of the term of any patent granted on the instant application that would extend to the expiration date of the full statutory term as defined in 35 U.S.C. 154 and 173 of the **prior patent**, "as the term of said **prior patent** is presently shortened by any terminal disclaimer," in the event that said **prior patent** later:

expires for failure to pay a maintenance fee;
is held unenforceable;
is found invalid by a court of competent jurisdiction;
is statutorily disclaimed in whole or terminally disclaimed under 37 CFR 1.321;
has all claims canceled by a reexamination certificate;
is reissued; or
is in any manner terminated prior to the expiration of its full statutory term as presently shortened by any terminal disclaimer.

Check either box 1 or 2 below, if appropriate.

1. ☐ For submissions on behalf of a business/organization (e.g., corporation, partnership, university, government agency, etc.), the undersigned is empowered to act on behalf of the business/organization.

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

2. ☑ The undersigned is an attorney or agent of record. Reg. No. 44,004

/gcz44004/ — Signature
2009-08-07 — Date

Geza C. Ziegler, Jr. — Typed or printed name

203-259-1800 — Telephone Number

☑ Terminal disclaimer fee under 37 CFR 1.20(d) included.

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*Statement under 37 CFR 3.73(b) is required if terminal disclaimer is signed by the assignee (owner).
Form PTO/SB/96 may be used for making this certification. See MPEP § 324.

This collection of information is required by 37 CFR 1.321. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.11 and 1.14. This collection is estimated to take 12 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

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5. A record related to an International Application filed under the Patent Cooperation Treaty in this system of records may be disclosed, as a routine use, to the International Bureau of the World Intellectual Property Organization, pursuant to the Patent Cooperation Treaty.
6. A record in this system of records may be disclosed, as a routine use, to another federal agency for purposes of National Security review (35 U.S.C. 181) and for review pursuant to the Atomic Energy Act (42 U.S.C. 218(c)).
7. A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (*i.e.*, GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.
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# Electronic Patent Application Fee Transmittal

| | |
|---|---|
| **Application Number:** | 11839205 |
| **Filing Date:** | 15-Aug-2007 |
| **Title of Invention:** | METHOD FOR SUB-PIXEL VALUE INTERPOLATION |
| **First Named Inventor/Applicant Name:** | Marta Karczewicz |
| **Filer:** | GEZA C ZIEGLER JR/fran snow |
| **Attorney Docket Number:** | 982-010567-US (C02) |

Filed as Large Entity

## Utility under 35 USC 111(a) Filing Fees

| Description | Fee Code | Quantity | Amount | Sub-Total in USD($) |
|---|---|---|---|---|
| **Basic Filing:** | | | | |
| **Pages:** | | | | |
| **Claims:** | | | | |
| Claims in excess of 20 | 1202 | 41 | 52 | 2132 |
| Independent claims in excess of 3 | 1201 | 10 | 220 | 2200 |
| Multiple dependent claims | 1203 | 1 | 390 | 390 |
| **Miscellaneous-Filing:** | | | | |
| **Petition:** | | | | |
| **Patent-Appeals-and-Interference:** | | | | |

| Description | Fee Code | Quantity | Amount | Sub-Total in USD($) |
|---|---|---|---|---|
| **Post-Allowance-and-Post-Issuance:** | | | | |
| **Extension-of-Time:** | | | | |
| Extension - 3 months with $0 paid | 1253 | 1 | 1110 | 1110 |
| **Miscellaneous:** | | | | |
| Statutory disclaimer | 1814 | 1 | 140 | 140 |
| | | **Total in USD ($)** | | **5972** |

# Electronic Acknowledgement Receipt

| | |
|---|---|
| **EFS ID:** | 5854657 |
| **Application Number:** | 11839205 |
| **International Application Number:** | |
| **Confirmation Number:** | 8091 |
| **Title of Invention:** | METHOD FOR SUB-PIXEL VALUE INTERPOLATION |
| **First Named Inventor/Applicant Name:** | Marta Karczewicz |
| **Customer Number:** | 02512 |
| **Filer:** | GEZA C ZIEGLER JR/fran snow |
| **Filer Authorized By:** | GEZA C ZIEGLER JR |
| **Attorney Docket Number:** | 982-010567-US (C02) |
| **Receipt Date:** | 10-AUG-2009 |
| **Filing Date:** | 15-AUG-2007 |
| **Time Stamp:** | 10:25:18 |
| **Application Type:** | Utility under 35 USC 111(a) |

## Payment information:

| | |
|---|---|
| Submitted with Payment | yes |
| Payment Type | Deposit Account |
| Payment was successfully received in RAM | $5972 |
| RAM confirmation Number | 6323 |
| Deposit Account | 161350 |
| Authorized User | |

## File Listing:

| Document Number | Document Description | File Name | File Size(Bytes)/ Message Digest | Multi Part /.zip | Pages (if appl.) |
|---|---|---|---|---|---|

| | | | | | |
|---|---|---|---|---|---|
| 1 | | OAResponse090810.pdf | 1061777<br>d60d657f95596597fe95a28019d63a1ee9813eda | yes | 30 |

| Multipart Description/PDF files in .zip description | | |
|---|---|---|
| **Document Description** | **Start** | **End** |
| Amendment/Req. Reconsideration-After Non-Final Reject | 1 | 1 |
| Claims | 2 | 29 |
| Applicant Arguments/Remarks Made in an Amendment | 30 | 30 |

**Warnings:**

**Information:**

| | | | | | |
|---|---|---|---|---|---|
| 2 | Terminal Disclaimer Filed | TerminalDisclaimer090807.pdf | 209593<br>b633a60e7cc55901d3ef1729deb52288690904f1 | no | 2 |

**Warnings:**

**Information:**

| | | | | | |
|---|---|---|---|---|---|
| 3 | Fee Worksheet (PTO-875) | fee-info.pdf | 39096<br>c175bec2b3e3035951e894a3fe14afaeb5b203ee | no | 2 |

**Warnings:**

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| **Total Files Size (in bytes):** | 1310466 |

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**If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.**

**New International Application Filed with the USPTO as a Receiving Office**

**If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.**

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# PATENT APPLICATION FEE DETERMINATION RECORD

Substitute for Form PTO-875

| Application or Docket Number | Filing Date | ☐ To be Mailed |
|---|---|---|
| 11/839,205 | 08/15/2007 | |

## APPLICATION AS FILED – PART I

| FOR | (Column 1) NUMBER FILED | (Column 2) NUMBER EXTRA | SMALL ENTITY ☐ RATE ($) | SMALL ENTITY ☐ FEE ($) | OR | OTHER THAN SMALL ENTITY RATE ($) | OTHER THAN SMALL ENTITY FEE ($) |
|---|---|---|---|---|---|---|---|
| ☐ BASIC FEE (37 CFR 1.16(a), (b), or (c)) | N/A | N/A | N/A | | | N/A | |
| ☐ SEARCH FEE (37 CFR 1.16(k), (i), or (m)) | N/A | N/A | N/A | | | N/A | |
| ☐ EXAMINATION FEE (37 CFR 1.16(o), (p), or (q)) | N/A | N/A | N/A | | | N/A | |
| TOTAL CLAIMS (37 CFR 1.16(i)) | minus 20 = | * | X $ = | | OR | X $ = | |
| INDEPENDENT CLAIMS (37 CFR 1.16(h)) | minus 3 = | * | X $ = | | | X $ = | |
| ☐ APPLICATION SIZE FEE (37 CFR 1.16(s)) | If the specification and drawings exceed 100 sheets of paper, the application size fee due is $250 ($125 for small entity) for each additional 50 sheets or fraction thereof. See 35 U.S.C. 41(a)(1)(G) and 37 CFR 1.16(s). | | | | | | |
| ☐ MULTIPLE DEPENDENT CLAIM PRESENT (37 CFR 1.16(j)) | | | | | | | |
| * If the difference in column 1 is less than zero, enter "0" in column 2. | | | TOTAL | | | TOTAL | |

## APPLICATION AS AMENDED – PART II

| AMENDMENT 08/10/2009 | (Column 1) CLAIMS REMAINING AFTER AMENDMENT | | (Column 2) HIGHEST NUMBER PREVIOUSLY PAID FOR | (Column 3) PRESENT EXTRA | SMALL ENTITY RATE ($) | SMALL ENTITY ADDITIONAL FEE ($) | OR | OTHER THAN SMALL ENTITY RATE ($) | OTHER THAN SMALL ENTITY ADDITIONAL FEE ($) |
|---|---|---|---|---|---|---|---|---|---|
| Total (37 CFR 1.16(i)) | * 61 | Minus | ** 20 | = 41 | X $ = | | OR | X $52= | 2132 |
| Independent (37 CFR 1.16(h)) | * 13 | Minus | ***3 | = 10 | X $ = | | OR | X $220= | 2200 |
| ☐ Application Size Fee (37 CFR 1.16(s)) | | | | | | | | | |
| ☐ FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j)) | | | | | | | OR | | |
| | | | | | TOTAL ADD'L FEE | | OR | TOTAL ADD'L FEE | 4332 |

| AMENDMENT | (Column 1) CLAIMS REMAINING AFTER AMENDMENT | | (Column 2) HIGHEST NUMBER PREVIOUSLY PAID FOR | (Column 3) PRESENT EXTRA | RATE ($) | ADDITIONAL FEE ($) | | RATE ($) | ADDITIONAL FEE ($) |
|---|---|---|---|---|---|---|---|---|---|
| Total (37 CFR 1.16(i)) | * | Minus | ** | = | X $ = | | OR | X $ = | |
| Independent (37 CFR 1.16(h)) | * | Minus | *** | = | X $ = | | OR | X $ = | |
| ☐ Application Size Fee (37 CFR 1.16(s)) | | | | | | | | | |
| ☐ FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j)) | | | | | | | OR | | |
| | | | | | TOTAL ADD'L FEE | | OR | TOTAL ADD'L FEE | |

* If the entry in column 1 is less than the entry in column 2, write "0" in column 3.

** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 20, enter "20".

*** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 3, enter "3".

The "Highest Number Previously Paid For" (Total or Independent) is the highest number found in the appropriate box in column 1.

Legal Instrument Examiner:
/ROSA HOLLAND/

This collection of information is required by 37 CFR 1.16. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 12 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

*If you need assistance in completing the form, call 1-800-PTO-9199 and select option 2.*

| Application Number | Application/Control No. | Applicant(s)/Patent under Reexamination | |
|---|---|---|---|
| | 11/839,205 | KARCZEWICZ ET AL. | |

| Document Code - DISQ | Internal Document – DO NOT MAIL |
|---|---|

| TERMINAL DISCLAIMER | ☐ APPROVED | ☒ DISAPPROVED |
|---|---|---|
| Date Filed : 8/10/09 | This patent is subject to a Terminal Disclaimer | |

**Approved/Disapproved by:**

ANDRE ROBINSON

ATTY. NOT OF RECORD

U.S. Patent and Trademark Office

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
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P.O. Box 1450
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| APPLICATION NO. | FILING DATE | FIRST NAMED INVENTOR | ATTORNEY DOCKET NO. | CONFIRMATION NO. |
|---|---|---|---|---|
| 11/839,205 | 08/15/2007 | Marta Karczewicz | 982-010567-US (C02) | 8091 |

2512 7590 12/08/2009

Perman & Green, LLP
99 Hawley Lane
Stratford, CT 06614

| EXAMINER | |
|---|---|
| AN, SHAWN S | |

| ART UNIT | PAPER NUMBER |
|---|---|
| 2621 | |

| MAIL DATE | DELIVERY MODE |
|---|---|
| 12/08/2009 | PAPER |

**Please find below and/or attached an Office communication concerning this application or proceeding.**

The time period for reply, if any, is set in the attached communication.

| Office Action Summary | Application No. | Applicant(s) | |
|---|---|---|---|
| | 11/839,205 | KARCZEWICZ ET AL. | |
| | Examiner | Art Unit | |
| | SHAWN AN | 2621 | |

*-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --*

**Period for Reply**

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE *3* MONTH(S) OR THIRTY (30) DAYS, WHICHEVER IS LONGER, FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133). Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

**Status**

1)☒ Responsive to communication(s) filed on *10 August 2009*.

2a)☒ This action is **FINAL**. 2b)☐ This action is non-final.

3)☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

**Disposition of Claims**

4)☒ Claim(s) *1-61* is/are pending in the application.

4a) Of the above claim(s) _____ is/are withdrawn from consideration.

5)☐ Claim(s) _____ is/are allowed.

6)☒ Claim(s) *1-61* is/are rejected.

7)☐ Claim(s) _____ is/are objected to.

8)☐ Claim(s) _____ are subject to restriction and/or election requirement.

**Application Papers**

9)☐ The specification is objected to by the Examiner.

10)☐ The drawing(s) filed on _____ is/are: a)☐ accepted or b)☐ objected to by the Examiner.

Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).

Replacement drawing sheet(s) including the correction is required if the drawing(s) is objected to. See 37 CFR 1.121(d).

11)☐ The oath or declaration is objected to by the Examiner. Note the attached Office Action or form PTO-152.

**Priority under 35 U.S.C. § 119**

12)☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

a)☐ All b)☐ Some * c)☐ None of:

1.☐ Certified copies of the priority documents have been received.

2.☐ Certified copies of the priority documents have been received in Application No. _____.

3.☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

* See the attached detailed Office action for a list of the certified copies not received.

**Attachment(s)**

1) ☒ Notice of References Cited (PTO-892)
2) ☐ Notice of Draftsperson's Patent Drawing Review (PTO-948)
3) ☒ Information Disclosure Statement(s) (PTO/SB/08) Paper No(s)/Mail Date *5/13/09*.
4) ☐ Interview Summary (PTO-413) Paper No(s)/Mail Date. _____ .
5) ☐ Notice of Informal Patent Application
6) ☐ Other: _____.

## DETAILED ACTION

### *Response to Amendment*

**1.** As per Applicant's instruction as filed on 8/10/09, claims1-3 have been amended and claims 4-61 have been newly added.

### *Response to Remarks*

**2.** Applicant's remarks with respect to amended claims 1-3 as filed on 8/10/09 have been carefully considered but are partially moot in view of the following new ground(s) of rejection.

### *Double Patenting*

**3.** The nonstatutory double patenting rejection is based on a judicially created doctrine grounded in public policy (a policy reflected in the statute) so as to prevent the unjustified or improper timewise extension of the "right to exclude" granted by a patent and to prevent possible harassment by multiple assignees. A nonstatutory obviousness-type double patenting rejection is appropriate where the conflicting claims are not identical, but at least one examined application claim is not patentably distinct from the reference claim(s) because the examined application claim is either anticipated by, or would have been obvious over, the reference claim(s). See, e.g., *In re Berg*, 140 F.3d 1428, 46 USPQ2d 1226 (Fed. Cir. 1998); *In re Goodman*, 11 F.3d 1046, 29 USPQ2d 2010 (Fed. Cir. 1993); *In re Longi*, 759 F.2d 887, 225 USPQ 645 (Fed. Cir. 1985); *In re Van Ornum*, 686 F.2d 937, 214 USPQ 761 (CCPA 1982); *In re Vogel*, 422 F.2d 438, 164 USPQ 619 (CCPA 1970); and *In re Thorington*, 418 F.2d 528, 163 USPQ 644 (CCPA 1969).

A timely filed terminal disclaimer in compliance with 37 CFR 1.321(c) or 1.321(d) may be used to overcome an actual or provisional rejection based on a nonstatutory double patenting ground provided the conflicting application or patent either is shown to be commonly owned with this application, or claims an invention made as a result of activities undertaken within the scope of a joint research agreement.

Effective January 1, 1994, a registered attorney or agent of record may sign a terminal disclaimer. A terminal disclaimer signed by the assignee must fully comply with 37 CFR 3.73(b).

**4.** Claims 1-61 are rejected on the ground of nonstatutory obviousness-type double patenting as being unpatentable over claims 1-51 of U.S. Patent No. (7,280,599 B2).

Although the conflicting claims are not identical, they are not patentably distinct from each other because the novel subject matter(s) of claims 1-61 in the instant/present application is fully disclosed in the above patent and is covered by the above patent, since the above patent and the instant/present application are claiming common subject matter, as follows:

**Claims 1-61** recite substantially all of claimed features **(**with the exceptions of (a display device) configured for display and various devices including an interpolator, a network apparatus, and a computer program embodied on a computer readable storage medium for performing the same methods**)** as recited in the patented claims 1-51.

However, various devices such as an interpolator, a network apparatus, a display device configured for display, and a computer program embodied on a computer readable storage medium are fundamentally well known devices for performing such conventional tasks. Furthermore, the corresponding patented apparatus claims can easily be used/implemented as various devices such as an interpolator, a network apparatus, a display device configured for display, and a computer program embodied on a computer readable storage medium.

Therefore, it would have been considered quite obvious to a person of ordinary skill in the relevant art employing the patent reference to utilize the above fundamental devices to perform the same method as recited in claims 1-61.

***Conclusion***

**5.** Applicant's amendment necessitated the new ground(s) of rejection presented in this Office action. Accordingly, **THIS ACTION IS MADE FINAL**. See MPEP § 706.07(a). Applicant is reminded of the extension of time policy as set forth in 37 CFR 1.136(a).

A shortened statutory period for reply to this final action is set to expire THREE MONTHS from the mailing date of this action. In the event a first reply is filed within TWO MONTHS of the mailing date of this final action and the advisory action is not mailed until after the end of the THREE-MONTH shortened statutory period, then the shortened statutory period will expire on the date the advisory action is mailed, and any extension fee pursuant to 37 CFR 1.136(a) will be calculated from the mailing date of the advisory action. In no event, however, will the statutory period for reply expire later than SIX MONTHS from the date of this final action.

**6.** Any inquiry concerning this communication or earlier communications from the Examiner should be directed to *Shawn An* whose telephone number is 571-272-7324.

If attempts to reach the Examiner by telephone are unsuccessful, the Examiner's supervisor, Mehrdad Dastouri can be reached on 571-272-7418.

**7.** Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see http://pair-direct.uspto.gov. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free). If you would like assistance from a USPTO Customer Service Representative or access to the automated information system, call 800-786-9199 (IN USA OR CANADA) or 571-272-1000.

**8.** The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300.

/SHAWN AN/
Primary Examiner, Art Unit 2621
12/04/09

| Notice of References Cited | Application/Control No. 11/839,205 | Applicant(s)/Patent Under Reexamination KARCZEWICZ ET AL. | |
|---|---|---|---|
| | Examiner SHAWN AN | Art Unit 2621 | Page 1 of 1 |

**U.S. PATENT DOCUMENTS**

| * | | Document Number Country Code-Number-Kind Code | Date MM-YYYY | Name | Classification |
|---|---|---|---|---|---|
| * | A | US-7,280,599 B2 | 10-2007 | Karczewicz et al. | 375/240.17 |
| | B | US- | | | |
| | C | US- | | | |
| | D | US- | | | |
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**FOREIGN PATENT DOCUMENTS**

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**NON-PATENT DOCUMENTS**

| * | | Include as applicable: Author, Title Date, Publisher, Edition or Volume, Pertinent Pages) |
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*A copy of this reference is not being furnished with this Office action. (See MPEP § 707.05(a).)
Dates in MM-YYYY format are publication dates. Classifications may be US or foreign.

## Index of Claims

| Application/Control No. | Applicant(s)/Patent under Reexamination |
|---|---|
| 11/839,205 | KARCZEWICZ ET AL. |
| **Examiner** | **Art Unit** |
| SHAWN AN | 2621 |

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PTO/SB/08a (04-09)
Approved for use through 05/31/2009. OMB 0651-0031
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# INFORMATION DISCLOSURE STATEMENT BY APPLICANT

**( Not for submission under 37 CFR 1.99)**

| | |
|---|---|
| Application Number | 11839205 |
| Filing Date | 2007-08-15 |
| First Named Inventor | Marta Karczewicz |
| Art Unit | 2621 |
| Examiner Name | Shawn S. An |
| Attorney Docket Number | 982-010567-US (C02) |

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| INFORMATION DISCLOSURE STATEMENT BY APPLICANT ( Not for submission under 37 CFR 1.99) | | |
|---|---|---|
| | Application Number | 11839205 |
| | Filing Date | 2007-08-15 |
| | First Named Inventor | Marta Karczewicz |
| | Art Unit | 2621 |
| | Examiner Name | Shawn S. An |
| | Attorney Docket Number | 982-010567-US (C02) |

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ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /S.A./ (12/04/2009)

**IN THE UNITED STATES PATENT AND TRADEMARK OFFICE**

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**AMENDMENT AFTER FINAL**

## I. INTRODUCTION

This is a response to the Final Office Action mailed 8 December 2009 for this application.

Reconsideration of the rejection of the claims is respectfully solicited in light of the following amendment and remarks.

## II. CLAIM AMENDMENTS

1. (Currently amended) A method for sub-pixel value interpolation to determine values for sub-pixels situated within a rectangular bounded region defined by four corner pixels with no intermediate pixels between the corners, the pixels and sub-pixels being configured for display in rows and columns, pixel and sub-pixel locations in the rows and columns being representable mathematically within the rectangular bounded region using the co-ordinate notation $K/2^N$, $L/2^N$, K and L being positive integers having respective values between zero and $2^N$, N being a positive integer greater than one and representing a particular degree of sub-pixel value interpolation, the method comprising causing an apparatus to:

- interpolate a sub-pixel value for a sub-pixel having co-ordinates with odd values of both K and L, according to a predetermined choice of either a weighted average of the value of a nearest-neighbouring pixel and the value of the sub-pixel situated at co-ordinates 1/2, 1/2, or a weighted average of the values of a pair of diagonally-opposed sub-pixels having co-ordinates with even values of both K and L, including zero, situated within a quadrant of the rectangular bounded region, the quadrant being defined by the sub-pixel having co-ordinates 1/2, 1/2 and the nearest neighbouring pixel;
- interpolate sub-pixel values for sub-pixels having co-ordinates with K equal to an even value and L equal to zero and sub-pixels having co-ordinates with K equal to zero and L equal to an even value, used in the interpolation of the sub-pixels having co-ordinates with odd values of both K and L, using weighted sums of the values of pixels located in rows and columns respectively; and
- interpolate sub-pixel values for sub-pixels having co-ordinates with even values of both K and L, used in the interpolation of sub-pixel values for the sub-pixels having co-ordinates with odd values of both K and L, using a predetermined choice of either a weighted sum of the values of sub-pixels having co-ordinates with K equal to an even value and L equal to zero and the values of sub-pixels having corresponding co-ordinates in immediately adjacent rectangular bounded regions,

or a weighted sum of the values of sub-pixels having co-ordinates with K equal to zero and L equal to an even value and the values of sub-pixels having corresponding co-ordinates in immediately adjacent bounded rectangular regions.

2. (Currently amended) A method for quarter resolution sub-pixel value interpolation to determine values for sub-pixels situated within a rectangular bounded region defined by four corner pixels with no intermediate pixels between the corners, the pixels and sub-pixels being configured for display in rows and columns, pixel and sub-pixel locations in the rows and columns being representable mathematically within the rectangular bounded region using the co-ordinate notation K/4, L/4, K and L being positive integers having respective values between zero and 4, the method comprising causing an apparatus to:

- interpolate a sub-pixel value for a sub-pixel having co-ordinates with both K and L equal to 1 or 3, according to a predetermined choice of either a weighted average of the value of a nearest-neighbouring pixel and the value of the sub-pixel situated at co-ordinates 2/4, 2/4, or a weighted average of the values of a pair of diagonally-opposed sub-pixels having co-ordinates with both K and L equal to zero, 2 or 4, situated within a quadrant of the rectangular bounded region, the quadrant being defined by the sub-pixel having co-ordinates 2/4, 2/4 and the nearest neighbouring pixel;
- interpolate sub-pixel values for sub-pixels having co-ordinates with K equal to 2 and L equal to zero and sub-pixels having co-ordinates with K equal to zero and L equal to 2, used in the interpolation of the sub-pixels having co-ordinates with both K and L equal to 1 or 3, using weighted sums of the values of pixels located in rows and columns respectively; and
- interpolate a sub-pixel value for the sub-pixel having co-ordinates with both K and L equal to 2, used in the interpolation of sub-pixel values for the sub-pixels having co-ordinates with both K and L equal to 1 or 3, using a predetermined choice of either a weighted sum of the values of the sub-pixel having co-ordinates with K equal to 2 and L equal to zero and the values of sub-pixels having corresponding

co-ordinates in immediately adjacent rectangular bounded regions, or a weighted sum of the value of the sub-pixel having co-ordinates with K equal to zero and L equal to 2 and the values of sub-pixels having corresponding co-ordinates in immediately adjacent rectangular bounded regions.

3. (Currently amended) A method for eighth resolution sub-pixel value interpolation to determine values for sub-pixels situated within a rectangular bounded region defined by four corner pixels with no intermediate pixels between the corners, the pixels and sub-pixels being configured for display in rows and columns, pixel and sub-pixel locations in the rows and columns being representable mathematically with the rectangular bounded region using the co-ordinate notation K/8, L/8, K and L being positive integers having respective values between zero and 8, the method comprising causing an apparatus to:

- interpolate a sub-pixel value for a sub-pixel having co-ordinates with both K and L equal to 1, 3, 5 or 7, according to a predetermined choice of either a weighted average of the value of a nearest-neighbouring pixel and the value of the sub-pixel situated at co-ordinates 4/8, 4/8, or a weighted average of the values of a pair of diagonally-opposed sub-pixels having co-ordinates with both K and L equal to zero, 2, 4, 6 or 8, situated within a quadrant of the rectangular bounded region, the quadrant being defined by the sub-pixel having co-ordinates 4/8, 4/8 and the nearest neighbouring pixel;
- interpolate sub-pixel values for sub-pixels having co-ordinates with K equal to 2, 4 or 6 and L equal to zero and sub-pixels having co-ordinates with K equal to zero and L equal to 2, 4 or 6, used in the interpolation of the sub-pixels having co-ordinates with both K and L equal to 1, 3, 5 or 7, using weighted sums of the values of pixels located in rows and columns respectively; and
- interpolate sub-pixel values for sub-pixels having co-ordinates with both K and L equal to 2, 4 or 6, used in the interpolation of sub-pixel values for the sub-pixels having co-ordinates with both K and L equal to 1, 3, 5 or 7, using a predetermined choice of either a weighted sum of the values of sub-pixels having co-ordinates

with K equal to 2, 4 or 6 and L equal to zero and the values of sub-pixels having corresponding co-ordinates in immediately adjacent rectangular bounded regions or a weighted sum of the values of sub-pixels having co-ordinates with K equal to zero and L equal to 2, 4 or 6 and the values of sub-pixels having corresponding co-ordinates in immediately adjacent rectangular bounded regions.

4. (Currently amended) A method according to claim 1, comprising causing the apparatus to use a first and a second weight in the weighted average chosen to interpolate the sub-pixel value for a sub-pixel having co-ordinates with odd values of both K and L, wherein when the chosen weighted average is that involving the value of a nearest neighbouring pixel and the value of the sub-pixel situated at co-ordinates 1/2, 1/2, ~~and~~causing the apparatus to select the relative magnitudes of the first and second weights to be inversely proportional to the respective straight-line diagonal distances of the nearest-neighbouring pixel and the sub-pixel situated at co-ordinates 1/2, 1/2 to the sub-pixel having co-ordinates with odd values of both K and L whose value is being interpolated.

5. (Currently amended) A method according to claim 1, comprising causing the apparatus to use a first and a second weight in the weighted average chosen to interpolate the sub-pixel value for a sub-pixel having co-ordinates with odd values of both K and L, wherein when the chosen weighted average is that involving the values of a pair of diagonally-opposed sub-pixels having co-ordinates with even values of both K and L, ~~and~~causing the apparatus to select the relative magnitudes of the first and second weights to be inversely proportional to the respective straight-line diagonal distances of the sub-pixels having co-ordinates with even values of both K and L to the sub-pixel having co-ordinates with odd values of both K and L whose value is being interpolated.

6. (Previously presented) A method according to claim 4, comprising causing the apparatus to use first and second weights with equal values when the nearest-

neighbouring pixel and sub-pixel situated at co-ordinates 1/2, 1/2 are equidistant from the sub-pixel having co-ordinates with odd values of both K and L whose value is being interpolated.

7. (Previously Presented) A method according to claim 5, comprising causing the apparatus to use first and second weights with equal values when the sub-pixels having co-ordinates with even values of both K and L are equidistant from the sub-pixel having co-ordinates with odd values of both K and L whose value is being interpolated.

8. (Previously Presented) A method according to claim 1, comprising causing the apparatus to interpolate sub-pixel values for sub-pixels having co-ordinates with even values of both K and L, used in interpolation of sub-pixel values for the sub-pixels having co-ordinates with odd values of both K and L, using a weighted sum of the values of sub-pixels having co-ordinates with K equal to an even value and L equal to zero and the values of sub-pixels having corresponding co-ordinates in immediately adjacent rectangular bounded regions when the value of a sub-pixel having co-ordinates with K equal to an even value and L equal to an odd value is also required.

9. (Previously Presented) A method according to claim 1, comprising causing the apparatus to interpolate sub-pixel values for sub-pixels having co-ordinates with even values of both K and L, used in interpolation of sub-pixel values for the sub-pixels having co-ordinates with odd values of both K and L, using a weighted sum of the values of sub-pixels having co-ordinates with K equal to zero and L equal to an even value and the values of sub-pixels having corresponding co-ordinates in immediately adjacent rectangular bounded regions when the value of a sub-pixel having co-ordinates with K equal to an odd value and L equal to an even value is also required.

10. (Previously Presented) A method according to claim 1, comprising causing the apparatus to interpolate sub-pixel values for sub-pixels having co-ordinates with K equal to an odd value O and L equal to an even value E, not including zero or $2^N$, by taking an

average of the value of a first sub-pixel having co-ordinates with K equal to the even value O - 1 and L equal to E and a second sub-pixel having co-ordinates with K equal to the even value O + 1 and L equal to E.

11. (Previously Presented) A method according to claim 1, comprising causing the apparatus to interpolate a sub-pixel value for a sub-pixel having co-ordinates with K equal to 1 and L equal to zero, by taking an average of the value of a pixel having co-ordinates with K equal to zero and L equal to zero, and a sub-pixel having co-ordinates with K equal to 2 and L equal to zero.

12. (Previously Presented) A method according to claim 1, comprising causing the apparatus to interpolate a sub-pixel value for a sub-pixel having co-ordinates with K equal to $2^N$ - 1 and L equal to zero, by taking an average of the value of a pixel having co-ordinates with K equal to $2^N$ and L equal to zero, and a sub-pixel having co-ordinates with K equal to $2^N$ - 2 and L equal to zero.

13. (Previously Presented) A method according to claim 1, comprising causing the apparatus to interpolate a sub-pixel value for a sub-pixel having co-ordinates with K equal to 1 and L equal to $2^N$, by taking an average of the value of a pixel having co-ordinates with K equal to zero and L equal to $2^N$, and a sub-pixel having co-ordinates with K equal to 2 and L equal to $2^N$.

14. (Previously Presented) A method according to claim 1, comprising causing the apparatus to interpolate a sub-pixel value for a sub-pixel having co-ordinates with K equal to $2^N$ - 1 and L equal to $2^N$, by taking an average of the value of a pixel having co-ordinates with K equal to $2^N$ and L equal to $2^N$, and a sub-pixel having co-ordinates with K equal to $2^N$ - 2 and L equal to $2^N$.

15. (Previously Presented) A method according to claim 1, comprising causing the apparatus to interpolate sub-pixel values for sub-pixels having co-ordinates with K equal

to an even value E, not including zero or $2^N$, and L equal to an odd value O, by taking an average of the value of a first sub-pixel having co-ordinates with K equal to E and L equal to the even value O - 1 and a second sub-pixel having co-ordinates with K equal to E and L equal to the even value O + 1.

16. (Previously Presented) A method according to claim 1, comprising causing the apparatus to interpolate a sub-pixel value for a sub-pixel having co-ordinates with K equal to zero and L equal to 1, by taking an average of the value of a pixel having co-ordinates with K equal to zero and L equal to zero, and a sub-pixel having co-ordinates with K equal to zero and L equal to 2.

17. (Currently amended) A method according to claim 1, comprising causing the apparatus to interpolate a sub-pixel value for a sub-pixel having co-ordinates with K equal to $2^N$ and L equal to 1, by taking an average of the value of a pixel having co-ordinates with K equal to $2^N$ and L equal to zero, and a sub-pixel having co-ordinates with K equal to ~~zero~~$2^N$ and L equal to $2^{-N}$.

18. (Previously Presented) A method according to claim 1, comprising causing the apparatus to interpolate a sub-pixel value for a sub-pixel having co-ordinates with K equal to 0 and L equal to $2^N$ - 1, by taking an average of the value of a pixel having co-ordinates with K equal to zero and L equal to $2^N$, and a sub-pixel having co-ordinates with K equal to zero and L equal to $2^N$ - 2.

19. (Previously Presented) A method according to claim 1, comprising causing the apparatus to interpolate a sub-pixel value for a sub-pixel having co-ordinates with K equal to $2^N$ and L equal to $2^N$ - 1, by taking an average of the value of a pixel having co-ordinates with K equal to $2^N$ and L equal to $2^N$, and a sub-pixel having co-ordinates with K equal to $2^N$ and L equal to $2^N$ - 2.

20. (Previously Presented) A method according to claim 1, comprising causing the apparatus to interpolate a sub-pixel value for the sub-pixel having co-ordinates with K equal to $2^N$ - 1 and L equal to $2^N$ - 1, by taking a weighted average of the values of the four corner pixels that define the rectangular bounded region.

21. (Previously Presented) A method according to claim 1, comprising causing the apparatus to select a value for N from a list consisting of the values 2, 3, and 4.

22. (Currently amended) An interpolator for sub-pixel value interpolation, the interpolator being configured to determine values for sub-pixels situated within a rectangular bounded region defined by four corner pixels with no intermediate pixels between the corners, the pixels and sub-pixels being configured for display in rows and columns, pixel and sub-pixel locations in the rows and columns being representable mathematically within the rectangular bounded region using the co-ordinate notation $K/2^N$, $L/2^N$, K and L being positive integers having respective values between zero and $2^N$, N being a positive integer greater than one and representing a particular degree of sub-pixel value interpolation, the interpolator being configured to:

- interpolate a sub-pixel value for a sub-pixel having co-ordinates with odd values of both K and L, according to a predetermined choice of either a weighted average of the value of a nearest-neighbouring pixel and the value of the sub-pixel situated at co-ordinates 1/2, 1/2, or a weighted average of the values of a pair of diagonally-opposed sub-pixels having co-ordinates with even values of both K and L, including zero, situated within a quadrant of the rectangular bounded region, the quadrant being defined by the sub-pixel having co-ordinates 1/2, 1/2 and the nearest neighbouring pixel;
- interpolate sub-pixel values for sub-pixels having co-ordinates with K equal to an even value and L equal to zero and sub-pixels having co-ordinates with K equal to zero and L equal to an even value, used in the interpolation of the sub-pixels having co-ordinates with odd values of both K and L, using weighted sums of the values of pixels located in rows and columns respectively; and

- interpolate sub-pixel values for sub-pixels having co-ordinates with even values of both K and L, used in the interpolation of sub-pixel values for the sub-pixels having co-ordinates with odd values of both K and L, using a predetermined choice of either a weighted sum of the values of sub-pixels having co-ordinates with K equal to an even value and L equal to zero and the values of sub-pixels having corresponding co-ordinates in immediately adjacent rectangular bounded regions, or a weighted sum of the values of sub-pixels having co-ordinates with K equal to zero and L equal to an even value and the values of sub-pixels having corresponding co-ordinates in immediately adjacent bounded rectangular regions.

23. (Previously Presented) An interpolator according to claim 22, wherein the interpolator is configured to use a first and a second weight in the weighted average chosen to interpolate the sub-pixel value for a sub-pixel having co-ordinates with odd values of both K and L, wherein when the chosen weighted average is that involving the value of a nearest neighbouring pixel and the value of the sub-pixel situated at co-ordinates 1/2, 1/2, the interpolator is configured to select the relative magnitudes of the first and second weights to be inversely proportional to the respective straight-line diagonal distances of the nearest-neighbouring pixel and the sub-pixel situated at co-ordinates 1/2, 1/2 to the sub-pixel having co-ordinates with odd values of both K and L whose value is being interpolated.

24. (Previously Presented) An interpolator according to claim 22, wherein the interpolator is configured to use a first and a second weight in the weighted average chosen to interpolate the sub-pixel value for a sub-pixel having co-ordinates with odd values of both K and L, wherein when the chosen weighted average is that involving the values of a pair of diagonally-opposed sub-pixels having co-ordinates with even values of both K and L, the interpolator is configured to select the relative magnitudes of the first and second weights to be inversely proportional to the respective straight-line diagonal distances of the sub-pixels having co-ordinates with even values of both K and

L to the sub-pixel having co-ordinates with odd values of both K and L whose value is being interpolated.

25. (Previously Presented) An interpolator according to claim 23, wherein the interpolator is configured to use first and second weights with equal values when the nearest-neighbouring pixel and sub-pixel situated at co-ordinates 1/2, 1/2 are equidistant from the sub-pixel having co-ordinates with odd values of both K and L whose value is being interpolated.

26. (Previously Presented) An interpolator according to claim 24, wherein the interpolator is configured to use first and second weights with equal values when the sub-pixels having co-ordinates with even values of both K and L are equidistant from the sub-pixel having co-ordinates with odd values of both K and L whose value is being interpolated.

27. (Previously Presented) An interpolator according to claim 22, wherein the interpolator is configured to interpolate sub-pixel values for sub-pixels having co-ordinates with even values of both K and L, used in interpolation of sub-pixel values for the sub-pixels having co-ordinates with odd values of both K and L, using a weighted sum of the values of sub-pixels having co-ordinates with K equal to an even value and L equal to zero and the values of sub-pixels having corresponding co-ordinates in immediately adjacent rectangular bounded regions when the value of a sub-pixel having co-ordinates with K equal to an even value and L equal to an odd value is also required.

28. (Previously Presented) An interpolator according to claim 22, wherein the interpolator is configured to interpolate sub-pixel values for sub-pixels having co-ordinates with even values of both K and L, used in interpolation of sub-pixel values for the sub-pixels having co-ordinates with odd values of both K and L, using a weighted sum of the values of sub-pixels having co-ordinates with K equal to zero and L equal to an even value and the values of sub-pixels having corresponding co-ordinates in

immediately adjacent rectangular bounded regions when the value of a sub-pixel having co-ordinates with K equal to an odd value and L equal to an even value is also required.

29. (Previously Presented) An interpolator according to claim 22, wherein the interpolator is configured to interpolate sub-pixel values for sub-pixels having co-ordinates with K equal to an odd value O and L equal to an even value E, not including zero or $2^N$, by taking an average of the value of a first sub-pixel having co-ordinates with K equal to the even value O - 1 and L equal to E and a second sub-pixel having co-ordinates with K equal to the even value O + 1 and L equal to E.

30. (Previously Presented) An interpolator according to claim 22, wherein the interpolator is configured to interpolate a sub-pixel value for a sub-pixel having co-ordinates with K equal to 1 and L equal to zero, by taking an average of the value of a pixel having co-ordinates with K equal to zero and L equal to zero, and a sub-pixel having co-ordinates with K equal to 2 and L equal to zero.

31. (Previously Presented) An interpolator according to claim 22, wherein the interpolator is configured to interpolate a sub-pixel value for a sub-pixel having co-ordinates with K equal to $2^N$ - 1 and L equal to zero, by taking an average of the value of a pixel having co-ordinates with K equal to $2^N$ and L equal to zero, and a sub-pixel having co-ordinates with K equal to $2^N$ - 2 and L equal to zero.

32. (Previously Presented) An interpolator according to claim 22, wherein the interpolator is configured to interpolate a sub-pixel value for a sub-pixel having co-ordinates with K equal to 1 and L equal to $2^N$, by taking an average of the value of a pixel having co-ordinates with K equal to zero and L equal to $2^N$, and a sub-pixel having co-ordinates with K equal to 2 and L equal to $2^N$.

33. (Previously Presented) An interpolator according to claim 22, wherein the interpolator is configured to interpolate a sub-pixel value for a sub-pixel having co-ordinates with K equal to $2^N$ - 1 and L equal to $2^N$, by taking an average of the value of a pixel having co-ordinates with K equal to $2^N$ and L equal to $2^N$, and a sub-pixel having co-ordinates with K equal to $2^N$ - 2 and L equal to $2^N$.

34. (Previously Presented) An interpolator according to claim 22, wherein the interpolator is configured to interpolate sub-pixel values for sub-pixels having co-ordinates with K equal to an even value E, not including zero or $2^N$, and L equal to an odd value O, by taking an average of the value of a first sub-pixel having co-ordinates with K equal to E and L equal to the even value O - 1 and a second sub-pixel having co-ordinates with K equal to E and L equal to the even value O + 1.

35. (Previously Presented) An interpolator according to claim 22, wherein the interpolator is configured to interpolate a sub-pixel value for a sub-pixel having co-ordinates with K equal to zero and L equal to 1, by taking an average of the value of a pixel having co-ordinates with K equal to zero and L equal to zero, and a sub-pixel having co-ordinates with K equal to zero and L equal to 2.

36. (Currently amended) An interpolator according to claim 22, wherein the interpolator is configured to interpolate a sub-pixel value for a sub-pixel having co-ordinates with K equal to $2^N$ and L equal to 1, by taking an average of the value of a pixel having co-ordinates with K equal to $2^N$ and L equal to zero, and a sub-pixel having co-ordinates with K equal to zero and L equal to $2^{-N}$.

37. (Previously Presented) An interpolator according to claim 22, wherein the interpolator is configured to interpolate a sub-pixel value for a sub-pixel having co-ordinates with K equal to 0 and L equal to $2^N$ - 1, by taking an average of the value of a pixel having co-ordinates with K equal to zero and L equal to $2^N$, and a sub-pixel having co-ordinates with K equal to zero and L equal to $2^N$ - 2.

38. (Previously Presented) An interpolator according to claim 22, wherein the interpolator is configured to interpolate a sub-pixel value for a sub-pixel having co-ordinates with K equal to $2^N$ and L equal to $2^N$ - 1, by taking an average of the value of a pixel having co-ordinates with K equal to $2^N$ and L equal to $2^N$, and a sub-pixel having co-ordinates with K equal to $2^N$ and L equal to $2^N$ - 2.

39. (Previously Presented) An interpolator according to claim 22, wherein the interpolator is configured to interpolate a sub-pixel value for the sub-pixel having co-ordinates with K equal to $2^N$ - 1 and L equal to $2^N$ - 1, by taking a weighted average of the values of the four corner pixels that define the rectangular bounded region.

40. (Previously Presented) An interpolator according to claim 22, wherein N is set equal to 2.

41. (Previously Presented) An interpolator according to claim 22, wherein N is set equal to 3.

42. (Currently amended) A video encoder comprising an interpolator for sub-pixel value interpolation, the interpolator being configured to determine values for sub-pixels situated within a rectangular bounded region defined by four corner pixels with no intermediate pixels between the corners, the pixels and sub-pixels being configured for display in rows and columns, pixel and sub-pixel locations in the rows and columns being representable mathematically within the rectangular bounded region using the co-ordinate notation $K/2^N$, $L/2^N$, K and L being positive integers having respective values between zero and $2^N$, N being a positive integer greater than one and representing a particular degree of sub-pixel value interpolation, the interpolator being configured to:

- interpolate a sub-pixel value for a sub-pixel having co-ordinates with odd values of both K and L, according to a predetermined choice of either a weighted average of the value of a nearest-neighbouring pixel and the value of the sub-pixel situated at

co-ordinates 1/2, 1/2, or a weighted average of the values of a pair of diagonally-opposed sub-pixels having co-ordinates with even values of both K and L, including zero, situated within a quadrant of the rectangular bounded region, the quadrant being defined by the sub-pixel having co-ordinates 1/2, 1/2 and the nearest neighbouring pixel;

- interpolate sub-pixel values for sub-pixels having co-ordinates with K equal to an even value and L equal to zero and sub-pixels having co-ordinates with K equal to zero and L equal to an even value, used in the interpolation of the sub-pixels having co-ordinates with odd values of both K and L, using weighted sums of the values of pixels located in rows and columns respectively; and
- interpolate sub-pixel values for sub-pixels having co-ordinates with even values of both K and L, used in the interpolation of sub-pixel values for the sub-pixels having co-ordinates with odd values of both K and L, using a predetermined choice of either a weighted sum of the values of sub-pixels having co-ordinates with K equal to an even value and L equal to zero and the values of sub-pixels having corresponding co-ordinates in immediately adjacent rectangular bounded regions, or a weighted sum of the values of sub-pixels having co-ordinates with K equal to zero and L equal to an even value and the values of sub-pixels having corresponding co-ordinates in immediately adjacent bounded rectangular regions.

43. (Currently amended) A still image encoder comprising an interpolator for sub-pixel value interpolation, the interpolator being configured to determine values for sub-pixels situated within a rectangular bounded region defined by four corner pixels with no intermediate pixels between the corners, the pixels and sub-pixels being configured for display in rows and columns, pixel and sub-pixel locations in the rows and columns being representable mathematically within the rectangular bounded region using the co-ordinate notation $K/2^N$, $L/2^N$, K and L being positive integers having respective values between zero and $2^N$, N being a positive integer greater than one and representing a particular degree of sub-pixel value interpolation, the interpolator being configured to:

- interpolate a sub-pixel value for a sub-pixel having co-ordinates with odd values of both K and L, according to a predetermined choice of either a weighted average of the value of a nearest-neighbouring pixel and the value of the sub-pixel situated at co-ordinates 1/2, 1/2, or a weighted average of the values of a pair of diagonally-opposed sub-pixels having co-ordinates with even values of both K and L, including zero, situated within a quadrant of the rectangular bounded region, the quadrant being defined by the sub-pixel having co-ordinates 1/2, 1/2 and the nearest neighbouring pixel;
- interpolate sub-pixel values for sub-pixels having co-ordinates with K equal to an even value and L equal to zero and sub-pixels having co-ordinates with K equal to zero and L equal to an even value, used in the interpolation of the sub-pixels having co-ordinates with odd values of both K and L, using weighted sums of the values of pixels located in rows and columns respectively; and
- interpolate sub-pixel values for sub-pixels having co-ordinates with even values of both K and L, used in the interpolation of sub-pixel values for the sub-pixels having co-ordinates with odd values of both K and L, using a predetermined choice of either a weighted sum of the values of sub-pixels having co-ordinates with K equal to an even value and L equal to zero and the values of sub-pixels having corresponding co-ordinates in immediately adjacent rectangular bounded regions, or a weighted sum of the values of sub-pixels having co-ordinates with K equal to zero and L equal to an even value and the values of sub-pixels having corresponding co-ordinates in immediately adjacent bounded rectangular regions.

44. (Currently amended) A video decoder comprising an interpolator for sub-pixel value interpolation, the interpolator being configured to determine values for sub-pixels situated within a rectangular bounded region defined by four corner pixels with no intermediate pixels between the corners, the pixels and sub-pixels being configured for display in rows and columns, pixel and sub-pixel locations in the rows and columns being representable mathematically within the rectangular bounded region using the co-ordinate notation $K/2^N$, $L/2^N$, K and L being positive integers having respective values

between zero and $2^N$, N being a positive integer greater than one and representing a particular degree of sub-pixel value interpolation, the interpolator being configured to:

- interpolate a sub-pixel value for a sub-pixel having co-ordinates with odd values of both K and L, according to a predetermined choice of a either weighted average of the value of a nearest-neighbouring pixel and the value of the sub-pixel situated at co-ordinates 1/2, 1/2, or a weighted average of the values of a pair of diagonally-opposed sub-pixels having co-ordinates with even values of both K and L, including zero, situated within a quadrant of the rectangular bounded region, the quadrant being defined by the sub-pixel having co-ordinates 1/2, 1/2 and the nearest neighbouring pixel;
- interpolate sub-pixel values for sub-pixels having co-ordinates with K equal to an even value and L equal to zero and sub-pixels having co-ordinates with K equal to zero and L equal to an even value, used in the interpolation of the sub-pixels having co-ordinates with odd values of both K and L, using weighted sums of the values of pixels located in rows and columns respectively; and
- interpolate sub-pixel values for sub-pixels having co-ordinates with even values of both K and L, used in the interpolation of sub-pixel values for the sub-pixels having co-ordinates with odd values of both K and L, using a predetermined choice of either a weighted sum of the values of sub-pixels having co-ordinates with K equal to an even value and L equal to zero and the values of sub-pixels having corresponding co-ordinates in immediately adjacent rectangular bounded regions, or a weighted sum of the values of sub-pixels having co-ordinates with K equal to zero and L equal to an even value and the values of sub-pixels having corresponding co-ordinates in immediately adjacent bounded rectangular regions.

45. (Currently amended) A still image decoder comprising an interpolator for sub-pixel value interpolation, the interpolator being configured to determine values for sub-pixels situated within a rectangular bounded region defined by four corner pixels with no intermediate pixels between the corners, the pixels and sub-pixels being configured for display in rows and columns, pixel and sub-pixel locations in the rows and columns

being representable mathematically within the rectangular bounded region using the co-ordinate notation $K/2^N$, $L/2^N$, K and L being positive integers having respective values between zero and $2^N$, N being a positive integer greater than one and representing a particular degree of sub-pixel value interpolation, the interpolator being configured to:

- interpolate a sub-pixel value for a sub-pixel having co-ordinates with odd values of both K and L, according to a predetermined choice of either a weighted average of the value of a nearest-neighbouring pixel and the value of the sub-pixel situated at co-ordinates 1/2, 1/2, or a weighted average of the values of a pair of diagonally-opposed sub-pixels having co-ordinates with even values of both K and L, including zero, situated within a quadrant of the rectangular bounded region, the quadrant being defined by the sub-pixel having co-ordinates 1/2, 1/2 and the nearest neighbouring pixel;
- interpolate sub-pixel values for sub-pixels having co-ordinates with K equal to an even value and L equal to zero and sub-pixels having co-ordinates with K equal to zero and L equal to an even value, used in the interpolation of the sub-pixels having co-ordinates with odd values of both K and L, using weighted sums of the values of pixels located in rows and columns respectively; and
- interpolate sub-pixel values for sub-pixels having co-ordinates with even values of both K and L, used in the interpolation of sub-pixel values for the sub-pixels having co-ordinates with odd values of both K and L, using a predetermined choice of either a weighted sum of the values of sub-pixels having co-ordinates with K equal to an even value and L equal to zero and the values of sub-pixels having corresponding co-ordinates in immediately adjacent rectangular bounded regions, or a weighted sum of the values of sub-pixels having co-ordinates with K equal to zero and L equal to an even value and the values of sub-pixels having corresponding co-ordinates in immediately adjacent bounded rectangular regions.

46. (Previously Presented) A codec comprising a video encoder according to claim 42 and a video decoder according to claim 44.

47. (Previously Presented) A codec comprising a still image encoder according to claim 43 and a still image decoder according to claim 45.

48. (Previously Presented) A communications terminal comprising a video encoder according to claim 42.

49. (Previously Presented) A communications terminal comprising a still image encoder according to claim 43.

50. (Previously Presented) A communications terminal comprising a video decoder according to claim 44.

51. (Previously Presented) A communications terminal comprising a still image decoder according to claim 45.

52. (Previously Presented) A communications terminal according to claim 48, wherein the communications terminal is a wireless terminal.

53. (Currently amended) An interpolator for sub-pixel value interpolation, the interpolator being configured to determine values for sub-pixels situated within a rectangular bounded region defined by four corner pixels with no intermediate pixels between the corners, the pixels and sub-pixels being configured for display in rows and columns, pixel and sub-pixel locations in the rows and columns being representable mathematically within the rectangular bounded region using the co-ordinate notation $K/2^N$, $L/2^N$, K and L being positive integers having respective values between zero and $2^N$, N being a positive integer greater than one and representing a particular degree of sub-pixel value interpolation, the interpolator comprising:

- circuitry configured to interpolate a sub-pixel value for a sub-pixel having co-ordinates with odd values of both K and L, according to a predetermined choice of either a weighted average of the value of a nearest-neighbouring pixel and the

value of the sub-pixel situated at co-ordinates 1/2, 1/2, and a weighted average of the values of a pair of diagonally-opposed sub-pixels having co-ordinates with even values of both K and L, including zero, situated within a quadrant of the rectangular bounded region, the quadrant being defined by the sub-pixel having co-ordinates 1/2, 1/2 and the nearest neighbouring pixel;

- circuitry configured to interpolate sub-pixel values for sub-pixels having co-ordinates with K equal to an even value and L equal to zero and sub-pixels having co-ordinates with K equal to zero and L equal to an even value, used in the interpolation of the sub-pixels having co-ordinates with odd values of both K and L, using weighted sums of the values of pixels located in rows and columns respectively; and
- circuitry configured to interpolate sub-pixel values for sub-pixels having co-ordinates with even values of both K and L, used in the interpolation of sub-pixel values for the sub-pixels having co-ordinates with odd values of both K and L, using a predetermined choice of either a weighted sum of the values of sub-pixels having co-ordinates with K equal to an even value and L equal to zero and the values of sub-pixels having corresponding co-ordinates in immediately adjacent rectangular bounded regions, or a weighted sum of the values of sub-pixels having co-ordinates with K equal to zero and L equal to an even value and the values of sub-pixels having corresponding co-ordinates in immediately adjacent bounded rectangular regions.

54. (Currently amended) An interpolator for quarter resolution sub-pixel value interpolation, the interpolator being configured to determine values for sub-pixels situated within a rectangular bounded region defined by four corner pixels with no intermediate pixels between the corners, the pixels and sub-pixels being configured for display in rows and columns, pixel and sub-pixel locations in the rows and columns being representable mathematically within the rectangular bounded region using the co-ordinate notation K/4, L/4, K and L being positive integers having respective values between zero and 4, the interpolator being configured to:

- interpolate a sub-pixel value for a sub-pixel having co-ordinates with both K and L equal to 1 or 3, according to a predetermined choice of either a weighted average of the value of a nearest-neighbouring pixel and the value of the sub-pixel situated at co-ordinates 2/4, 2/4, or a weighted average of the values of a pair of diagonally-opposed sub-pixels having co-ordinates with both K and L equal to zero, 2 or 4, situated within a quadrant of the rectangular bounded region, the quadrant being defined by the sub-pixel having co-ordinates 2/4, 2/4 and the nearest neighbouring pixel;
- interpolate sub-pixel values for sub-pixels having co-ordinates with K equal to 2 and L equal to zero and sub-pixels having co-ordinates with K equal to zero and L equal to 2, used in the interpolation of the sub-pixels having co-ordinates with both K and L equal to 1 or 3, using weighted sums of the values of pixels located in rows and columns respectively; and
- interpolate a sub-pixel value for the sub-pixel having co-ordinates with both K and L equal to 2, used in the interpolation of sub-pixel values for the sub-pixels having co-ordinates with both K and L equal to 1 or 3, using a predetermined choice of either a weighted sum of the values of the sub-pixel having co-ordinates with K equal to 2 and L equal to zero and the values of sub-pixels having corresponding co-ordinates in immediately adjacent rectangular bounded regions, or a weighted sum of the value of the sub-pixel having co-ordinates with K equal to zero and L equal to 2 and the values of sub-pixels having corresponding co-ordinates in immediately adjacent rectangular bounded regions.

55. (Currently amended) An interpolator for eighth resolution sub-pixel value interpolation, the interpolator being configured to determine values for sub-pixels situated within a rectangular bounded region defined by four corner pixels with no intermediate pixels between the corners, the pixels and sub-pixels being configured for display in rows and columns, pixel and sub-pixel locations in the rows and columns being representable mathematically with the rectangular bounded region using the co-

ordinate notation K/8, L/8, K and L being positive integers having respective values between zero and 8, the interpolator being configured to:

- interpolate a sub-pixel value for a sub-pixel having co-ordinates with both K and L equal to 1, 3, 5 or 7, according to a predetermined choice of either a weighted average of the value of a nearest-neighbouring pixel and the value of the sub-pixel situated at co-ordinates 4/8, 4/8, or a weighted average of the values of a pair of diagonally-opposed sub-pixels having co-ordinates with both K and L equal to zero, 2, 4, 6 or 8, situated within a quadrant of the rectangular bounded region, the quadrant being defined by the sub-pixel having co-ordinates 4/8, 4/8 and the nearest neighbouring pixel;
- interpolate sub-pixel values for sub-pixels having co-ordinates with K equal to 2, 4 or 6 and L equal to zero and sub-pixels having co-ordinates with K equal to zero and L equal to 2, 4 or 6, used in the interpolation of the sub-pixels having co-ordinates with both K and L equal to 1, 3, 5 or 7, using weighted sums of the values of pixels located in rows and columns respectively; and
- interpolate sub-pixel values for sub-pixels having co-ordinates with both K and L equal to 2, 4 or 6, used in the interpolation of sub-pixel values for the sub-pixels having co-ordinates with both K and L equal to 1, 3, 5 or 7, using a predetermined choice of either a weighted sum of the values of sub-pixels having co-ordinates with K equal to 2, 4 or 6 and L equal to zero and the values of sub-pixels having corresponding co-ordinates in immediately adjacent rectangular bounded regions or a weighted sum of the values of sub-pixels having co-ordinates with K equal to zero and L equal to 2, 4 or 6 and the values of sub-pixels having corresponding co-ordinates in immediately adjacent rectangular bounded regions.

56. (Previously Presented) A video encoder or still image encoder comprising an interpolator according to claim 54 or 55.

57. (Previously Presented) A video decoder or still image decoder comprising an interpolator according to claim 54 or 55.

58. (Previously Presented) A communications terminal comprising a video encoder or still image encoder according to claim 56.

59. (Previously Presented) A communications terminal comprising a video decoder or still image decoder according to claim 57.

60. (Currently amended) A computer program embodied on a computer readable storage medium for sub-pixel value interpolation, the computer program being configured to determine values for sub-pixels situated within a rectangular bounded region defined by four corner pixels with no intermediate pixels between the corners, the pixels and sub-pixels being configured for display in rows and columns, pixel and sub-pixel locations in the rows and columns being representable mathematically within the rectangular bounded region using the co-ordinate notation $K/2^N$, $L/2^N$, K and L being positive integers having respective values between zero and $2^N$, N being a positive integer greater than one and representing a particular degree of sub-pixel value interpolation, the computer program comprising:

- computer program code for interpolating a sub-pixel value for a sub-pixel having co-ordinates with odd values of both K and L, according to a predetermined choice of either a weighted average of the value of a nearest-neighbouring pixel and the value of the sub-pixel situated at co-ordinates 1/2, 1/2, or a weighted average of the values of a pair of diagonally-opposed sub-pixels having co-ordinates with even values of both K and L, including zero, situated within a quadrant of the rectangular bounded region, the quadrant being defined by the sub-pixel having co-ordinates 1/2, 1/2 and the nearest neighbouring pixel;
- computer program code for interpolating sub-pixel values for sub-pixels having co-ordinates with K equal to an even value and L equal to zero and sub-pixels having co-ordinates with K equal to zero and L equal to an even value, used in the interpolation of the sub-pixels having co-ordinates with odd values of both K and L,

using weighted sums of the values of pixels located in rows and columns respectively; and

- computer program code for interpolating sub-pixel values for sub-pixels having co-ordinates with even values of both K and L, used in the interpolation of sub-pixel values for the sub-pixels having co-ordinates with odd values of both K and L, using a predetermined choice of either a weighted sum of the values of sub-pixels having co-ordinates with K equal to an even value and L equal to zero and the values of sub-pixels having corresponding co-ordinates in immediately adjacent rectangular bounded regions, or a weighted sum of the values of sub-pixels having co-ordinates with K equal to zero and L equal to an even value and the values of sub-pixels having corresponding co-ordinates in immediately adjacent bounded rectangular regions.

61. (Currently amended) A network apparatus comprising an interpolator for sub-pixel value interpolation, the interpolator being configured to determine values for sub-pixels situated within a rectangular bounded region defined by four corner pixels with no intermediate pixels between the corners, the pixels and sub-pixels being configured for display in rows and columns, pixel and sub-pixel locations in the rows and columns being representable mathematically within the rectangular bounded region using the co-ordinate notation $K/2^N$, $L/2^N$, K and L being positive integers having respective values between zero and $2^N$, N being a positive integer greater than one and representing a particular degree of sub-pixel value interpolation, the interpolator being configured to:

- interpolate a sub-pixel value for a sub-pixel having co-ordinates with odd values of both K and L, according to a predetermined choice of either a weighted average of the value of a nearest-neighbouring pixel and the value of the sub-pixel situated at co-ordinates 1/2, 1/2, or a weighted average of the values of a pair of diagonally-opposed sub-pixels having co-ordinates with even values of both K and L, including zero, situated within a quadrant of the rectangular bounded region, the quadrant being defined by the sub-pixel having co-ordinates 1/2, 1/2 and the nearest neighbouring pixel;

- interpolate sub-pixel values for sub-pixels having co-ordinates with K equal to an even value and L equal to zero and sub-pixels having co-ordinates with K equal to zero and L equal to an even value, used in the interpolation of the sub-pixels having co-ordinates with odd values of both K and L, using weighted sums of the values of pixels located in rows and columns respectively; and
- interpolate sub-pixel values for sub-pixels having co-ordinates with even values of both K and L, used in the interpolation of sub-pixel values for the sub-pixels having co-ordinates with odd values of both K and L, using a predetermined choice of either a weighted sum of the values of sub-pixels having co-ordinates with K equal to an even value and L equal to zero and the values of sub-pixels having corresponding co-ordinates in immediately adjacent rectangular bounded regions, or a weighted sum of the values of sub-pixels having co-ordinates with K equal to zero and L equal to an even value and the values of sub-pixels having corresponding co-ordinates in immediately adjacent bounded rectangular regions.

## III. REMARKS

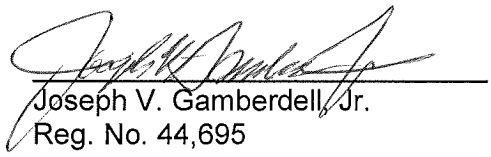
1. Only minor amendments to the claims have been made for clarity and consistency. Applicants respectfully submit that the amendments do not change the scope of the claims, do not require any substantial amount of work on the part of the Office, and do not require an additional search.

2. A terminal disclaimer is enclosed with this response.

For all of the foregoing reasons, it is respectfully submitted that all of the claims now present in the application are clearly novel and patentable over the prior art of record, and are in proper form for allowance. Accordingly, favorable reconsideration and allowance is respectfully requested. Should any unresolved issues remain, the Examiner is invited to call Applicants' attorney at the telephone number indicated below.

The Commissioner is hereby authorized to charge payment for any fees associated with this communication or credit any over payment to Deposit Account No. 16-1350.

Respectfully submitted,



Joseph V. Gamberdell, Jr.
Reg. No. 44,695



Date

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# Electronic Patent Application Fee Transmittal

| | |
|---|---|
| **Application Number:** | 11839205 |
| **Filing Date:** | 15-Aug-2007 |
| **Title of Invention:** | METHOD FOR SUB-PIXEL VALUE INTERPOLATION |
| **First Named Inventor/Applicant Name:** | Marta Karczewicz |
| **Filer:** | Joseph V. Gamberdell/Sarah Huber |
| **Attorney Docket Number:** | 982-010567-US (C02) |

Filed as Large Entity

## Utility under 35 USC 111(a) Filing Fees

| Description | Fee Code | Quantity | Amount | Sub-Total in USD($) |
|---|---|---|---|---|
| **Basic Filing:** | | | | |
| **Pages:** | | | | |
| **Claims:** | | | | |
| **Miscellaneous-Filing:** | | | | |
| **Petition:** | | | | |
| **Patent-Appeals-and-Interference:** | | | | |
| **Post-Allowance-and-Post-Issuance:** | | | | |
| **Extension-of-Time:** | | | | |
| Extension - 1 month with $0 paid | 1251 | 1 | 130 | 130 |

| Description | Fee Code | Quantity | Amount | Sub-Total in USD($) |
|---|---|---|---|---|
| **Miscellaneous:** | | | | |
| Statutory disclaimer | 1814 | 1 | 140 | 140 |
| | | **Total in USD ($)** | | **270** |

# Electronic Acknowledgement Receipt

| | |
|---|---|
| **EFS ID:** | 7573245 |
| **Application Number:** | 11839205 |
| **International Application Number:** | |
| **Confirmation Number:** | 8091 |
| **Title of Invention:** | METHOD FOR SUB-PIXEL VALUE INTERPOLATION |
| **First Named Inventor/Applicant Name:** | Marta Karczewicz |
| **Customer Number:** | 02512 |
| **Filer:** | Joseph V. Gamberdell/Sarah Huber |
| **Filer Authorized By:** | Joseph V. Gamberdell |
| **Attorney Docket Number:** | 982-010567-US (C02) |
| **Receipt Date:** | 07-MAY-2010 |
| **Filing Date:** | 15-AUG-2007 |
| **Time Stamp:** | 16:16:59 |
| **Application Type:** | Utility under 35 USC 111(a) |

## Payment information:

| | |
|---|---|
| Submitted with Payment | yes |
| Payment Type | Deposit Account |
| Payment was successfully received in RAM | $270 |
| RAM confirmation Number | 2530 |
| Deposit Account | 161350 |
| Authorized User | |
| The Director of the USPTO is hereby authorized to charge indicated fees and credit any overpayment as follows: Charge any Additional Fees required under 37 C.F.R. Section 1.21 (Miscellaneous fees and charges) | |

## File Listing:

| Document Number | Document Description | File Name | File Size(Bytes)/ Message Digest | Multi Part /.zip | Pages (if appl.) |
|---|---|---|---|---|---|
| 1 | Terminal Disclaimer Filed | TerminalDisclaimer100108.pdf | 183208<br>ca2230755ecd773689f0f9b3221d0427145e8af3 | no | 2 |
| **Warnings:** | | | | | |
| **Information:** | | | | | |
| 2 | Amendment After Final | AFAmendment100507.pdf | 1470524<br>927679876bed5604c834d9d59db2166a9c09036c | no | 26 |
| **Warnings:** | | | | | |
| **Information:** | | | | | |
| 3 | Fee Worksheet (PTO-875) | fee-info.pdf | 32704<br>e446bd6c12a65d8ecd4748222c362e0691486728 | no | 2 |
| **Warnings:** | | | | | |
| **Information:** | | | | | |
| | | **Total Files Size (in bytes):** | 1686436 | | |

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**If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.**

**<u>National Stage of an International Application under 35 U.S.C. 371</u>**
**If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.**

**<u>New International Application Filed with the USPTO as a Receiving Office</u>**
**If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.**

PTO/SB/26 (07-09)
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U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
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| TERMINAL DISCLAIMER TO OBVIATE A DOUBLE PATENTING REJECTION OVER A "PRIOR" PATENT | Docket Number (Optional) 982-010567-US (C02) |
|---|---|

In re Application of: Marta Karczewicz

Application No.: 11/839,205

Filed: 2007-08-15

For: METHOD FOR SUB-PIXEL VALUE INTERPOLATION

The owner*, Nokia Corporation, of 100 percent interest in the instant application hereby disclaims, except as provided below, the terminal part of the statutory term of any patent granted on the instant application which would extend beyond the expiration date of the full statutory term **prior patent** No. 7,280,599 as the term of said prior patent is defined in 35 U.S.C. 154 and 173, and as the term of said **prior patent** is presently shortened by any terminal disclaimer. The owner hereby agrees that any patent so granted on the instant application shall be enforceable only for and during such period that it and the **prior patent** are commonly owned. This agreement runs with any patent granted on the instant application and is binding upon the grantee, its successors or assigns.

In making the above disclaimer, the owner does not disclaim the terminal part of the term of any patent granted on the instant application that would extend to the expiration date of the full statutory term as defined in 35 U.S.C. 154 and 173 of the **prior patent**, "as the term of said **prior patent** is presently shortened by any terminal disclaimer," in the event that said **prior patent** later:

expires for failure to pay a maintenance fee;
is held unenforceable;
is found invalid by a court of competent jurisdiction;
is statutorily disclaimed in whole or terminally disclaimed under 37 CFR 1.321;
has all claims canceled by a reexamination certificate;
is reissued; or
is in any manner terminated prior to the expiration of its full statutory term as presently shortened by any terminal disclaimer.

*Check either box 1 or 2 below, if appropriate.*

1. ☐ For submissions on behalf of a business/organization (e.g., corporation, partnership, university, government agency, etc.), the undersigned is empowered to act on behalf of the business/organization.

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

2. ☑ The undersigned is an attorney or agent of record. Reg. No. 24,622

Signature — Date: 1/8/2010

Clarence A. Green
Typed or printed name

(203) 259-1800
Telephone Number

☑ Terminal disclaimer fee under 37 CFR 1.20(d) previously paid

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This collection of information is required by 37 CFR 1.321. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.11 and 1.14. This collection is estimated to take 12 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

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2. A record from this system of records may be disclosed, as a routine use, in the course of presenting evidence to a court, magistrate, or administrative tribunal, including disclosures to opposing counsel in the course of settlement negotiations.
3. A record in this system of records may be disclosed, as a routine use, to a Member of Congress submitting a request involving an individual, to whom the record pertains, when the individual has requested assistance from the Member with respect to the subject matter of the record.
4. A record in this system of records may be disclosed, as a routine use, to a contractor of the Agency having need for the information in order to perform a contract. Recipients of information shall be required to comply with the requirements of the Privacy Act of 1974, as amended, pursuant to 5 U.S.C. 552a(m).
5. A record related to an International Application filed under the Patent Cooperation Treaty in this system of records may be disclosed, as a routine use, to the International Bureau of the World Intellectual Property Organization, pursuant to the Patent Cooperation Treaty.
6. A record in this system of records may be disclosed, as a routine use, to another federal agency for purposes of National Security review (35 U.S.C. 181) and for review pursuant to the Atomic Energy Act (42 U.S.C. 218(c)).
7. A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (*i.e.*, GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.
8. A record from this system of records may be disclosed, as a routine use, to the public after either publication of the application pursuant to 35 U.S.C. 122(b) or issuance of a patent pursuant to 35 U.S.C. 151. Further, a record may be disclosed, subject to the limitations of 37 CFR 1.14, as a routine use, to the public if the record was filed in an application which became abandoned or in which the proceedings were terminated and which application is referenced by either a published application, an application open to public inspection or an issued patent.
9. A record from this system of records may be disclosed, as a routine use, to a Federal, State, or local law enforcement agency, if the USPTO becomes aware of a violation or potential violation of law or regulation.

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**IN THE UNITED STATES PATENT AND TRADEMARK OFFICE**

| | | | |
|---|---|---|---|
| APPLICANT(s): | Marta Karczewicz | CONF. NO.: | 8091 |
| SERIAL NO.: | 11/839,205 | ART UNIT: | 2621 |
| FILING DATE: | 08/15/2007 | EXAMINER: | An, Shawn S. |
| TITLE: | METHOD FOR SUB-PIXEL VALUE INTERPOLATION | | |
| ATTORNEY DOCKET NO.: | 982-010567-US (C02) | | |

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Alexandria VA 22313-1450

**AMENDMENT AFTER FINAL**

## I. INTRODUCTION

This is a response to the Final Office Action mailed 8 December 2009 for this application.

Reconsideration of the rejection of the claims is respectfully solicited in light of the following amendment and remarks.

## EAST Search History

## EAST Search History (Interference)

| Ref # | Hits | Search Query | DBs | Default Operator | Plurals | Time Stamp |
|---|---|---|---|---|---|---|
| S226 | 40 | S220 and S224 | USPAT; UPAD | SAME | OFF | 2010/05/11 21:23 |
| S227 | 35 | S223 and S224 | USPAT; UPAD | SAME | OFF | 2010/05/11 21:23 |
| S238 | 4301 | 375/240.17 375/240.16 375/240.12 | USPAT; UPAD | OR | OFF | 2010/05/12 21:17 |
| S239 | 4999 | 382/238 382/236 | USPAT; UPAD | OR | OFF | 2010/05/12 21:17 |
| S240 | 7628 | S238 S239 | USPAT; UPAD | OR | OFF | 2010/05/12 21:17 |
| S241 | 21848 | ((half sub quarter) near$4 pixel) same interpolat$3 | USPAT; UPAD | OR | OFF | 2010/05/12 21:17 |
| S242 | 625 | S241 same weight $3 same average | USPAT; UPAD | OR | OFF | 2010/05/12 21:18 |
| S243 | 46 | S240 and S242 | USPAT; UPAD | OR | OFF | 2010/05/12 21:18 |

**5/13/2010 6:46:46 PM**
**C:\Documents and Settings\san\My Documents\EAST\Workspaces\EASTPush.wsp**

US006693960B2

(12) **United States Patent**
**Ito et al.**

(10) **Patent No.: US 6,693,960 B2**
(45) **Date of Patent: *Feb. 17, 2004**

(54) **MOVING PICTURE ENCODER AND MOVING PICTURE DECODER**

(75) Inventors: **Norio Ito**, Chiba (JP); **Hiroyuki Katata**, Chiba (JP); **Tomoko Aono**, Chiba (JP); **Hiroshi Kusao**, Chiba (JP)

(73) Assignee: **Sharp Kabushiki Kaisha**, Osaka (JP)

( * ) Notice: This patent issued on a continued prosecution application filed under 37 CFR 1.53(d), and is subject to the twenty year patent term provisions of 35 U.S.C. 154(a)(2).

Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **09/242,452**

(22) PCT Filed: **May 16, 1997**

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(2), (4) Date: **Feb. 17, 1999**

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(30) **Foreign Application Priority Data**

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(51) **Int. Cl.**[7] ..... **H04N 7/12**
(52) **U.S. Cl.** ..... **375/240.11**; 375/240.1; 375/240.16
(58) **Field of Search** ..... 375/240.1, 240.16, 375/240, 240.11; 348/422, 405, 413, 415

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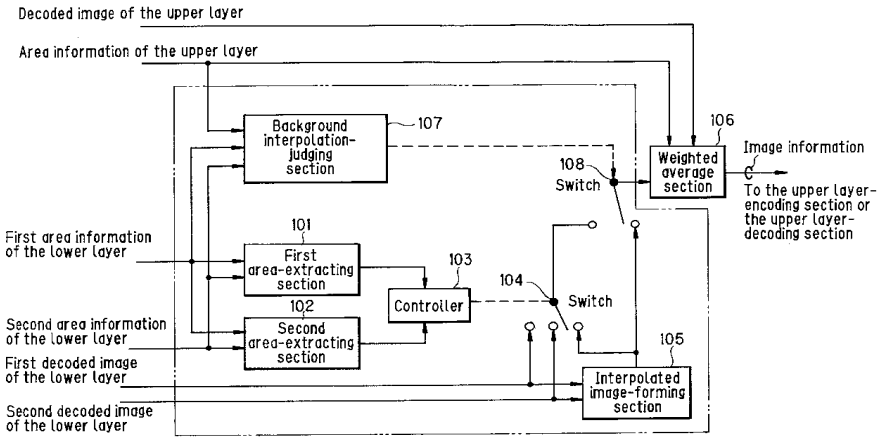
(List continued on next page.)

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(74) *Attorney, Agent, or Firm*—Birch, Stewart, Kolasch & Birch, LLP

(57) **ABSTRACT**

When a background interpolation-judging section **107** judges that parts areas of a lower layer and an upper layer move significantly, and a visual effect can be obtained by the background interpolation, a controller **103** controls a switch **104** based on the area information of the parts area of the lower layer to perform the background interpolation. A weighted average section **106** takes an average by weighting to the upper layer and the lower layer by using the interpolated background to generate an interpolated image. By using this interpolated image, the prediction-encoding/decoding of the upper layer is performed. On the contrary, when the background interpolation-judging section **107** judges that parts areas do not move so significantly, and a visual effect cannot be obtained by the background interpolation, a background is synthesized by using the output of the interpolated image-forming section **105** to generate an interpolated image. Hence, the shape information for the background interpolation is reduced and high quality of an image can be obtained.

**12 Claims, 14 Drawing Sheets**



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* cited by examiner

FIG. 1

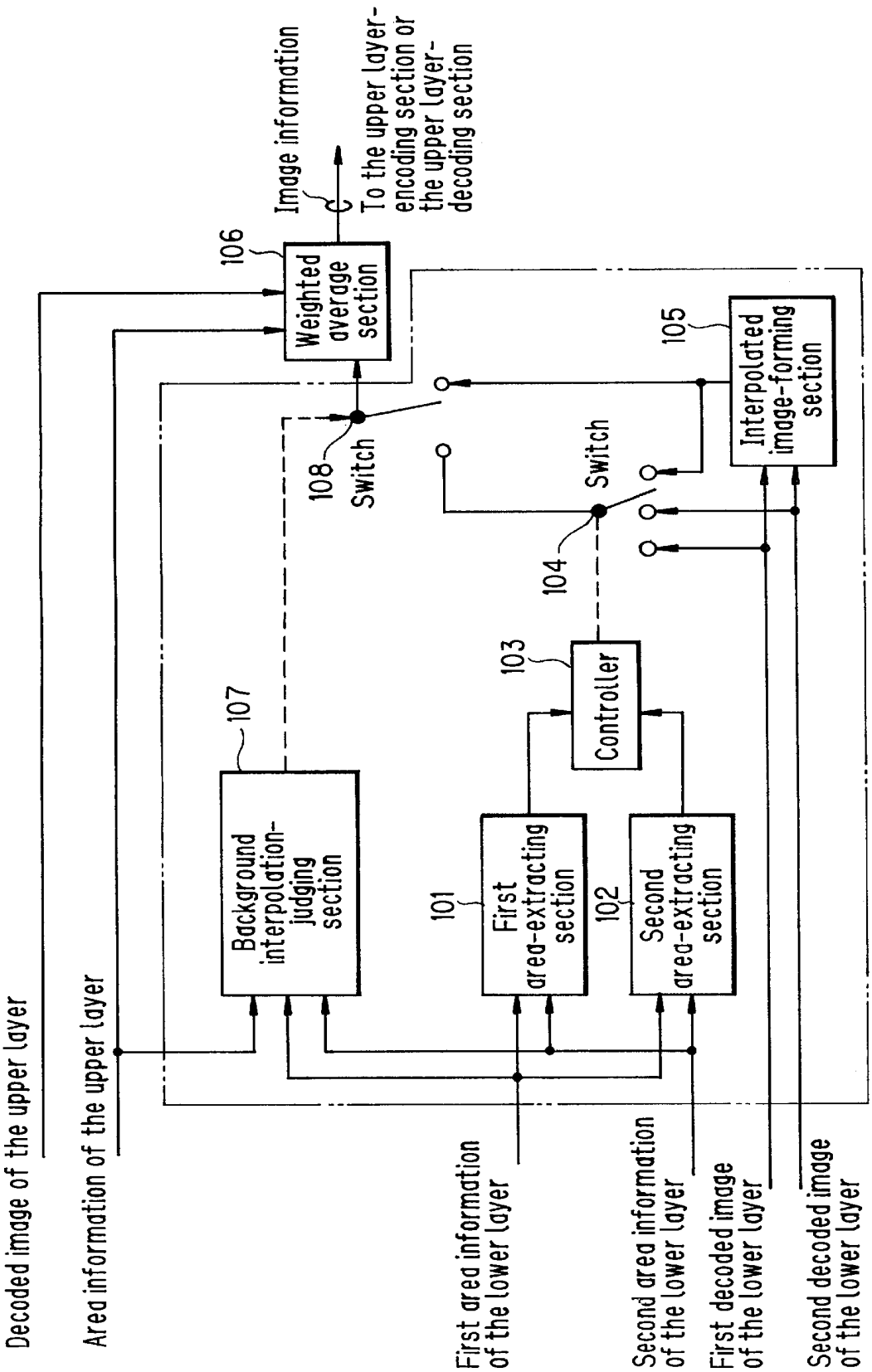

Decoded image of the upper layer
Area information of the upper layer
Background interpolation-judging section
107
First area-extracting section
101
Second area-extracting section
102
Controller
103
Switch
104
Interpolated image-forming section
105
Weighted average section
106
Switch
108
Image information
To the upper layer-encoding section or the upper layer-decoding section
First area information of the lower layer
Second area information of the lower layer
First decoded image of the lower layer
Second decoded image of the lower layer

FIG. 2

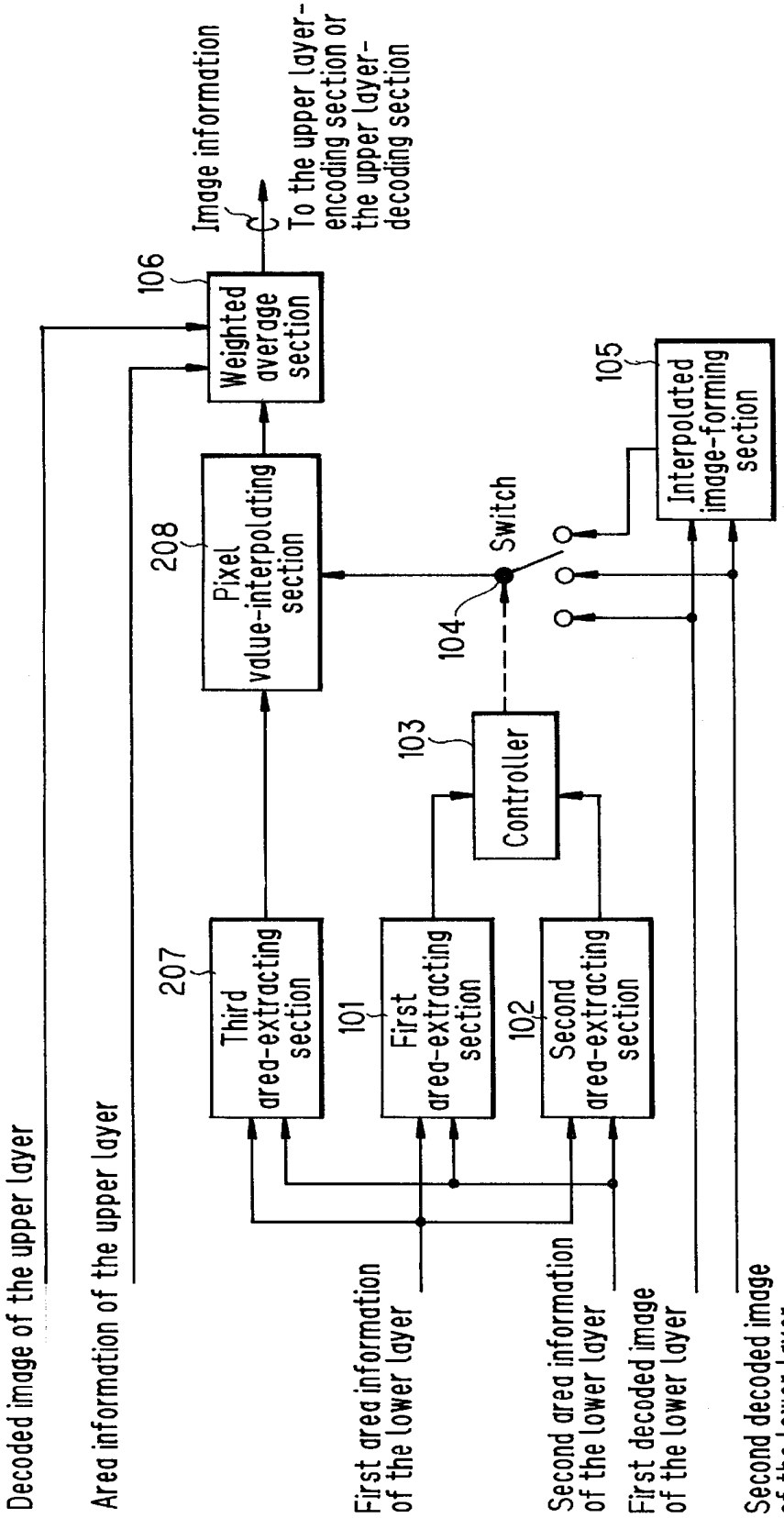

Decoded image of the upper layer
Area information of the upper layer
First area information of the lower layer
Second area information of the lower layer
First decoded image of the lower layer
Second decoded image of the lower layer
207
Third area-extracting section
101
First area-extracting section
102
Second area-extracting section
103
Controller
104
Switch
208
Pixel value-interpolating section
105
Interpolated image-forming section
106
Weighted average section
Image information
To the upper layer-encoding section or the upper layer-decoding section

FIG. 3

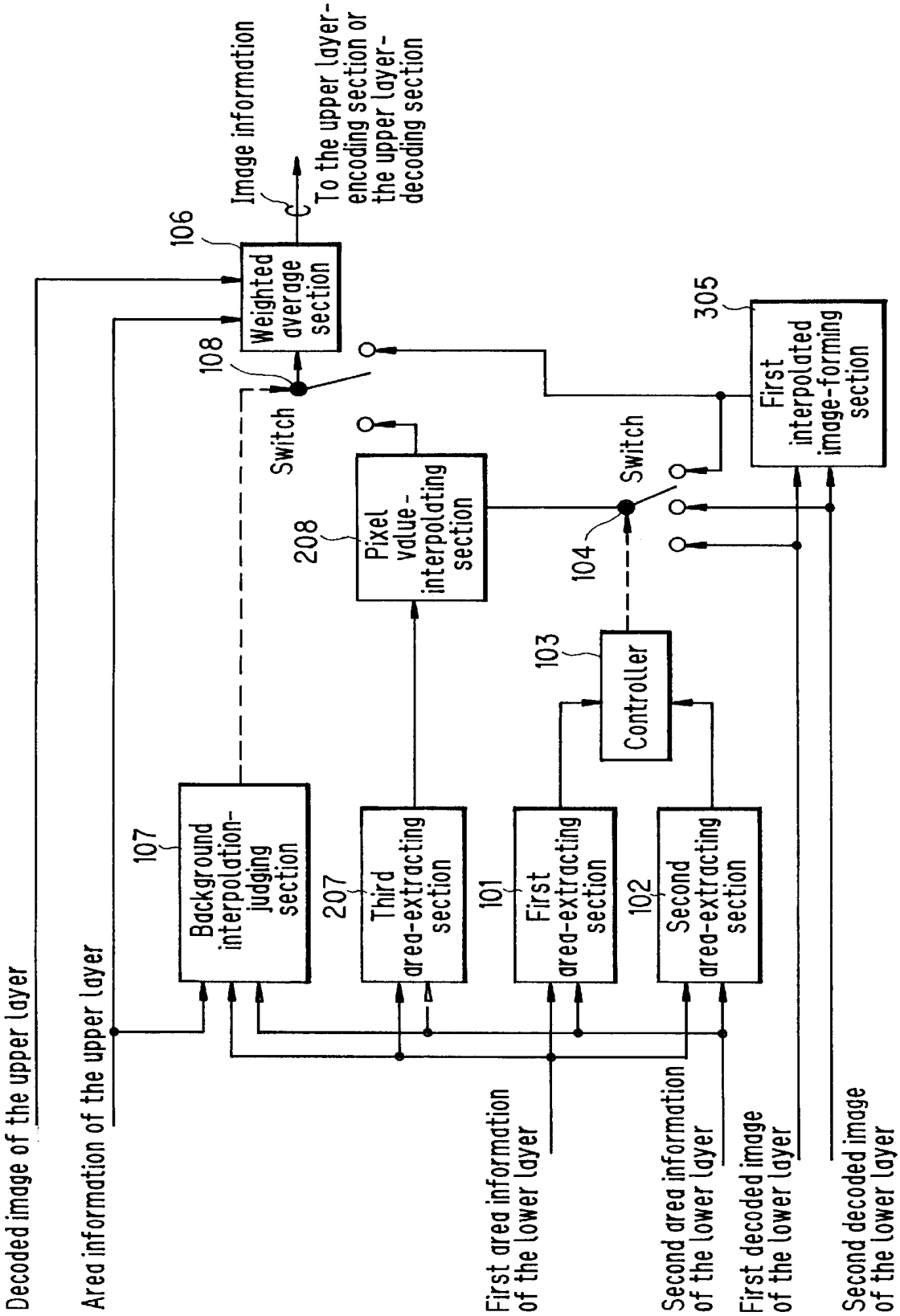

Decoded image of the upper layer
Area information of the upper layer
Background interpolation-judging section
107
Third area-extracting section
207
First area-extracting section
101
Second area-extracting section
102
Controller
103
Pixel value-interpolating section
208
Switch
104
Switch
108
Weighted average section
106
Image information
To the upper layer-encoding section or the upper layer-decoding section
First interpolated image-forming section
305
First area information of the lower layer
Second area information of the lower layer
First decoded image of the lower layer
Second decoded image of the lower layer

FIG. 4

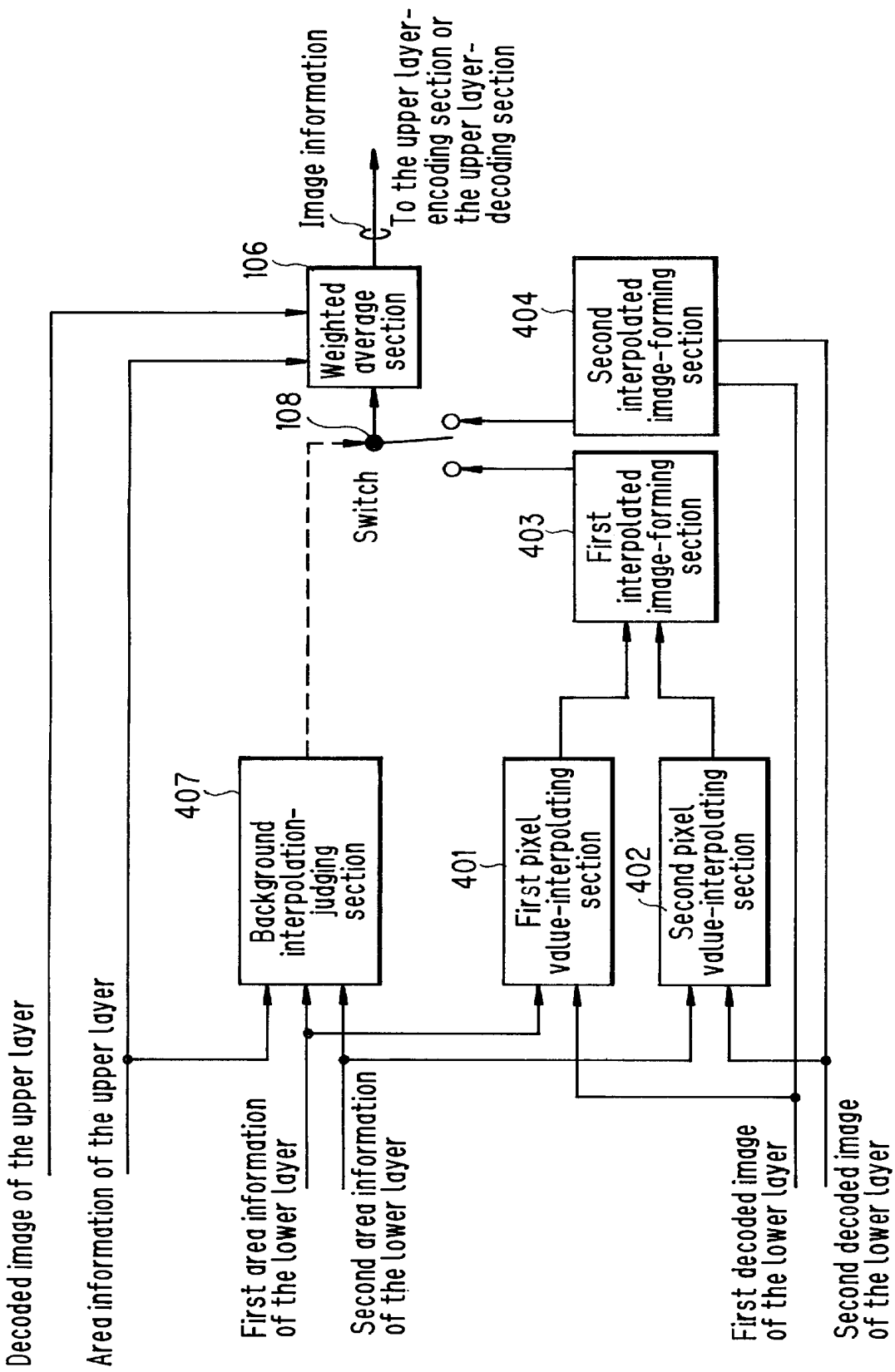

Decoded image of the upper layer
Area information of the upper layer
First area information of the lower layer
Second area information of the lower layer
First decoded image of the lower layer
Second decoded image of the lower layer
Background interpolation-judging section
407
First pixel value-interpolating section
401
Second pixel value-interpolating section
402
First interpolated image-forming section
403
Second interpolated image-forming section
404
Switch
108
Weighted average section
106
Image information
To the upper layer-encoding section or the upper layer-decoding section

FIG. 5

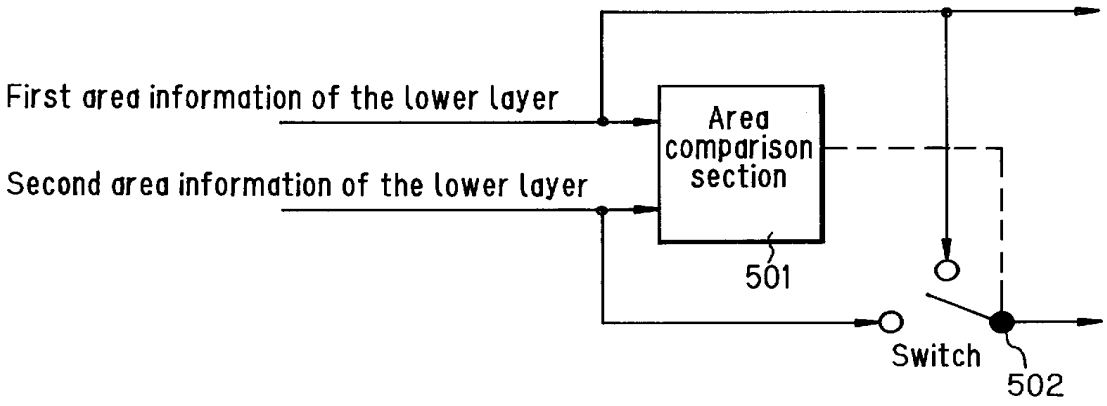

First area information of the lower layer
Second area information of the lower layer
Area comparison section
501
Switch
502

FIG. 6

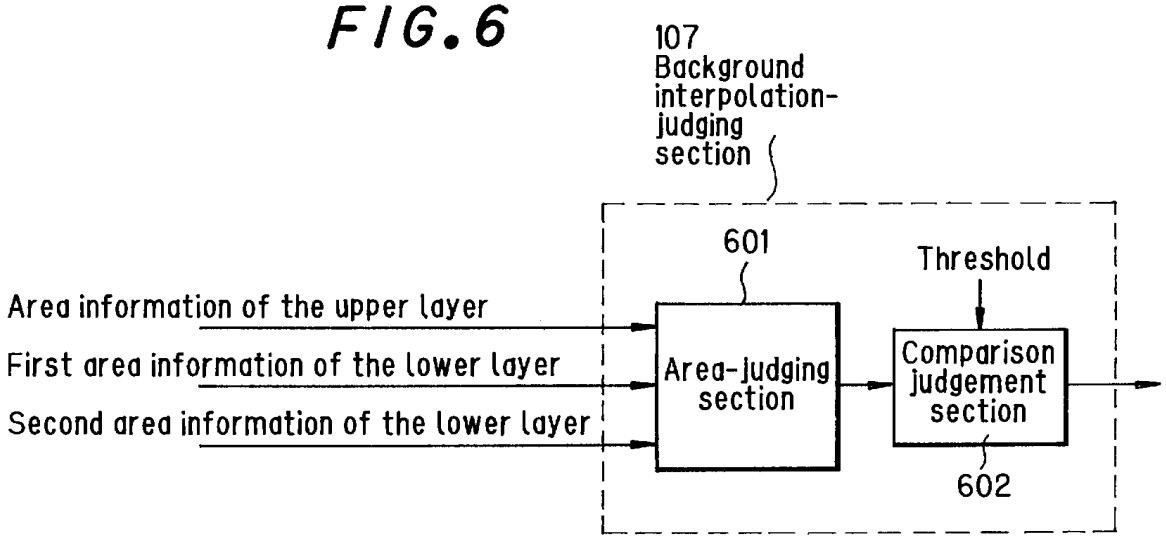

107
Background interpolation-judging section
601
Threshold
Area information of the upper layer
First area information of the lower layer
Second area information of the lower layer
Area-judging section
Comparison judgement section
602

FIG. 7

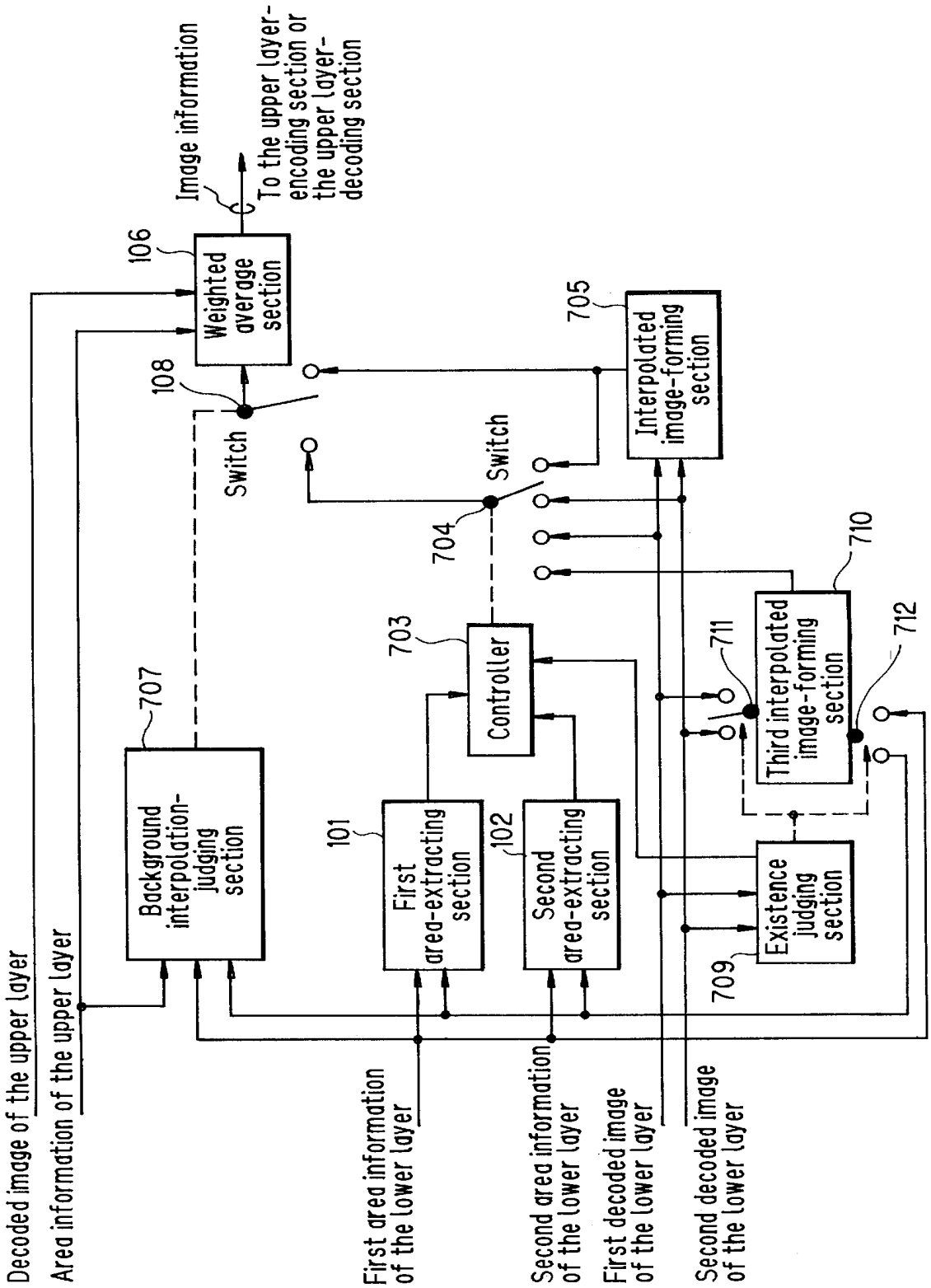

Image information
To the upper layer-encoding section or the upper layer-decoding section
106
Weighted average section
108
Switch
705
Interpolated image-forming section
Switch
704
703
Controller
710
711
712
Third interpolated image-forming section
707
Background interpolation-judging section
101
First area-extracting section
102
Second area-extracting section
Existence judging section
709
Decoded image of the upper layer
Area information of the upper layer
First area information of the lower layer
Second area information of the lower layer
First decoded image of the lower layer
Second decoded image of the lower layer

FIG. 8

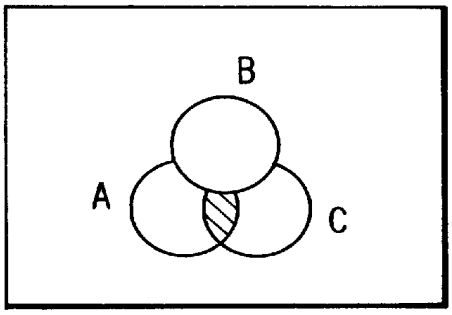



FIG. 9

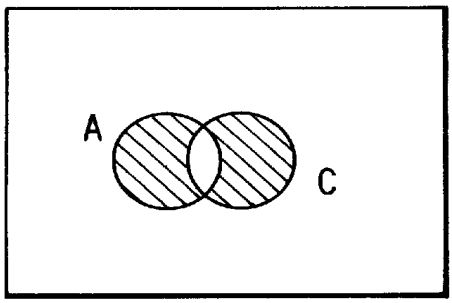



FIG. 10

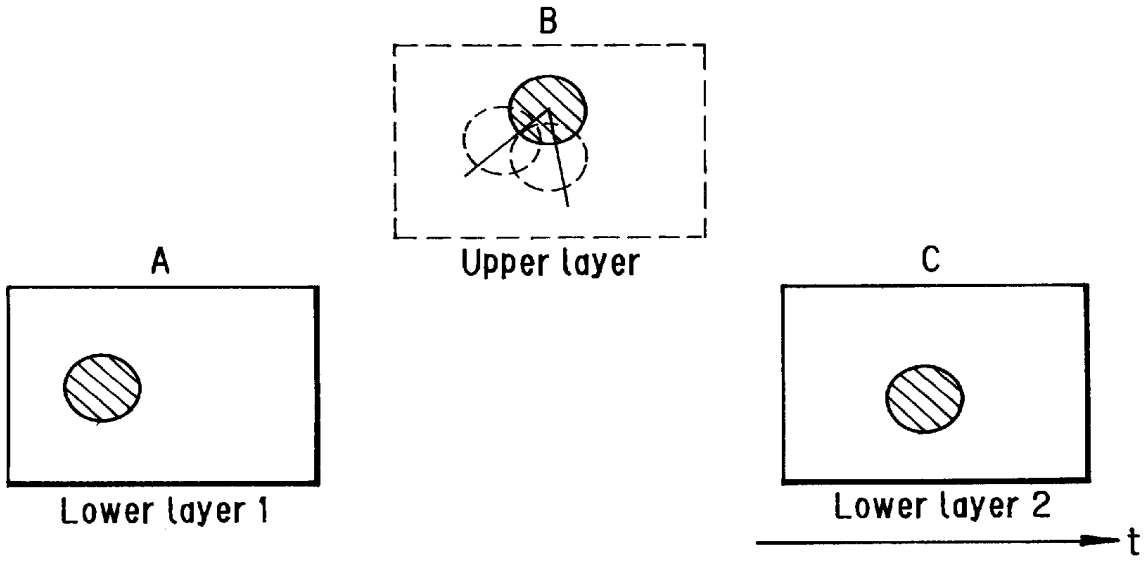


FIG. 11

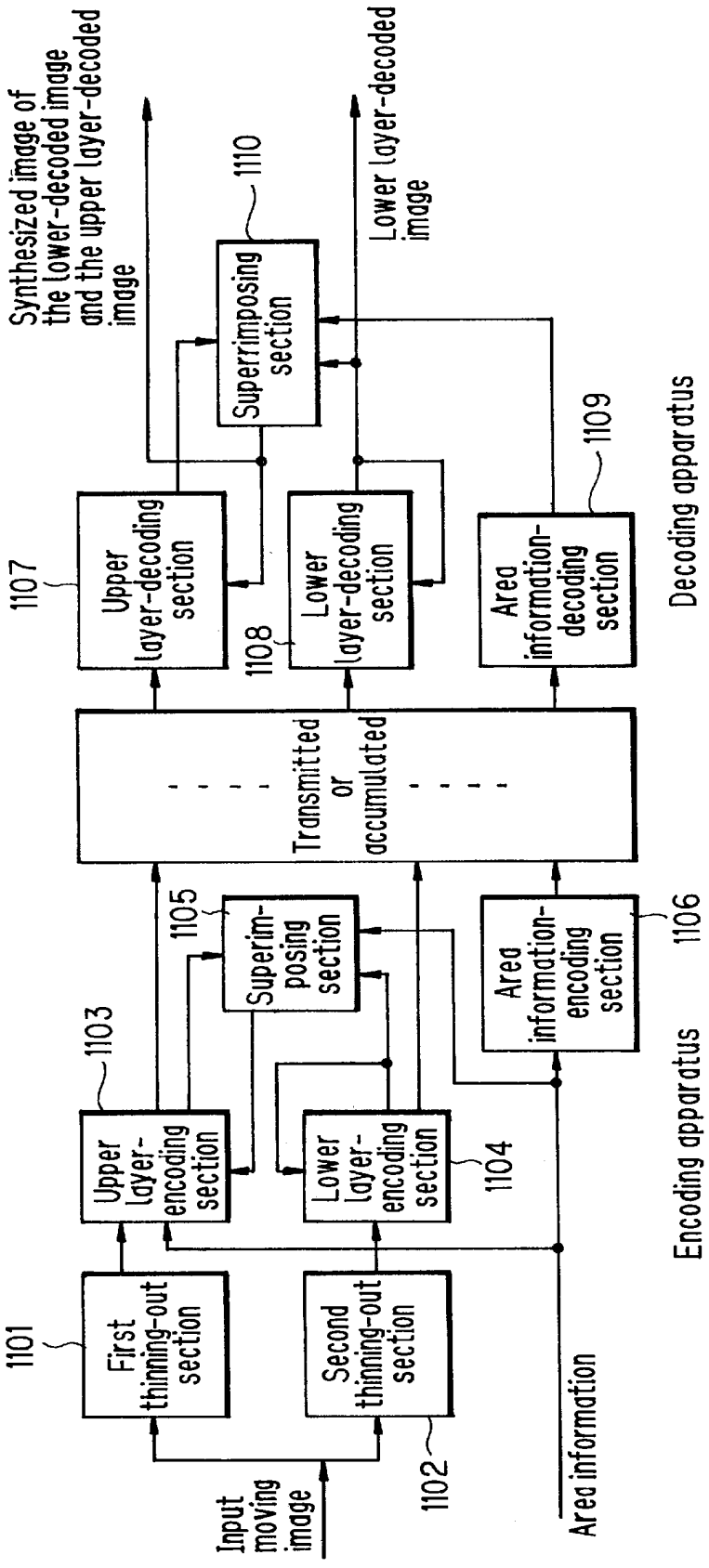

Synthesized image of the lower-decoded image and the upper layer-decoded image
Lower layer-decoded image
1110
Superrimposing section
1107
Upper layer-decoding section
1108
Lower layer-decoding section
1109
Area information-decoding section
Decoding apparatus
Transmitted or accumulated
1105
Superim-posing section
1103
Upper layer-encoding section
Lower layer-encoding section
1104
Area information-encoding section
1106
Encoding apparatus
1101
First thinning-out section
Second thinning-out section
1102
Input moving image
Area information

FIG. 12

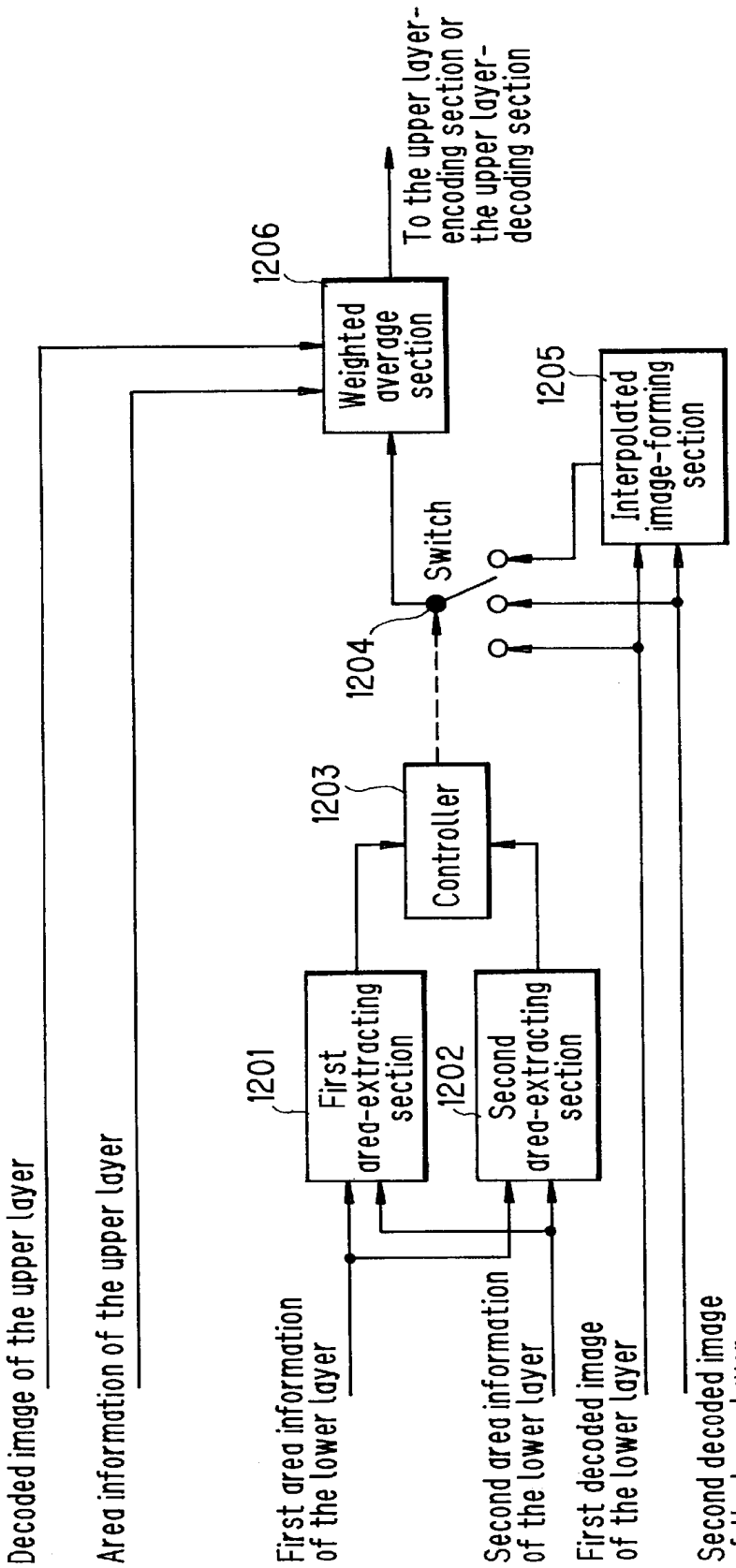
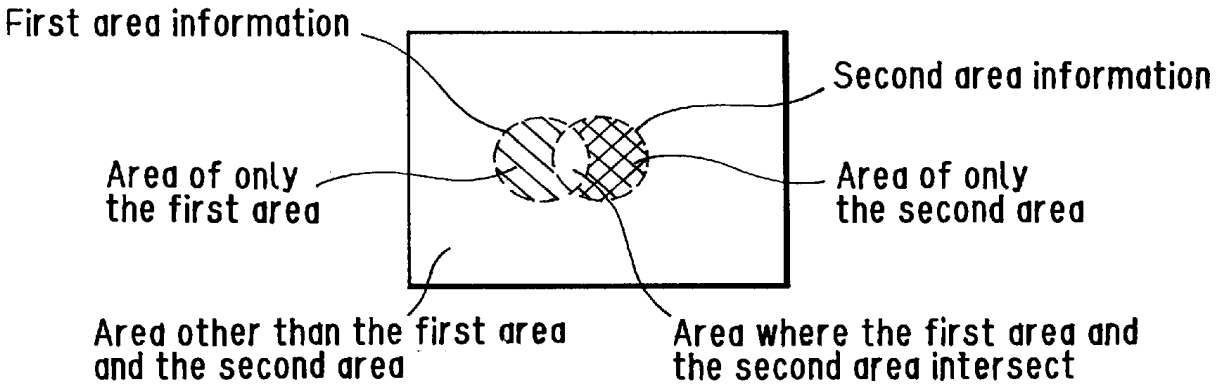
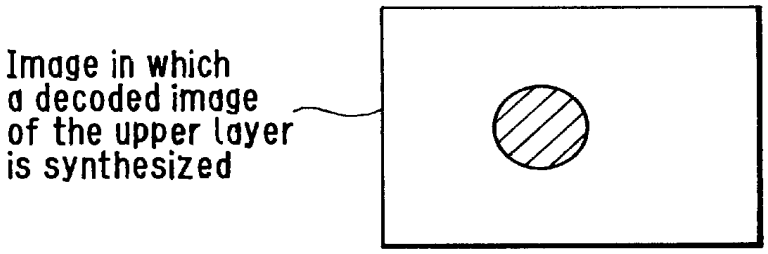

Decoded image of the upper layer
Area information of the upper layer
First area information of the lower layer
Second area information of the lower layer
First decoded image of the lower layer
Second decoded image of the lower layer
1201
First area-extracting section
1202
Second area-extracting section
1203
Controller
1204
Switch
1205
Interpolated image-forming section
1206
Weighted average section
To the upper layer-encoding section or the upper layer-decoding section

FIG. 13

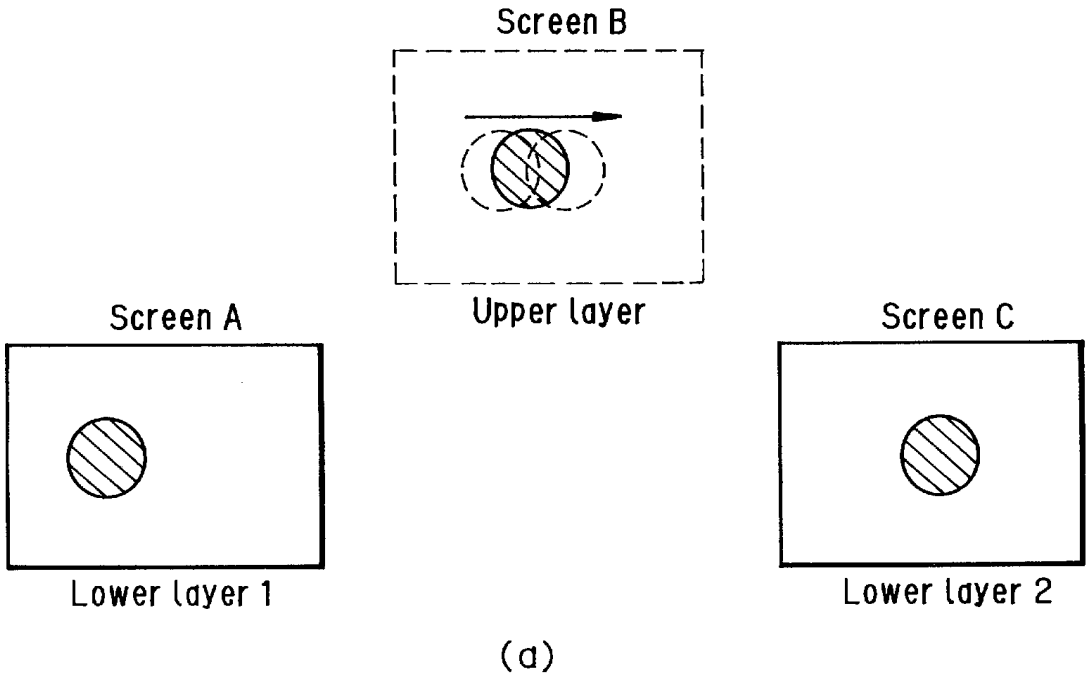

First area information
Second area information
Area of only the first area
Area of only the second area
Area other than the first area and the second area
Area where the first area and the second area intersect

(a)

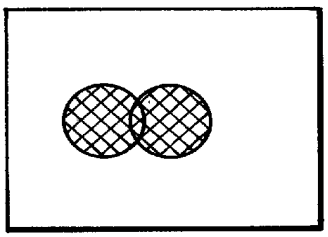

Image in which a decoded image of the upper layer is synthesized

(b)

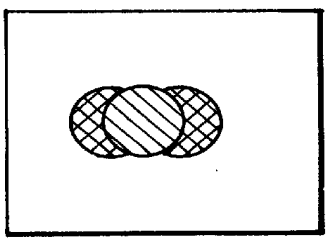
FIG. 14


Screen B
Upper layer
Screen A
Lower layer 1
Screen C
Lower layer 2

(a)



(b)



(c)

FIG. 15

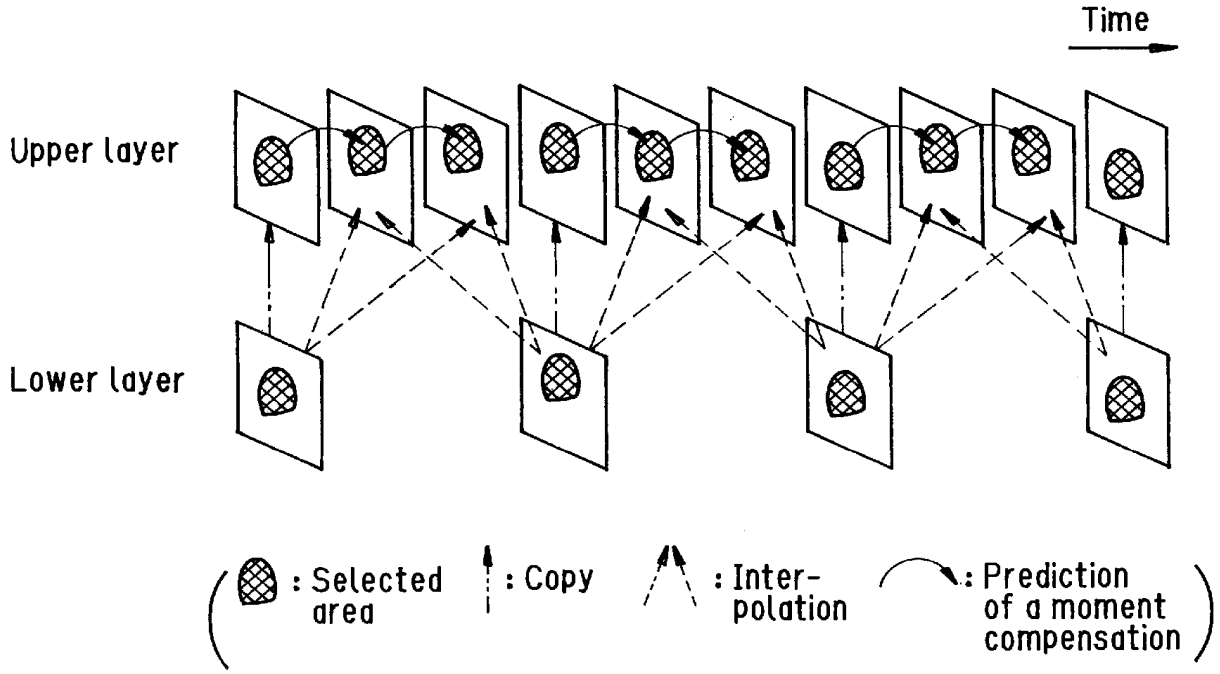
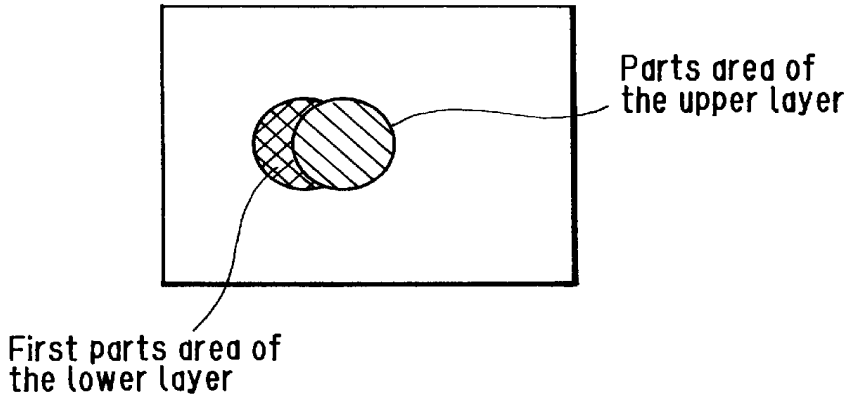

Time
Upper layer
Lower layer
: Selected area
: Copy
: Inter-polation
: Prediction of a moment compensation

FIG. 16


Parts area of the upper layer
First parts area of the lower layer

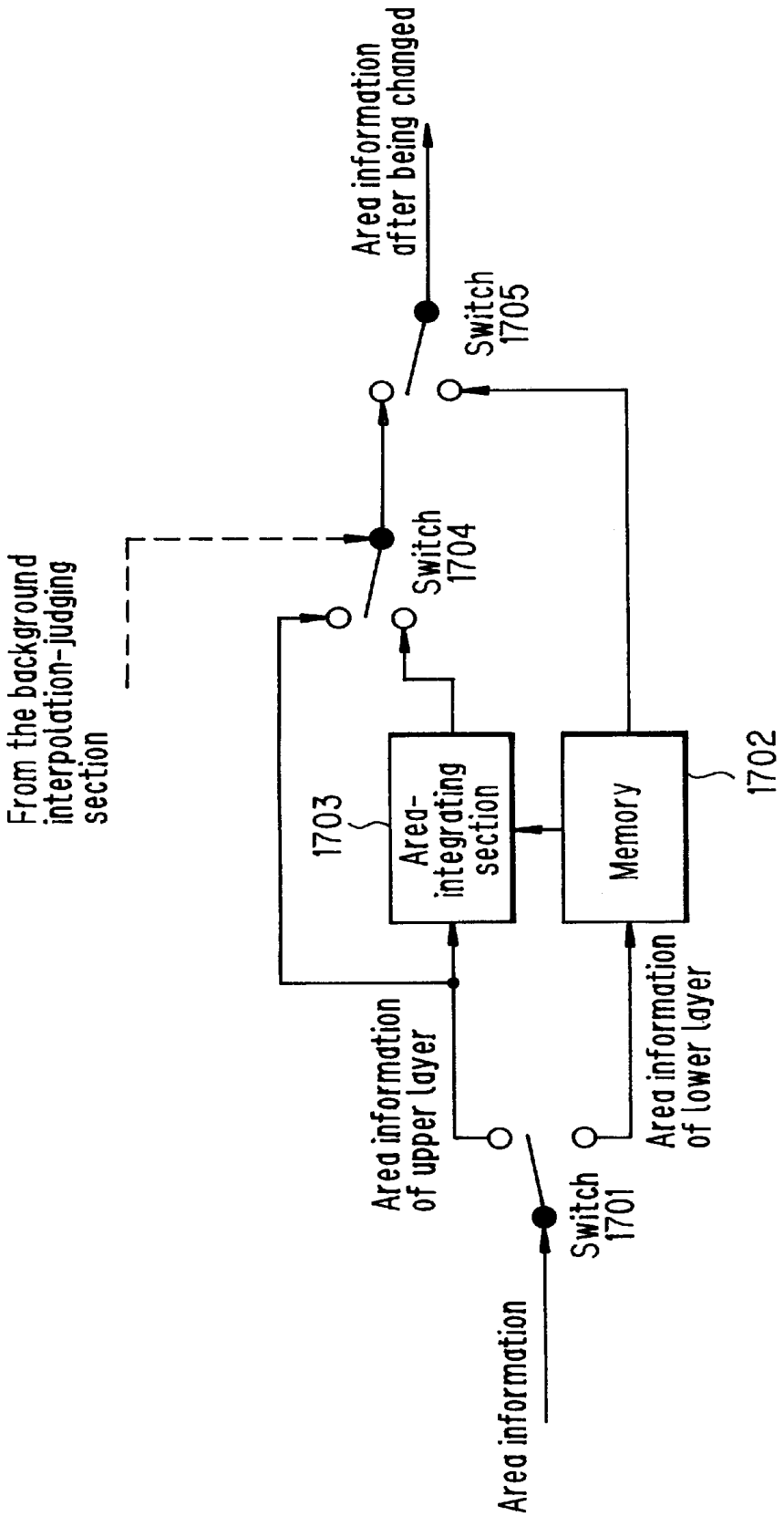

Area information after being changed
Switch 1705
Switch 1704
From the background interpolation-judging section
1703
Area-integrating section
Memory
1702
Area information of upper layer
Area information of lower layer
Switch 1701
Area information

FIG. 17

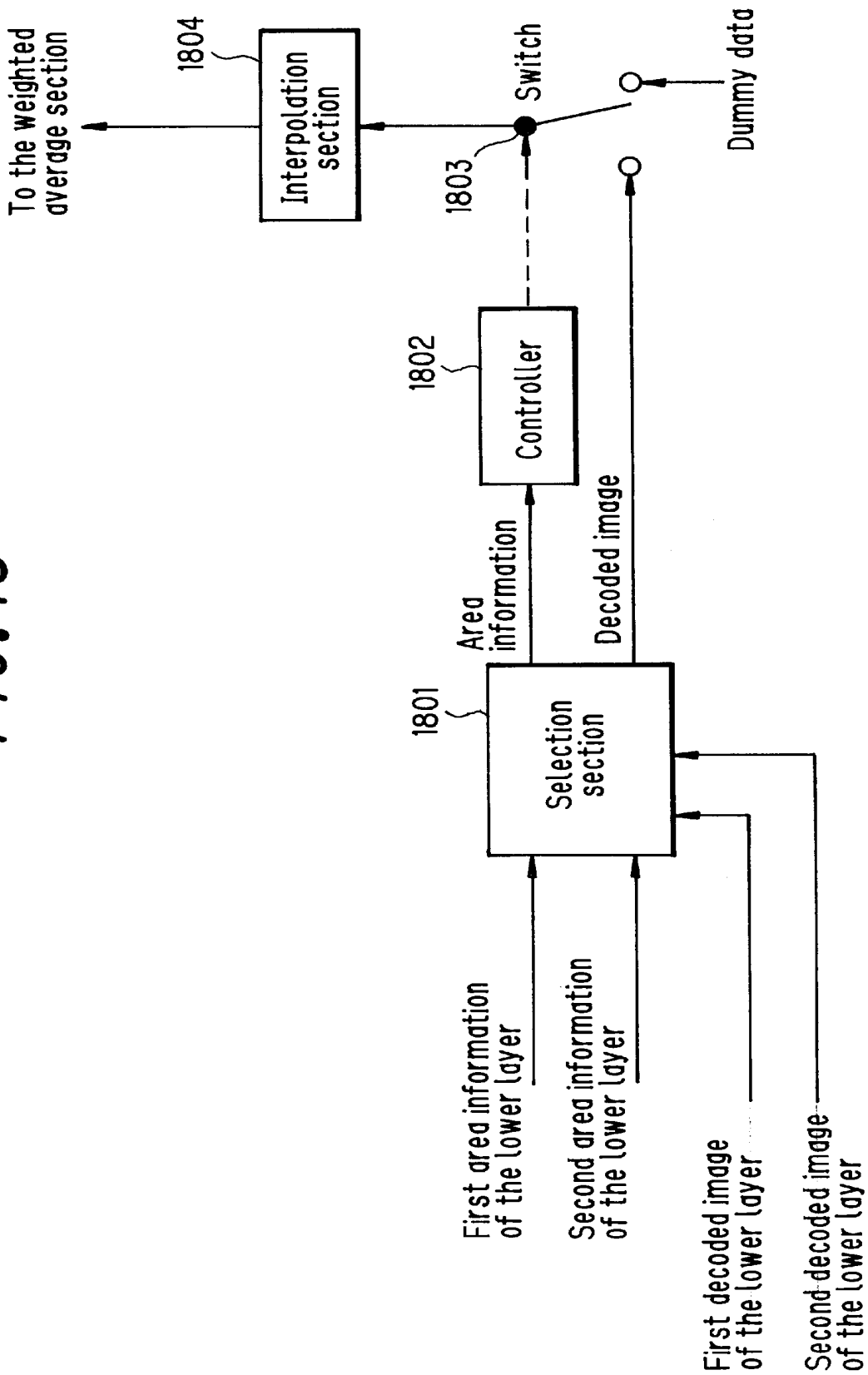

To the weighted average section
1804
Interpolation section
Switch
1803
Dummy data
1802
Controller
Area information
Decoded image
1801
Selection section
First area information of the lower layer
Second area information of the lower layer
First decoded image of the lower layer
Second decoded image of the lower layer

FIG. 18

# MOVING PICTURE ENCODER AND MOVING PICTURE DECODER

This application is the national phase under 35 U.S.C. §371 of prior PCT International Application No. PCT/JP97/01659 which has an International filing date of May 16, 1997 which designated the United States of America.

## TECHNICAL FIELD

The present invention relates to technical field of a digital image processing and especially relates to a moving image encoding apparatus for efficiently encoding image data, and a moving image decoding apparatus for decoding the encoded data produced by the moving image encoding apparatus.

## BACKGROUND ART

In the image encoding, a method of synthesizing different moving image sequences has been studied.

In a literature, "Image Encoding Using a Hierarchical Expression and Multiple Templates" (Shingaku Giho IE94-159, pp. 99–106 (1995)), there is described a method in which a moving image sequence as a background and a moving image sequence of a partial moving image as a foreground (for example, human image, picture of fish and the like cut down by a Chroma key technique) are superimposed to prepare a new sequence.

In addition, in a literature, "Temporal Scalability based on Image Content", (ISO/IEC/JTC1/SC29/WG11 MPEG95/211 (1995)), there is described a method in which a moving image sequence of a partial moving image having a high frame rate is superimposed on a moving image sequence having a low frame rate to prepare a new sequence.

With this method, as shown in FIG. **15**, prediction-encoding is performed at a low frame rate in a lower layer, and prediction-encoding is performed at a high frame rate only for a selected area (dotted portion) in an upper layer. In this case, an image frame decoded up to the upper layer is obtained by superimposing an image frame decoded by the lower layer and an area decoded by the upper layer. Moreover, a frame encoded by the lower layer is not encoded in the upper layer, and the decoded image of the lower layer is directly copied. In addition, it is assumed that a portion which attracts the audience's attention, such as a personality portion is selected as the selected area.

FIG. **11** shows a block diagram of the conventional art. On the encoding side in the conventional art, the input moving image layer is thinned out between frames by a first thinning-out section **1101** and a second thinning-out section **1102**, and made to be the frame rate or less of the input image, then input to an upper layer encoding section and a lower layer encoding section. Here, the frame rate in the upper layer is assumed to be higher than the frame rate of the lower layer.

In the lower layer encoding section **1104**, the entire input moving image is encoded. As the encoding method, an international standard method for encoding moving images, for example, MPEG or H. 261 is used. In the lower layer encoding section **1104**, decoded image of the lower layer is prepared, and input to a superimposing section **1105** upon being utilized for prediction-encoding.

In the upper layer encoding section **1103**, only a selected area of the input moving image is encoded. Here, the international standard method for encoding moving images such as MPEG and H.261 is again used, but only the selected area is encoded based on the area information. However, the frame encoded in the lower layer is not encoded in the upper layer. The area information is the information showing the selected area of, for example, a personality portion, and is a binarized image which takes value 1 at a position in the selected area and takes value 0 at a position other than the selected area. Also in the upper layer encoding section **1103**, only the selected area of the moving image is decoded, and input to the superimposing section **1105**.



In an area information encoding section **1106**, the area information is encoded by utilizing a chain code or the like.

The superimposing section **1105** outputs a decoded image of the lower layer, when the lower layer frame has been encoded in the frame to be superimposed. When the lower layer frame has not been encoded in the frame to be superimposed, the superimposing section **1105** outputs a moving image by using two decoded image of the lower layer before and behind the frame to be superimposed and one decoded image of the upper layer. The two image frames of the lower layer are before and behind the upper layer frame. The moving image prepared here is input to the lower layer encoding section **1103** and utilized for the prediction-encoding. The image forming method in the superimposing section **1105** is as described below.

First, two interpolated images of the lower layer are prepared. If it is assumed that the decoded image of the lower layer at time "t" is B(x, y, t)(provided that x and y are coordinates representing a position of a pixel in the space), and that the time of the two frames of the lower layer are t1 and t2, respectively, and the time of the upper layer is t3 (provided that t1<t3<t2), the interpolated image at time t3 (x, y, t3) can be calculated by the following expression (1):

$$I(x, y, t3)=[(t2-t3)B(x, y, t1)+(t3-t1)B(x, y, t2)]/(t2-t1) \quad (1)$$

Then, a decoded image E of the upper layer is superimposed on the interpolated image I determined by the above expression (1). For this purpose, weight information W (x, y, t) for interpolation is prepared from the area information M (x, y, t), to obtain a superimposed image S by the following expression (2):

$$S(x, y, t)=[1-W(x, y, t)]I(x, y, t)+E(x, y, t)W(x, y, t) \quad (2)$$

Here, the area information M (x, y, t) is a binarized image which takes 1 within the selected area and takes 0 outside the selected area, and by applying a low-pass filter to this image for plural times, the weight information W (x, y, t) can be obtained. That is to say, the weight information W (x, y, t) takes 1 within the selected area, takes 0 outside the selected area, and takes 0 to 1 in the boundary of the selected area. The above-mentioned description is for the image forming method in the superimposing section **1105**. The encoded data encoded in the lower layer encoding section, the upper layer encoding section, and the area information encoding section is integrated in an encoded data-integrating section (not shown) and transmitted or accumulated.

Then, on the decoding side in the conventional art, the encoded data is disintegrated into an encoded data of the lower layer, an encoded data of the upper layer and an encoded data of the area information by an encoded data-disintegrating section (not shown). These encoded data is decoded by a lower layer decoding section **1108**, an upper layer decoding section **1107** and an area information decoding section **1109**, as shown in FIG. **11**.

A superimposing section **1110** on the decoding side comprises the same apparatus as that of the superimposing section **1105** on the encoding side, and an image is super-

imposed in the same method as described in the description on the encoding side, using a lower-layer decoded image and an upper-layer decoded image. The moving image superimposed here displayed on a display, as well as being input to the upper layer decoding section **1107**, and utilized for the prediction of the upper layer. Though a decoding apparatus for decoding both the lower layer and the upper layer has been described here, if it is a decoding apparatus having only a decoding section of the lower layer, the upper layer encoding section **1107** and the superimposing section **1110** are not required, hence a part of the encoded data can be reproduced with a small hardware scale.

At this time, since the frame rates of the lower layer and the upper layer are different, it is necessary to synthesize the lower layer corresponding to the upper layer from the lower layer frames temporally before and after of the lower layer frame. However, when an output image is obtained from two lower-layer decoded images and one upper-layer decoded image, the output image is synthesized by the interpolation of two lower layer frames, therefore when the position of the selected area changes with time, a big distortion is caused in the periphery of the selected area, resulting in a big deterioration of the image quality.

This problem can be solved by using a method such as the one described in a literature "Temporal Scalability algorithm based on image content", ISO/IEC/JTC1/SC29/WG11 MPEG96/0277 (1996). FIG. **14** illustrates a method for solving this problem, shown in the above-mentioned literature. In FIG. **14***a,* images A and C are two encoded images of the lower layer and an image B is an encoded image of the upper layer, the temporal order of display is an order of A, B and C. The selected area is shown by hatching.

Moreover, since only the selected area is encoded in the upper layer, outside of the selected area is shown by broken line. Since the selected area moves in the direction of an arrow in the figure, the interpolated image obtained by the image A and the image C becomes the one in which two selected areas are superposed, as shown in meshed portion in FIG. **14***b.* Furthermore, when the image B is superimposed by using the expression (2), the output image becomes an image in which three selected areas are superposed, as shown in FIG. **14***c.*

Particularly in the periphery (outside) of the selected area of the upper layer, the selected area of the lower layer appears like an afterimage to deteriorate the image quality widely. As for the entire moving image, when only the lower layer is displayed, the above-mentioned distortion does not appear, and when the superimposed image of the upper layer and the lower layer is displayed, the above-mentioned distortion appears, hence distortion like flicker appears, resulting in a big deterioration in the image quality. However, since the meshed portion on the left side of FIG. **14***c* can be obtained from the image C, and the meshed portion on the right side of FIG. **14***c* can be obtained from the image A, the above-mentioned distortion can be dissolved by using the lower layer synthesized as described above.

FIG. **12** shows a block diagram of a conventional image superimposing apparatus shown in the above-mentioned literature. A first area-extracting section **1201** in FIG. **12** extracts an area which is the first area and is not the second area, from the first area information of the lower layer and the second area information of the lower layer. In FIG. **13***a,* if it is assumed that the first area information is expressed by a dotted line (it is assumed that the inside of the dotted line has a value 0 and the outside of the dotted like has a value 1), and the second area information is similarly expressed by a broken like, the area extracted by the first area-extracting section **1201** becomes the hatched portion of FIG. **13***a.*

The second area-extracting section **1202** in FIG. **12** extracts an area which is the second area and is not the first area, from the first area information of the lower layer and the second area information of the lower layer. In the case of FIG. **13***a,* the meshed portion is extracted.

A controller **1203** in FIG. **12** is a section for controlling a switch **1204** with an output of the first area-extracting section **1201** and the second area-extracting section **1202**. That is to say, when the position of a target pixel is only in the first area, the switch **1204** is connected to the second decoded image side, and when the position of the target pixel is only in the second area, the switch **1204** is connected to the first decoded image side, and when the position of the target pixel is in other areas, the switch **1204** is connected to the output from the interpolated image-forming section **1205**.

The interpolated image-forming section **1205** in FIG. **12** calculates the interpolated image of the first decoded image of the lower layer and the second decoded image of the lower layer, according to the expression (1). Provided that in the expression (1), B (x, y, t1) is the first decoded image, B (x, y, t2) is the second decoded image, I (x, y, t3) is the interpolated image, wherein t1, t2 and t3 are the time of the first decoded image, of the second decoded image and of the interpolated image, respectively.

An image is formed as described above, therefore, in the case of FIG. **13***a,* for example, since the second decoded image is used in the hatched portion, a background pixel outside of the selected area appears, and in the meshed portion, since the first decoded image is used, a background pixel outside of the selected area appears, and in other portions, the interpolated image of the first decoded image and the second decoded image appears.

A decoded image of the upper layer is superimposed on the thus formed image by a weighted average section **1206** in FIG. **12**, hence the superimposed image does not have an afterimage in the selected area (meshed portion) as shown in FIG. **13***b,* and an image having little distortion can be obtained. The weighted average section **1206** in FIG. **12** superimposes the above-mentioned synthesized image and the decoded image of the upper layer by a weighted average.

However, with the conventional apparatus, there are problems as described below.

First, when the degree of shape change due to the movement of the parts area is small, large improvement in the image quality cannot be expected with the conventional art, and since it is required to encode two shape information before and behind of the parts shape of the upper layer, the amount of codes which can be used for the texture information encoding decreases relatively, hence there is such a problem that the image quality deteriorates (the first problem).

Secondly, the conventional art has an effect when the parts area moves in one direction, but when the parts image makes reciprocating movement, the background information of the parts cannot be obtained in principle, hence there is such a problem that the image quality is not improved (the second problem).

FIG. **8** and FIG. **10** are diagrams for explaining this problem. For example, the background image of the area where the parts image areas in images A and C of FIG. **10** overlap (hatched area in FIG. **8**) cannot be obtained from the image A and the image C.

Furthermore, with the conventional art, lower layer frames temporally before and after with respect to the image

of the upper layer are required, but there may be a case in which one lower layer frame does not exist at the beginning or at the end of the image sequence, or before and after the scene change. Therefore, there is such a problem that the image quality is not improved in the vicinity of the parts image (the third problem).

Furthermore, the conventional art requires to change over the interpolation processing selectively for each four area, thus there is such a problem that the processing becomes complicated (the fourth problem).

It is an object of the present invention to solve these problems and to provide a moving image encoding apparatus and a moving image decoding apparatus which do not deteriorate the quality of the decoded image, while reducing data quantity after encoding without deteriorating the quality of the decoded image.

## DISCLOSURE OF THE INVENTION

In view of the above situation, it is an object of the present invention to provide a moving image encoding apparatus and a moving image decoding apparatus which can reduce data quantity after encoding without deteriorating the quality of the decoded image.

With a view to solving the above problems, the gist of the present invention is as follows.

The first gist of the present invention is a moving image encoding apparatus which separates one moving image sequence to a lower layer having a low frame rate and an upper layer having a high frame rate, encodes a shape of a parts area for synthesizing the lower layer, on the condition that there is no frame corresponding to the upper layer, and encodes the upper layer by prediction, wherein

when the parts area of the lower layer appearing as a background is larger than a predetermined threshold, the moving image encoding apparatus encodes the shape of the parts area, and synthesizes a frame obtained by taking the average by weighting the lower layer and a frame of the lower layer to generate image information, and when the parts area of the lower layer appearing as a background is smaller than the predetermined threshold, the moving image encoding apparatus does not encode the shape of the parts area and generates image information by the weighted average of the lower layer.

The second gist of the present invention is a moving image decoding apparatus which synthesizes a lower layer having a low frame rate on the condition that there is no frame corresponding to an upper layer having a high frame rate, decodes the upper layer by prediction, and superimposes the prediction-decoded upper layer on the lower layer to decode them into one moving image sequence, wherein

when the shape of parts area has been encoded, the moving image decoding apparatus decodes the shape of the parts area, and synthesizes a frame obtained by taking the average by weighting the lower layer and a frame of the lower layer to generate image information, and when the shape of parts area has not been encoded, the moving image decoding apparatus generates image information by the weighted average of the lower layer.

The third gist of the present invention is a moving image encoding apparatus which separates one moving image sequence to a lower layer having a low frame rate and an upper layer having a high frame rate, encodes a shape of a parts area for synthesizing the lower layer on the condition that there is no frame of the lower layer corresponding to the upper layer, and encodes the upper layer by prediction, wherein

the moving image encoding apparatus interpolates a pixel value within the overlapping area of the lower layer, using a pixel value in the periphery of the area appearing as a background, to generate image information.

The 4th gist of the present invention is a moving image decoding apparatus which synthesizes a lower layer having a low frame rate on the condition that there is no lower layer frame corresponding to an upper layer having a high frame rate, decodes the upper layer by prediction, and superimposes the prediction-decoded upper layer on the lower layer to decode them into one moving image sequence, wherein

the moving image decoding apparatus interpolates a pixel value within the overlapping area, using a pixel value in the periphery of the overlapping area of the parts area of the lower layer appearing as a background, to generate image information.

The 5th gist of the present invention is a moving image encoding apparatus according to the first gist, wherein the pixel value within the parts area is interpolated by using a pixel value in the periphery of the parts area of the lower layer, and image information is generated by using the interpolated lower layer frame.

The 6th gist of the present invention is a moving image decoding apparatus according to the second gist, wherein the pixel value within the parts area is interpolated by using a pixel value in the periphery of the parts area of the lower layer, and image information is generated by using the interpolated lower layer frame.

The 7th gist of the present invention is a moving image encoding apparatus according to the first gist, wherein in the case where the number of frames of the lower layer required for the synthesis of the lower layer is not satisfied,

the image information is generated by using a frame obtained by interpolating the parts area of the lower layer.

The 8th gist of the present invention is a moving image decoding apparatus according to the second gist, wherein in the case where the number of frames of the lower layer required for the synthesis of the lower layer is not satisfied,

the image information is generated by using a frame obtained by interpolating the parts area of the lower layer.

The 9th gist of the present invention is a moving image encoding apparatus according to the first gist, wherein in the case where there are a plurality of frames of the upper layer between two adjacent frames of the lower layer,

when the parts area of the lower layer appearing as a background of any one of the plurality of frames of the upper layer is larger than the predetermined threshold, the shape of the parts area for synthesizing the lower layer frame is encoded with respect to the plurality of the upper layer frames.

The 10th gist of the present invention is a moving image encoding apparatus according to the third gist, wherein in the case where there are a plurality of frames of the upper layer between two adjacent frames of the lower layer,

when the parts area of the lower layer appearing as a background of any one of the plurality of frames of the upper layer is larger than the predetermined threshold, the shape of the parts area for synthesizing the lower layer frame is encoded with respect to the plurality of the upper layer frames.

The 11th gist of the present invention is a moving image encoding apparatus according to the 5th gist, wherein in the case where there are a plurality of frames of the upper layer between two adjacent frames of the lower layer,

when the parts area of the lower layer appearing as a background of any one of the plurality of frames of the upper layer is larger than the predetermined threshold, the shape of the parts area for synthesizing the lower layer frame is encoded with respect to the plurality of the upper layer frames.

The 12th gist of the present invention is a moving image encoding apparatus according to the 7th gist, wherein in the case where there are a plurality of frames of the upper layer between two adjacent frames of the lower layer,

when the parts area of the lower layer appearing as a background of any one of the plurality of frames of the upper layer is larger than the predetermined threshold, the shape of the parts area for synthesizing the lower layer frame is encoded with respect to the plurality of the upper layer frames.

The 13th gist of the present invention is a moving image decoding apparatus according to the second gist, wherein in the case where there are a plurality of frames of the upper layer between two adjacent frames of the lower layer,

when the shape of the parts area for synthesizing the frames of the lower layer is encoded with respect to any one of the plurality of frames of the upper layer, a frame obtained by taking the average by weighting the lower layer and a frame of the lower layer are synthesized with respect to all of the plurality of frames of the upper layer to generate image information.

The 14th gist of the present invention is a moving image decoding apparatus according to the 4th gist, wherein in the case where there are a plurality of frames of the upper layer between two adjacent frames of the lower layer,

when the shape of the parts area for synthesizing the frames of the lower layer is encoded with respect to any one of the plurality of frames of the upper layer, a frame obtained by taking the average by weighting the lower layer and a frame of the lower layer are synthesized with respect to all of the plurality of frames of the upper layer to generate image information.

The 15th gist of the present invention is a moving image decoding apparatus according to the 6th gist, wherein in the case where there are a plurality of frames of the upper layer between two adjacent frames of the lower layer,

when the shape of the parts area for synthesizing the frames of the lower layer is encoded with respect to any one of the plurality of frames of the upper layer, a frame obtained by taking the average by weighting the lower layer and a frame of the lower layer are synthesized with respect to all of the plurality of frames of the upper layer to generate image information.

The 16th gist of the present invention is a moving image decoding apparatus according to the 8th gist, wherein in the case where there are a plurality of frames of the upper layer between two adjacent frames of the lower layer,

when the shape of the parts area for synthesizing the frames of the lower layer is encoded with respect to any one of the plurality of frames of the upper layer, a frame obtained by taking the average by weighting the lower layer and a frame of the lower layer are synthesized with respect to all of the plurality of frames of the upper layer to generate image information.

The 17th gist of the present invention is a moving image encoding apparatus according to the first gist, wherein

when the parts area of the lower layer appearing as a background is smaller than the predetermined threshold, the parts area of the upper layer is expanded by using the parts area of the lower layer to generate a parts area of image information.

The 18th gist of the present invention is a moving image encoding apparatus according to the third gist, wherein

when the parts area of the lower layer appearing as a background is smaller than the predetermined threshold, the parts area of the upper layer is expanded by using the parts area of the lower layer to generate a parts area of image information.

The 19th gist of the present invention is a moving image encoding apparatus according to the 5th gist, wherein

when the parts area of the lower layer appearing as a background is smaller than the predetermined threshold, the parts area of the upper layer is expanded by using the parts area of the lower layer to generate a parts area of image information.

The 20th gist of the present invention is a moving image encoding apparatus according to the 7th gist, wherein

when the parts area of the lower layer appearing as a background is smaller than the predetermined threshold, the parts area of the upper layer is expanded by using the parts area of the lower layer to generate a parts area of image information.

The 21st gist of the present invention is a moving image encoding apparatus according to the 9th gist, wherein

when the parts area of the lower layer appearing as a background is smaller than the predetermined threshold, the parts area of the upper layer is expanded by using the parts area of the lower layer to generate a parts area of image information.

The 22nd gist of the present invention is a moving image encoding apparatus according to the 10th gist, wherein

when the parts area of the lower layer appearing as a background is smaller than the predetermined threshold, the parts area of the upper layer is expanded by using the parts area of the lower layer to generate a parts area of image information.

The 23rd gist of the present invention is a moving image encoding apparatus according to the 11th gist, wherein

when the parts area of the lower layer appearing as a background is smaller than the predetermined threshold, the parts area of the upper layer is expanded by using the parts area of the lower layer to generate a parts area of image information.

The 24th gist of the present invention is a moving image encoding apparatus according to the 12th gist, wherein

when the parts area of the lower layer appearing as a background is smaller than the predetermined threshold, the parts area of the upper layer is expanded by using the parts area of the lower layer to generate a parts area of image information.

The 25th gist of the present invention is a moving image decoding apparatus according to the second gist, wherein when the frames of the lower layer are synthesized, a pixel value of one of the lower layer frames which exist front and behind of a frame of the lower layer is used, with respect to an area where the first parts area and the second parts area overlap, or an area which is neither the first parts area nor the second parts area.

The 26th gist of the present invention is a moving image decoding apparatus according to the 6th gist, wherein when the lower layer frames are synthesized, a pixel value of one of the lower layer frames which exist front and behind of a frame of the lower layer is used, with respect to an area where the first parts area and the second parts area overlap, or an area which is neither the first parts area nor the second parts area.

The 27th gist of the present invention is a moving image decoding apparatus according to the second gist, wherein

when the lower layer frame is synthesized, a pixel value of one of the lower layer frames which exist front and behind of a frame of the lower layer is used, with respect to an area where the first parts area and the second parts area overlap, or an area which is neither the first parts area nor the second parts area, and at the time of the synthesis, interpolation is performed by using a pixel value of a frame of the lower layer with respect to a pixel value outside of one parts area of the lower layer, and using a pixel value in the periphery of the parts area with respect to a pixel value inside of the one parts image of the lower layer.

The 28th gist of the present invention is a moving image decoding apparatus according to the 4th gist, wherein when the lower layer frame is synthesized, a pixel value of one of the lower layer frames which exist front and behind of a frame of the lower layer is used, with respect to an area where the first parts area and the second parts area overlap, or an area which is neither the first parts area nor the second parts area, and at the time of the synthesis, interpolation is performed by using a pixel value of a frame of the lower layer with respect to a pixel value outside of one parts area of the lower layer, and using a pixel value in the periphery of the parts area with respect to a pixel value inside of the one parts image of the lower layer.

The 29th gist of the present invention is a moving image decoding apparatus according to the 6th gist, wherein when the lower layer frame is synthesized, a pixel value of one of the lower layer frames which exist front and behind of a frame of the lower layer is used, with respect to an area where the first parts area and the second parts area overlap, or an area which is neither the first parts area nor the second parts area, and at the time of the synthesis, interpolation is performed by using a pixel value of a frame of the lower layer with respect to a pixel value outside of one parts area of the lower layer, and using a pixel value in the periphery of the parts area with respect to a pixel value inside of the one parts image of the lower layer.

The 30th gist of the present invention is a moving image decoding apparatus according to the 25th gist, wherein when the lower layer frame is synthesized, a pixel value of one of the lower layer frames which exist front and behind of a frame of the lower layer is used, with respect to an area where the first parts area and the second parts area overlap, or an area which is neither the first parts area nor the second parts area, and at the time of the synthesis, interpolation is performed by using a pixel value of a frame of the lower layer with respect to a pixel value outside of one parts area of the lower layer, and using a pixel value in the periphery of the parts area with respect to a pixel value inside of the one parts image of the lower layer.

The 31st gist of the present invention is a moving image decoding apparatus according to the 26th gist, wherein when the lower layer frame is synthesized, a pixel value of one of the lower layer frames which exist front and behind of a frame of the lower layer is used, with respect to an area where the first parts area and the second parts area overlap, or an area which is neither the first parts area nor the second parts area, and at the time of the synthesis, interpolation is performed by using a pixel value of a frame of the lower layer with respect to a pixel value outside of one parts area of the lower layer, and using a pixel value in the periphery of the parts area with respect to a pixel value inside of the one parts image of the lower layer.

## BRIEF DESCRIPTION OF DRAWINGS

FIG. **1** is a block diagram showing a construction of an image superimposing section provided in a moving image encoding apparatus and a moving image decoding apparatus according to the first embodiment of the present invention.

FIG. **2** is a block diagram showing a construction of the image superimposing section provided in the moving image encoding apparatus and the moving image decoding apparatus according to the second embodiment of the present invention.

FIG. **3** is a block diagram showing a construction of the image superimposing section provided in the moving image encoding apparatus and the moving image decoding apparatus according to the third embodiment of the present invention.

FIG. **4** a block diagram showing a construction of the image superimposing section provided in the moving image encoding apparatus and the moving image decoding apparatus according to the fourth embodiment of the present invention.

FIG. **5** is a block diagram showing a construction of an area information changing section provided in the moving image encoding apparatus and the moving image decoding apparatus according to the fifth embodiment of the present invention.

FIG. **6** is a block diagram showing a construction of a background interpolation judging section provided in the image superimposing section of an apparatus according to the first embodiment of the present invention.

FIG. **7** is a block diagram showing a construction of the image superimposing section provided in an apparatus according to the 6th embodiment of the present invention.

FIG. **8** is a diagram illustrating problems of the conventional apparatus.

FIG. **9** is a diagram illustrating operation of an apparatus according to the fifth embodiment of the art of the present invention.

FIG. **10** is a diagram illustrating problems of the conventional apparatus.

FIG. **11** is a block diagram showing the construction of the moving image encoding apparatus and the moving image decoding apparatus.

FIG. **12** is a block diagram showing the construction of the image superimposing section provided in a conventional apparatus.

FIGS. **13***a* and **13***b* are views illustrating operation of the image superimposing section provided in the conventional apparatus.

FIGS. **14***a* to **14***c* are views illustrating problems of the image superimposing section provided in the conventional apparatus.

FIG. **15** is a view illustrating the concept of frame synthesis in the moving image encoding apparatus and the moving image decoding apparatus.

FIG. **16** is a view illustrating the operation of an interpolated image-forming section provided in the image superimposing section of the apparatus according to the first embodiment.

FIG. **17** is a block diagram showing the construction of an area information changing section provided in an apparatus according to the embodiment of the present invention.

FIG. **18** is a block diagram showing another construction of the image superimposing section provided in the apparatus according to the embodiment of the present invention.

## BEST MODE FOR CARRYING OUT THE INVENTION

Embodiments of the present invention will now be described in detail with reference to the accompanying drawings.

The moving image encoding apparatus and the moving image decoding apparatus of the present invention are characterized in a portion corresponding to the image superimposing sections **1105** and **1110** of the conventional apparatus shown in FIG. **11**, wherein when a lower layer frame is synthesized, and a lower layer frame and an upper layer frame is superimposed on the synthesized lower layer frame, distortion in the image which looks like an afterimage generated in the periphery of the selected area of the upper layer is suppressed visually.

The first embodiment of the present invention will now be described.

The moving image encoding apparatus and the moving image decoding apparatus according to this embodiment are for solving the first problem described above, and in the construction of the conventional apparatus shown in FIG. **11**, an image superimposing section shown in FIG. **1** is provided instead of the superimposing sections **1105** and **1110**.

This image superimposing section interpolates a frame of the lower layer, when a frame corresponding to the upper layer of one moving image sequence does not exist in the lower layer, and superimposes the frame obtained by the interpolation on the parts area of the upper layer as a background to obtain an interpolated image (image information). The interpolated image is used for the prediction encoding/decoding of the upper layer. The apparatus according to this embodiment will now be described based on this image superimposing section.

Referring to FIG. **1**, the first area-extracting section **101** extracts an area which is the first area and is not the second area, from the first area information of the lower layer and the second area information of the lower layer. Specifically, in FIG. **13***a*, when the first area information is expressed by a dotted line (it is assumed that the inside of the dotted line has a value 0, and the outside of the dotted line has a value 1), and the second area information is similarly expressed by a broken line, the area extracted by the first area-extracting section **101** is the hatched portion in FIG. **13***a*.

The second area-extracting section **102** in FIG. **1** extracts an area which is the second area and is not the first area, from the first area information of the lower layer and the second area information of the lower layer. In the case of FIG. **13***a*, the meshed portion is extracted.

A controller **103** in FIG. **1** is a section for controlling a switch **104** with an output of the first area-extracting section **101** and the second area-extracting section **102**. That is to say, when the position of a target pixel is only in the first area, the switch **104** is connected to the second decoded image side, and when the position of the target pixel is only in the second area, the switch **104** is connected to the first decoded image side, and when the position of the target pixel is in other areas, the switch **104** is connected to the output from the interpolated image-forming section **105**.

The interpolated image-forming section **105** in FIG. **1** calculates the interpolated image of the first decoded image of the lower layer and the second decoded image of the lower layer, according to the expression (1) described in the above "Prior Art" section. Here, in the expression (1), B (x, y, t1) is the first decoded image, B (x, y, t2) is the second decoded image, I (x, y, t3) is the decoded image, wherein t1, t2 and t3 are the time of the first decoded image, of the second decoded image and of the interpolated image, respectively.

The weighted average section **106** in FIG. **1** superimposes the interpolated image prepared according to the above expression (2) and the decoded image of the upper layer.

The background interpolation-judging section **107** judges whether the synthesizing processing for suppressing a distortion such as the above-mentioned afterimage is to be performed or not, depending upon the size of an area where the upper layer expressed by meshes in FIG. **14***c* cannot cover the above-mentioned two areas of the lower layer (that is, the parts area of the lower layer appearing as a background), based on the three area information, i.e., the first area information of the lower layer, the second area information of the lower layer, and the area information of the upper layer.

When the above-mentioned area is larger than a predetermined threshold, a switch **108** is connected to the left side (the output side of a switch **104**), to perform the synthesizing processing followed by the background interpolation. That is to say, a frame obtained by taking the average by weighting the lower layer and a frame of the lower layer are subjected to the synthesizing processing followed by the background interpolation, to generate image information for prediction encoding/decoding the upper layer.

On the other hand, when the above-mentioned area is smaller than a predetermined threshold, the switch **108** is connected to the right side (the output side of an interpolated image-forming section **105**), and the output of the interpolated image-forming section **105** is used as the lower layer to be synthesized with the upper layer. That is to say, the interpolated image-forming section **105** provides the image obtained by taking the average by weighting the lower layer via the switch **108** to the weighted average section **106**.

The weighted average section **106** then superimposes this image on the upper layer as a background to generate image information for prediction encoding/decoding the upper layer. In this case, (when the above-mentioned area is below the predetermined threshold), since both the first area information and the second area information of the lower layer are not used with the apparatus of this embodiment, these information is not encoded. Hence, the amount of codes for the area information can be reduced.

FIG. **6** is a block diagram showing the construction of the background interpolation-judging section **107** of FIG. **1**. In this embodiment, the judgement if the above-mentioned synthesizing processing is to be performed or not is performed depending upon the size of the meshed portion in FIG. **14***c*. As other methods to realize this, for example, a method using size of the area may be used. The area-judging section **601** of FIG. **14***a* is a section for calculating the size, and when it is assumed that the parts area of screen A (foreground area) of FIG. **14***a* is Fr (A), and the parts area of screen C is Fr (C), and the background area of screen B is Br (B), the area can be expressed as:

$$\{Fr(A) \cup Fr(C)\} \cap Br(B), \tag{3}$$

wherein '∪' in this expression denotes a union of a set, and '∩' denotes a meet of the set.

Furthermore, the size of the area can be expressed by the number of pixels in the area expressed by the expression (3). Alternatively, the size of the area may be obtained by normalizing the number of pixels in the area by the number of images of the whole image. Moreover, there can be considered, in addition to the area, the length of the periphery of the area, the area of a square circumscribing of the area and the like, but these values are required to be normalized by using the number of pixels of the whole screen and the size, as in the calculation of the area described above.

As shown in FIG. **14**, when the area of Fr (A) ∩Fr (C) (it is assumed to be Fr (D)) is all included in Fr (C), the area

can be determined by using the expression (3), but in general, the area is expressed by:

$$\{\{(Fr(A)\cup Fr(C))\cap Br(D)\}\cap Br(B), \quad (4)$$

wherein Br (D) denotes a background area of the screen in which Fr (D) is designated as the parts area.

The comparison judgement section **602** of FIG. **6** compares the area obtained by the area-measuring section **601** with the threshold determined in advance (the predetermined threshold), and if the area is larger than the threshold, the switch **108** shown in FIG. **1** is connected to the switch **104** side, to perform the synthesizing processing. If the area is smaller than the threshold, the switch **108** is connected to the interpolated image-forming section **105** shown in FIG. **1**, and without performing the synthesizing processing, the interpolated image calculated according to the expression (1) is provided to the weighted average section **106**.

Up to this point, it has been assumed that the interpolated image-forming section **105** in FIG. **1** prepares an interpolated image by using the expression (1), but instead of preparing the interpolated image, one of frames before and behind of the lower layer may be directly designated as an output of the interpolated image-forming section **105**. For example, if it is assumed that the time of the two lower layer frames is t1 and t2, respectively, and the time of the upper layer is t3 (provided that t1<t3<t2), when a pixel of the lower layer frame closer to the time of the current upper layer frame is used, the interpolated pixel I (s, y, t3) is calculated by the following expression (5a) or (5b).
In case of t3−t1<t2−t3,

$$I(x, y, t3)=B(x, y, t1) \quad (5a)$$

In case of t3−t1>t2−t3,

$$I(x, y, t3)=B(s, y, t2) \quad (5b)$$

In this case, the distortion area shown by a meshed portion in FIG. **14***c* (that is, the area interpolated by the background interpolation) becomes the meshed portion in FIG. **16**. Therefore, as the area used for the judgement of the background interpolation-judging section **107** in FIG. **1**, the meshed portion of FIG. **16** is used. If the same symbols in the expression (3) are used, the area (meshed portion in FIG. **16**) can be expressed by the following expression (6):

$$\{Fr(a)\cap Br(D)\}\cap Br(B) \quad (6)$$

When the background portion changes with time, with the above method, the lower layer may not be synthesized well. In such a case, in the invoked FIG. **14**, with respect to the area of Br (A), the pixel value of the image C is copied, and with respect to the area of Fr (A), the pixel value in the periphery of Fr (A) is used to interpolate the pixel value, thus the background can be simply synthesized.

The construction of the image superimposing section for realizing this method can be obtained by replacing the construction surrounded by a two-dot chain line in FIG. **1** by the construction shown in FIG. **18**. Here, it is assumed that there is no input of the area information of the upper layer.

Here, the selection section **1801** shown in FIG. **18** selects a frame of the two lower layer frames closer to the current upper layer frame. The area information selected by the selection section **1801** is input to the controller **1802** and the interpolation section **1804**, and the decoded image (pixel information) is input to the switch **1803**. The controller **1802** controls the switch **1803**, and provides a dummy data to the interpolation section **1804**, if the pixel of the image of the lower layer to be synthesized is inside the area (for example, Fr (A)), and provides a pixel value of the decoded image to the interpolation section **1804**, if the pixel of the image of the lower layer to be synthesized is outside the area (for example, Br (A)).

The interpolation section **1804** determines the pixel value inside the area by the interpolation from the pixel value in the periphery thereof. Since the interpolation processing is performed by using the background information (pixel value), the pixel value of the interpolated area (inside the area) becomes closer to that of the background image, thereby visual deterioration of the image quality is alleviated. As a specific interpolation method, there can be mentioned a padding method, shown in a literature, "MPEG 4 Video Verification Model Version 2.0" (ISO/IEC JTC1/SC29 n1260, 1996). In addition to this, there can be used an interpolation method using a mean value of the pixel value of the background area or using a certain value determined in advance, or an interpolated image-forming method in which texture information of the background area is reproduced by utilizing a fractal.

The second embodiment of the present invention will now be described. This embodiment is for solving the second problem described above, and FIG. **2** is a block diagram showing a construction of the image superimposing section provided in this embodiment. The first area-extracting section **101**, the second area-extracting section **102**, the controller **103**, the switch **104**, the interpolated image-forming section **105**, and the weighted average section **106** shown in FIG. **2** are the same as in FIG. **1**, therefore, detailed description of them will be omitted.

The third area-extracting section **207** in FIG. **2** extracts an area where the first area and the second area of the lower layer intersect (that is, an overlapped area of the parts area in the lower layer appearing as a background). In an example of FIG. **13***a*, the white area surrounded by a dotted line and a broken line corresponds to this area.

The pixel value-interpolating section **208** in FIG. **2** interpolates the area extracted by the third area-extracting section **207**. That is to say, the pixel value-interpolating section **208** interpolates a pixel value in the above-mentioned area (overlapped area) based on the information adjacent to the periphery (that is, a pixel value in the periphery of the overlapped area of the parts area in the lower layer appearing as a background) of the synthesized pixel prepared by the controller **103** and the switch **104**. Thereby, the image information for prediction-encoding/decoding the upper layer is generated. This interpolation processing is similar to that of the interpolation section **1804** shown in FIG. **18** as described above.

The third embodiment of the present invention will now be described. The apparatus of this embodiment is to solve the first and the second problems described above, and is constituted by incorporating an adaptable background interpolation-judging device described in the first embodiment into the second embodiment.

FIG. **3** is a block diagram showing a construction of the image superimposing section provided in the third embodiment. The first area-extracting section **101**, the second area-extracting section **102**, the controller **103**, the switch **104**, the interpolated image-forming section **105**, the background interpolation-judging section **108**, the weighted average section **106** and the switch **110** operate similarly as those shown in FIG. **1**, and the third area-extracting section **207** and the pixel value-interpolating section **208** operate similarly as those shown in FIG. **2**, therefore, description of them will be omitted here.

As described above, the apparatus of this embodiment has the construction of the first embodiment and the second embodiment, hence it not only can avoid useless encoding of the shape information in the case where the movement is minor and the effect of interpolation cannot be seen, but also alleviate deterioration of the image quality resulting from a reciprocating (turning back) movement of the parts area in the upper layer.

The fourth embodiment of the present invention will now be described. This embodiment is to solve the first, the second and the fourth problems described above, and FIG. **4** is a block diagram showing a construction of the image superimposing section provided in the apparatus of this embodiment.

Here, the first pixel value-interpolating section **401** in FIG. **4** interpolates the first parts area in the first decoded image of the lower layer, as in the pixel value-interpolating section **208** of FIG. **2**. Similarly, the second pixel value-interpolating section **402** in FIG. **4** interpolates the second parts area in the second decoded image of the lower layer. Since the specific operation has been already described for the pixel value-interpolating section **208** in FIG. **2**, here the description will be omitted.

The first interpolated image-forming section **403** in FIG. **4** interpolates the output of the first pixel value-interpolating section **401** and the second pixel value-interpolating section **402** according to the expression (1) described above. On the other hand, the second interpolated image-forming section **404** in FIG. **4** interpolates the first decoded image and the second decoded image of the lower layer according to the expression (1), as in the first interpolated image-forming section **403**. Either of the interpolated image-forming section performs the same operation as that of the interpolated image-forming section **105** in FIG. **1**, therefore the description thereof will be omitted here. Moreover, the weighted average section and the switch are the same as those shown in FIG. **1**.

The background interpolation-judging section **407** in FIG. **4** is a section for judging if the synthesizing processing is to be performed or not, as in the background interpolation-judging section **107** in FIG. **1**, and the background image (lower layer superimposed on the upper layer) provided to the weighted average section **106** is determined based on this judgement. That is to say, when the background interpolation-judging section **407** judges that the parts area of the lower layer appearing as a background is larger than the predetermined threshold, the weighted average section **106** inputs the pixel value in the periphery of the parts area of the lower layer from the first interpolated image-forming section **403**, and interpolates the pixel value inside of the parts area by using the input pixel value to generate image information.

Furthermore, when the background interpolation judging section **407** judges that the parts area appearing as a background is smaller than the predetermined threshold, the weighted average section **106** inputs an image obtained by taking the average by weighting the lower layer from the second interpolated image-forming section **404**, and interpolates the pixel value inside the parts area by using the input pixel value to generate image information.

The present invention is to simplify the synthesizing processing in the conventional example, thereby the scale of the hardware can be reduced without causing big deterioration in the image quality.

It is assumed that the second interpolated image-forming section **404** shown in FIG. **4** of this embodiment performs interpolation according to the expression (1), but it may be so constituted that the second interpolated image-forming section **404** performs interpolation using a pixel of the lower layer frame temporally close to the current upper layer according to the expression (5). That is to say, for example, when a temporally former lower layer frame is temporally close to the upper layer, the background interpolation-judging section **407** judges whether the background interpolation is to be performed or not based on the area expressed by the expression (6). In addition, the first interpolated image-forming section **403** in FIG. **4** directly outputs the image prepared by the first pixel value-interpolating section **401**.

The fifth embodiment of the present invention will now be described. This embodiment is to solve the first problem described above, wherein when the difference in the position and shape between the first parts area and the second parts area of the lower layer is small, the amount of codes required for the second parts area information is reduced by replacing the second parts area by the first parts area.

The image superimposing section provided in the apparatus of this embodiment has a constituent shown in FIG. **5** in the input section of the first area information and the second area information of the lower layer, in the construction shown in FIG. **1** to FIG. **4**.

Here, the comparison section **501** in FIG. **5** is a section for judging the difference between the two area information of the lower layer. If the parts image of the lower layer moves not so significantly, and the change in the area information which shows the movement is small, instead of utilizing the second area information of the lower layer, the switch **502** in FIG. **5** is connected to the upper side, to output the first area information of the lower layer, thereby the area information required to be encoded is reduced by 1. Furthermore, when the parts area of the lower layer moves largely, the switch is connected to the lower side, to output the respective area information. As a material for judgment of the change in the area information, for example, the dimension of the hatched portion shown in FIG. **9** may be used.

The sixth embodiment of the present invention will now be described. This embodiment is to solve the third problem described above. FIG. **7** is a block diagram showing a construction of the image superimposing section constituting an apparatus according to this embodiment. As shown in this figure, the image superimposing section provided in this apparatus is composed of an existence judging section **709**, a third interpolated image-forming section **711**, and switches **711** and **712** in addition to the construction of the first embodiment.

The operation of the first area-extracting section **101**, the second area-extracting section **102**, the weighted average section **106** and the switch **108** are the same as in FIG. **1**, therefore, the description thereof will be omitted here. The controller **703**, the switch **704**, and the interpolated image-forming section **705** correspond to the controller **103**, the switch **104**, and the interpolated image-forming section **105**, respectively.

First, when the background interpolation-judging section **707** judges that the parts area of the lower layer appearing as a background is larger than the predetermined threshold, the switch **108** is connected to the left side (the output of the switch **704**). Then, the existence judging section **709** in FIG. **7** judges whether the first decoded image and the second decoded image of the lower layer exist or not, that is, whether the number of frames of the lower layer required for the background interpolation is satisfied or not.

Here, when the existence judging section **709** judges that one of the decoded images is not input, it connects the switch

704 to the leftmost side (the output of the third interpolated image-forming section 711) via the controller 703. At the same time, the switch 711 and the switch 712 are connected so that the existing decoded image and the area information corresponding thereto are input to the third interpolated image-forming section 710. For example, when the second decoded image which is the temporally later decoded image does not exist, the switches are connected so that the first decoded image and the first area information are input.

Then, the third interpolated image-forming section 710 in FIG. 7 performs interpolation processing of the parts area inside the decoded image by using a pixel value in the periphery thereof, with the similar operation as that of the pixel value-interpolating section 208 in FIG. 2. When it has been judged by the existence judging section 709 that one input is lacking, since the switch 704 is connected to the leftmost side, in this case, the output of the third interpolated image-forming section 710 is used for the superimposition of the image frame.

Among the interpolated image-forming section 705 and the background interpolation-judging section 707 in FIG. 7, there is a case where one input is lacking. In this case, the interpolated image-forming section 707 in FIG. 7 judges whether the background interpolation is to be performed or not by using the size of the area which cannot be covered by the parts area of the upper layer among the parts area of the input lower layer. Moreover, the interpolated image-forming section 705 does not perform interpolation, and directly outputs the decoded image.

In the first to the sixth embodiments described above, the judgement whether the background interpolation is to be performed or not is performed with respect to each upper layer frame. However, when there are a plurality of upper layer frames between two continuous lower layer frames, the background interpolation may be performed as described below.

That is to say, judgement whether the background interpolation is to be performed or not is performed with respect to each frame of the plurality of upper layer frames (upper layer frames whose counterparts do not exist in the lower layer), and when all the respective judgement results are not to perform the background interpolation, the background interpolation is not performed with respect to all the plurality of upper layer frames. In this case, the upper layer frame is superimposed on the interpolated image of the two lower layer frames before and behind or superimposed on the lower layer frame temporally closer.

Furthermore, when it is judged to perform the background interpolation with respect to at least one upper layer frame (when the parts area of the lower layer appearing as a background for any one of the plurality of upper layer frames is larger than the predetermined threshold), the lower layer frame synthesized by the background interpolation is superimposed on all the plurality of upper layer frames.

Specifically, a frame obtained by taking the average by weighting the lower layer and a frame of the lower layer are synthesized with respect to all the plurality of upper layer frames to generate image information. In this case, among frames of the plurality of upper layer frames, for example, with respect only to the temporally first frame, the background interpolation is performed to synthesize the lower layer frame, and with respect to other upper layer frames, the lower layer frame synthesized for the first upper layer frame may be directly used.

Furthermore, with an apparatus of the first to the sixth embodiments, when distortion of the image shown by a meshed portion in FIG. 14*c* and FIG. 16 is large, this distortion is removed by the background interpolation. However, when the distortion of the image is small, the background interpolation is not performed, and the distortion of the image slightly exists. Though the distortion of the image in this case is not visually conspicuous, the distortion can be suppressed so as not to be caused visually as follows.

That is to say, when the upper layer is encoded, the parts area of the lower layer shown by the meshed portion in FIG. 14*c* and FIG. 16 is also encoded together with the parts area of the upper layer. For that purpose, the parts area of the upper layer is changed so that it includes the hatched portion and the meshed portion of FIG. 14*c* and FIG. 16 (enlarged/expanded).

FIG. 17 is a block diagram of an area changing section for performing processing of changing the parts area. This area changing section enlarges the parts area of the upper layer by using the parts area of the lower layer to generate a parts area of the image information, thereby changes the area information provided to the upper layer encoding section 1103 shown in FIG. 11.

The operation of each constituent of the area changing section shown in FIG. 17 will now be described. In this figure, a switch 1701 separates the area information into the area information of the upper layer and the area information of the lower layer. A memory 1702 in FIG. 17 stores temporarily the area information of the lower layer. An area integrating section 1703 integrates the area information of the upper layer and a part of the area information of the lower layer to prepare new area information.

Specifically, for example, when the interpolated image-forming section 105 in FIG. 1 prepares an interpolated image according to the expression (1), the meshed portion in FIG. 14*c* is integrated into the area information of the upper layer to prepare new area information. Moreover, when the interpolated image-forming section 105 is so constructed that a temporally close lower layer is selected according to the expression (5) to prepare an interpolated image, the meshed portion in FIG. 16 is integrated into the area information of the upper layer.

A switch 1704 in FIG. 17 is connected to the upper side (the area information of the upper layer) when the background interpolation is carried out, and connected to the lower side (the output of the area-integrating section 1703) when the background interpolation is not carried out. Moreover, a switch 1705 is connected to the upper side while the area information of the upper layer is being processed, and connected to the lower side while the area information of the lower layer is being processed, synchronously with the switch 1701.

As described above, when the background interpolation is not carried out, the distortion of the image can be suppressed so as not to be caused, by changing the area information of the upper layer to be expanded/enlarged.

## INDUSTRIAL APPLICABILITY

As understood from the above description, according to the present invention, the following effects can be obtained.

First, when the parts area in the images of the lower layer and the upper layer moves not so significantly, and even if the background interpolation is carried out, a visual effect cannot be obtained, the background interpolation is not performed. On the contrary, when the parts area moves significantly, the background interpolation is carried out, thereby the shape information for the background interpolation can be reduced, and the image quality can be improved by the reduction of the information.

Secondly, when the parts image in the images of the lower layer and the upper layer performs reciprocating movement,

turning back movement, or a movement of changing the direction instead of moving in one direction, interpolation is performed with respect to an area where the parts image areas of the lower layer overlap by using a pixel value in the periphery thereof, hence visual deterioration of the image quality can be alleviated.

Furthermore, when a lower layer which is temporally before and behind the image of the upper layer to be encoded does not exist, by using only the existing lower layer and using a pixel value in the periphery thereof to interpolate the parts image area, apparent deterioration of the image quality can be alleviated.

Moreover, the processing is simplified by the interpolation using a pixel value in the periphery of the parts image area without changing over the screen to be used for the interpolation processing of the parts image area for every area, hence the scale of the hardware can be reduced.

In addition, when there are a plurality of upper layer frames between two continuous lower layer frames, at the time of the background interpolation, the background interpolation is performed only to the first upper layer frame of the plurality of upper layer frames, thereby the amount of the background interpolation processing and the amount of codes of the parts area information of the lower layer required for the background interpolation can be reduced.

Furthermore, in the case where the background interpolation is not performed, when the upper layer is encoded, the area interpolated by the background interpolation is also encoded together with the parts area of the upper layer, thereby the distortion of the image which may be caused because the background interpolation is not performed can be suppressed so as not to be caused visually.

What is claimed is:

**1**. A moving image encoding apparatus comprising:

means for separating one moving image sequence into a lower layer having a low frame rate and an upper layer having a high frame rate;

lower layer encoding means for encoding the whole image in said moving image sequence in said lower layer;

upper layer encoding means for encoding a partial area of the image in said moving image sequence in said upper layer;

area information encoding means for encoding area information indicating a shape of the partial area of the image in said moving image sequence; and

superimposition means which, in the case where there is no lower layer frame corresponding timewise to said upper layer frame, generates a lower layer frame corresponding timewise to said upper layer frame as a background image, by using a lower layer frame existing timewise before or after thereof, and superimposes the parts image of said upper layer frame on said background image,

said moving image encoding apparatus using the image prepared by said superimposition means to prediction encoding said upper layer,

wherein, in the case where the parts image area in said lower layer frame which cannot be covered with the parts image in said upper layer frame is larger than a predetermined threshold, said superimposition means generates said background image by synthesizing a frame obtained by taking the weight average of the lower layer frames existing timewise before and after said upper layer frame, and a lower layer frame existing timewise before or after said upper layer frame, and

in the case where the parts image area in said lower layer frame which cannot be covered with the parts image in said upper layer frame is smaller than the predetermined threshold, said superimposition means generates said background image by taking the weight average of the lower layer frames existing timewise before and after said upper layer frame.

**2**. A moving image encoding apparatus according to claim **1**, wherein, in the case where the parts image area in said lower layer frame which cannot be covered with the parts image in said upper layer frame is larger than the predetermined threshold, said superimposition means generates said background image by taking the weight average of the lower layer frames existing timewise before and after said upper layer frame, with respect to an area where a first parts image area corresponding to a partial area of the image in said moving image sequence in the lower layer frame existing timewise before said upper layer frame overlaps on a second parts image area corresponding to a partial area of the image in said moving image sequence in the lower layer frame existing timewise after said upper layer frame, or an area which is neither said first parts image area nor said second parts image area; and

by using the lower layer frame existing timewise after said upper layer frame, with respect to the area of only said first parts image area, and the lower layer frame existing timewise before said upper layer frame, with respect to the area of only said second parts image area, to thereby generate said background image.

**3**. A moving image encoding apparatus according to claim **1**, wherein, in the case where the parts image area in said lower layer frame which cannot be covered with the parts image in said upper layer frame is larger than a predetermined threshold, said superimposition means generates said background image by performing interpolation, using a pixel value in the circumference thereof, with respect to an area where a first parts image area corresponding to a partial area of the image in said moving image sequence in the lower layer frame existing timewise before said upper layer frame overlaps on a second parts image area corresponding to a partial area of the image in said moving image sequence in the lower layer frame existing timewise after said upper layer frame, and

by taking the weight average of the lower layer frames existing timewise before and after said upper layer frame, with respect to the area which is neither said first parts image area nor said second parts image area,

and by using the lower layer frame existing timewise after said upper layer frame, with respect to the area of only said first parts image area, and the lower layer frame existing timewise before said upper layer frame, with respect to the area of only said second parts image area.

**4**. A moving image encoding apparatus according to one of the claims **1**, **2**, and **3**, comprising:

comparison means for comparing the position or the size of a shape change of the parts image area in the lower layer frames existing timewise before and after said upper layer frame, wherein

in the case where the position or the shape change of said parts image area is larger than a predetermined threshold, first and second area information indicating the parts image area in the lower layer frames existing timewise before and after said upper layer frame is output respectively to said superimposition means, and

in the case where the position or the shape change of said parts image area is smaller than the predetermined

threshold, either of said first and second area information indicating the parts image area in the lower layer frame existing timewise before or after said upper layer frame is output to said superimposition means.

**5**. A moving image encoding apparatus according to one of the claims **1**, **2**, and **3**, wherein, in the case where the parts image area in said lower layer frame which cannot be covered with the parts image in said upper layer frame is smaller than the predetermined threshold, the parts image area in said upper layer frame is expanded so as to include the parts image area in said lower layer frame.

**6**. A moving image decoding apparatus comprising:

lower layer decoding means for decoding encoded data of the lower layer obtained by encoding the whole image in a moving image sequence at a low frame rate;

upper layer decoding means f or decoding encoded data of the upper layer obtained by encoding a partial area of the image in said moving image sequence as a parts image at a high frame rate;

area information decoding means for decoding the encoded data of the area information obtained by encoding the area information indicating a shape of the partial area of the image in said moving image sequence; and

superimposition means which, in the case where there is no lower layer frame corresponding timewise to said upper layer frame, generates a lower layer frame corresponding timewise to said upper layer frame as a background image, by using a lower layer frame existing timewise before or after thereof, and superimposes the parts image of said upper layer frame on said background image,

said moving image decoding apparatus displaying the image prepared by said superimposition means on a display,

wherein, in the case where the parts image area in said lower layer frame which cannot be covered with the parts image in said upper layer frame is larger than a predetermined threshold, said superimposition means generates said background image by synthesizing a frame obtained by taking the weight average of the lower layer frames existing timewise before and after said upper layer frame, and a lower layer frame existing timewise before or after said upper layer frame, and

in the case where the parts image area in said lower layer frame which cannot be covered with the parts image in said upper layer frame is smaller than the predetermined threshold, said superimposition means generates said background image by taking the weight average of the lower layer frames existing timewise before and after said upper layer frame.

**7**. A moving image decoding apparatus according to claim **6**, wherein, in the case where the parts image area in said lower layer frame which cannot be covered with the parts image in said upper layer frame is larger than the predetermined threshold, said superimposition means generates said background image by taking the weight average of the lower layer frames existing timewise before and after said upper layer frame, with respect to an area where a first parts image area corresponding to a partial area of the image in said moving image sequence in the lower layer frame existing timewise before said upper layer frame overlaps on a second parts image area corresponding to a partial area of the image in said moving image sequence in the lower layer frame existing timewise after said upper layer frame, or an area which is neither said first parts image area nor said second parts image area; and

by using the lower layer frame existing timewise after said upper layer frame, with respect to the area of only said first parts image area, and using the lower layer frame existing timewise before said upper layer frame, with respect to the area of only said second parts image.

**8**. A moving image decoding apparatus according to claim **6**, wherein, in the case where the parts image area in said lower layer frame which cannot be covered with the parts image in said upper layer frame is larger than the predetermined threshold, said superimposition means generates said background image by performing interpolation, using a pixel value in the circumference thereof, with respect to an area where a first parts image area corresponding to a partial area of the image in said moving image sequence in the lower layer frame existing timewise before said upper layer frame overlaps on a second parts image area corresponding to a partial area of the image in said moving image sequence in the lower layer frame existing timewise after said upper layer frame, and

by taking the weight average of the lower layer frames existing timewise before and after said upper layer frame with respect to an area which is neither said first parts image area nor said second parts image area; and

by using the lower layer frame existing timewise after said upper layer frame, with respect to the area of only said first parts image area, and using the lower layer frame existing timewise before said upper layer frame, with respect to the area of only said second parts image area.

**9**. A moving image decoding apparatus comprising:

lower layer decoding means for decoding encoded data of the lower layer obtained by encoding the whole image in a moving image sequence at a low frame rate;

upper layer decoding means for decoding encoded data of the upper layer obtained by encoding a partial area of the image in said moving image sequence as a parts image at a high frame rate;

area information decoding means for decoding the encoded data of the area information obtained by encoding the area information indicating a shape of the partial area of the image in said moving image sequence; and

superimposition means which, in the case where there is no lower layer frame corresponding timewise to said upper layer frame, generates a lower layer frame corresponding timewise to said upper layer frame as a background image, by using a lower layer frame existing timewise before or after thereof, and superimposes the parts image of said upper layer frame on said background image,

said moving image decoding apparatus displaying the image prepared by said superimposition means on a display,

wherein, said superimposition means generates said background image by performing interpolation, using a pixel value in the circumference thereof, with respect to the inside of the area where a first parts image area corresponding to a partial area of the image in said moving image sequence in the lower layer frame existing timewise before said upper layer frame overlaps on a second parts image area corresponding to a partial area of the image in said moving image sequence in the lower layer frame existing timewise after said upper layer frame.

**10**. A moving image decoding apparatus comprising:

lower layer decoding means for decoding encoded data of the lower layer obtained by encoding the whole image in a moving image sequence at a low frame rate;

upper layer decoding means for decoding encoded data of the upper layer obtained by encoding a partial area of the image in said moving image sequence as a parts image at a high frame rate;

area information decoding means for decoding the encoded data of the area information obtained by encoding the area information indicating a shape of the partial area of the image in said moving image sequence; and

superimposition means which, in the case where there is no lower layer frame corresponding timewise to said upper layer frame, generates a lower layer frame corresponding timewise to said upper layer frame as a background image, by using a lower layer frame existing timewise before or after thereof, and superimposes the parts image of said upper layer frame on said background image,

said moving image decoding apparatus displaying the image prepared by said superimposition means on a display,

wherein, in the case where said lower layer frame exists timewise only before the upper layer frame, said superimposition means interpolates the inside of a parts image area corresponding to a partial area of the image in said moving image sequence in the lower layer frame existing timewise before said upper layer frame, using a pixel value in the circumference thereof, to thereby generate said background image.

**11**. A moving image decoding apparatus comprising:

lower layer decoding means for decoding encoded data of the lower layer obtained by encoding the whole image in a moving image sequence at a low frame rate;

upper layer decoding means for decoding encoded data of the upper layer obtained by encoding a partial area of the image in said moving image sequence as a parts image at a high frame rate;

area information decoding means for decoding the encoded data of the area information obtained by encoding the area information indicating a shape of the partial area of the image in said moving image sequence; and

superimposition means which, in the case where there is no lower layer frame corresponding timewise to said upper layer frame, generates a lower layer frame corresponding timewise to said upper layer frame as a background image, by using a lower layer frame existing timewise before or after thereof, and superimposes the parts image of said upper layer frame on said background image,

said moving image decoding apparatus displaying the image prepared by said superimposition means on a display,

wherein, in the case where said lower layer frame exists timewise only after the upper layer frame, said superimposition means interpolates the inside of a parts image area corresponding to a partial area of the image in said moving image sequence in the lower layer frame existing timewise after said upper layer frame, using a pixel value in the circumference thereof, to thereby generate said background image.

**12**. A moving image decoding apparatus comprising:

lower layer decoder for decoding encoded data of the lower layer obtained by encoding the whole image in a moving image sequence at a low frame rate;

upper layer decoder for decoding encoded data of the upper layer obtained by encoding a partial area of the image in said moving image sequence as a parts image at a high frame rate;

area information decoder for decoding the encoded data of the area information obtained by encoding the area information indicating a shape of the partial area of the image in said moving image sequence; and

superimposition module which, in the case where there is no lower layer frame corresponding timewise to said upper layer frame, generates a lower layer frame corresponding timewise to said upper layer frame as a background image, by using a lower layer frame existing timewise before or after thereof, and superimposes the parts image of said upper layer frame on said background image,

wherein said superimposition means interpolates the inside of the parts image area in the lower layer frames existing timewise before and after said upper layer frame, using a pixel value in the circumference of an overlapping area of the parts area of the lower layer, and uses said interpolated lower layer frame to generate said background image.

* * * * *

## Index of Claims

| Application/Control No. | Applicant(s)/Patent under Reexamination |
|---|---|
| 11/839,205 | KARCZEWICZ ET AL. |
| **Examiner** | **Art Unit** |
| SHAWN AN | 2621 |

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|---|---|---|---|---|---|---|---|
| √ | Rejected | – | (Through numeral) Cancelled | N | Non-Elected | A | Appeal |
| = | Allowed | ÷ | Restricted | I | Interference | O | Objected |

| Claim | | Date | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Final | Original | 5/12/10 | | | | | | | | |
| 1 | 1 | = | | | | | | | | |
| 20 | 2 | = | | | | | | | | |
| 21 | 3 | = | | | | | | | | |
| 2 | 4 | = | | | | | | | | |
| 4 | 5 | = | | | | | | | | |
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| 5 | 7 | = | | | | | | | | |
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| 8 | 10 | = | | | | | | | | |
| 9 | 11 | = | | | | | | | | |
| 10 | 12 | = | | | | | | | | |
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| 12 | 14 | = | | | | | | | | |
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| 16 | 18 | = | | | | | | | | |
| 17 | 19 | = | | | | | | | | |
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| 22 | 22 | = | | | | | | | | |
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| Claim | | Date | | | | | | | | |
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| Final | Original | 5/12/10 | | | | | | | | |
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| Search Notes | Application/Control No. | Applicant(s)/Patent under Reexamination | |
|---|---|---|---|
| | 11/839,205 | KARCZEWICZ ET AL. | |
| | Examiner | Art Unit | |
| | SHAWN AN | 2621 | |

| SEARCHED | | | |
|---|---|---|---|
| Class | Subclass | Date | Examiner |
| 375 | 240.17 | 5/12/2010 | SA |
| | 240.16 | | SA |
| | 240.25 | | SA |
| | 240.26 | | SA |
| | 240.12 | | SA |
| 382 | 238 | | SA |
| | 236 | | SA |
| | 233 | | SA |
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| INTERFERENCE SEARCHED | | | |
|---|---|---|---|
| Class | Subclass | Date | Examiner |
| **375** | **240.17** | 5/12/2010 | **SA** |
| | 240.16 | | SA |
| | 240.25 | | SA |
| 382/238<br>382/236 | | | SA |

| SEARCH NOTES (INCLUDING SEARCH STRATEGY) | | |
|---|---|---|
| | DATE | EXMR |
| Search updated. | 5/12/2010 | SA |
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# NOTICE OF ALLOWANCE AND FEE(S) DUE

2512 7590 05/19/2010

Perman & Green, LLP
99 Hawley Lane
Stratford, CT 06614

| EXAMINER | |
|---|---|
| AN, SHAWN S | |
| ART UNIT | PAPER NUMBER |
| 2621 | |

DATE MAILED: 05/19/2010

| APPLICATION NO. | FILING DATE | FIRST NAMED INVENTOR | ATTORNEY DOCKET NO. | CONFIRMATION NO. |
|---|---|---|---|---|
| 11/839,205 | 08/15/2007 | Marta Karczewicz | 982-010567-US (C02) | 8091 |

TITLE OF INVENTION: METHOD FOR SUB-PIXEL VALUE INTERPOLATION

| APPLN. TYPE | SMALL ENTITY | ISSUE FEE DUE | PUBLICATION FEE DUE | PREV. PAID ISSUE FEE | TOTAL FEE(S) DUE | DATE DUE |
|---|---|---|---|---|---|---|
| nonprovisional | NO | $1510 | $300 | $0 | $1810 | 08/19/2010 |

**THE APPLICATION IDENTIFIED ABOVE HAS BEEN EXAMINED AND IS ALLOWED FOR ISSUANCE AS A PATENT. PROSECUTION ON THE MERITS IS CLOSED. THIS NOTICE OF ALLOWANCE IS NOT A GRANT OF PATENT RIGHTS. THIS APPLICATION IS SUBJECT TO WITHDRAWAL FROM ISSUE AT THE INITIATIVE OF THE OFFICE OR UPON PETITION BY THE APPLICANT. SEE 37 CFR 1.313 AND MPEP 1308.**

**THE ISSUE FEE AND PUBLICATION FEE (IF REQUIRED) MUST BE PAID WITHIN THREE MONTHS FROM THE MAILING DATE OF THIS NOTICE OR THIS APPLICATION SHALL BE REGARDED AS ABANDONED. THIS STATUTORY PERIOD CANNOT BE EXTENDED. SEE 35 U.S.C. 151. THE ISSUE FEE DUE INDICATED ABOVE DOES NOT REFLECT A CREDIT FOR ANY PREVIOUSLY PAID ISSUE FEE IN THIS APPLICATION. IF AN ISSUE FEE HAS PREVIOUSLY BEEN PAID IN THIS APPLICATION (AS SHOWN ABOVE), THE RETURN OF PART B OF THIS FORM WILL BE CONSIDERED A REQUEST TO REAPPLY THE PREVIOUSLY PAID ISSUE FEE TOWARD THE ISSUE FEE NOW DUE.**

**HOW TO REPLY TO THIS NOTICE:**

I. Review the SMALL ENTITY status shown above.

If the SMALL ENTITY is shown as YES, verify your current SMALL ENTITY status:

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B. If the status above is to be removed, check box 5b on Part B - Fee(s) Transmittal and pay the PUBLICATION FEE (if required) and twice the amount of the ISSUE FEE shown above, or

If the SMALL ENTITY is shown as NO:

A. Pay TOTAL FEE(S) DUE shown above, or

B. If applicant claimed SMALL ENTITY status before, or is now claiming SMALL ENTITY status, check box 5a on Part B - Fee(s) Transmittal and pay the PUBLICATION FEE (if required) and 1/2 the ISSUE FEE shown above.

II. PART B - FEE(S) TRANSMITTAL, or its equivalent, must be completed and returned to the United States Patent and Trademark Office (USPTO) with your ISSUE FEE and PUBLICATION FEE (if required). If you are charging the fee(s) to your deposit account, section "4b" of Part B - Fee(s) Transmittal should be completed and an extra copy of the form should be submitted. If an equivalent of Part B is filed, a request to reapply a previously paid issue fee must be clearly made, and delays in processing may occur due to the difficulty in recognizing the paper as an equivalent of Part B.

III. All communications regarding this application must give the application number. Please direct all communications prior to issuance to Mail Stop ISSUE FEE unless advised to the contrary.

**IMPORTANT REMINDER: Utility patents issuing on applications filed on or after Dec. 12, 1980 may require payment of maintenance fees. It is patentee's responsibility to ensure timely payment of maintenance fees when due.**

# PART B - FEE(S) TRANSMITTAL

**Complete and send this form, together with applicable fee(s), to: Mail** **Mail Stop ISSUE FEE**
**Commissioner for Patents**
**P.O. Box 1450**
**Alexandria, Virginia 22313-1450**
**or Fax (571)-273-2885**

INSTRUCTIONS: This form should be used for transmitting the ISSUE FEE and PUBLICATION FEE (if required). Blocks 1 through 5 should be completed where appropriate. All further correspondence including the Patent, advance orders and notification of maintenance fees will be mailed to the current correspondence address as indicated unless corrected below or directed otherwise in Block 1, by (a) specifying a new correspondence address; and/or (b) indicating a separate "FEE ADDRESS" for maintenance fee notifications.

CURRENT CORRESPONDENCE ADDRESS (Note: Use Block 1 for any change of address)

2512 7590 05/19/2010

Perman & Green, LLP
99 Hawley Lane
Stratford, CT 06614

Note: A certificate of mailing can only be used for domestic mailings of the Fee(s) Transmittal. This certificate cannot be used for any other accompanying papers. Each additional paper, such as an assignment or formal drawing, must have its own certificate of mailing or transmission.

**Certificate of Mailing or Transmission**

I hereby certify that this Fee(s) Transmittal is being deposited with the United States Postal Service with sufficient postage for first class mail in an envelope addressed to the Mail Stop ISSUE FEE address above, or being facsimile transmitted to the USPTO (571) 273-2885, on the date indicated below.

| |
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| (Depositor's name) |
| (Signature) |
| (Date) |

| APPLICATION NO. | FILING DATE | FIRST NAMED INVENTOR | ATTORNEY DOCKET NO. | CONFIRMATION NO. |
|---|---|---|---|---|
| 11/839,205 | 08/15/2007 | Marta Karczewicz | 982-010567-US (C02) | 8091 |

TITLE OF INVENTION: METHOD FOR SUB-PIXEL VALUE INTERPOLATION

| APPLN. TYPE | SMALL ENTITY | ISSUE FEE DUE | PUBLICATION FEE DUE | PREV. PAID ISSUE FEE | TOTAL FEE(S) DUE | DATE DUE |
|---|---|---|---|---|---|---|
| nonprovisional | NO | $1510 | $300 | $0 | $1810 | 08/19/2010 |

| EXAMINER | ART UNIT | CLASS-SUBCLASS |
|---|---|---|
| AN, SHAWN S | 2621 | 375-240170 |

1. Change of correspondence address or indication of "Fee Address" (37 CFR 1.363).

❑ Change of correspondence address (or Change of Correspondence Address form PTO/SB/122) attached.

❑ "Fee Address" indication (or "Fee Address" Indication form PTO/SB/47; Rev 03-02 or more recent) attached. **Use of a Customer Number is required.**

2. For printing on the patent front page, list

(1) the names of up to 3 registered patent attorneys or agents OR, alternatively,

(2) the name of a single firm (having as a member a registered attorney or agent) and the names of up to 2 registered patent attorneys or agents. If no name is listed, no name will be printed.

1 _____

2 _____

3 _____

3. ASSIGNEE NAME AND RESIDENCE DATA TO BE PRINTED ON THE PATENT (print or type)

PLEASE NOTE: Unless an assignee is identified below, no assignee data will appear on the patent. If an assignee is identified below, the document has been filed for recordation as set forth in 37 CFR 3.11. Completion of this form is NOT a substitute for filing an assignment.

(A) NAME OF ASSIGNEE (B) RESIDENCE: (CITY and STATE OR COUNTRY)

Please check the appropriate assignee category or categories (will not be printed on the patent) : ❑ Individual ❑ Corporation or other private group entity ❑ Government

4a. The following fee(s) are submitted:

❑ Issue Fee

❑ Publication Fee (No small entity discount permitted)

❑ Advance Order - # of Copies _____

4b. Payment of Fee(s): **(Please first reapply any previously paid issue fee shown above)**

❑ A check is enclosed.

❑ Payment by credit card. Form PTO-2038 is attached.

❑ The Director is hereby authorized to charge the required fee(s), any deficiency, or credit any overpayment, to Deposit Account Number _____ (enclose an extra copy of this form).

5. **Change in Entity Status** (from status indicated above)

❑ a. Applicant claims SMALL ENTITY status. See 37 CFR 1.27.

❑ b. Applicant is no longer claiming SMALL ENTITY status. See 37 CFR 1.27(g)(2).

NOTE: The Issue Fee and Publication Fee (if required) will not be accepted from anyone other than the applicant; a registered attorney or agent; or the assignee or other party in interest as shown by the records of the United States Patent and Trademark Office.

Authorized Signature _____ Date _____

Typed or printed name _____ Registration No. _____

This collection of information is required by 37 CFR 1.311. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 12 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, Virginia 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, Virginia 22313-1450.

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Alexandria, Virginia 22313-1450
www.uspto.gov

| APPLICATION NO. | FILING DATE | FIRST NAMED INVENTOR | ATTORNEY DOCKET NO. | CONFIRMATION NO. |
|---|---|---|---|---|
| 11/839,205 | 08/15/2007 | Marta Karczewicz | 982-010567-US (C02) | 8091 |

2512 7590 05/19/2010

Perman & Green, LLP
99 Hawley Lane
Stratford, CT 06614

| EXAMINER | |
|---|---|
| AN, SHAWN S | |
| ART UNIT | PAPER NUMBER |
| 2621 | |

DATE MAILED: 05/19/2010

**Determination of Patent Term Adjustment under 35 U.S.C. 154 (b)**
(application filed on or after May 29, 2000)

The Patent Term Adjustment to date is 0 day(s). If the issue fee is paid on the date that is three months after the mailing date of this notice and the patent issues on the Tuesday before the date that is 28 weeks (six and a half months) after the mailing date of this notice, the Patent Term Adjustment will be 0 day(s).

If a Continued Prosecution Application (CPA) was filed in the above-identified application, the filing date that determines Patent Term Adjustment is the filing date of the most recent CPA.

Applicant will be able to obtain more detailed information by accessing the Patent Application Information Retrieval (PAIR) WEB site (http://pair.uspto.gov).

Any questions regarding the Patent Term Extension or Adjustment determination should be directed to the Office of Patent Legal Administration at (571)-272-7702. Questions relating to issue and publication fee payments should be directed to the Customer Service Center of the Office of Patent Publication at 1-(888)-786-0101 or (571)-272-4200.

| Notice of Allowability | Application No. | Applicant(s) | |
|---|---|---|---|
| | 11/839,205 | KARCZEWICZ ET AL. | |
| | Examiner | Art Unit | |
| | SHAWN AN | 2621 | |

***-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address--***

All claims being allowable, PROSECUTION ON THE MERITS IS (OR REMAINS) CLOSED in this application. If not included herewith (or previously mailed), a Notice of Allowance (PTOL-85) or other appropriate communication will be mailed in due course. **THIS NOTICE OF ALLOWABILITY IS NOT A GRANT OF PATENT RIGHTS.** This application is subject to withdrawal from issue at the initiative of the Office or upon petition by the applicant. See 37 CFR 1.313 and MPEP 1308.

1. ☒ This communication is responsive to *4/30/10*.

2. ☒ The allowed claim(s) is/are *1-61*.

3. ☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).
   a) ☐ All b) ☐ Some* c) ☐ None of the:
      1. ☐ Certified copies of the priority documents have been received.
      2. ☐ Certified copies of the priority documents have been received in Application No. _____ .
      3. ☐ Copies of the certified copies of the priority documents have been received in this national stage application from the International Bureau (PCT Rule 17.2(a)).

   * Certified copies not received: _____.

Applicant has THREE MONTHS FROM THE "MAILING DATE" of this communication to file a reply complying with the requirements noted below. Failure to timely comply will result in ABANDONMENT of this application.
**THIS THREE-MONTH PERIOD IS NOT EXTENDABLE**.

4. ☐ A SUBSTITUTE OATH OR DECLARATION must be submitted. Note the attached EXAMINER'S AMENDMENT or NOTICE OF INFORMAL PATENT APPLICATION (PTO-152) which gives reason(s) why the oath or declaration is deficient.

5. ☐ CORRECTED DRAWINGS ( as "replacement sheets") must be submitted.
   (a) ☐ including changes required by the Notice of Draftsperson's Patent Drawing Review ( PTO-948) attached
      1) ☐ hereto or 2) ☐ to Paper No./Mail Date _____.
   (b) ☐ including changes required by the attached Examiner's Amendment / Comment or in the Office action of Paper No./Mail Date _____.

   **Identifying indicia such as the application number (see 37 CFR 1.84(c)) should be written on the drawings in the front (not the back) of each sheet. Replacement sheet(s) should be labeled as such in the header according to 37 CFR 1.121(d).**

6. ☐ DEPOSIT OF and/or INFORMATION about the deposit of BIOLOGICAL MATERIAL must be submitted. Note the attached Examiner's comment regarding REQUIREMENT FOR THE DEPOSIT OF BIOLOGICAL MATERIAL.

**Attachment(s)**

1. ☒ Notice of References Cited (PTO-892)
2. ☐ Notice of Draftperson's Patent Drawing Review (PTO-948)
3. ☒ Information Disclosure Statements (PTO/SB/08), Paper No./Mail Date 8/15/07
4. ☐ Examiner's Comment Regarding Requirement for Deposit of Biological Material
5. ☐ Notice of Informal Patent Application
6. ☐ Interview Summary (PTO-413), Paper No./Mail Date _____ .
7. ☐ Examiner's Amendment/Comment
8. ☒ Examiner's Statement of Reasons for Allowance
9. ☐ Other _____.

## Reasons for Allowance

**1.** As per Applicant's instructions as filed on 4/30/10, claims 1-5, 22, 42-45, 53-55, and 60-61 have been amended.

**2.** Claims 1-61 are allowed.

**3.** Claims 1-61 are allowed based on Applicant's filing of Terminal Disclaimer as filed on 5/07/10, and an updated search.

The prior art of record fails to anticipate or make obvious the amended claimed features as specified in independent claims 1-3, 22, 42-45, 53-55, and 60-61.

Any comments considered necessary by Applicant must be submitted no later than the payment of the issue fee and, to avoid processing delays, should preferably accompany the issue fee. Such submissions should be clearly labeled "Comments on Statement of Reasons for Allowance."

### *Conclusion*

**4.** The prior art made of record is considered pertinent to Applicant's disclosure.

A) Ito et al (6,693,960 B2), Moving picture encoder and moving picture decoder.

**5.** Any inquiry concerning this communication or earlier communications from the Examiner should be directed to *Shawn An* whose telephone number is 571-272-7324.

If attempts to reach the examiner by telephone are unsuccessful, the Examiner's supervisor, Mehrdad Dastouri can be reached on 571-272-7418.

**6.** The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300.

**7.** Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see http://pair-direct.uspto.gov. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free). If you would like assistance from a USPTO Customer Service Representative or access to the automated information system, call 800-786-9199 (IN USA OR CANADA) or 571-272-1000.

/SHAWN AN/
Primary Examiner, Art Unit 2621
5/13/10

| Notice of References Cited | Application/Control No. 11/839,205 | Applicant(s)/Patent Under Reexamination KARCZEWICZ ET AL. | |
|---|---|---|---|
| | Examiner SHAWN AN | Art Unit 2621 | Page 1 of 1 |

**U.S. PATENT DOCUMENTS**

| * | | Document Number Country Code-Number-Kind Code | Date MM-YYYY | Name | Classification |
|---|---|---|---|---|---|
| | A | US-6,693,960 B2 | 02-2004 | Ito et al. | 375/240.11 |
| | B | US- | | | |
| | C | US- | | | |
| | D | US- | | | |
| | E | US- | | | |
| | F | US- | | | |
| | G | US- | | | |
| | H | US- | | | |
| | I | US- | | | |
| | J | US- | | | |
| | K | US- | | | |
| | L | US- | | | |
| | M | US- | | | |

**FOREIGN PATENT DOCUMENTS**

| * | | Document Number Country Code-Number-Kind Code | Date MM-YYYY | Country | Name | Classification |
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**NON-PATENT DOCUMENTS**

| * | | Include as applicable: Author, Title Date, Publisher, Edition or Volume, Pertinent Pages) |
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| | U | |
| | V | |
| | W | |
| | X | |

*A copy of this reference is not being furnished with this Office action. (See MPEP § 707.05(a).)
Dates in MM-YYYY format are publication dates. Classifications may be US or foreign.

| Issue Classification | Application/Control No. | Applicant(s)/Patent under Reexamination | |
|---|---|---|---|
| | 11/839,205 | KARCZEWICZ ET AL. | |
| | Examiner | Art Unit | |
| | SHAWN AN | 2621 | |

# ISSUE CLASSIFICATION

| ORIGINAL | | | CROSS REFERENCE(S) | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| CLASS | SUBCLASS | CLASS | SUBCLASS (ONE SUBCLASS PER BLOCK) | | | | | | |
| 375 | 240.17 | 375 | 240.16 | 240.25 | 240.26 | 240.12 | | | |
| INTERNATIONAL CLASSIFICATION | | 382 | 238 | 236 | 233 | 235 | | | |
| H 0 4 B | 1/66 | | | | | | | | |
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| (Assistant Examiner) (Date) | /SHAWN AN/ 5/13/2010 (Primary Examiner) (Date) | Total Claims Allowed: 61 | |
|---|---|---|---|
| (Legal Instruments Examiner) (Date) | | O.G. Print Claim(s): 1 | O.G. Print Fig.: 7 |

☐ Claims renumbered in the same order as presented by applicant ☐ CPA ☐ T.D. ☐ R.1.47

| Final | Original | Final | Original | Final | Original | Final | Original | Final | Original | Final | Original | Final | Original |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1 | 31 | 31 | 61 | 61 | | 91 | | 121 | | 151 | | 181 |
| 20 | 2 | 32 | 32 | | 62 | | 92 | | 122 | | 152 | | 182 |
| 21 | 3 | 33 | 33 | | 63 | | 93 | | 123 | | 153 | | 183 |
| 2 | 4 | 34 | 34 | | 64 | | 94 | | 124 | | 154 | | 184 |
| 4 | 5 | 35 | 35 | | 65 | | 95 | | 125 | | 155 | | 185 |
| 3 | 6 | 36 | 36 | | 66 | | 96 | | 126 | | 156 | | 186 |
| 5 | 7 | 37 | 37 | | 67 | | 97 | | 127 | | 157 | | 187 |
| 6 | 8 | 38 | 38 | | 68 | | 98 | | 128 | | 158 | | 188 |
| 7 | 9 | 39 | 39 | | 69 | | 99 | | 129 | | 159 | | 189 |
| 8 | 10 | 40 | 40 | | 70 | | 100 | | 130 | | 160 | | 190 |
| 9 | 11 | 41 | 41 | | 71 | | 101 | | 131 | | 161 | | 191 |
| 10 | 12 | 42 | 42 | | 72 | | 102 | | 132 | | 162 | | 192 |
| 11 | 13 | 48 | 43 | | 73 | | 103 | | 133 | | 163 | | 193 |
| 12 | 14 | 43 | 44 | | 74 | | 104 | | 134 | | 164 | | 194 |
| 13 | 15 | 50 | 45 | | 75 | | 105 | | 135 | | 165 | | 195 |
| 14 | 16 | 45 | 46 | | 76 | | 106 | | 136 | | 166 | | 196 |
| 15 | 17 | 51 | 47 | | 77 | | 107 | | 137 | | 167 | | 197 |
| 16 | 18 | 46 | 48 | | 78 | | 108 | | 138 | | 168 | | 198 |
| 17 | 19 | 49 | 49 | | 79 | | 109 | | 139 | | 169 | | 199 |
| 18 | 20 | 44 | 50 | | 80 | | 110 | | 140 | | 170 | | 200 |
| 19 | 21 | 52 | 51 | | 81 | | 111 | | 141 | | 171 | | 201 |
| 22 | 22 | 47 | 52 | | 82 | | 112 | | 142 | | 172 | | 202 |
| 23 | 23 | 53 | 53 | | 83 | | 113 | | 143 | | 173 | | 203 |
| 25 | 24 | 54 | 54 | | 84 | | 114 | | 144 | | 174 | | 204 |
| 24 | 25 | 55 | 55 | | 85 | | 115 | | 145 | | 175 | | 205 |
| 26 | 26 | 56 | 56 | | 86 | | 116 | | 146 | | 176 | | 206 |
| 27 | 27 | 57 | 57 | | 87 | | 117 | | 147 | | 177 | | 207 |
| 28 | 28 | 58 | 58 | | 88 | | 118 | | 148 | | 178 | | 208 |
| 29 | 29 | 59 | 59 | | 89 | | 119 | | 149 | | 179 | | 209 |
| 30 | 30 | 60 | 60 | | 90 | | 120 | | 150 | | 180 | | 210 |

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# BIB DATA SHEET

**CONFIRMATION NO. 8091**

| SERIAL NUMBER | FILING or 371(c) DATE / RULE | CLASS | GROUP ART UNIT | ATTORNEY DOCKET NO. |
|---|---|---|---|---|
| 11/839,205 | 08/15/2007 | 375 | 2621 | 982-010567-US (C02) |

**APPLICANTS**

Marta Karczewicz, Irving, TX;
Antti Olli Hallapuro, Tampere, FINLAND;

**** CONTINUING DATA ***************************

This application is a CON of 11/090,717 03/25/2005 PAT 7,280,599
which is a CON of 09/954,608 09/17/2001 PAT 6,950,469

**** FOREIGN APPLICATIONS ***************************

**** IF REQUIRED, FOREIGN FILING LICENSE GRANTED ****

08/22/2007

| Foreign Priority claimed ☐ Yes ☑ No<br>35 USC 119(a-d) conditions met ☐ Yes ☑ No<br>Verified and Acknowledged /SHAWN AN/ Examiner's Signature | ☐ Met after Allowance<br>Initials | STATE OR COUNTRY | SHEETS DRAWINGS | TOTAL CLAIMS | INDEPENDENT CLAIMS |
|---|---|---|---|---|---|
| | | TX | 28 | 61 | 13 |

**ADDRESS**

Perman & Green, LLP
99 Hawley Lane
Stratford, CT 06614
UNITED STATES

**TITLE**

METHOD FOR SUB-PIXEL VALUE INTERPOLATION

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| 5982 | FEES: Authority has been given in Paper No._____ to charge/credit DEPOSIT ACCOUNT No._____ for following: | ☐ All Fees<br>☐ 1.16 Fees (Filing)<br>☐ 1.17 Fees (Processing Ext. of time)<br>☐ 1.18 Fees (Issue)<br>☐ Other _____<br>☐ Credit |

BIB (Rev. 05/07).

## EAST Search History

## EAST Search History (Prior Art)

| Ref # | Hits | Search Query | DBs | Default Operator | Plurals | Time Stamp |
|---|---|---|---|---|---|---|
| S229 | 1 | "11839205" | US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB | OR | OFF | 2010/05/12 19:09 |
| S230 | 1 | (computer program software carrier wave medium media) and S229 | US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB | OR | OFF | 2010/05/12 19:09 |
| S231 | 10817 | 375/240.17 375/240.16 375/240.12 375/240.25 375/240.26 | US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB | OR | OFF | 2010/05/12 19:16 |
| S232 | 8581 | 382/238 382/236 375/233 375/235 | US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB | OR | OFF | 2010/05/12 19:17 |
| S233 | 17415 | S231 S232 | US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB | OR | OFF | 2010/05/12 19:17 |
| S234 | 48847 | ((half sub quarter) near$4 pixel) same interpolat$3 | US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB | OR | OFF | 2010/05/12 19:23 |
| S235 | 1168 | S234 same weight $3 same average | US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB | OR | OFF | 2010/05/12 19:24 |
| S236 | 72 | S233 and S235 | US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB | OR | OFF | 2010/05/12 19:24 |

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PTO/SB/08a (05-07)
Approved for use through 09/30/2007. OMB 0651-0031
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
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| **INFORMATION DISCLOSURE STATEMENT BY APPLICANT** ( **Not for submission under 37 CFR 1.99**) | | |
|---|---|---|
| | Application Number | |
| | Filing Date | 2007-08-15 |
| | First Named Inventor | Karczewicz et al. |
| | Art Unit | |
| | Examiner Name | |
| | Attorney Docket Number | 982-010567-US (C02) |

| **U.S.PATENTS** | | | | | | |
|---|---|---|---|---|---|---|
| Examiner Initial* | Cite No | Patent Number | Kind Code[1] | Issue Date | Name of Patentee or Applicant of cited Document | Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear |
| /S.A./ | 1 | 4937666 | | 1990-06-26 | Yang | |
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| /S.A./ | 3 | 5488419 | | 1996-01-30 | Hui et al. | |
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| INFORMATION DISCLOSURE STATEMENT BY APPLICANT ( Not for submission under 37 CFR 1.99) | | |
|---|---|---|
| | Application Number | |
| | Filing Date | 2007-08-15 |
| | First Named Inventor | Karczewicz et al. |
| | Art Unit | |
| | Examiner Name | |
| | Attorney Docket Number | 982-010567-US (C02) |

| | | | | | | |
|---|---|---|---|---|---|---|
| /S.A./ | 9 | 6219464 | B1 | 2001-04-17 | Greggain et al. | |
| /S.A./ | 10 | 6252576 | B1 | 2001-06-26 | Nottingham | |

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**U.S.PATENT APPLICATION PUBLICATIONS**

| Examiner Initial* | Cite No | Publication Number | Kind Code[1] | Publication Date | Name of Patentee or Applicant of cited Document | Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear |
|---|---|---|---|---|---|---|
| /S.A./ | 1 | 20020064229 | | 2002-05-30 | Nakaya | |

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**FOREIGN PATENT DOCUMENTS**

| Examiner Initial* | Cite No | Foreign Document Number[3] | Country Code[2] ¡ | Kind Code[4] | Publication Date | Name of Patentee or Applicant of cited Document | Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear | T[5] |
|---|---|---|---|---|---|---|---|---|
| /S.A./ | 1 | 9904574 | WO | | 1999-01-28 | Robert Bosch GMBH | | ☐ |
| /S.A./ | 2 | 0576290 | EP | A2 | 1993-12-29 | Sony Corp. | | ☐ |
| /S.A./ | 3 | 2205707 | GB | | 1988-12-14 | Sony Corp. | | ☐ |

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| Examiner Initials* | Cite No | Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc), date, pages(s), volume-issue number(s), publisher, city and/or country where published. | T[5] |
|---|---|---|---|

| INFORMATION DISCLOSURE STATEMENT BY APPLICANT ( Not for submission under 37 CFR 1.99) | | |
|---|---|---|
| | Application Number | |
| | Filing Date | 2007-08-15 |
| | First Named Inventor | Karczewicz et al. |
| | Art Unit | |
| | Examiner Name | |
| | Attorney Docket Number | 982-010567-US (C02) |

| | | | |
|---|---|---|---|
| No Date | 1 | ~~Chae, et a., FPM 21.3, "An Interpolator for HD MAC Decoder".~~ | ☐ |
| /S.A./ | 2 | Mehran Mashfeghi, "Directional Interpolation for Magnetic Resonance Angiography Data", IEEE Transactions on Medical Imaging, Vol. 12, No. 2, June 1993. | ☐ |
| No Date | 3 | ~~Document Q15-K-59, "H.26L Test Model Long Term Number 5 (TML-5) draft0", ITU, Study Group 16.~~ | ☐ |
| No Date | 4 | Document VCEG-L20, "Complexity Reduced Motion Compensated Prediction with 1/8-pel Displacement Vector Resolution", ITU, Study Group 16. | ☐ |
| No Date | 5 | ~~English translation of Japanese publication No. Hei 6-14730.~~ | ☐ |
| No Date | 6 | ~~Japanese Patent Document No. JP 62-039920.~~ | ☐ |

If you wish to add additional non-patent literature document citation information please click the Add button

**EXAMINER SIGNATURE**

| Examiner Signature | /Shawn An/ (05/16/2010) | Date Considered | 05/16/2010 |
|---|---|---|---|

*EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through a citation if not in conformance and not considered. Include copy of this form with next communication to applicant.

[1] See Kind Codes of USPTO Patent Documents at www.USPTO.GOV or MPEP 901.04. [2] Enter office that issued the document, by the two-letter code (WIPO Standard ST.3). [3] For Japanese patent documents, the indication of the year of the reign of the Emperor must precede the serial number of the patent document. [4] Kind of document by the appropriate symbols as indicated on the document under WIPO Standard ST.16 if possible. [5] Applicant is to place a check mark here if English language translation is attached.

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /S.A./ (05/16/2010)

| INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99) | | |
|---|---|---|
| | Application Number | |
| | Filing Date | 2007-08-15 |
| | First Named Inventor | Karczewicz et al. |
| | Art Unit | |
| | Examiner Name | |
| | Attorney Docket Number | 982-010567-US (C02) |

**CERTIFICATION STATEMENT**

Please see 37 CFR 1.97 and 1.98 to make the appropriate selection(s):

☐ That each item of information contained in the information disclosure statement was first cited in any communication from a foreign patent office in a counterpart foreign application not more than three months prior to the filing of the information disclosure statement. See 37 CFR 1.97(e)(1).

**OR**

☐ That no item of information contained in the information disclosure statement was cited in a communication from a foreign patent office in a counterpart foreign application, and, to the knowledge of the person signing the certification after making reasonable inquiry, no item of information contained in the information disclosure statement was known to any individual designated in 37 CFR 1.56(c) more than three months prior to the filing of the information disclosure statement. See 37 CFR 1.97(e)(2).

☐ See attached certification statement.

☐ Fee set forth in 37 CFR 1.17 (p) has been submitted herewith.

☐ None

**SIGNATURE**

A signature of the applicant or representative is required in accordance with CFR 1.33, 10.18. Please see CFR 1.4(d) for the form of the signature.

| Signature | /gcz44004/ | Date (YYYY-MM-DD) | 2007-08-15 |
|---|---|---|---|
| Name/Print | Geza C. Ziegler, Jr. | Registration Number | 44,004 |

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The Privacy Act of 1974 (P.L. 93-579) requires that you be given certain information in connection with your submission of the attached form related to a patent application or patent. Accordingly, pursuant to the requirements of the Act, please be advised that: (1) the general authority for the collection of this information is 35 U.S.C. 2(b)(2); (2) furnishing of the information solicited is voluntary; and (3) the principal purpose for which the information is used by the U.S. Patent and Trademark Office is to process and/or examine your submission related to a patent application or patent. If you do not furnish the requested information, the U.S. Patent and Trademark Office may not be able to process and/or examine your submission, which may result in termination of proceedings or abandonment of the application or expiration of the patent.

The information provided by you in this form will be subject to the following routine uses:

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2. A record from this system of records may be disclosed, as a routine use, in the course of presenting evidence to a court, magistrate, or administrative tribunal, including disclosures to opposing counsel in the course of settlement negotiations.

3. A record in this system of records may be disclosed, as a routine use, to a Member of Congress submitting a request involving an individual, to whom the record pertains, when the individual has requested assistance from the Member with respect to the subject matter of the record.

4. A record in this system of records may be disclosed, as a routine use, to a contractor of the Agency having need for the information in order to perform a contract. Recipients of information shall be required to comply with the requirements of the Privacy Act of 1974, as amended, pursuant to 5 U.S.C. 552a(m).

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| Application Number | Application/Control No. | Applicant(s)/Patent under Reexamination | |
|---|---|---|---|
| | 11/839,205 | KARCZEWICZ ET AL. | |

| Document Code - DISQ | Internal Document – DO NOT MAIL |
|---|---|

| TERMINAL DISCLAIMER | ☒ APPROVED | ☐ DISAPPROVED |
|---|---|---|
| Date Filed : 5/7/10 | This patent is subject to a Terminal Disclaimer | |

| Approved/Disapproved by: |
|---|
| Felicia D. Roberts<br><br>7,280,599 |

U.S. Patent and Trademark Office

PTO/SB/30EFS (07-09)
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# REQUEST FOR CONTINUED EXAMINATION(RCE)TRANSMITTAL
## (Submitted Only via EFS-Web)

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Application Number | 11839205 | Filing Date | 2007-08-15 | Docket Number (if applicable) | 982-010567-US (C02) | Art Unit | 2621 |
| First Named Inventor | Marta Karczewicz | | | Examiner Name | An, Shawn S. | | |

**This is a Request for Continued Examination (RCE) under 37 CFR 1.114 of the above-identified application.**
Request for Continued Examination (RCE) practice under 37 CFR 1.114 does not apply to any utility or plant application filed prior to June 8, 1995, or to any design application. The Instruction Sheet for this form is located at WWW.USPTO.GOV

### SUBMISSION REQUIRED UNDER 37 CFR 1.114

Note: If the RCE is proper, any previously filed unentered amendments and amendments enclosed with the RCE will be entered in the order in which they were filed unless applicant instructs otherwise. If applicant does not wish to have any previously filed unentered amendment(s) entered, applicant must request non-entry of such amendment(s).

☐ Previously submitted. If a final Office action is outstanding, any amendments filed after the final Office action may be considered as a submission even if this box is not checked.

- ☐ Consider the arguments in the Appeal Brief or Reply Brief previously filed on _____
- ☐ Other _____

☒ Enclosed

- ☒ Amendment/Reply
- ☒ Information Disclosure Statement (IDS)
- ☐ Affidavit(s)/ Declaration(s)
- ☐ Other _____

### MISCELLANEOUS

☐ Suspension of action on the above-identified application is requested under 37 CFR 1.103(c) for a period of months _____ (Period of suspension shall not exceed 3 months; Fee under 37 CFR 1.17(i) required)

☐ Other _____

### FEES

☒ **The RCE fee under 37 CFR 1.17(e) is required by 37 CFR 1.114 when the RCE is filed.**
The Director is hereby authorized to charge any underpayment of fees, or credit any overpayments, to Deposit Account No 161350

### SIGNATURE OF APPLICANT, ATTORNEY, OR AGENT REQUIRED

☒ Patent Practitioner Signature

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| Signature of Registered U.S. Patent Practitioner | | | |
|---|---|---|---|
| Signature | /jvg44695/ | Date (YYYY-MM-DD) | 2010-08-18 |
| Name | Joseph V. Gamberdell, Jr. | Registration Number | 44695 |

This collection of information is required by 37 CFR 1.114. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.11 and 1.14. This collection is estimated to take 12 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450.

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3. A record in this system of records may be disclosed, as a routine use, to a Member of Congress submitting a request involving an individual, to whom the record pertains, when the individual has requested assistance from the Member with respect to the subject matter of the record.

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6. A record in this system of records may be disclosed, as a routine use, to another federal agency for purposes of National Security review (35 U.S.C. 181) and for review pursuant to the Atomic Energy Act (42 U.S.C. 218(c)).

7. A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (i.e., GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.

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9. A record from this system of records may be disclosed, as a routine use, to a Federal, State, or local law enforcement agency, if the USPTO becomes aware of a violation or potential violation of law or regulation.

PTO/SB/08a (01-10)
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**( Not for submission under 37 CFR 1.99)**

| | |
|---|---|
| Application Number | 11839205 |
| Filing Date | 2007-08-15 |
| First Named Inventor | Marta Karczewicz |
| Art Unit | 2621 |
| Examiner Name | An, Shawn S. |
| Attorney Docket Number | 982-010567-US (C02) |

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| INFORMATION DISCLOSURE STATEMENT BY APPLICANT ( Not for submission under 37 CFR 1.99) | | |
|---|---|---|
| | Application Number | 11839205 |
| | Filing Date | 2007-08-15 |
| | First Named Inventor | Marta Karczewicz |
| | Art Unit | 2621 |
| | Examiner Name | An, Shawn S. |
| | Attorney Docket Number | 982-010567-US (C02) |

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[1] See Kind Codes of USPTO Patent Documents at www.USPTO.GOV or MPEP 901.04. [2] Enter office that issued the document, by the two-letter code (WIPO Standard ST.3). [3] For Japanese patent documents, the indication of the year of the reign of the Emperor must precede the serial number of the patent document. [4] Kind of document by the appropriate symbols as indicated on the document under WIPO Standard ST.16 if possible. [5] Applicant is to place a check mark here if English language translation is attached.

| INFORMATION DISCLOSURE STATEMENT BY APPLICANT ( Not for submission under 37 CFR 1.99) | | |
|---|---|---|
| | Application Number | 11839205 |
| | Filing Date | 2007-08-15 |
| | First Named Inventor | Marta Karczewicz |
| | Art Unit | 2621 |
| | Examiner Name | An, Shawn S. |
| | Attorney Docket Number | 982-010567-US (C02) |

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Please see 37 CFR 1.97 and 1.98 to make the appropriate selection(s):

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**OR**

☐ That no item of information contained in the information disclosure statement was cited in a communication from a foreign patent office in a counterpart foreign application, and, to the knowledge of the person signing the certification after making reasonable inquiry, no item of information contained in the information disclosure statement was known to any individual designated in 37 CFR 1.56(c) more than three months prior to the filing of the information disclosure statement. See 37 CFR 1.97(e)(2).

☐ See attached certification statement.

☐ Fee set forth in 37 CFR 1.17 (p) has been submitted herewith.

☐ None

**SIGNATURE**

A signature of the applicant or representative is required in accordance with CFR 1.33, 10.18. Please see CFR 1.4(d) for the form of the signature.

| Signature | /jvg44695/ | Date (YYYY-MM-DD) | 2010-08-18 |
|---|---|---|---|
| Name/Print | Joseph V. Gamberdell, Jr. | Registration Number | 44,695 |

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# Electronic Patent Application Fee Transmittal

| | |
|---|---|
| **Application Number:** | 11839205 |
| **Filing Date:** | 15-Aug-2007 |
| **Title of Invention:** | METHOD FOR SUB-PIXEL VALUE INTERPOLATION |
| **First Named Inventor/Applicant Name:** | Marta Karczewicz |
| **Filer:** | Joseph V. Gamberdell/Maureen Silveira |
| **Attorney Docket Number:** | 982-010567-US (C02) |

Filed as Large Entity

## Utility under 35 USC 111(a) Filing Fees

| Description | Fee Code | Quantity | Amount | Sub-Total in USD($) |
|---|---|---|---|---|
| **Basic Filing:** | | | | |
| **Pages:** | | | | |
| **Claims:** | | | | |
| **Miscellaneous-Filing:** | | | | |
| **Petition:** | | | | |
| **Patent-Appeals-and-Interference:** | | | | |
| **Post-Allowance-and-Post-Issuance:** | | | | |
| **Extension-of-Time:** | | | | |

| Description | Fee Code | Quantity | Amount | Sub-Total in USD($) |
|---|---|---|---|---|
| **Miscellaneous:** | | | | |
| Request for continued examination | 1801 | 1 | 810 | 810 |
| | | **Total in USD ($)** | | **810** |

# Electronic Acknowledgement Receipt

| | |
|---|---|
| **EFS ID:** | 8246495 |
| **Application Number:** | 11839205 |
| **International Application Number:** | |
| **Confirmation Number:** | 8091 |
| **Title of Invention:** | METHOD FOR SUB-PIXEL VALUE INTERPOLATION |
| **First Named Inventor/Applicant Name:** | Marta Karczewicz |
| **Customer Number:** | 02512 |
| **Filer:** | Joseph V. Gamberdell/Maureen Silveira |
| **Filer Authorized By:** | Joseph V. Gamberdell |
| **Attorney Docket Number:** | 982-010567-US (C02) |
| **Receipt Date:** | 18-AUG-2010 |
| **Filing Date:** | 15-AUG-2007 |
| **Time Stamp:** | 17:39:58 |
| **Application Type:** | Utility under 35 USC 111(a) |

## Payment information:

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|---|---|
| Submitted with Payment | yes |
| Payment Type | Deposit Account |
| Payment was successfully received in RAM | $810 |
| RAM confirmation Number | 4055 |
| Deposit Account | 161350 |
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## File Listing:

| Document Number | Document Description | File Name | File Size(Bytes)/ Message Digest | Multi Part /.zip | Pages (if appl.) |
|---|---|---|---|---|---|
| 1 | Amendment after Notice of Allowance (Rule 312) | AmendmentAFWRCE100818.pdf | 1347253<br>b8af0077794e535319b5ac249fbdd9d6d5437ff4 | no | 22 |
| **Warnings:** | | | | | |
| **Information:** | | | | | |
| 2 | Request for Continued Examination (RCE) | sb0030e_fill.pdf | 697868<br>9b5f6732f59528bb0f592ee649e6f78bcb810ac9 | no | 3 |
| **Warnings:** | | | | | |
| **Information:** | | | | | |
| 3 | Information Disclosure Statement (IDS) Filed (SB/08) | updated_IDS.pdf | 612327<br>cdbad61ac992faf9162482576261b0d3872d71c9 | no | 4 |
| **Warnings:** | | | | | |
| **Information:** | | | | | |
| A U.S. Patent Number Citation or a U.S. Publication Number Citation is required in the Information Disclosure Statement (IDS) form for autoloading of data into USPTO systems. You may remove the form to add the required data in order to correct the Informational Message if you are citing U.S. References. If you chose not to include U.S. References, the image of the form will be processed and be made available within the Image File Wrapper (IFW) system. However, no data will be extracted from this form. Any additional data such as Foreign Patent Documents or Non Patent Literature will be manually reviewed and keyed into USPTO systems. | | | | | |
| 4 | NPL Documents | EuropeanOfficeAction100726.pdf | 193157<br>01f1a3e6e324eb979e0007495ff863362bb81e01 | no | 5 |
| **Warnings:** | | | | | |
| **Information:** | | | | | |
| 5 | Fee Worksheet (PTO-875) | fee-info.pdf | 31188<br>97dd008d0eaed4f2617c9e2051a16e960dcc8ef8 | no | 2 |
| **Warnings:** | | | | | |
| **Information:** | | | | | |
| | | **Total Files Size (in bytes):** | 2881793 | | |

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**New International Application Filed with the USPTO as a Receiving Office**

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**IN THE UNITED STATES PATENT AND TRADEMARK OFFICE**

| | | | |
|---|---|---|---|
| APPLICANT(s): | Marta Karczewicz | CONF. NO.: | 8091 |
| SERIAL NO.: | 11/839,205 | ART UNIT: | 2621 |
| FILING DATE: | 08/15/2007 | EXAMINER: | An, Shawn S. |
| TITLE: | METHOD FOR SUB-PIXEL VALUE INTERPOLATION | | |
| ATTORNEY DOCKET NO.: | 982-010567-US (C02) | | |

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Commissioner of Patents
P.O. Box 1450
Alexandria VA 22313-1450

**AMENDMENT**

## I. INTRODUCTION

This is a submission included with a Request for Continued Examination for the above-identified patent application in response to the Notice of Allowance mailed May 19, 2010.

Reconsideration of the rejection of the claims is respectfully solicited in light of the following amendment and remarks.

## II. CLAIM AMENDMENTS

1. (Currently Amended) A method for sub-pixel value interpolation to determine values for sub-pixels situated within a rectangular bounded region defined by four corner pixels with no intermediate pixels between the corners, the pixels and sub-pixels being configured for display in rows and columns, pixel and sub-pixel locations in the rows and columns being representable mathematically within the rectangular bounded region using the co-ordinate notation $K/2^N$, $L/2^N$, K and L being positive integers having respective values between zero and $2^N$, N being a positive integer greater than one and representing a particular degree of sub-pixel value interpolation, the method comprising causing an apparatus to:

- interpolate a sub-pixel value for a sub-pixel having co-ordinates with odd values of both K and L, according to a predetermined choice of either a weighted average of the value of a nearest-neighbouring pixel and the value of the sub-pixel situated at co-ordinates 1/2, 1/2, or a weighted average of the values of a pair of diagonally-opposed sub-pixels having co-ordinates with even values of both K and L, including zero, situated within a quadrant of the rectangular bounded region, the quadrant being defined by the sub-pixel having co-ordinates 1/2, 1/2 and the nearest neighbouring pixel;
- interpolate sub-pixel values for sub-pixels having co-ordinates with K equal to an even value and L equal to zero and sub-pixels having co-ordinates with K equal to zero and L equal to an even value, used in the interpolation of the sub-pixels having co-ordinates with odd values of both K and L, using weighted sums of the values of pixels located in rows and columns respectively; and
- interpolate sub-pixel values for sub-pixels having co-ordinates with even values of both K and L, used in the interpolation of sub-pixel values for the sub-pixels having co-ordinates with odd values of both K and L, using a predetermined choice of either a weighted sum of the values of sub-pixels having co-ordinates with K equal to an even value and L equal to zero and the values of sub-pixels having corresponding co-ordinates in immediately adjacent rectangular bounded regions, or a weighted sum of the values of sub-pixels having co-ordinates with K equal to zero and L equal to an even value and the values of sub-pixels having corresponding co-ordinates in immediately adjacent <u>rectangular</u> bounded ~~rectangular~~ regions.

2. (Currently Amended) A method for quarter resolution sub-pixel value interpolation to determine values for sub-pixels situated within a rectangular bounded region defined by four corner pixels with no intermediate pixels between the corners, the pixels and sub-pixels being configured for display in rows and columns, pixel and sub-pixel locations in the rows and columns being representable mathematically within the rectangular bounded region using the co-ordinate notation K/4, L/4, K and L being positive integers having respective values between zero and 4, the method comprising causing an apparatus to:

- interpolate a sub-pixel value for a sub-pixel having co-ordinates with ~~both~~ K and L equal to 1 or 3, according to a predetermined choice of either a weighted average of the value of a nearest-neighbouring pixel and the value of the sub-pixel situated at co-ordinates 2/4, 2/4, or a weighted average of the values of a pair of diagonally-opposed sub-pixels having co-ordinates with ~~both~~ K and L equal to zero, 2 or 4, situated within a quadrant of the rectangular bounded region, the quadrant being defined by the sub-pixel having co-ordinates 2/4, 2/4 and the nearest neighbouring pixel;
- interpolate sub-pixel values for sub-pixels having co-ordinates with K equal to 2 and L equal to zero and sub-pixels having co-ordinates with K equal to zero and L equal to 2, used in the interpolation of the sub-pixels having co-ordinates with ~~both~~ K and L equal to 1 or 3, using weighted sums of the values of pixels located in rows and columns respectively; and
- interpolate a sub-pixel value for the sub-pixel having co-ordinates with both K and L equal to 2, used in the interpolation of sub-pixel values for the sub-pixels having co-ordinates with ~~both~~ K and L equal to 1 or 3, using a predetermined choice of either a weighted sum of the values of the sub-pixel having co-ordinates with K equal to 2 and L equal to zero and the values of sub-pixels having corresponding co-ordinates in immediately adjacent rectangular bounded regions, or a weighted sum of the value of the sub-pixel having co-ordinates with K equal to zero and L equal to 2 and the values of sub-pixels having corresponding co-ordinates in immediately adjacent rectangular bounded regions.

3. (Currently Amended) A method for eighth resolution sub-pixel value interpolation to determine values for sub-pixels situated within a rectangular bounded region defined by four corner pixels with no intermediate pixels between the corners, the pixels and sub-pixels being configured for display in rows and columns, pixel and sub-pixel locations in the rows and columns being representable mathematically with the rectangular bounded region using the co-

ordinate notation K/8, L/8, K and L being positive integers having respective values between zero and 8, the method comprising causing an apparatus to:

- interpolate a sub-pixel value for a sub-pixel having co-ordinates with ~~both~~ K and L equal to 1, 3, 5 or 7, according to a predetermined choice of either a weighted average of the value of a nearest-neighbouring pixel and the value of the sub-pixel situated at co-ordinates 4/8, 4/8, or a weighted average of the values of a pair of diagonally-opposed sub-pixels having co-ordinates with ~~both~~ K and L equal to zero, 2, 4, 6 or 8, situated within a quadrant of the rectangular bounded region, the quadrant being defined by the sub-pixel having co-ordinates 4/8, 4/8 and the nearest neighbouring pixel;
- interpolate sub-pixel values for sub-pixels having co-ordinates with K equal to 2, 4 or 6 and L equal to zero and sub-pixels having co-ordinates with K equal to zero and L equal to 2, 4 or 6, used in the interpolation of the sub-pixels having co-ordinates with ~~both~~ K and L equal to 1, 3, 5 or 7, using weighted sums of the values of pixels located in rows and columns respectively; and
- interpolate sub-pixel values for sub-pixels having co-ordinates with ~~both~~ K and L equal to 2, 4 or 6, used in the interpolation of sub-pixel values for the sub-pixels having co-ordinates with ~~both~~ K and L equal to 1, 3, 5 or 7, using a predetermined choice of either a weighted sum of the values of sub-pixels having co-ordinates with K equal to 2, 4 or 6 and L equal to zero and the values of sub-pixels having corresponding co-ordinates in immediately adjacent rectangular bounded regions or a weighted sum of the values of sub-pixels having co-ordinates with K equal to zero and L equal to 2, 4 or 6 and the values of sub-pixels having corresponding co-ordinates in immediately adjacent rectangular bounded regions.

4. (Previously Presented) A method according to claim 1, comprising causing the apparatus to use a first and a second weight in the weighted average chosen to interpolate the sub-pixel value for a sub-pixel having co-ordinates with odd values of both K and L, wherein when the chosen weighted average is that involving the value of a nearest neighbouring pixel and the value of the sub-pixel situated at co-ordinates 1/2, 1/2, causing the apparatus to select the relative magnitudes of the first and second weights to be inversely proportional to the respective straight-line diagonal distances of the nearest-neighbouring pixel and the sub-pixel situated at co-ordinates 1/2, 1/2 to the sub-pixel having co-ordinates with odd values of both K and L whose value is being interpolated.

5. (Previously Presented) A method according to claim 1, comprising causing the apparatus to use a first and a second weight in the weighted average chosen to interpolate the sub-pixel value for a sub-pixel having co-ordinates with odd values of both K and L, wherein when the chosen weighted average is that involving the values of a pair of diagonally-opposed sub-pixels having co-ordinates with even values of both K and L, causing the apparatus to select the relative magnitudes of the first and second weights to be inversely proportional to the respective straight-line diagonal distances of the sub-pixels having co-ordinates with even values of both K and L to the sub-pixel having co-ordinates with odd values of both K and L whose value is being interpolated.

6. (Previously presented) A method according to claim 4, comprising causing the apparatus to use first and second weights with equal values when the nearest-neighbouring pixel and sub-pixel situated at co-ordinates 1/2, 1/2 are equidistant from the sub-pixel having co-ordinates with odd values of both K and L whose value is being interpolated.

7. (Previously Presented) A method according to claim 5, comprising causing the apparatus to use first and second weights with equal values when the sub-pixels having co-ordinates with even values of both K and L are equidistant from the sub-pixel having co-ordinates with odd values of both K and L whose value is being interpolated.

8. (Previously Presented) A method according to claim 1, comprising causing the apparatus to interpolate sub-pixel values for sub-pixels having co-ordinates with even values of both K and L, used in interpolation of sub-pixel values for the sub-pixels having co-ordinates with odd values of both K and L, using a weighted sum of the values of sub-pixels having co-ordinates with K equal to an even value and L equal to zero and the values of sub-pixels having corresponding co-ordinates in immediately adjacent rectangular bounded regions when the value of a sub-pixel having co-ordinates with K equal to an even value and L equal to an odd value is also required.

9. (Previously Presented) A method according to claim 1, comprising causing the apparatus to interpolate sub-pixel values for sub-pixels having co-ordinates with even values of both K and L, used in interpolation of sub-pixel values for the sub-pixels having co-ordinates with odd

values of both K and L, using a weighted sum of the values of sub-pixels having co-ordinates with K equal to zero and L equal to an even value and the values of sub-pixels having corresponding co-ordinates in immediately adjacent rectangular bounded regions when the value of a sub-pixel having co-ordinates with K equal to an odd value and L equal to an even value is also required.

10. (Previously Presented) A method according to claim 1, comprising causing the apparatus to interpolate sub-pixel values for sub-pixels having co-ordinates with K equal to an odd value O and L equal to an even value E, not including zero or $2^N$, by taking an average of the value of a first sub-pixel having co-ordinates with K equal to the even value O - 1 and L equal to E and a second sub-pixel having co-ordinates with K equal to the even value O + 1 and L equal to E.

11. (Previously Presented) A method according to claim 1, comprising causing the apparatus to interpolate a sub-pixel value for a sub-pixel having co-ordinates with K equal to 1 and L equal to zero, by taking an average of the value of a pixel having co-ordinates with K equal to zero and L equal to zero, and a sub-pixel having co-ordinates with K equal to 2 and L equal to zero.

12. (Previously Presented) A method according to claim 1, comprising causing the apparatus to interpolate a sub-pixel value for a sub-pixel having co-ordinates with K equal to $2^N$ - 1 and L equal to zero, by taking an average of the value of a pixel having co-ordinates with K equal to $2^N$ and L equal to zero, and a sub-pixel having co-ordinates with K equal to $2^N$ - 2 and L equal to zero.

13. (Previously Presented) A method according to claim 1, comprising causing the apparatus to interpolate a sub-pixel value for a sub-pixel having co-ordinates with K equal to 1 and L equal to $2^N$, by taking an average of the value of a pixel having co-ordinates with K equal to zero and L equal to $2^N$, and a sub-pixel having co-ordinates with K equal to 2 and L equal to $2^N$.

14. (Previously Presented) A method according to claim 1, comprising causing the apparatus to interpolate a sub-pixel value for a sub-pixel having co-ordinates with K equal to $2^N$ - 1 and L equal to $2^N$, by taking an average of the value of a pixel having co-ordinates with K equal to $2^N$ and L equal to $2^N$, and a sub-pixel having co-ordinates with K equal to $2^N$ - 2 and L equal to $2^N$.

15. (Previously Presented) A method according to claim 1, comprising causing the apparatus to interpolate sub-pixel values for sub-pixels having co-ordinates with K equal to an even value E, not including zero or $2^N$, and L equal to an odd value O, by taking an average of the value of a first sub-pixel having co-ordinates with K equal to E and L equal to the even value O - 1 and a second sub-pixel having co-ordinates with K equal to E and L equal to the even value O + 1.

16. (Previously Presented) A method according to claim 1, comprising causing the apparatus to interpolate a sub-pixel value for a sub-pixel having co-ordinates with K equal to zero and L equal to 1, by taking an average of the value of a pixel having co-ordinates with K equal to zero and L equal to zero, and a sub-pixel having co-ordinates with K equal to zero and L equal to 2.

17. (Previously Presented) A method according to claim 1, comprising causing the apparatus to interpolate a sub-pixel value for a sub-pixel having co-ordinates with K equal to $2^N$ and L equal to 1, by taking an average of the value of a pixel having co-ordinates with K equal to $2^N$ and L equal to zero, and a sub-pixel having co-ordinates with K equal to $2^N$ and L equal to 2.

18. (Previously Presented) A method according to claim 1, comprising causing the apparatus to interpolate a sub-pixel value for a sub-pixel having co-ordinates with K equal to 0 and L equal to $2^N$ - 1, by taking an average of the value of a pixel having co-ordinates with K equal to zero and L equal to $2^N$, and a sub-pixel having co-ordinates with K equal to zero and L equal to $2^N$ - 2.

19. (Previously Presented) A method according to claim 1, comprising causing the apparatus to interpolate a sub-pixel value for a sub-pixel having co-ordinates with K equal to $2^N$ and L equal to $2^N$ - 1, by taking an average of the value of a pixel having co-ordinates with K equal to $2^N$ and L equal to $2^N$, and a sub-pixel having co-ordinates with K equal to $2^N$ and L equal to $2^N$ - 2.

20. (Previously Presented) A method according to claim 1, comprising causing the apparatus to interpolate a sub-pixel value for the sub-pixel having co-ordinates with K equal to $2^N$ - 1 and L equal to $2^N$ - 1, by taking a weighted average of the values of the four corner pixels that define the rectangular bounded region.

21. (Previously Presented) A method according to claim 1, comprising causing the apparatus to select a value for N from a list consisting of the values 2, 3, and 4.

22. (Previously Presented) An interpolator for sub-pixel value interpolation, the interpolator being configured to determine values for sub-pixels situated within a rectangular bounded region defined by four corner pixels with no intermediate pixels between the corners, the pixels and sub-pixels being configured for display in rows and columns, pixel and sub-pixel locations in the rows and columns being representable mathematically within the rectangular bounded region using the co-ordinate notation $K/2^N$, $L/2^N$, K and L being positive integers having respective values between zero and $2^N$, N being a positive integer greater than one and representing a particular degree of sub-pixel value interpolation, the interpolator being configured to:

- interpolate a sub-pixel value for a sub-pixel having co-ordinates with odd values of both K and L, according to a predetermined choice of either a weighted average of the value of a nearest-neighbouring pixel and the value of the sub-pixel situated at co-ordinates 1/2, 1/2, or a weighted average of the values of a pair of diagonally-opposed sub-pixels having co-ordinates with even values of both K and L, including zero, situated within a quadrant of the rectangular bounded region, the quadrant being defined by the sub-pixel having co-ordinates 1/2, 1/2 and the nearest neighbouring pixel;
- interpolate sub-pixel values for sub-pixels having co-ordinates with K equal to an even value and L equal to zero and sub-pixels having co-ordinates with K equal to zero and L equal to an even value, used in the interpolation of the sub-pixels having co-ordinates with odd values of both K and L, using weighted sums of the values of pixels located in rows and columns respectively; and
- interpolate sub-pixel values for sub-pixels having co-ordinates with even values of both K and L, used in the interpolation of sub-pixel values for the sub-pixels having co-ordinates with odd values of both K and L, using a predetermined choice of either a weighted sum of the values of sub-pixels having co-ordinates with K equal to an even value and L equal to zero and the values of sub-pixels having corresponding co-ordinates in immediately adjacent rectangular bounded regions, or a weighted sum of the values of sub-pixels having co-ordinates with K equal to zero and L equal to an even value and the values of sub-pixels having corresponding co-ordinates in immediately adjacent bounded rectangular regions.

23. (Previously Presented) An interpolator according to claim 22, wherein the interpolator is configured to use a first and a second weight in the weighted average chosen to interpolate the sub-pixel value for a sub-pixel having co-ordinates with odd values of both K and L, wherein when the chosen weighted average is that involving the value of a nearest neighbouring pixel and the value of the sub-pixel situated at co-ordinates 1/2, 1/2, the interpolator is configured to select the relative magnitudes of the first and second weights to be inversely proportional to the respective straight-line diagonal distances of the nearest-neighbouring pixel and the sub-pixel situated at co-ordinates 1/2, 1/2 to the sub-pixel having co-ordinates with odd values of both K and L whose value is being interpolated.

24. (Previously Presented) An interpolator according to claim 22, wherein the interpolator is configured to use a first and a second weight in the weighted average chosen to interpolate the sub-pixel value for a sub-pixel having co-ordinates with odd values of both K and L, wherein when the chosen weighted average is that involving the values of a pair of diagonally-opposed sub-pixels having co-ordinates with even values of both K and L, the interpolator is configured to select the relative magnitudes of the first and second weights to be inversely proportional to the respective straight-line diagonal distances of the sub-pixels having co-ordinates with even values of both K and L to the sub-pixel having co-ordinates with odd values of both K and L whose value is being interpolated.

25. (Previously Presented) An interpolator according to claim 23, wherein the interpolator is configured to use first and second weights with equal values when the nearest-neighbouring pixel and sub-pixel situated at co-ordinates 1/2, 1/2 are equidistant from the sub-pixel having co-ordinates with odd values of both K and L whose value is being interpolated.

26. (Previously Presented) An interpolator according to claim 24, wherein the interpolator is configured to use first and second weights with equal values when the sub-pixels having co-ordinates with even values of both K and L are equidistant from the sub-pixel having co-ordinates with odd values of both K and L whose value is being interpolated.

27. (Previously Presented) An interpolator according to claim 22, wherein the interpolator is configured to interpolate sub-pixel values for sub-pixels having co-ordinates with even values of

both K and L, used in interpolation of sub-pixel values for the sub-pixels having co-ordinates with odd values of both K and L, using a weighted sum of the values of sub-pixels having co-ordinates with K equal to an even value and L equal to zero and the values of sub-pixels having corresponding co-ordinates in immediately adjacent rectangular bounded regions when the value of a sub-pixel having co-ordinates with K equal to an even value and L equal to an odd value is also required.

28. (Previously Presented) An interpolator according to claim 22, wherein the interpolator is configured to interpolate sub-pixel values for sub-pixels having co-ordinates with even values of both K and L, used in interpolation of sub-pixel values for the sub-pixels having co-ordinates with odd values of both K and L, using a weighted sum of the values of sub-pixels having co-ordinates with K equal to zero and L equal to an even value and the values of sub-pixels having corresponding co-ordinates in immediately adjacent rectangular bounded regions when the value of a sub-pixel having co-ordinates with K equal to an odd value and L equal to an even value is also required.

29. (Previously Presented) An interpolator according to claim 22, wherein the interpolator is configured to interpolate sub-pixel values for sub-pixels having co-ordinates with K equal to an odd value O and L equal to an even value E, not including zero or $2^N$, by taking an average of the value of a first sub-pixel having co-ordinates with K equal to the even value O - 1 and L equal to E and a second sub-pixel having co-ordinates with K equal to the even value O + 1 and L equal to E.

30. (Previously Presented) An interpolator according to claim 22, wherein the interpolator is configured to interpolate a sub-pixel value for a sub-pixel having co-ordinates with K equal to 1 and L equal to zero, by taking an average of the value of a pixel having co-ordinates with K equal to zero and L equal to zero, and a sub-pixel having co-ordinates with K equal to 2 and L equal to zero.

31. (Previously Presented) An interpolator according to claim 22, wherein the interpolator is configured to interpolate a sub-pixel value for a sub-pixel having co-ordinates with K equal to $2^N$ - 1 and L equal to zero, by taking an average of the value of a pixel having co-ordinates with K

equal to $2^N$ and L equal to zero, and a sub-pixel having co-ordinates with K equal to $2^N$ - 2 and L equal to zero.

32. (Previously Presented) An interpolator according to claim 22, wherein the interpolator is configured to interpolate a sub-pixel value for a sub-pixel having co-ordinates with K equal to 1 and L equal to $2^N$, by taking an average of the value of a pixel having co-ordinates with K equal to zero and L equal to $2^N$, and a sub-pixel having co-ordinates with K equal to 2 and L equal to $2^N$.

33. (Previously Presented) An interpolator according to claim 22, wherein the interpolator is configured to interpolate a sub-pixel value for a sub-pixel having co-ordinates with K equal to $2^N$ - 1 and L equal to $2^N$, by taking an average of the value of a pixel having co-ordinates with K equal to $2^N$ and L equal to $2^N$, and a sub-pixel having co-ordinates with K equal to $2^N$ - 2 and L equal to $2^N$.

34. (Previously Presented) An interpolator according to claim 22, wherein the interpolator is configured to interpolate sub-pixel values for sub-pixels having co-ordinates with K equal to an even value E, not including zero or $2^N$, and L equal to an odd value O, by taking an average of the value of a first sub-pixel having co-ordinates with K equal to E and L equal to the even value O - 1 and a second sub-pixel having co-ordinates with K equal to E and L equal to the even value O + 1.

35. (Previously Presented) An interpolator according to claim 22, wherein the interpolator is configured to interpolate a sub-pixel value for a sub-pixel having co-ordinates with K equal to zero and L equal to 1, by taking an average of the value of a pixel having co-ordinates with K equal to zero and L equal to zero, and a sub-pixel having co-ordinates with K equal to zero and L equal to 2.

36. (Previously Presented) An interpolator according to claim 22, wherein the interpolator is configured to interpolate a sub-pixel value for a sub-pixel having co-ordinates with K equal to $2^N$ and L equal to 1, by taking an average of the value of a pixel having co-ordinates with K equal to $2^N$ and L equal to zero, and a sub-pixel having co-ordinates with K equal to zero and L equal to 2.

37. (Previously Presented) An interpolator according to claim 22, wherein the interpolator is configured to interpolate a sub-pixel value for a sub-pixel having co-ordinates with K equal to 0 and L equal to $2^N$ - 1, by taking an average of the value of a pixel having co-ordinates with K equal to zero and L equal to $2^N$, and a sub-pixel having co-ordinates with K equal to zero and L equal to $2^N$ - 2.

38. (Previously Presented) An interpolator according to claim 22, wherein the interpolator is configured to interpolate a sub-pixel value for a sub-pixel having co-ordinates with K equal to $2^N$ and L equal to $2^N$ - 1, by taking an average of the value of a pixel having co-ordinates with K equal to $2^N$ and L equal to $2^N$, and a sub-pixel having co-ordinates with K equal to $2^N$ and L equal to $2^N$ - 2.

39. (Previously Presented) An interpolator according to claim 22, wherein the interpolator is configured to interpolate a sub-pixel value for the sub-pixel having co-ordinates with K equal to $2^N$ - 1 and L equal to $2^N$ - 1, by taking a weighted average of the values of the four corner pixels that define the rectangular bounded region.

40. (Previously Presented) An interpolator according to claim 22, wherein N is set equal to 2.

41. (Previously Presented) An interpolator according to claim 22, wherein N is set equal to 3.

42. (Previously Presented) A video encoder comprising an interpolator for sub-pixel value interpolation, the interpolator being configured to determine values for sub-pixels situated within a rectangular bounded region defined by four corner pixels with no intermediate pixels between the corners, the pixels and sub-pixels being configured for display in rows and columns, pixel and sub-pixel locations in the rows and columns being representable mathematically within the rectangular bounded region using the co-ordinate notation $K/2^N$, $L/2^N$, K and L being positive integers having respective values between zero and $2^N$, N being a positive integer greater than one and representing a particular degree of sub-pixel value interpolation, the interpolator being configured to:

- interpolate a sub-pixel value for a sub-pixel having co-ordinates with odd values of both K and L, according to a predetermined choice of either a weighted average of the value of a

nearest-neighbouring pixel and the value of the sub-pixel situated at co-ordinates 1/2, 1/2, or a weighted average of the values of a pair of diagonally-opposed sub-pixels having co-ordinates with even values of both K and L, including zero, situated within a quadrant of the rectangular bounded region, the quadrant being defined by the sub-pixel having co-ordinates 1/2, 1/2 and the nearest neighbouring pixel;

- interpolate sub-pixel values for sub-pixels having co-ordinates with K equal to an even value and L equal to zero and sub-pixels having co-ordinates with K equal to zero and L equal to an even value, used in the interpolation of the sub-pixels having co-ordinates with odd values of both K and L, using weighted sums of the values of pixels located in rows and columns respectively; and
- interpolate sub-pixel values for sub-pixels having co-ordinates with even values of both K and L, used in the interpolation of sub-pixel values for the sub-pixels having co-ordinates with odd values of both K and L, using a predetermined choice of either a weighted sum of the values of sub-pixels having co-ordinates with K equal to an even value and L equal to zero and the values of sub-pixels having corresponding co-ordinates in immediately adjacent rectangular bounded regions, or a weighted sum of the values of sub-pixels having co-ordinates with K equal to zero and L equal to an even value and the values of sub-pixels having corresponding co-ordinates in immediately adjacent bounded rectangular regions.

43. (Previously Presented) A still image encoder comprising an interpolator for sub-pixel value interpolation, the interpolator being configured to determine values for sub-pixels situated within a rectangular bounded region defined by four corner pixels with no intermediate pixels between the corners, the pixels and sub-pixels being configured for display in rows and columns, pixel and sub-pixel locations in the rows and columns being representable mathematically within the rectangular bounded region using the co-ordinate notation $K/2^N$, $L/2^N$, K and L being positive integers having respective values between zero and $2^N$, N being a positive integer greater than one and representing a particular degree of sub-pixel value interpolation, the interpolator being configured to:

- interpolate a sub-pixel value for a sub-pixel having co-ordinates with odd values of both K and L, according to a predetermined choice of either a weighted average of the value of a nearest-neighbouring pixel and the value of the sub-pixel situated at co-ordinates 1/2, 1/2, or a weighted average of the values of a pair of diagonally-opposed sub-pixels having co-

ordinates with even values of both K and L, including zero, situated within a quadrant of the rectangular bounded region, the quadrant being defined by the sub-pixel having co-ordinates 1/2, 1/2 and the nearest neighbouring pixel;

- interpolate sub-pixel values for sub-pixels having co-ordinates with K equal to an even value and L equal to zero and sub-pixels having co-ordinates with K equal to zero and L equal to an even value, used in the interpolation of the sub-pixels having co-ordinates with odd values of both K and L, using weighted sums of the values of pixels located in rows and columns respectively; and
- interpolate sub-pixel values for sub-pixels having co-ordinates with even values of both K and L, used in the interpolation of sub-pixel values for the sub-pixels having co-ordinates with odd values of both K and L, using a predetermined choice of either a weighted sum of the values of sub-pixels having co-ordinates with K equal to an even value and L equal to zero and the values of sub-pixels having corresponding co-ordinates in immediately adjacent rectangular bounded regions, or a weighted sum of the values of sub-pixels having co-ordinates with K equal to zero and L equal to an even value and the values of sub-pixels having corresponding co-ordinates in immediately adjacent bounded rectangular regions.

44. (Previously Presented) A video decoder comprising an interpolator for sub-pixel value interpolation, the interpolator being configured to determine values for sub-pixels situated within a rectangular bounded region defined by four corner pixels with no intermediate pixels between the corners, the pixels and sub-pixels being configured for display in rows and columns, pixel and sub-pixel locations in the rows and columns being representable mathematically within the rectangular bounded region using the co-ordinate notation $K/2^N$, $L/2^N$, K and L being positive integers having respective values between zero and $2^N$, N being a positive integer greater than one and representing a particular degree of sub-pixel value interpolation, the interpolator being configured to:

- interpolate a sub-pixel value for a sub-pixel having co-ordinates with odd values of both K and L, according to a predetermined choice of a either weighted average of the value of a nearest-neighbouring pixel and the value of the sub-pixel situated at co-ordinates 1/2, 1/2, or a weighted average of the values of a pair of diagonally-opposed sub-pixels having co-ordinates with even values of both K and L, including zero, situated within a quadrant of

the rectangular bounded region, the quadrant being defined by the sub-pixel having co-ordinates 1/2, 1/2 and the nearest neighbouring pixel;

- interpolate sub-pixel values for sub-pixels having co-ordinates with K equal to an even value and L equal to zero and sub-pixels having co-ordinates with K equal to zero and L equal to an even value, used in the interpolation of the sub-pixels having co-ordinates with odd values of both K and L, using weighted sums of the values of pixels located in rows and columns respectively; and
- interpolate sub-pixel values for sub-pixels having co-ordinates with even values of both K and L, used in the interpolation of sub-pixel values for the sub-pixels having co-ordinates with odd values of both K and L, using a predetermined choice of either a weighted sum of the values of sub-pixels having co-ordinates with K equal to an even value and L equal to zero and the values of sub-pixels having corresponding co-ordinates in immediately adjacent rectangular bounded regions, or a weighted sum of the values of sub-pixels having co-ordinates with K equal to zero and L equal to an even value and the values of sub-pixels having corresponding co-ordinates in immediately adjacent bounded rectangular regions.

45. (Previously Presented) A still image decoder comprising an interpolator for sub-pixel value interpolation, the interpolator being configured to determine values for sub-pixels situated within a rectangular bounded region defined by four corner pixels with no intermediate pixels between the corners, the pixels and sub-pixels being configured for display in rows and columns, pixel and sub-pixel locations in the rows and columns being representable mathematically within the rectangular bounded region using the co-ordinate notation $K/2^N$, $L/2^N$, K and L being positive integers having respective values between zero and $2^N$, N being a positive integer greater than one and representing a particular degree of sub-pixel value interpolation, the interpolator being configured to:

- interpolate a sub-pixel value for a sub-pixel having co-ordinates with odd values of both K and L, according to a predetermined choice of either a weighted average of the value of a nearest-neighbouring pixel and the value of the sub-pixel situated at co-ordinates 1/2, 1/2, or a weighted average of the values of a pair of diagonally-opposed sub-pixels having co-ordinates with even values of both K and L, including zero, situated within a quadrant of the rectangular bounded region, the quadrant being defined by the sub-pixel having co-ordinates 1/2, 1/2 and the nearest neighbouring pixel;

- interpolate sub-pixel values for sub-pixels having co-ordinates with K equal to an even value and L equal to zero and sub-pixels having co-ordinates with K equal to zero and L equal to an even value, used in the interpolation of the sub-pixels having co-ordinates with odd values of both K and L, using weighted sums of the values of pixels located in rows and columns respectively; and
- interpolate sub-pixel values for sub-pixels having co-ordinates with even values of both K and L, used in the interpolation of sub-pixel values for the sub-pixels having co-ordinates with odd values of both K and L, using a predetermined choice of either a weighted sum of the values of sub-pixels having co-ordinates with K equal to an even value and L equal to zero and the values of sub-pixels having corresponding co-ordinates in immediately adjacent rectangular bounded regions, or a weighted sum of the values of sub-pixels having co-ordinates with K equal to zero and L equal to an even value and the values of sub-pixels having corresponding co-ordinates in immediately adjacent bounded rectangular regions.

46. (Previously Presented) A codec comprising a video encoder according to claim 42 and a video decoder according to claim 44.

47. (Previously Presented) A codec comprising a still image encoder according to claim 43 and a still image decoder according to claim 45.

48. (Previously Presented) A communications terminal comprising a video encoder according to claim 42.

49. (Previously Presented) A communications terminal comprising a still image encoder according to claim 43.

50. (Previously Presented) A communications terminal comprising a video decoder according to claim 44.

51. (Previously Presented) A communications terminal comprising a still image decoder according to claim 45.

52. (Previously Presented) A communications terminal according to claim 48, wherein the communications terminal is a wireless terminal.

53. (Previously Presented) An interpolator for sub-pixel value interpolation, the interpolator being configured to determine values for sub-pixels situated within a rectangular bounded region defined by four corner pixels with no intermediate pixels between the corners, the pixels and sub-pixels being configured for display in rows and columns, pixel and sub-pixel locations in the rows and columns being representable mathematically within the rectangular bounded region using the co-ordinate notation $K/2^N$, $L/2^N$, K and L being positive integers having respective values between zero and $2^N$, N being a positive integer greater than one and representing a particular degree of sub-pixel value interpolation, the interpolator comprising:

- circuitry configured to interpolate a sub-pixel value for a sub-pixel having co-ordinates with odd values of both K and L, according to a predetermined choice of either a weighted average of the value of a nearest-neighbouring pixel and the value of the sub-pixel situated at co-ordinates 1/2, 1/2, and a weighted average of the values of a pair of diagonally-opposed sub-pixels having co-ordinates with even values of both K and L, including zero, situated within a quadrant of the rectangular bounded region, the quadrant being defined by the sub-pixel having co-ordinates 1/2, 1/2 and the nearest neighbouring pixel;
- circuitry configured to interpolate sub-pixel values for sub-pixels having co-ordinates with K equal to an even value and L equal to zero and sub-pixels having co-ordinates with K equal to zero and L equal to an even value, used in the interpolation of the sub-pixels having co-ordinates with odd values of both K and L, using weighted sums of the values of pixels located in rows and columns respectively; and
- circuitry configured to interpolate sub-pixel values for sub-pixels having co-ordinates with even values of both K and L, used in the interpolation of sub-pixel values for the sub-pixels having co-ordinates with odd values of both K and L, using a predetermined choice of either a weighted sum of the values of sub-pixels having co-ordinates with K equal to an even value and L equal to zero and the values of sub-pixels having corresponding co-ordinates in immediately adjacent rectangular bounded regions, or a weighted sum of the values of sub-pixels having co-ordinates with K equal to zero and L equal to an even value and the values of sub-pixels having corresponding co-ordinates in immediately adjacent bounded rectangular regions.

54. (Currently Amended) An interpolator for quarter resolution sub-pixel value interpolation, the interpolator being configured to determine values for sub-pixels situated within a rectangular bounded region defined by four corner pixels with no intermediate pixels between the corners, the pixels and sub-pixels being configured for display in rows and columns, pixel and sub-pixel locations in the rows and columns being representable mathematically within the rectangular bounded region using the co-ordinate notation K/4, L/4, K and L being positive integers having respective values between zero and 4, the interpolator being configured to:

- interpolate a sub-pixel value for a sub-pixel having co-ordinates with ~~both~~ K and L equal to 1 or 3, according to a predetermined choice of either a weighted average of the value of a nearest-neighbouring pixel and the value of the sub-pixel situated at co-ordinates 2/4, 2/4, or a weighted average of the values of a pair of diagonally-opposed sub-pixels having co-ordinates with ~~both~~ K and L equal to zero, 2 or 4, situated within a quadrant of the rectangular bounded region, the quadrant being defined by the sub-pixel having co-ordinates 2/4, 2/4 and the nearest neighbouring pixel;
- interpolate sub-pixel values for sub-pixels having co-ordinates with K equal to 2 and L equal to zero and sub-pixels having co-ordinates with K equal to zero and L equal to 2, used in the interpolation of the sub-pixels having co-ordinates with ~~both~~ K and L equal to 1 or 3, using weighted sums of the values of pixels located in rows and columns respectively; and
- interpolate a sub-pixel value for the sub-pixel having co-ordinates with both K and L equal to 2, used in the interpolation of sub-pixel values for the sub-pixels having co-ordinates with ~~both~~ K and L equal to 1 or 3, using a predetermined choice of either a weighted sum of the values of the sub-pixel having co-ordinates with K equal to 2 and L equal to zero and the values of sub-pixels having corresponding co-ordinates in immediately adjacent rectangular bounded regions, or a weighted sum of the value of the sub-pixel having co-ordinates with K equal to zero and L equal to 2 and the values of sub-pixels having corresponding co-ordinates in immediately adjacent rectangular bounded regions.

55. (Currently Amended) An interpolator for eighth resolution sub-pixel value interpolation, the interpolator being configured to determine values for sub-pixels situated within a rectangular bounded region defined by four corner pixels with no intermediate pixels between the corners, the pixels and sub-pixels being configured for display in rows and columns, pixel and sub-pixel

locations in the rows and columns being representable mathematically with the rectangular bounded region using the co-ordinate notation K/8, L/8, K and L being positive integers having respective values between zero and 8, the interpolator being configured to:

- interpolate a sub-pixel value for a sub-pixel having co-ordinates with ~~both~~ K and L equal to 1, 3, 5 or 7, according to a predetermined choice of either a weighted average of the value of a nearest-neighbouring pixel and the value of the sub-pixel situated at co-ordinates 4/8, 4/8, or a weighted average of the values of a pair of diagonally-opposed sub-pixels having co-ordinates with ~~both~~ K and L equal to zero, 2, 4, 6 or 8, situated within a quadrant of the rectangular bounded region, the quadrant being defined by the sub-pixel having co-ordinates 4/8, 4/8 and the nearest neighbouring pixel;
- interpolate sub-pixel values for sub-pixels having co-ordinates with K equal to 2, 4 or 6 and L equal to zero and sub-pixels having co-ordinates with K equal to zero and L equal to 2, 4 or 6, used in the interpolation of the sub-pixels having co-ordinates with ~~both~~ K and L equal to 1, 3, 5 or 7, using weighted sums of the values of pixels located in rows and columns respectively; and
- interpolate sub-pixel values for sub-pixels having co-ordinates with ~~both~~ K and L equal to 2, 4 or 6, used in the interpolation of sub-pixel values for the sub-pixels having co-ordinates with ~~both~~ K and L equal to 1, 3, 5 or 7, using a predetermined choice of either a weighted sum of the values of sub-pixels having co-ordinates with K equal to 2, 4 or 6 and L equal to zero and the values of sub-pixels having corresponding co-ordinates in immediately adjacent rectangular bounded regions or a weighted sum of the values of sub-pixels having co-ordinates with K equal to zero and L equal to 2, 4 or 6 and the values of sub-pixels having corresponding co-ordinates in immediately adjacent rectangular bounded regions.

56. (Previously Presented) A video encoder or still image encoder comprising an interpolator according to claim 54 or 55.

57. (Previously Presented) A video decoder or still image decoder comprising an interpolator according to claim 54 or 55.

58. (Previously Presented) A communications terminal comprising a video encoder or still image encoder according to claim 56.

59. (Previously Presented) A communications terminal comprising a video decoder or still image decoder according to claim 57.

60. (Previously Presented) A computer program embodied on a computer readable storage medium for sub-pixel value interpolation, the computer program being configured to determine values for sub-pixels situated within a rectangular bounded region defined by four corner pixels with no intermediate pixels between the corners, the pixels and sub-pixels being configured for display in rows and columns, pixel and sub-pixel locations in the rows and columns being representable mathematically within the rectangular bounded region using the co-ordinate notation $K/2^N$, $L/2^N$, K and L being positive integers having respective values between zero and $2^N$, N being a positive integer greater than one and representing a particular degree of sub-pixel value interpolation, the computer program comprising:

- computer program code for interpolating a sub-pixel value for a sub-pixel having co-ordinates with odd values of both K and L, according to a predetermined choice of either a weighted average of the value of a nearest-neighbouring pixel and the value of the sub-pixel situated at co-ordinates 1/2, 1/2, or a weighted average of the values of a pair of diagonally-opposed sub-pixels having co-ordinates with even values of both K and L, including zero, situated within a quadrant of the rectangular bounded region, the quadrant being defined by the sub-pixel having co-ordinates 1/2, 1/2 and the nearest neighbouring pixel;
- computer program code for interpolating sub-pixel values for sub-pixels having co-ordinates with K equal to an even value and L equal to zero and sub-pixels having co-ordinates with K equal to zero and L equal to an even value, used in the interpolation of the sub-pixels having co-ordinates with odd values of both K and L, using weighted sums of the values of pixels located in rows and columns respectively; and
- computer program code for interpolating sub-pixel values for sub-pixels having co-ordinates with even values of both K and L, used in the interpolation of sub-pixel values for the sub-pixels having co-ordinates with odd values of both K and L, using a predetermined choice of either a weighted sum of the values of sub-pixels having co-ordinates with K equal to an even value and L equal to zero and the values of sub-pixels having corresponding co-ordinates in immediately adjacent rectangular bounded regions, or a weighted sum of the values of sub-pixels having co-ordinates with K equal to zero

and L equal to an even value and the values of sub-pixels having corresponding co-ordinates in immediately adjacent bounded rectangular regions.

61. (Previously Presented) A network apparatus comprising an interpolator for sub-pixel value interpolation, the interpolator being configured to determine values for sub-pixels situated within a rectangular bounded region defined by four corner pixels with no intermediate pixels between the corners, the pixels and sub-pixels being configured for display in rows and columns, pixel and sub-pixel locations in the rows and columns being representable mathematically within the rectangular bounded region using the co-ordinate notation $K/2^N$, $L/2^N$, K and L being positive integers having respective values between zero and $2^N$, N being a positive integer greater than one and representing a particular degree of sub-pixel value interpolation, the interpolator being configured to:

- interpolate a sub-pixel value for a sub-pixel having co-ordinates with odd values of both K and L, according to a predetermined choice of either a weighted average of the value of a nearest-neighbouring pixel and the value of the sub-pixel situated at co-ordinates 1/2, 1/2, or a weighted average of the values of a pair of diagonally-opposed sub-pixels having co-ordinates with even values of both K and L, including zero, situated within a quadrant of the rectangular bounded region, the quadrant being defined by the sub-pixel having co-ordinates 1/2, 1/2 and the nearest neighbouring pixel;
- interpolate sub-pixel values for sub-pixels having co-ordinates with K equal to an even value and L equal to zero and sub-pixels having co-ordinates with K equal to zero and L equal to an even value, used in the interpolation of the sub-pixels having co-ordinates with odd values of both K and L, using weighted sums of the values of pixels located in rows and columns respectively; and
- interpolate sub-pixel values for sub-pixels having co-ordinates with even values of both K and L, used in the interpolation of sub-pixel values for the sub-pixels having co-ordinates with odd values of both K and L, using a predetermined choice of either a weighted sum of the values of sub-pixels having co-ordinates with K equal to an even value and L equal to zero and the values of sub-pixels having corresponding co-ordinates in immediately adjacent rectangular bounded regions, or a weighted sum of the values of sub-pixels having co-ordinates with K equal to zero and L equal to an even value and the values of sub-pixels having corresponding co-ordinates in immediately adjacent bounded rectangular regions.

## III. REMARKS

1. Claims 1-61 remain in the application. Claims 1-3, 54, and 55 have been amended.

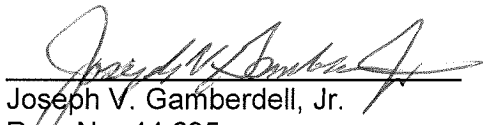
The claims have been amended to encompass embodiments in which integers K and L may have the same values and may have different values.

There have been no art rejections and Applicants respectfully submit that the claims are patentable over any references.

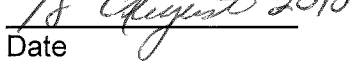
It is therefore respectfully submitted that all of the claims now present in the application are clearly novel and patentable over any prior art, and are in proper form for allowance. Accordingly, favorable reconsideration and allowance is respectfully requested. Should any unresolved issues remain, the Examiner is invited to call Applicants' attorney at the telephone number indicated below.

The Commissioner is hereby authorized to charge payment for any fees associated with this communication or credit any over payment to Deposit Account No. 16-1350.

Respectfully submitted,



Joseph V. Gamberdell, Jr.
Reg. No. 44,695



Date

Perman & Green, LLP
99 Hawley Lane
Stratford, CT 06614
(203) 259-1800
Customer No.: 2512

PTO/SB/06 (07-06)
Approved for use through 1/31/2007. OMB 0651-0032
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# PATENT APPLICATION FEE DETERMINATION RECORD

Substitute for Form PTO-875

| Application or Docket Number | Filing Date | ☐ To be Mailed |
|---|---|---|
| 11/839,205 | 08/15/2007 | |

## APPLICATION AS FILED – PART I

| FOR | (Column 1) NUMBER FILED | (Column 2) NUMBER EXTRA | SMALL ENTITY ☐ RATE ($) | SMALL ENTITY ☐ FEE ($) | OR | OTHER THAN SMALL ENTITY RATE ($) | OTHER THAN SMALL ENTITY FEE ($) |
|---|---|---|---|---|---|---|---|
| ☐ BASIC FEE (37 CFR 1.16(a), (b), or (c)) | N/A | N/A | N/A | | | N/A | |
| ☐ SEARCH FEE (37 CFR 1.16(k), (i), or (m)) | N/A | N/A | N/A | | | N/A | |
| ☐ EXAMINATION FEE (37 CFR 1.16(o), (p), or (q)) | N/A | N/A | N/A | | | N/A | |
| TOTAL CLAIMS (37 CFR 1.16(i)) | minus 20 = | * | X $ = | | OR | X $ = | |
| INDEPENDENT CLAIMS (37 CFR 1.16(h)) | minus 3 = | * | X $ = | | | X $ = | |
| ☐ APPLICATION SIZE FEE (37 CFR 1.16(s)) | If the specification and drawings exceed 100 sheets of paper, the application size fee due is $250 ($125 for small entity) for each additional 50 sheets or fraction thereof. See 35 U.S.C. 41(a)(1)(G) and 37 CFR 1.16(s). | | | | | | |
| ☐ MULTIPLE DEPENDENT CLAIM PRESENT (37 CFR 1.16(j)) | | | | | | | |
| * If the difference in column 1 is less than zero, enter "0" in column 2. | | | TOTAL | | | TOTAL | |

## APPLICATION AS AMENDED – PART II

| AMENDMENT 08/18/2010 | (Column 1) CLAIMS REMAINING AFTER AMENDMENT | | (Column 2) HIGHEST NUMBER PREVIOUSLY PAID FOR | (Column 3) PRESENT EXTRA | SMALL ENTITY RATE ($) | SMALL ENTITY ADDITIONAL FEE ($) | OR | OTHER THAN SMALL ENTITY RATE ($) | OTHER THAN SMALL ENTITY ADDITIONAL FEE ($) |
|---|---|---|---|---|---|---|---|---|---|
| Total (37 CFR 1.16(i)) | * 61 | Minus | ** 61 | = 0 | X $ = | | OR | X $52= | 0 |
| Independent (37 CFR 1.16(h)) | * 13 | Minus | ***13 | = 0 | X $ = | | OR | X $220= | 0 |
| ☐ Application Size Fee (37 CFR 1.16(s)) | | | | | | | | | |
| ☐ FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j)) | | | | | | | OR | | |
| | | | | | TOTAL ADD'L FEE | | OR | TOTAL ADD'L FEE | 0 |

| AMENDMENT | (Column 1) CLAIMS REMAINING AFTER AMENDMENT | | (Column 2) HIGHEST NUMBER PREVIOUSLY PAID FOR | (Column 3) PRESENT EXTRA | RATE ($) | ADDITIONAL FEE ($) | | RATE ($) | ADDITIONAL FEE ($) |
|---|---|---|---|---|---|---|---|---|---|
| Total (37 CFR 1.16(i)) | * | Minus | ** | = | X $ = | | OR | X $ = | |
| Independent (37 CFR 1.16(h)) | * | Minus | *** | = | X $ = | | OR | X $ = | |
| ☐ Application Size Fee (37 CFR 1.16(s)) | | | | | | | | | |
| ☐ FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j)) | | | | | | | OR | | |
| | | | | | TOTAL ADD'L FEE | | OR | TOTAL ADD'L FEE | |

* If the entry in column 1 is less than the entry in column 2, write "0" in column 3.

** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 20, enter "20".

*** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 3, enter "3".

The "Highest Number Previously Paid For" (Total or Independent) is the highest number found in the appropriate box in column 1.

Legal Instrument Examiner:
/JOSEPHINE DOUGLAS/

This collection of information is required by 37 CFR 1.16. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 12 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

*If you need assistance in completing the form, call 1-800-PTO-9199 and select option 2.*

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# NOTICE OF ALLOWANCE AND FEE(S) DUE

2512 7590 09/08/2010

Perman & Green, LLP
99 Hawley Lane
Stratford, CT 06614

| EXAMINER | |
|---|---|
| AN, SHAWN S | |
| ART UNIT | PAPER NUMBER |
| 2621 | |

DATE MAILED: 09/08/2010

| APPLICATION NO. | FILING DATE | FIRST NAMED INVENTOR | ATTORNEY DOCKET NO. | CONFIRMATION NO. |
|---|---|---|---|---|
| 11/839,205 | 08/15/2007 | Marta Karczewicz | 982-010567-US (C02) | 8091 |

TITLE OF INVENTION: METHOD FOR SUB-PIXEL VALUE INTERPOLATION

| APPLN. TYPE | SMALL ENTITY | ISSUE FEE DUE | PUBLICATION FEE DUE | PREV. PAID ISSUE FEE | TOTAL FEE(S) DUE | DATE DUE |
|---|---|---|---|---|---|---|
| nonprovisional | NO | $1510 | $300 | $0 | $1810 | 12/08/2010 |

**THE APPLICATION IDENTIFIED ABOVE HAS BEEN EXAMINED AND IS ALLOWED FOR ISSUANCE AS A PATENT. PROSECUTION ON THE MERITS IS CLOSED. THIS NOTICE OF ALLOWANCE IS NOT A GRANT OF PATENT RIGHTS. THIS APPLICATION IS SUBJECT TO WITHDRAWAL FROM ISSUE AT THE INITIATIVE OF THE OFFICE OR UPON PETITION BY THE APPLICANT. SEE 37 CFR 1.313 AND MPEP 1308.**

**THE ISSUE FEE AND PUBLICATION FEE (IF REQUIRED) MUST BE PAID WITHIN THREE MONTHS FROM THE MAILING DATE OF THIS NOTICE OR THIS APPLICATION SHALL BE REGARDED AS ABANDONED. THIS STATUTORY PERIOD CANNOT BE EXTENDED. SEE 35 U.S.C. 151. THE ISSUE FEE DUE INDICATED ABOVE DOES NOT REFLECT A CREDIT FOR ANY PREVIOUSLY PAID ISSUE FEE IN THIS APPLICATION. IF AN ISSUE FEE HAS PREVIOUSLY BEEN PAID IN THIS APPLICATION (AS SHOWN ABOVE), THE RETURN OF PART B OF THIS FORM WILL BE CONSIDERED A REQUEST TO REAPPLY THE PREVIOUSLY PAID ISSUE FEE TOWARD THE ISSUE FEE NOW DUE.**

**HOW TO REPLY TO THIS NOTICE:**

I. Review the SMALL ENTITY status shown above.

If the SMALL ENTITY is shown as YES, verify your current SMALL ENTITY status:

A. If the status is the same, pay the TOTAL FEE(S) DUE shown above.

B. If the status above is to be removed, check box 5b on Part B - Fee(s) Transmittal and pay the PUBLICATION FEE (if required) and twice the amount of the ISSUE FEE shown above, or

If the SMALL ENTITY is shown as NO:

A. Pay TOTAL FEE(S) DUE shown above, or

B. If applicant claimed SMALL ENTITY status before, or is now claiming SMALL ENTITY status, check box 5a on Part B - Fee(s) Transmittal and pay the PUBLICATION FEE (if required) and 1/2 the ISSUE FEE shown above.

II. PART B - FEE(S) TRANSMITTAL, or its equivalent, must be completed and returned to the United States Patent and Trademark Office (USPTO) with your ISSUE FEE and PUBLICATION FEE (if required). If you are charging the fee(s) to your deposit account, section "4b" of Part B - Fee(s) Transmittal should be completed and an extra copy of the form should be submitted. If an equivalent of Part B is filed, a request to reapply a previously paid issue fee must be clearly made, and delays in processing may occur due to the difficulty in recognizing the paper as an equivalent of Part B.

III. All communications regarding this application must give the application number. Please direct all communications prior to issuance to Mail Stop ISSUE FEE unless advised to the contrary.

**IMPORTANT REMINDER: Utility patents issuing on applications filed on or after Dec. 12, 1980 may require payment of maintenance fees. It is patentee's responsibility to ensure timely payment of maintenance fees when due.**

# PART B - FEE(S) TRANSMITTAL

**Complete and send this form, together with applicable fee(s), to: Mail** **Mail Stop ISSUE FEE**
**Commissioner for Patents**
**P.O. Box 1450**
**Alexandria, Virginia 22313-1450**
**or Fax (571)-273-2885**

INSTRUCTIONS: This form should be used for transmitting the ISSUE FEE and PUBLICATION FEE (if required). Blocks 1 through 5 should be completed where appropriate. All further correspondence including the Patent, advance orders and notification of maintenance fees will be mailed to the current correspondence address as indicated unless corrected below or directed otherwise in Block 1, by (a) specifying a new correspondence address; and/or (b) indicating a separate "FEE ADDRESS" for maintenance fee notifications.

CURRENT CORRESPONDENCE ADDRESS (Note: Use Block 1 for any change of address)

2512 7590 09/08/2010

Perman & Green, LLP
99 Hawley Lane
Stratford, CT 06614

Note: A certificate of mailing can only be used for domestic mailings of the Fee(s) Transmittal. This certificate cannot be used for any other accompanying papers. Each additional paper, such as an assignment or formal drawing, must have its own certificate of mailing or transmission.

**Certificate of Mailing or Transmission**

I hereby certify that this Fee(s) Transmittal is being deposited with the United States Postal Service with sufficient postage for first class mail in an envelope addressed to the Mail Stop ISSUE FEE address above, or being facsimile transmitted to the USPTO (571) 273-2885, on the date indicated below.

| |
|---|
| (Depositor's name) |
| (Signature) |
| (Date) |

| APPLICATION NO. | FILING DATE | FIRST NAMED INVENTOR | ATTORNEY DOCKET NO. | CONFIRMATION NO. |
|---|---|---|---|---|
| 11/839,205 | 08/15/2007 | Marta Karczewicz | 982-010567-US (C02) | 8091 |

TITLE OF INVENTION: METHOD FOR SUB-PIXEL VALUE INTERPOLATION

| APPLN. TYPE | SMALL ENTITY | ISSUE FEE DUE | PUBLICATION FEE DUE | PREV. PAID ISSUE FEE | TOTAL FEE(S) DUE | DATE DUE |
|---|---|---|---|---|---|---|
| nonprovisional | NO | $1510 | $300 | $0 | $1810 | 12/08/2010 |

| EXAMINER | ART UNIT | CLASS-SUBCLASS |
|---|---|---|
| AN, SHAWN S | 2621 | 375-240170 |

1. Change of correspondence address or indication of "Fee Address" (37 CFR 1.363).

❑ Change of correspondence address (or Change of Correspondence Address form PTO/SB/122) attached.

❑ "Fee Address" indication (or "Fee Address" Indication form PTO/SB/47; Rev 03-02 or more recent) attached. **Use of a Customer Number is required.**

2. For printing on the patent front page, list

(1) the names of up to 3 registered patent attorneys or agents OR, alternatively,

(2) the name of a single firm (having as a member a registered attorney or agent) and the names of up to 2 registered patent attorneys or agents. If no name is listed, no name will be printed.

1 _____

2 _____

3 _____

3. ASSIGNEE NAME AND RESIDENCE DATA TO BE PRINTED ON THE PATENT (print or type)

PLEASE NOTE: Unless an assignee is identified below, no assignee data will appear on the patent. If an assignee is identified below, the document has been filed for recordation as set forth in 37 CFR 3.11. Completion of this form is NOT a substitute for filing an assignment.

(A) NAME OF ASSIGNEE (B) RESIDENCE: (CITY and STATE OR COUNTRY)

Please check the appropriate assignee category or categories (will not be printed on the patent) : ❑ Individual ❑ Corporation or other private group entity ❑ Government

4a. The following fee(s) are submitted:

❑ Issue Fee

❑ Publication Fee (No small entity discount permitted)

❑ Advance Order - # of Copies _____

4b. Payment of Fee(s): **(Please first reapply any previously paid issue fee shown above)**

❑ A check is enclosed.

❑ Payment by credit card. Form PTO-2038 is attached.

❑ The Director is hereby authorized to charge the required fee(s), any deficiency, or credit any overpayment, to Deposit Account Number _____ (enclose an extra copy of this form).

5. **Change in Entity Status** (from status indicated above)

❑ a. Applicant claims SMALL ENTITY status. See 37 CFR 1.27.

❑ b. Applicant is no longer claiming SMALL ENTITY status. See 37 CFR 1.27(g)(2).

NOTE: The Issue Fee and Publication Fee (if required) will not be accepted from anyone other than the applicant; a registered attorney or agent; or the assignee or other party in interest as shown by the records of the United States Patent and Trademark Office.

Authorized Signature _____ Date _____

Typed or printed name _____ Registration No. _____

This collection of information is required by 37 CFR 1.311. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 12 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, Virginia 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, Virginia 22313-1450.

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www.uspto.gov

| APPLICATION NO. | FILING DATE | FIRST NAMED INVENTOR | ATTORNEY DOCKET NO. | CONFIRMATION NO. |
|---|---|---|---|---|
| 11/839,205 | 08/15/2007 | Marta Karczewicz | 982-010567-US (C02) | 8091 |

2512 7590 09/08/2010

Perman & Green, LLP
99 Hawley Lane
Stratford, CT 06614

| EXAMINER | |
|---|---|
| AN, SHAWN S | |
| ART UNIT | PAPER NUMBER |
| 2621 | |

DATE MAILED: 09/08/2010

**Determination of Patent Term Adjustment under 35 U.S.C. 154 (b)**
(application filed on or after May 29, 2000)

The Patent Term Adjustment to date is 0 day(s). If the issue fee is paid on the date that is three months after the mailing date of this notice and the patent issues on the Tuesday before the date that is 28 weeks (six and a half months) after the mailing date of this notice, the Patent Term Adjustment will be 0 day(s).

If a Continued Prosecution Application (CPA) was filed in the above-identified application, the filing date that determines Patent Term Adjustment is the filing date of the most recent CPA.

Applicant will be able to obtain more detailed information by accessing the Patent Application Information Retrieval (PAIR) WEB site (http://pair.uspto.gov).

Any questions regarding the Patent Term Extension or Adjustment determination should be directed to the Office of Patent Legal Administration at (571)-272-7702. Questions relating to issue and publication fee payments should be directed to the Customer Service Center of the Office of Patent Publication at 1-(888)-786-0101 or (571)-272-4200.

| Notice of Allowability | Application No. | Applicant(s) | |
|---|---|---|---|
| | 11/839,205 | KARCZEWICZ ET AL. | |
| | Examiner | Art Unit | |
| | SHAWN AN | 2621 | |

***-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address--***

All claims being allowable, PROSECUTION ON THE MERITS IS (OR REMAINS) CLOSED in this application. If not included herewith (or previously mailed), a Notice of Allowance (PTOL-85) or other appropriate communication will be mailed in due course. **THIS NOTICE OF ALLOWABILITY IS NOT A GRANT OF PATENT RIGHTS.** This application is subject to withdrawal from issue at the initiative of the Office or upon petition by the applicant. See 37 CFR 1.313 and MPEP 1308.

1. ☒ This communication is responsive to *8/18/10*.

2. ☒ The allowed claim(s) is/are *1-61*.

3. ☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).
   a) ☐ All b) ☐ Some* c) ☐ None of the:
      1. ☐ Certified copies of the priority documents have been received.
      2. ☐ Certified copies of the priority documents have been received in Application No. _____ .
      3. ☐ Copies of the certified copies of the priority documents have been received in this national stage application from the International Bureau (PCT Rule 17.2(a)).

   * Certified copies not received: _____.

Applicant has THREE MONTHS FROM THE "MAILING DATE" of this communication to file a reply complying with the requirements noted below. Failure to timely comply will result in ABANDONMENT of this application.
**THIS THREE-MONTH PERIOD IS NOT EXTENDABLE**.

4. ☐ A SUBSTITUTE OATH OR DECLARATION must be submitted. Note the attached EXAMINER'S AMENDMENT or NOTICE OF INFORMAL PATENT APPLICATION (PTO-152) which gives reason(s) why the oath or declaration is deficient.

5. ☐ CORRECTED DRAWINGS ( as "replacement sheets") must be submitted.
   (a) ☐ including changes required by the Notice of Draftsperson's Patent Drawing Review ( PTO-948) attached
      1) ☐ hereto or 2) ☐ to Paper No./Mail Date _____.
   (b) ☐ including changes required by the attached Examiner's Amendment / Comment or in the Office action of Paper No./Mail Date _____.

   **Identifying indicia such as the application number (see 37 CFR 1.84(c)) should be written on the drawings in the front (not the back) of each sheet. Replacement sheet(s) should be labeled as such in the header according to 37 CFR 1.121(d).**

6. ☐ DEPOSIT OF and/or INFORMATION about the deposit of BIOLOGICAL MATERIAL must be submitted. Note the attached Examiner's comment regarding REQUIREMENT FOR THE DEPOSIT OF BIOLOGICAL MATERIAL.

**Attachment(s)**

1. ☒ Notice of References Cited (PTO-892)
2. ☐ Notice of Draftperson's Patent Drawing Review (PTO-948)
3. ☒ Information Disclosure Statements (PTO/SB/08), Paper No./Mail Date 8/18/10
4. ☐ Examiner's Comment Regarding Requirement for Deposit of Biological Material
5. ☐ Notice of Informal Patent Application
6. ☐ Interview Summary (PTO-413), Paper No./Mail Date _____ .
7. ☐ Examiner's Amendment/Comment
8. ☒ Examiner's Statement of Reasons for Allowance
9. ☐ Other _____.

## Reasons for Allowance

**1.** The Examiner acknowledges Applicant's RCE (Request for Continued Examination) filed on 8/18/10.

**2.** As per Applicant's instructions as filed on 4/30/10, claims 1-3 and 54-55 have been amended.

**3.** Claims 1-61 are allowed.

**4.** Claims 1-61 are allowed based on Applicant's filing of Terminal Disclaimer as filed on 5/07/10, wherein the prior art of record fails to anticipate or make obvious the claimed features as specified in independent claims 1-3, 22, 42-45, 53-55, and 60-61.

Any comments considered necessary by Applicant must be submitted no later than the payment of the issue fee and, to avoid processing delays, should preferably accompany the issue fee. Such submissions should be clearly labeled "Comments on Statement of Reasons for Allowance."

### *Conclusion*

**5.** The prior art made of record is considered pertinent to Applicant's disclosure.

A) Ito et al (6,693,960 B2), Moving picture encoder and moving picture decoder.

**6.** Any inquiry concerning this communication or earlier communications from the Examiner should be directed to *Shawn An* whose telephone number is 571-272-7324.

If attempts to reach the Examiner by telephone are unsuccessful, the Examiner's supervisor, *Mehrdad Dastouri* can be reached on 571-272-7418.

**7.** The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300.

**8.** Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see http://pair-direct.uspto.gov. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free). If you would like assistance from a USPTO Customer Service Representative or access to the automated information system, call 800-786-9199 (IN USA OR CANADA) or 571-272-1000.

/SHAWN AN/
Primary Examiner, Art Unit 2621
9/05/10

| Notice of References Cited | Application/Control No. 11/839,205 | Applicant(s)/Patent Under Reexamination KARCZEWICZ ET AL. | |
|---|---|---|---|
| | Examiner SHAWN AN | Art Unit 2621 | Page 1 of 1 |

**U.S. PATENT DOCUMENTS**

| * | | Document Number Country Code-Number-Kind Code | Date MM-YYYY | Name | Classification |
|---|---|---|---|---|---|
| * | A | US-6,693,960 B2 | 02-2004 | Ito et al. | 375/240.11 |
| | B | US- | | | |
| | C | US- | | | |
| | D | US- | | | |
| | E | US- | | | |
| | F | US- | | | |
| | G | US- | | | |
| | H | US- | | | |
| | I | US- | | | |
| | J | US- | | | |
| | K | US- | | | |
| | L | US- | | | |
| | M | US- | | | |

**FOREIGN PATENT DOCUMENTS**

| * | | Document Number Country Code-Number-Kind Code | Date MM-YYYY | Country | Name | Classification |
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**NON-PATENT DOCUMENTS**

| * | | Include as applicable: Author, Title Date, Publisher, Edition or Volume, Pertinent Pages) |
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*A copy of this reference is not being furnished with this Office action. (See MPEP § 707.05(a).)
Dates in MM-YYYY format are publication dates. Classifications may be US or foreign.

| Search Notes | Application/Control No. | Applicant(s)/Patent under Reexamination | |
|---|---|---|---|
| | 11/839,205 | KARCZEWICZ ET AL. | |
| | Examiner | Art Unit | |
| | SHAWN AN | 2621 | |

| SEARCHED | | | |
|---|---|---|---|
| Class | Subclass | Date | Examiner |
| 375 | 240.17 | 9/5/2010 | SA |
| | 240.16 | | SA |
| | 240.25 | | SA |
| | 240.26 | | SA |
| | 240.12 | | SA |
| 382 | 238 | | SA |
| | 236 | | SA |
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| INTERFERENCE SEARCHED | | | |
|---|---|---|---|
| Class | Subclass | Date | Examiner |
| **375** | **240.17** | 9/5/2010 | **SA** |
| | 240.16 | | SA |
| | 240.25 | | SA |
| 382/238<br>382/236 | | | SA |

| SEARCH NOTES (INCLUDING SEARCH STRATEGY) | | |
|---|---|---|
| | DATE | EXMR |
| Search updated. | 9/5/2010 | SA |
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**CONFIRMATION NO. 8091**

| SERIAL NUMBER | FILING or 371(c) DATE<br>RULE | CLASS | GROUP ART UNIT | ATTORNEY DOCKET NO. |
|---|---|---|---|---|
| 11/839,205 | 08/15/2007 | 375 | 2621 | 982-010567-US (C02) |

**APPLICANTS**

Marta Karczewicz, Irving, TX;
Antti Olli Hallapuro, Tampere, FINLAND;

**** CONTINUING DATA ***************************

This application is a CON of 11/090,717 03/25/2005 PAT 7,280,599
which is a CON of 09/954,608 09/17/2001 PAT 6,950,469

**** FOREIGN APPLICATIONS ***************************

**** IF REQUIRED, FOREIGN FILING LICENSE GRANTED ****

08/22/2007

| Foreign Priority claimed ☐ Yes ☑ No<br>35 USC 119(a-d) conditions met ☐ Yes ☑ No<br>Verified and Acknowledged /SHAWN AN/ Examiner's Signature | ☐ Met after Allowance<br>Initials | STATE OR COUNTRY | SHEETS DRAWINGS | TOTAL CLAIMS | INDEPENDENT CLAIMS |
|---|---|---|---|---|---|
| | | TX | 28 | 61 | 13 |

**ADDRESS**

Perman & Green, LLP
99 Hawley Lane
Stratford, CT 06614
UNITED STATES

**TITLE**

METHOD FOR SUB-PIXEL VALUE INTERPOLATION

| FILING FEE RECEIVED | | |
|---|---|---|
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BIB (Rev. 05/07).

PTO/SB/08a (01-10)
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U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
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# INFORMATION DISCLOSURE STATEMENT BY APPLICANT

**( Not for submission under 37 CFR 1.99)**

| | |
|---|---|
| Application Number | 11839205 |
| Filing Date | 2007-08-15 |
| First Named Inventor | Marta Karczewicz |
| Art Unit | 2621 |
| Examiner Name | An, Shawn S. |
| Attorney Docket Number | 982-010567-US (C02) |

**U.S.PATENTS** Remove

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| Examiner Initials* | Cite No | Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc), date, pages(s), volume-issue number(s), publisher, city and/or country where published. | T[5] |
|---|---|---|---|

| INFORMATION DISCLOSURE STATEMENT BY APPLICANT ( Not for submission under 37 CFR 1.99) | | |
|---|---|---|
| | Application Number | 11839205 |
| | Filing Date | 2007-08-15 |
| | First Named Inventor | Marta Karczewicz |
| | Art Unit | 2621 |
| | Examiner Name | An, Shawn S. |
| | Attorney Docket Number | 982-010567-US (C02) |

| | | | |
|---|---|---|---|
| /S.A./ | 1 | European Office Action dated 26 July 2010 | ☐ |

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**EXAMINER SIGNATURE**

| Examiner Signature | /Shawn An/ (09/05/2010) | Date Considered | 09/05/2010 |
|---|---|---|---|

*EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through a citation if not in conformance and not considered. Include copy of this form with next communication to applicant.

[1] See Kind Codes of USPTO Patent Documents at www.USPTO.GOV or MPEP 901.04. [2] Enter office that issued the document, by the two-letter code (WIPO Standard ST.3). [3] For Japanese patent documents, the indication of the year of the reign of the Emperor must precede the serial number of the patent document. [4] Kind of document by the appropriate symbols as indicated on the document under WIPO Standard ST.16 if possible. [5] Applicant is to place a check mark here if English language translation is attached.

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /S.A./ (09/05/2010)

## Index of Claims

| Application/Control No. | Applicant(s)/Patent under Reexamination |
|---|---|
| 11/839,205 | KARCZEWICZ ET AL. |
| **Examiner** | **Art Unit** |
| SHAWN AN | 2621 |

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| √ | Rejected | – | (Through numeral) Cancelled | N | Non-Elected | A | Appeal |
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| Issue Classification | Application/Control No. | Applicant(s)/Patent under Reexamination | |
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| | 11/839,205 | KARCZEWICZ ET AL. | |
| | Examiner | Art Unit | |
| | SHAWN AN | 2621 | |

# ISSUE CLASSIFICATION

| ORIGINAL | | | CROSS REFERENCE(S) | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| CLASS | SUBCLASS | CLASS | SUBCLASS (ONE SUBCLASS PER BLOCK) | | | | | | |
| 375 | 240.17 | 375 | 240.16 | 240.25 | 240.26 | 240.12 | | | |
| INTERNATIONAL CLASSIFICATION | | 382 | 238 | 236 | 233 | 235 | | | |
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| (Assistant Examiner) (Date) | /SHAWN AN/ 9/05/10 (Primary Examiner) (Date) | Total Claims Allowed: 61 | |
|---|---|---|---|
| (Legal Instruments Examiner) (Date) | | O.G. Print Claim(s): 1 | O.G. Print Fig.: 7 |

☐ Claims renumbered in the same order as presented by applicant ☐ CPA ☐ T.D. ☐ R.1.47

| Final | Original | Final | Original | Final | Original | Final | Original | Final | Original | Final | Original | Final | Original |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
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| 20 | 2 | 32 | 32 | | 62 | | 92 | | 122 | | 152 | | 182 |
| 21 | 3 | 33 | 33 | | 63 | | 93 | | 123 | | 153 | | 183 |
| 2 | 4 | 34 | 34 | | 64 | | 94 | | 124 | | 154 | | 184 |
| 4 | 5 | 35 | 35 | | 65 | | 95 | | 125 | | 155 | | 185 |
| 3 | 6 | 36 | 36 | | 66 | | 96 | | 126 | | 156 | | 186 |
| 5 | 7 | 37 | 37 | | 67 | | 97 | | 127 | | 157 | | 187 |
| 6 | 8 | 38 | 38 | | 68 | | 98 | | 128 | | 158 | | 188 |
| 7 | 9 | 39 | 39 | | 69 | | 99 | | 129 | | 159 | | 189 |
| 8 | 10 | 40 | 40 | | 70 | | 100 | | 130 | | 160 | | 190 |
| 9 | 11 | 41 | 41 | | 71 | | 101 | | 131 | | 161 | | 191 |
| 10 | 12 | 42 | 42 | | 72 | | 102 | | 132 | | 162 | | 192 |
| 11 | 13 | 48 | 43 | | 73 | | 103 | | 133 | | 163 | | 193 |
| 12 | 14 | 43 | 44 | | 74 | | 104 | | 134 | | 164 | | 194 |
| 13 | 15 | 50 | 45 | | 75 | | 105 | | 135 | | 165 | | 195 |
| 14 | 16 | 45 | 46 | | 76 | | 106 | | 136 | | 166 | | 196 |
| 15 | 17 | 51 | 47 | | 77 | | 107 | | 137 | | 167 | | 197 |
| 16 | 18 | 46 | 48 | | 78 | | 108 | | 138 | | 168 | | 198 |
| 17 | 19 | 49 | 49 | | 79 | | 109 | | 139 | | 169 | | 199 |
| 18 | 20 | 44 | 50 | | 80 | | 110 | | 140 | | 170 | | 200 |
| 19 | 21 | 52 | 51 | | 81 | | 111 | | 141 | | 171 | | 201 |
| 22 | 22 | 47 | 52 | | 82 | | 112 | | 142 | | 172 | | 202 |
| 23 | 23 | 53 | 53 | | 83 | | 113 | | 143 | | 173 | | 203 |
| 24 | 24 | 54 | 54 | | 84 | | 114 | | 144 | | 174 | | 204 |
| 25 | 25 | 55 | 55 | | 85 | | 115 | | 145 | | 175 | | 205 |
| 26 | 26 | 56 | 56 | | 86 | | 116 | | 146 | | 176 | | 206 |
| 27 | 27 | 57 | 57 | | 87 | | 117 | | 147 | | 177 | | 207 |
| 28 | 28 | 58 | 58 | | 88 | | 118 | | 148 | | 178 | | 208 |
| 29 | 29 | 59 | 59 | | 89 | | 119 | | 149 | | 179 | | 209 |
| 30 | 30 | 60 | 60 | | 90 | | 120 | | 150 | | 180 | | 210 |

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# REQUEST FOR CONTINUED EXAMINATION(RCE)TRANSMITTAL
## (Submitted Only via EFS-Web)

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Application Number | 11839205 | Filing Date | 2007-08-15 | Docket Number (if applicable) | 982-010567-US (C02) | Art Unit | 2621 |
| First Named Inventor | Marta Karczewicz | | | Examiner Name | An, Shawn S. | | |

**This is a Request for Continued Examination (RCE) under 37 CFR 1.114 of the above-identified application.**
Request for Continued Examination (RCE) practice under 37 CFR 1.114 does not apply to any utility or plant application filed prior to June 8, 1995, or to any design application. The Instruction Sheet for this form is located at WWW.USPTO.GOV

### SUBMISSION REQUIRED UNDER 37 CFR 1.114

Note: If the RCE is proper, any previously filed unentered amendments and amendments enclosed with the RCE will be entered in the order in which they were filed unless applicant instructs otherwise. If applicant does not wish to have any previously filed unentered amendment(s) entered, applicant must request non-entry of such amendment(s).

☐ Previously submitted. If a final Office action is outstanding, any amendments filed after the final Office action may be considered as a submission even if this box is not checked.

- ☐ Consider the arguments in the Appeal Brief or Reply Brief previously filed on _____
- ☐ Other _____

☒ Enclosed

- ☒ Amendment/Reply
- ☐ Information Disclosure Statement (IDS)
- ☐ Affidavit(s)/ Declaration(s)
- ☐ Other _____

### MISCELLANEOUS

☐ Suspension of action on the above-identified application is requested under 37 CFR 1.103(c) for a period of months _____ (Period of suspension shall not exceed 3 months; Fee under 37 CFR 1.17(i) required)

☐ Other _____

### FEES

☒ **The RCE fee under 37 CFR 1.17(e) is required by 37 CFR 1.114 when the RCE is filed.**
The Director is hereby authorized to charge any underpayment of fees, or credit any overpayments, to Deposit Account No 161350

### SIGNATURE OF APPLICANT, ATTORNEY, OR AGENT REQUIRED

☒ Patent Practitioner Signature

☐ Applicant Signature

PTO/SB/30EFS (07-09)
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| Signature of Registered U.S. Patent Practitioner | | | |
|---|---|---|---|
| Signature | /jvg44695/ | Date (YYYY-MM-DD) | 2010-12-07 |
| Name | Joseph V. Gamberdell, Jr. | Registration Number | 44695 |

This collection of information is required by 37 CFR 1.114. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.11 and 1.14. This collection is estimated to take 12 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450.

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**IN THE UNITED STATES PATENT AND TRADEMARK OFFICE**

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**AMENDMENT**

## I. INTRODUCTION

This is a submission included with a Request for Continued Examination for the above-identified patent application in response to the Notice of Allowance mailed September 08, 2010.

Reconsideration of the rejection of the claims is respectfully solicited in light of the following amendment and remarks.

## II. CLAIM AMENDMENTS

1. (Currently Amended) A method for sub-pixel value interpolation to determine values for sub-pixels situated within a rectangular bounded region defined by four corner pixels with no intermediate pixels between the corners, the pixels and sub-pixels being configured for display in rows and columns, pixel and sub-pixel locations in the rows and columns being representable mathematically within the rectangular bounded region using the co-ordinate notation $K/2^N$, $L/2^N$, K and L being positive integers having respective values between zero and $2^N$, N being a positive integer greater than one and representing a particular degree of sub-pixel value interpolation, the method comprising causing an apparatus to:

- interpolate a sub-pixel value for a sub-pixel having co-ordinates with odd values of ~~both~~ K and L, according to a predetermined choice of either a weighted average of the value of a nearest-neighbouring pixel and the value of the sub-pixel situated at co-ordinates 1/2, 1/2, or a weighted average of the values of a pair of diagonally-opposed sub-pixels having co-ordinates with even values of ~~both~~ K and L, including zero, situated within a quadrant of the rectangular bounded region, the quadrant being defined by the sub-pixel having co-ordinates 1/2, 1/2 and the nearest neighbouring pixel;
- interpolate sub-pixel values for sub-pixels having co-ordinates with K equal to an even value and L equal to zero and sub-pixels having co-ordinates with K equal to zero and L equal to an even value, used in the interpolation of the sub-pixels having co-ordinates with odd values of ~~both~~ K and L, using weighted sums of the values of pixels located in rows and columns respectively; and
- interpolate sub-pixel values for sub-pixels having co-ordinates with even values of ~~both~~ K and L, used in the interpolation of sub-pixel values for the sub-pixels having co-ordinates with odd values of ~~both~~ K and L, using a predetermined choice of either a weighted sum of the values of sub-pixels having co-ordinates with K equal to an even value and L equal to zero and the values of sub-pixels having corresponding co-ordinates in immediately adjacent rectangular bounded regions, or a weighted sum of the values of sub-pixels having co-ordinates with K equal to zero and L equal to an even value and the values of sub-pixels having corresponding co-ordinates in immediately adjacent rectangular bounded regions.

2. (Currently Amended) A method for quarter resolution sub-pixel value interpolation to determine values for sub-pixels situated within a rectangular bounded region defined by four corner pixels with no intermediate pixels between the corners, the pixels and sub-pixels being configured for display in rows and columns, pixel and sub-pixel locations in the rows and columns being representable mathematically within the rectangular bounded region using the co-ordinate notation K/4, L/4, K and L being positive integers having respective values between zero and 4, the method comprising causing an apparatus to:

- interpolate a sub-pixel value for a sub-pixel having co-ordinates with K and L equal to 1 or 3, according to a predetermined choice of either a weighted average of the value of a nearest-neighbouring pixel and the value of the sub-pixel situated at co-ordinates 2/4, 2/4, or a weighted average of the values of a pair of diagonally-opposed sub-pixels having co-ordinates with K and L equal to zero, 2 or 4, situated within a quadrant of the rectangular bounded region, the quadrant being defined by the sub-pixel having co-ordinates 2/4, 2/4 and the nearest neighbouring pixel;
- interpolate sub-pixel values for sub-pixels having co-ordinates with K equal to 2 and L equal to zero and sub-pixels having co-ordinates with K equal to zero and L equal to 2, used in the interpolation of the sub-pixels having co-ordinates with K and L equal to 1 or 3, using weighted sums of the values of pixels located in rows and columns respectively; and
- interpolate a sub-pixel value for the sub-pixel having co-ordinates with ~~both~~ K and L equal to 2, used in the interpolation of sub-pixel values for the sub-pixels having co-ordinates with K and L equal to 1 or 3, using a predetermined choice of either a weighted sum of the values of the sub-pixel having co-ordinates with K equal to 2 and L equal to zero and the values of sub-pixels having corresponding co-ordinates in immediately adjacent rectangular bounded regions, or a weighted sum of the value of the sub-pixel having co-ordinates with K equal to zero and L equal to 2 and the values of sub-pixels having corresponding co-ordinates in immediately adjacent rectangular bounded regions.

3. (Previously Presented) A method for eighth resolution sub-pixel value interpolation to determine values for sub-pixels situated within a rectangular bounded region defined by four corner pixels with no intermediate pixels between the corners, the pixels and sub-pixels being configured for display in rows and columns, pixel and sub-pixel locations in the rows and columns being representable mathematically with the rectangular bounded region using the co-

ordinate notation K/8, L/8, K and L being positive integers having respective values between zero and 8, the method comprising causing an apparatus to:

- interpolate a sub-pixel value for a sub-pixel having co-ordinates with K and L equal to 1, 3, 5 or 7, according to a predetermined choice of either a weighted average of the value of a nearest-neighbouring pixel and the value of the sub-pixel situated at co-ordinates 4/8, 4/8, or a weighted average of the values of a pair of diagonally-opposed sub-pixels having co-ordinates with K and L equal to zero, 2, 4, 6 or 8, situated within a quadrant of the rectangular bounded region, the quadrant being defined by the sub-pixel having co-ordinates 4/8, 4/8 and the nearest neighbouring pixel;
- interpolate sub-pixel values for sub-pixels having co-ordinates with K equal to 2, 4 or 6 and L equal to zero and sub-pixels having co-ordinates with K equal to zero and L equal to 2, 4 or 6, used in the interpolation of the sub-pixels having co-ordinates with K and L equal to 1, 3, 5 or 7, using weighted sums of the values of pixels located in rows and columns respectively; and
- interpolate sub-pixel values for sub-pixels having co-ordinates with K and L equal to 2, 4 or 6, used in the interpolation of sub-pixel values for the sub-pixels having co-ordinates with K and L equal to 1, 3, 5 or 7, using a predetermined choice of either a weighted sum of the values of sub-pixels having co-ordinates with K equal to 2, 4 or 6 and L equal to zero and the values of sub-pixels having corresponding co-ordinates in immediately adjacent rectangular bounded regions or a weighted sum of the values of sub-pixels having co-ordinates with K equal to zero and L equal to 2, 4 or 6 and the values of sub-pixels having corresponding co-ordinates in immediately adjacent rectangular bounded regions.

4. (Currently Amended) A method according to claim 1, comprising causing the apparatus to use a first and a second weight in the weighted average chosen to interpolate the sub-pixel value for a sub-pixel having co-ordinates with odd values of ~~both~~ K and L, wherein when the chosen weighted average is that involving the value of a nearest neighbouring pixel and the value of the sub-pixel situated at co-ordinates 1/2, 1/2, causing the apparatus to select the relative magnitudes of the first and second weights to be inversely proportional to the respective straight-line diagonal distances of the nearest-neighbouring pixel and the sub-pixel situated at co-ordinates 1/2, 1/2 to the sub-pixel having co-ordinates with odd values of ~~both~~ K and L whose value is being interpolated.

5. (Currently Amended) A method according to claim 1, comprising causing the apparatus to use a first and a second weight in the weighted average chosen to interpolate the sub-pixel value for a sub-pixel having co-ordinates with odd values of ~~both~~ K and L, wherein when the chosen weighted average is that involving the values of a pair of diagonally-opposed sub-pixels having co-ordinates with even values of ~~both~~ K and L, causing the apparatus to select the relative magnitudes of the first and second weights to be inversely proportional to the respective straight-line diagonal distances of the sub-pixels having co-ordinates with even values of ~~both~~ K and L to the sub-pixel having co-ordinates with odd values of ~~both~~ K and L whose value is being interpolated.

6. (Currently Amended) A method according to claim 4, comprising causing the apparatus to use first and second weights with equal values when the nearest-neighbouring pixel and sub-pixel situated at co-ordinates 1/2, 1/2 are equidistant from the sub-pixel having co-ordinates with odd values of ~~both~~ K and L whose value is being interpolated.

7. (Currently Amended) A method according to claim 5, comprising causing the apparatus to use first and second weights with equal values when the sub-pixels having co-ordinates with even values of ~~both~~ K and L are equidistant from the sub-pixel having co-ordinates with odd values of ~~both~~ K and L whose value is being interpolated.

8. (Currently Amended) A method according to claim 1, comprising causing the apparatus to interpolate sub-pixel values for sub-pixels having co-ordinates with even values of ~~both~~ K and L, used in interpolation of sub-pixel values for the sub-pixels having co-ordinates with odd values of ~~both~~ K and L, using a weighted sum of the values of sub-pixels having co-ordinates with K equal to an even value and L equal to zero and the values of sub-pixels having corresponding co-ordinates in immediately adjacent rectangular bounded regions when the value of a sub-pixel having co-ordinates with K equal to an even value and L equal to an odd value is also required.

9. (Currently Amended) A method according to claim 1, comprising causing the apparatus to interpolate sub-pixel values for sub-pixels having co-ordinates with even values of ~~both~~ K and L, used in interpolation of sub-pixel values for the sub-pixels having co-ordinates with odd

values of ~~both~~ K and L, using a weighted sum of the values of sub-pixels having co-ordinates with K equal to zero and L equal to an even value and the values of sub-pixels having corresponding co-ordinates in immediately adjacent rectangular bounded regions when the value of a sub-pixel having co-ordinates with K equal to an odd value and L equal to an even value is also required.

10. (Previously Presented) A method according to claim 1, comprising causing the apparatus to interpolate sub-pixel values for sub-pixels having co-ordinates with K equal to an odd value O and L equal to an even value E, not including zero or $2^N$, by taking an average of the value of a first sub-pixel having co-ordinates with K equal to the even value O - 1 and L equal to E and a second sub-pixel having co-ordinates with K equal to the even value O + 1 and L equal to E.

11. (Previously Presented) A method according to claim 1, comprising causing the apparatus to interpolate a sub-pixel value for a sub-pixel having co-ordinates with K equal to 1 and L equal to zero, by taking an average of the value of a pixel having co-ordinates with K equal to zero and L equal to zero, and a sub-pixel having co-ordinates with K equal to 2 and L equal to zero.

12. (Previously Presented) A method according to claim 1, comprising causing the apparatus to interpolate a sub-pixel value for a sub-pixel having co-ordinates with K equal to $2^N$ - 1 and L equal to zero, by taking an average of the value of a pixel having co-ordinates with K equal to $2^N$ and L equal to zero, and a sub-pixel having co-ordinates with K equal to $2^N$ - 2 and L equal to zero.

13. (Previously Presented) A method according to claim 1, comprising causing the apparatus to interpolate a sub-pixel value for a sub-pixel having co-ordinates with K equal to 1 and L equal to $2^N$, by taking an average of the value of a pixel having co-ordinates with K equal to zero and L equal to $2^N$, and a sub-pixel having co-ordinates with K equal to 2 and L equal to $2^N$.

14. (Previously Presented) A method according to claim 1, comprising causing the apparatus to interpolate a sub-pixel value for a sub-pixel having co-ordinates with K equal to $2^N$ - 1 and L equal to $2^N$, by taking an average of the value of a pixel having co-ordinates with K equal to $2^N$ and L equal to $2^N$, and a sub-pixel having co-ordinates with K equal to $2^N$ - 2 and L equal to $2^N$.

15. (Previously Presented) A method according to claim 1, comprising causing the apparatus to interpolate sub-pixel values for sub-pixels having co-ordinates with K equal to an even value E, not including zero or $2^N$, and L equal to an odd value O, by taking an average of the value of a first sub-pixel having co-ordinates with K equal to E and L equal to the even value O - 1 and a second sub-pixel having co-ordinates with K equal to E and L equal to the even value O + 1.

16. (Previously Presented) A method according to claim 1, comprising causing the apparatus to interpolate a sub-pixel value for a sub-pixel having co-ordinates with K equal to zero and L equal to 1, by taking an average of the value of a pixel having co-ordinates with K equal to zero and L equal to zero, and a sub-pixel having co-ordinates with K equal to zero and L equal to 2.

17. (Previously Presented) A method according to claim 1, comprising causing the apparatus to interpolate a sub-pixel value for a sub-pixel having co-ordinates with K equal to $2^N$ and L equal to 1, by taking an average of the value of a pixel having co-ordinates with K equal to $2^N$ and L equal to zero, and a sub-pixel having co-ordinates with K equal to $2^N$ and L equal to 2.

18. (Previously Presented) A method according to claim 1, comprising causing the apparatus to interpolate a sub-pixel value for a sub-pixel having co-ordinates with K equal to 0 and L equal to $2^N$ - 1, by taking an average of the value of a pixel having co-ordinates with K equal to zero and L equal to $2^N$, and a sub-pixel having co-ordinates with K equal to zero and L equal to $2^N$ - 2.

19. (Previously Presented) A method according to claim 1, comprising causing the apparatus to interpolate a sub-pixel value for a sub-pixel having co-ordinates with K equal to $2^N$ and L equal to $2^N$ - 1, by taking an average of the value of a pixel having co-ordinates with K equal to $2^N$ and L equal to $2^N$, and a sub-pixel having co-ordinates with K equal to $2^N$ and L equal to $2^N$ - 2.

20. (Previously Presented) A method according to claim 1, comprising causing the apparatus to interpolate a sub-pixel value for the sub-pixel having co-ordinates with K equal to $2^N$ - 1 and L equal to $2^N$ - 1, by taking a weighted average of the values of the four corner pixels that define the rectangular bounded region.

21. (Currently Amended) A method according to claim 1, ~~comprising causing the apparatus to select a value for~~in which N ~~from a list consisting~~is one of the values 2, 3, and 4.

22. (Currently Amended) An interpolator for sub-pixel value interpolation, the interpolator being configured to determine values for sub-pixels situated within a rectangular bounded region defined by four corner pixels with no intermediate pixels between the corners, the pixels and sub-pixels being configured for display in rows and columns, pixel and sub-pixel locations in the rows and columns being representable mathematically within the rectangular bounded region using the co-ordinate notation $K/2^N$, $L/2^N$, K and L being positive integers having respective values between zero and $2^N$, N being a positive integer greater than one and representing a particular degree of sub-pixel value interpolation, the interpolator being configured to:

- interpolate a sub-pixel value for a sub-pixel having co-ordinates with odd values of ~~both~~ K and L, according to a predetermined choice of either a weighted average of the value of a nearest-neighbouring pixel and the value of the sub-pixel situated at co-ordinates 1/2, 1/2, or a weighted average of the values of a pair of diagonally-opposed sub-pixels having co-ordinates with even values of ~~both~~ K and L, including zero, situated within a quadrant of the rectangular bounded region, the quadrant being defined by the sub-pixel having co-ordinates 1/2, 1/2 and the nearest neighbouring pixel;
- interpolate sub-pixel values for sub-pixels having co-ordinates with K equal to an even value and L equal to zero and sub-pixels having co-ordinates with K equal to zero and L equal to an even value, used in the interpolation of the sub-pixels having co-ordinates with odd values of ~~both~~ K and L, using weighted sums of the values of pixels located in rows and columns respectively; and
- interpolate sub-pixel values for sub-pixels having co-ordinates with even values of ~~both~~ K and L, used in the interpolation of sub-pixel values for the sub-pixels having co-ordinates with odd values of ~~both~~ K and L, using a predetermined choice of either a weighted sum of the values of sub-pixels having co-ordinates with K equal to an even value and L equal to zero and the values of sub-pixels having corresponding co-ordinates in immediately adjacent rectangular bounded regions, or a weighted sum of the values of sub-pixels having co-ordinates with K equal to zero and L equal to an even value and the values of sub-pixels having corresponding co-ordinates in immediately adjacent bounded rectangular regions.

23. (Currently Amended) An interpolator according to claim 22, wherein the interpolator is configured to use a first and a second weight in the weighted average chosen to interpolate the sub-pixel value for a sub-pixel having co-ordinates with odd values of ~~both~~ K and L, wherein when the chosen weighted average is that involving the value of a nearest neighbouring pixel and the value of the sub-pixel situated at co-ordinates 1/2, 1/2, the interpolator is configured to select the relative magnitudes of the first and second weights to be inversely proportional to the respective straight-line diagonal distances of the nearest-neighbouring pixel and the sub-pixel situated at co-ordinates 1/2, 1/2 to the sub-pixel having co-ordinates with odd values of ~~both~~ K and L whose value is being interpolated.

24. (Currently Amended) An interpolator according to claim 22, wherein the interpolator is configured to use a first and a second weight in the weighted average chosen to interpolate the sub-pixel value for a sub-pixel having co-ordinates with odd values of ~~both~~ K and L, wherein when the chosen weighted average is that involving the values of a pair of diagonally-opposed sub-pixels having co-ordinates with even values of ~~both~~ K and L, the interpolator is configured to select the relative magnitudes of the first and second weights to be inversely proportional to the respective straight-line diagonal distances of the sub-pixels having co-ordinates with even values of ~~both~~ K and L to the sub-pixel having co-ordinates with odd values of ~~both~~ K and L whose value is being interpolated.

25. (Currently Amended) An interpolator according to claim 23, wherein the interpolator is configured to use first and second weights with equal values when the nearest-neighbouring pixel and sub-pixel situated at co-ordinates 1/2, 1/2 are equidistant from the sub-pixel having co-ordinates with odd values of ~~both~~ K and L whose value is being interpolated.

26. (Currently Amended) An interpolator according to claim 24, wherein the interpolator is configured to use first and second weights with equal values when the sub-pixels having co-ordinates with even values of ~~both~~ K and L are equidistant from the sub-pixel having co-ordinates with odd values of ~~both~~ K and L whose value is being interpolated.

27. (Currently Amended) An interpolator according to claim 22, wherein the interpolator is configured to interpolate sub-pixel values for sub-pixels having co-ordinates with even values of

~~both~~ K and L, used in interpolation of sub-pixel values for the sub-pixels having co-ordinates with odd values of ~~both~~ K and L, using a weighted sum of the values of sub-pixels having co-ordinates with K equal to an even value and L equal to zero and the values of sub-pixels having corresponding co-ordinates in immediately adjacent rectangular bounded regions when the value of a sub-pixel having co-ordinates with K equal to an even value and L equal to an odd value is also required.

28. (Currently Amended) An interpolator according to claim 22, wherein the interpolator is configured to interpolate sub-pixel values for sub-pixels having co-ordinates with even values of ~~both~~ K and L, used in interpolation of sub-pixel values for the sub-pixels having co-ordinates with odd values of ~~both~~ K and L, using a weighted sum of the values of sub-pixels having co-ordinates with K equal to zero and L equal to an even value and the values of sub-pixels having corresponding co-ordinates in immediately adjacent rectangular bounded regions when the value of a sub-pixel having co-ordinates with K equal to an odd value and L equal to an even value is also required.

29. (Previously Presented) An interpolator according to claim 22, wherein the interpolator is configured to interpolate sub-pixel values for sub-pixels having co-ordinates with K equal to an odd value O and L equal to an even value E, not including zero or $2^N$, by taking an average of the value of a first sub-pixel having co-ordinates with K equal to the even value O - 1 and L equal to E and a second sub-pixel having co-ordinates with K equal to the even value O + 1 and L equal to E.

30. (Previously Presented) An interpolator according to claim 22, wherein the interpolator is configured to interpolate a sub-pixel value for a sub-pixel having co-ordinates with K equal to 1 and L equal to zero, by taking an average of the value of a pixel having co-ordinates with K equal to zero and L equal to zero, and a sub-pixel having co-ordinates with K equal to 2 and L equal to zero.

31. (Previously Presented) An interpolator according to claim 22, wherein the interpolator is configured to interpolate a sub-pixel value for a sub-pixel having co-ordinates with K equal to $2^N$ - 1 and L equal to zero, by taking an average of the value of a pixel having co-ordinates with K

equal to $2^N$ and L equal to zero, and a sub-pixel having co-ordinates with K equal to $2^N$ - 2 and L equal to zero.

32. (Previously Presented) An interpolator according to claim 22, wherein the interpolator is configured to interpolate a sub-pixel value for a sub-pixel having co-ordinates with K equal to 1 and L equal to $2^N$, by taking an average of the value of a pixel having co-ordinates with K equal to zero and L equal to $2^N$, and a sub-pixel having co-ordinates with K equal to 2 and L equal to $2^N$.

33. (Previously Presented) An interpolator according to claim 22, wherein the interpolator is configured to interpolate a sub-pixel value for a sub-pixel having co-ordinates with K equal to $2^N$ - 1 and L equal to $2^N$, by taking an average of the value of a pixel having co-ordinates with K equal to $2^N$ and L equal to $2^N$, and a sub-pixel having co-ordinates with K equal to $2^N$ - 2 and L equal to $2^N$.

34. (Previously Presented) An interpolator according to claim 22, wherein the interpolator is configured to interpolate sub-pixel values for sub-pixels having co-ordinates with K equal to an even value E, not including zero or $2^N$, and L equal to an odd value O, by taking an average of the value of a first sub-pixel having co-ordinates with K equal to E and L equal to the even value O - 1 and a second sub-pixel having co-ordinates with K equal to E and L equal to the even value O + 1.

35. (Previously Presented) An interpolator according to claim 22, wherein the interpolator is configured to interpolate a sub-pixel value for a sub-pixel having co-ordinates with K equal to zero and L equal to 1, by taking an average of the value of a pixel having co-ordinates with K equal to zero and L equal to zero, and a sub-pixel having co-ordinates with K equal to zero and L equal to 2.

36. (Previously Presented) An interpolator according to claim 22, wherein the interpolator is configured to interpolate a sub-pixel value for a sub-pixel having co-ordinates with K equal to $2^N$ and L equal to 1, by taking an average of the value of a pixel having co-ordinates with K equal to $2^N$ and L equal to zero, and a sub-pixel having co-ordinates with K equal to zero and L equal to 2.

37. (Previously Presented) An interpolator according to claim 22, wherein the interpolator is configured to interpolate a sub-pixel value for a sub-pixel having co-ordinates with K equal to 0 and L equal to $2^N$ - 1, by taking an average of the value of a pixel having co-ordinates with K equal to zero and L equal to $2^N$, and a sub-pixel having co-ordinates with K equal to zero and L equal to $2^N$ - 2.

38. (Previously Presented) An interpolator according to claim 22, wherein the interpolator is configured to interpolate a sub-pixel value for a sub-pixel having co-ordinates with K equal to $2^N$ and L equal to $2^N$ - 1, by taking an average of the value of a pixel having co-ordinates with K equal to $2^N$ and L equal to $2^N$, and a sub-pixel having co-ordinates with K equal to $2^N$ and L equal to $2^N$ - 2.

39. (Previously Presented) An interpolator according to claim 22, wherein the interpolator is configured to interpolate a sub-pixel value for the sub-pixel having co-ordinates with K equal to $2^N$ - 1 and L equal to $2^N$ - 1, by taking a weighted average of the values of the four corner pixels that define the rectangular bounded region.

40. (Previously Presented) An interpolator according to claim 22, wherein N is set equal to 2.

41. (Previously Presented) An interpolator according to claim 22, wherein N is set equal to 3.

42. (Currently Amended) A video encoder comprising an interpolator for sub-pixel value interpolation, the interpolator being configured to determine values for sub-pixels situated within a rectangular bounded region defined by four corner pixels with no intermediate pixels between the corners, the pixels and sub-pixels being configured for display in rows and columns, pixel and sub-pixel locations in the rows and columns being representable mathematically within the rectangular bounded region using the co-ordinate notation $K/2^N$, $L/2^N$, K and L being positive integers having respective values between zero and $2^N$, N being a positive integer greater than one and representing a particular degree of sub-pixel value interpolation, the interpolator being configured to:

- interpolate a sub-pixel value for a sub-pixel having co-ordinates with odd values of ~~both~~ K and L, according to a predetermined choice of either a weighted average of the value of a

nearest-neighbouring pixel and the value of the sub-pixel situated at co-ordinates 1/2, 1/2, or a weighted average of the values of a pair of diagonally-opposed sub-pixels having co-ordinates with even values of ~~both~~ K and L, including zero, situated within a quadrant of the rectangular bounded region, the quadrant being defined by the sub-pixel having co-ordinates 1/2, 1/2 and the nearest neighbouring pixel;

- interpolate sub-pixel values for sub-pixels having co-ordinates with K equal to an even value and L equal to zero and sub-pixels having co-ordinates with K equal to zero and L equal to an even value, used in the interpolation of the sub-pixels having co-ordinates with odd values of ~~both~~ K and L, using weighted sums of the values of pixels located in rows and columns respectively; and
- interpolate sub-pixel values for sub-pixels having co-ordinates with even values of ~~both~~ K and L, used in the interpolation of sub-pixel values for the sub-pixels having co-ordinates with odd values of ~~both~~ K and L, using a predetermined choice of either a weighted sum of the values of sub-pixels having co-ordinates with K equal to an even value and L equal to zero and the values of sub-pixels having corresponding co-ordinates in immediately adjacent rectangular bounded regions, or a weighted sum of the values of sub-pixels having co-ordinates with K equal to zero and L equal to an even value and the values of sub-pixels having corresponding co-ordinates in immediately adjacent bounded rectangular regions.

43. (Currently Amended) A still image encoder comprising an interpolator for sub-pixel value interpolation, the interpolator being configured to determine values for sub-pixels situated within a rectangular bounded region defined by four corner pixels with no intermediate pixels between the corners, the pixels and sub-pixels being configured for display in rows and columns, pixel and sub-pixel locations in the rows and columns being representable mathematically within the rectangular bounded region using the co-ordinate notation $K/2^N$, $L/2^N$, K and L being positive integers having respective values between zero and $2^N$, N being a positive integer greater than one and representing a particular degree of sub-pixel value interpolation, the interpolator being configured to:

- interpolate a sub-pixel value for a sub-pixel having co-ordinates with odd values of ~~both~~ K and L, according to a predetermined choice of either a weighted average of the value of a nearest-neighbouring pixel and the value of the sub-pixel situated at co-ordinates 1/2, 1/2, or a weighted average of the values of a pair of diagonally-opposed sub-pixels having co-

ordinates with even values of ~~both~~ K and L, including zero, situated within a quadrant of the rectangular bounded region, the quadrant being defined by the sub-pixel having co-ordinates 1/2, 1/2 and the nearest neighbouring pixel;

- interpolate sub-pixel values for sub-pixels having co-ordinates with K equal to an even value and L equal to zero and sub-pixels having co-ordinates with K equal to zero and L equal to an even value, used in the interpolation of the sub-pixels having co-ordinates with odd values of ~~both~~ K and L, using weighted sums of the values of pixels located in rows and columns respectively; and
- interpolate sub-pixel values for sub-pixels having co-ordinates with even values of ~~both~~ K and L, used in the interpolation of sub-pixel values for the sub-pixels having co-ordinates with odd values of ~~both~~ K and L, using a predetermined choice of either a weighted sum of the values of sub-pixels having co-ordinates with K equal to an even value and L equal to zero and the values of sub-pixels having corresponding co-ordinates in immediately adjacent rectangular bounded regions, or a weighted sum of the values of sub-pixels having co-ordinates with K equal to zero and L equal to an even value and the values of sub-pixels having corresponding co-ordinates in immediately adjacent bounded rectangular regions.

44. (Currently Amended) A video decoder comprising an interpolator for sub-pixel value interpolation, the interpolator being configured to determine values for sub-pixels situated within a rectangular bounded region defined by four corner pixels with no intermediate pixels between the corners, the pixels and sub-pixels being configured for display in rows and columns, pixel and sub-pixel locations in the rows and columns being representable mathematically within the rectangular bounded region using the co-ordinate notation $K/2^N$, $L/2^N$, K and L being positive integers having respective values between zero and $2^N$, N being a positive integer greater than one and representing a particular degree of sub-pixel value interpolation, the interpolator being configured to:

- interpolate a sub-pixel value for a sub-pixel having co-ordinates with odd values of ~~both~~ K and L, according to a predetermined choice of a either weighted average of the value of a nearest-neighbouring pixel and the value of the sub-pixel situated at co-ordinates 1/2, 1/2, or a weighted average of the values of a pair of diagonally-opposed sub-pixels having co-ordinates with even values of ~~both~~ K and L, including zero, situated within a quadrant of

the rectangular bounded region, the quadrant being defined by the sub-pixel having co-ordinates 1/2, 1/2 and the nearest neighbouring pixel;

- interpolate sub-pixel values for sub-pixels having co-ordinates with K equal to an even value and L equal to zero and sub-pixels having co-ordinates with K equal to zero and L equal to an even value, used in the interpolation of the sub-pixels having co-ordinates with odd values of ~~both~~ K and L, using weighted sums of the values of pixels located in rows and columns respectively; and
- interpolate sub-pixel values for sub-pixels having co-ordinates with even values of ~~both~~ K and L, used in the interpolation of sub-pixel values for the sub-pixels having co-ordinates with odd values of ~~both~~ K and L, using a predetermined choice of either a weighted sum of the values of sub-pixels having co-ordinates with K equal to an even value and L equal to zero and the values of sub-pixels having corresponding co-ordinates in immediately adjacent rectangular bounded regions, or a weighted sum of the values of sub-pixels having co-ordinates with K equal to zero and L equal to an even value and the values of sub-pixels having corresponding co-ordinates in immediately adjacent bounded rectangular regions.

45. (Currently Amended) A still image decoder comprising an interpolator for sub-pixel value interpolation, the interpolator being configured to determine values for sub-pixels situated within a rectangular bounded region defined by four corner pixels with no intermediate pixels between the corners, the pixels and sub-pixels being configured for display in rows and columns, pixel and sub-pixel locations in the rows and columns being representable mathematically within the rectangular bounded region using the co-ordinate notation $K/2^N$, $L/2^N$, K and L being positive integers having respective values between zero and $2^N$, N being a positive integer greater than one and representing a particular degree of sub-pixel value interpolation, the interpolator being configured to:

- interpolate a sub-pixel value for a sub-pixel having co-ordinates with odd values of ~~both~~ K and L, according to a predetermined choice of either a weighted average of the value of a nearest-neighbouring pixel and the value of the sub-pixel situated at co-ordinates 1/2, 1/2, or a weighted average of the values of a pair of diagonally-opposed sub-pixels having co-ordinates with even values of ~~both~~ K and L, including zero, situated within a quadrant of the rectangular bounded region, the quadrant being defined by the sub-pixel having co-ordinates 1/2, 1/2 and the nearest neighbouring pixel;

- interpolate sub-pixel values for sub-pixels having co-ordinates with K equal to an even value and L equal to zero and sub-pixels having co-ordinates with K equal to zero and L equal to an even value, used in the interpolation of the sub-pixels having co-ordinates with odd values of ~~both~~ K and L, using weighted sums of the values of pixels located in rows and columns respectively; and
- interpolate sub-pixel values for sub-pixels having co-ordinates with even values of ~~both~~ K and L, used in the interpolation of sub-pixel values for the sub-pixels having co-ordinates with odd values of ~~both~~ K and L, using a predetermined choice of either a weighted sum of the values of sub-pixels having co-ordinates with K equal to an even value and L equal to zero and the values of sub-pixels having corresponding co-ordinates in immediately adjacent rectangular bounded regions, or a weighted sum of the values of sub-pixels having co-ordinates with K equal to zero and L equal to an even value and the values of sub-pixels having corresponding co-ordinates in immediately adjacent bounded rectangular regions.

46. (Previously Presented) A codec comprising a video encoder according to claim 42 and a video decoder according to claim 44.

47. (Previously Presented) A codec comprising a still image encoder according to claim 43 and a still image decoder according to claim 45.

48. (Previously Presented) A communications terminal comprising a video encoder according to claim 42.

49. (Previously Presented) A communications terminal comprising a still image encoder according to claim 43.

50. (Previously Presented) A communications terminal comprising a video decoder according to claim 44.

51. (Previously Presented) A communications terminal comprising a still image decoder according to claim 45.

52. (Previously Presented) A communications terminal according to claim 48, wherein the communications terminal is a wireless terminal.

53. (Currently Amended) An interpolator for sub-pixel value interpolation, the interpolator being configured to determine values for sub-pixels situated within a rectangular bounded region defined by four corner pixels with no intermediate pixels between the corners, the pixels and sub-pixels being configured for display in rows and columns, pixel and sub-pixel locations in the rows and columns being representable mathematically within the rectangular bounded region using the co-ordinate notation $K/2^N$, $L/2^N$, K and L being positive integers having respective values between zero and $2^N$, N being a positive integer greater than one and representing a particular degree of sub-pixel value interpolation, the interpolator comprising:

- circuitry configured to interpolate a sub-pixel value for a sub-pixel having co-ordinates with odd values of ~~both~~ K and L, according to a predetermined choice of either a weighted average of the value of a nearest-neighbouring pixel and the value of the sub-pixel situated at co-ordinates 1/2, 1/2, and a weighted average of the values of a pair of diagonally-opposed sub-pixels having co-ordinates with even values of ~~both~~ K and L, including zero, situated within a quadrant of the rectangular bounded region, the quadrant being defined by the sub-pixel having co-ordinates 1/2, 1/2 and the nearest neighbouring pixel;
- circuitry configured to interpolate sub-pixel values for sub-pixels having co-ordinates with K equal to an even value and L equal to zero and sub-pixels having co-ordinates with K equal to zero and L equal to an even value, used in the interpolation of the sub-pixels having co-ordinates with odd values of ~~both~~ K and L, using weighted sums of the values of pixels located in rows and columns respectively; and
- circuitry configured to interpolate sub-pixel values for sub-pixels having co-ordinates with even values of ~~both~~ K and L, used in the interpolation of sub-pixel values for the sub-pixels having co-ordinates with odd values of ~~both~~ K and L, using a predetermined choice of either a weighted sum of the values of sub-pixels having co-ordinates with K equal to an even value and L equal to zero and the values of sub-pixels having corresponding co-ordinates in immediately adjacent rectangular bounded regions, or a weighted sum of the values of sub-pixels having co-ordinates with K equal to zero and L equal to an even value and the values of sub-pixels having corresponding co-ordinates in immediately adjacent bounded rectangular regions.

54. (Currently Amended) An interpolator for quarter resolution sub-pixel value interpolation, the interpolator being configured to determine values for sub-pixels situated within a rectangular bounded region defined by four corner pixels with no intermediate pixels between the corners, the pixels and sub-pixels being configured for display in rows and columns, pixel and sub-pixel locations in the rows and columns being representable mathematically within the rectangular bounded region using the co-ordinate notation K/4, L/4, K and L being positive integers having respective values between zero and 4, the interpolator being configured to:

- interpolate a sub-pixel value for a sub-pixel having co-ordinates with K and L equal to 1 or 3, according to a predetermined choice of either a weighted average of the value of a nearest-neighbouring pixel and the value of the sub-pixel situated at co-ordinates 2/4, 2/4, or a weighted average of the values of a pair of diagonally-opposed sub-pixels having co-ordinates with K and L equal to zero, 2 or 4, situated within a quadrant of the rectangular bounded region, the quadrant being defined by the sub-pixel having co-ordinates 2/4, 2/4 and the nearest neighbouring pixel;
- interpolate sub-pixel values for sub-pixels having co-ordinates with K equal to 2 and L equal to zero and sub-pixels having co-ordinates with K equal to zero and L equal to 2, used in the interpolation of the sub-pixels having co-ordinates with K and L equal to 1 or 3, using weighted sums of the values of pixels located in rows and columns respectively; and
- interpolate a sub-pixel value for the sub-pixel having co-ordinates with ~~both~~ K and L equal to 2, used in the interpolation of sub-pixel values for the sub-pixels having co-ordinates with K and L equal to 1 or 3, using a predetermined choice of either a weighted sum of the values of the sub-pixel having co-ordinates with K equal to 2 and L equal to zero and the values of sub-pixels having corresponding co-ordinates in immediately adjacent rectangular bounded regions, or a weighted sum of the value of the sub-pixel having co-ordinates with K equal to zero and L equal to 2 and the values of sub-pixels having corresponding co-ordinates in immediately adjacent rectangular bounded regions.

55. (Previously Presented) An interpolator for eighth resolution sub-pixel value interpolation, the interpolator being configured to determine values for sub-pixels situated within a rectangular bounded region defined by four corner pixels with no intermediate pixels between the corners, the pixels and sub-pixels being configured for display in rows and columns, pixel and sub-pixel locations in the rows and columns being representable mathematically with the rectangular

bounded region using the co-ordinate notation K/8, L/8, K and L being positive integers having respective values between zero and 8, the interpolator being configured to:

- interpolate a sub-pixel value for a sub-pixel having co-ordinates with K and L equal to 1, 3, 5 or 7, according to a predetermined choice of either a weighted average of the value of a nearest-neighbouring pixel and the value of the sub-pixel situated at co-ordinates 4/8, 4/8, or a weighted average of the values of a pair of diagonally-opposed sub-pixels having co-ordinates with K and L equal to zero, 2, 4, 6 or 8, situated within a quadrant of the rectangular bounded region, the quadrant being defined by the sub-pixel having co-ordinates 4/8, 4/8 and the nearest neighbouring pixel;
- interpolate sub-pixel values for sub-pixels having co-ordinates with K equal to 2, 4 or 6 and L equal to zero and sub-pixels having co-ordinates with K equal to zero and L equal to 2, 4 or 6, used in the interpolation of the sub-pixels having co-ordinates with K and L equal to 1, 3, 5 or 7, using weighted sums of the values of pixels located in rows and columns respectively; and
- interpolate sub-pixel values for sub-pixels having co-ordinates with K and L equal to 2, 4 or 6, used in the interpolation of sub-pixel values for the sub-pixels having co-ordinates with K and L equal to 1, 3, 5 or 7, using a predetermined choice of either a weighted sum of the values of sub-pixels having co-ordinates with K equal to 2, 4 or 6 and L equal to zero and the values of sub-pixels having corresponding co-ordinates in immediately adjacent rectangular bounded regions or a weighted sum of the values of sub-pixels having co-ordinates with K equal to zero and L equal to 2, 4 or 6 and the values of sub-pixels having corresponding co-ordinates in immediately adjacent rectangular bounded regions.

56. (Previously Presented) A video encoder or still image encoder comprising an interpolator according to claim 54 or 55.

57. (Previously Presented) A video decoder or still image decoder comprising an interpolator according to claim 54 or 55.

58. (Previously Presented) A communications terminal comprising a video encoder or still image encoder according to claim 56.

59. (Previously Presented) A communications terminal comprising a video decoder or still image decoder according to claim 57.

60. (Currently Amended) A computer program embodied on a computer readable storage medium for sub-pixel value interpolation, the computer program being configured to determine values for sub-pixels situated within a rectangular bounded region defined by four corner pixels with no intermediate pixels between the corners, the pixels and sub-pixels being configured for display in rows and columns, pixel and sub-pixel locations in the rows and columns being representable mathematically within the rectangular bounded region using the co-ordinate notation $K/2^N$, $L/2^N$, K and L being positive integers having respective values between zero and $2^N$, N being a positive integer greater than one and representing a particular degree of sub-pixel value interpolation, the computer program comprising:

- computer program code for interpolating a sub-pixel value for a sub-pixel having co-ordinates with odd values of ~~both~~ K and L, according to a predetermined choice of either a weighted average of the value of a nearest-neighbouring pixel and the value of the sub-pixel situated at co-ordinates 1/2, 1/2, or a weighted average of the values of a pair of diagonally-opposed sub-pixels having co-ordinates with even values of ~~both~~ K and L, including zero, situated within a quadrant of the rectangular bounded region, the quadrant being defined by the sub-pixel having co-ordinates 1/2, 1/2 and the nearest neighbouring pixel;
- computer program code for interpolating sub-pixel values for sub-pixels having co-ordinates with K equal to an even value and L equal to zero and sub-pixels having co-ordinates with K equal to zero and L equal to an even value, used in the interpolation of the sub-pixels having co-ordinates with odd values of ~~both~~ K and L, using weighted sums of the values of pixels located in rows and columns respectively; and
- computer program code for interpolating sub-pixel values for sub-pixels having co-ordinates with even values of ~~both~~ K and L, used in the interpolation of sub-pixel values for the sub-pixels having co-ordinates with odd values of ~~both~~ K and L, using a predetermined choice of either a weighted sum of the values of sub-pixels having co-ordinates with K equal to an even value and L equal to zero and the values of sub-pixels having corresponding co-ordinates in immediately adjacent rectangular bounded regions, or a weighted sum of the values of sub-pixels having co-ordinates with K equal to zero

and L equal to an even value and the values of sub-pixels having corresponding co-ordinates in immediately adjacent bounded rectangular regions.

61. (Currently Amended) A network apparatus comprising an interpolator for sub-pixel value interpolation, the interpolator being configured to determine values for sub-pixels situated within a rectangular bounded region defined by four corner pixels with no intermediate pixels between the corners, the pixels and sub-pixels being configured for display in rows and columns, pixel and sub-pixel locations in the rows and columns being representable mathematically within the rectangular bounded region using the co-ordinate notation $K/2^N$, $L/2^N$, K and L being positive integers having respective values between zero and $2^N$, N being a positive integer greater than one and representing a particular degree of sub-pixel value interpolation, the interpolator being configured to:

- interpolate a sub-pixel value for a sub-pixel having co-ordinates with odd values of ~~both~~ K and L, according to a predetermined choice of either a weighted average of the value of a nearest-neighbouring pixel and the value of the sub-pixel situated at co-ordinates 1/2, 1/2, or a weighted average of the values of a pair of diagonally-opposed sub-pixels having co-ordinates with even values of ~~both~~ K and L, including zero, situated within a quadrant of the rectangular bounded region, the quadrant being defined by the sub-pixel having co-ordinates 1/2, 1/2 and the nearest neighbouring pixel;
- interpolate sub-pixel values for sub-pixels having co-ordinates with K equal to an even value and L equal to zero and sub-pixels having co-ordinates with K equal to zero and L equal to an even value, used in the interpolation of the sub-pixels having co-ordinates with odd values of ~~both~~ K and L, using weighted sums of the values of pixels located in rows and columns respectively; and
- interpolate sub-pixel values for sub-pixels having co-ordinates with even values of ~~both~~ K and L, used in the interpolation of sub-pixel values for the sub-pixels having co-ordinates with odd values of ~~both~~ K and L, using a predetermined choice of either a weighted sum of the values of sub-pixels having co-ordinates with K equal to an even value and L equal to zero and the values of sub-pixels having corresponding co-ordinates in immediately adjacent rectangular bounded regions, or a weighted sum of the values of sub-pixels having co-ordinates with K equal to zero and L equal to an even value and the values of sub-pixels having corresponding co-ordinates in immediately adjacent bounded rectangular regions.

62. (New) A method according to claim 1, wherein the pixels have a predetermined dynamic range, said predetermined dynamic range corresponding to the range of values said pixels can take.

63 (New) A method according to claim 62, comprising interpolating sub-pixel values for sub-pixels having co-ordinates with K equal to an even value and L equal zero and for sub-pixels having co-ordinates with K equal to zero and L equal to an even value, using weighted sums of the values of pixels located in rows and columns respectively, to produce a first intermediate value, said first intermediate value having a dynamic range equal to the predetermined dynamic range of the pixels used in said weighted sum multiplied by a value equal to the sum of the respective weights used in said weighted sum.

64. (New) A method according to claim 63, wherein the dynamic range of said first intermediate value is defined by the number of bits used to represent the respective pixels used in said weighted sum plus the number of bits required to represent the sum of the respective weights used in said weighted sum.

65. (New) A method according to claim 63, comprising truncating the first intermediate value by mathematically dividingthe first intermediate value by a first scale factor, said first scale factor having a value equal to the sum of the respective weights used in said weighted sum, thereby forming a sub-pixel value with a dynamic range equal to the predetermined dynamic range of said pixels.

66. (New) A method according to claim 63, comprising interpolating sub-pixel values for sub-pixels having co-ordinates with even values of K and L, using a weighted sum comprising first intermediate values for sub-pixels having co-ordinates with K equal to an even value and L equal to zero and intermediate values for sub-pixels having corresponding co-ordinates in immediately adjacent rectangular bounded regions, to produce a second intermediate value, said second intermediate value having a dynamic range equal to the dynamic range of the first intermediate values used in said weighted sum, multiplied by a value equal to the sum of the respective weights used in said weighted sum.

67. (New) A method according to claim 63, comprising interpolating sub-pixel values for sub-pixels having co-ordinates with even values of K and L, using a weighted sum comprising first intermediate values for sub-pixels having co-ordinates with K equal to zero and L equal to an even value and intermediate values for sub-pixels having corresponding co-ordinates in immediately adjacent bounded rectangular regions to produce a second intermediate value, said second intermediate value having a dynamic range equal to the dynamic range of the first intermediate values used in said weighted sum, multiplied by a value equal to the sum of the respective weights used in said weighted sum.

68. (New) A method according to claim 66, comprising truncating the second intermediate value by mathematically dividing the second intermediate value by a second scale factor, said second scale factor having a value equal to the sum of the respective weights used in the weighted sum of claim 63 multiplied by the sum of the respective weights used in the weighted sum of claim 66, thereby forming a sub-pixel value with a dynamic range equal to the predetermined dynamic range of said pixels.

69. (New) A method according to claim 67, comprising truncating the second intermediate value by mathematically dividing the second intermediate value by a second scale factor, said second scale factor having a value equal to the sum of the respective weights used in the weighted sum of claim 63 multiplied by the sum of the respective weights used in the weighted sum of claim 67, thereby forming a sub-pixel value with a dynamic range equal to the dynamic range of said pixels.

70. (New) A method according to claim 65, comprising using a truncated first intermediate sub-pixel value when interpolating a value for a sub-pixel having co-ordinates with odd values of K and L.

71. (New) A method according to claim 68, comprising using a truncated second intermediate sub-pixel value when interpolating a value for a sub-pixel having co-ordinates with odd values of K and L.

72. (New) An interpolator according to claim 22, wherein the pixels have a predetermined dynamic range, said predetermined dynamic range corresponding to the range of values said pixels can take.

73. (New) An interpolator according to claim 72, wherein the interpolator is configured to interpolate sub-pixel values for sub-pixels having co-ordinates with K equal to an even value and L equal zero and for sub-pixels having co-ordinates with K equal to zero and L equal to an even value, using weighted sums of the values of pixels located in rows and columns respectively, to produce a first intermediate value, said first intermediate value having a dynamic range equal to the predetermined dynamic range of the pixels used in said weighted sum multiplied by a value equal to the sum of the respective weights used in said weighted sum.

74. (New) An interpolator according to claim 73, wherein the dynamic range of said first intermediate value is defined by the number of bits used to represent the respective pixels used in said weighted sum plus the number of bits required to represent the sum of the respective weights used in said weighted sum.

75. (New) An interpolator according to claim 73, wherein the interpolator is configured to truncate the first intermediate value by mathematically dividing the first intermediate value by a first scale factor, said first scale factor having a value equal to the sum of the respective weights used in said weighted sum, thereby forming a sub-pixel value with a dynamic range equal to the predetermined dynamic range of said pixels.

76. (New) An interpolator according to claim 73, wherein the interpolator is configured to interpolate sub-pixel values for sub-pixels having co-ordinates with even values of K and L, using a weighted sum comprising first intermediate values for sub-pixels having co-ordinates with K equal to an even value and L equal to zero and intermediate values for sub-pixels having corresponding co-ordinates in immediately adjacent rectangular bounded regions, to produce a second intermediate value, said second intermediate value having a dynamic range equal to the dynamic range of the first intermediate values used in said weighted sum, multiplied by a value equal to the sum of the respective weights used in said weighted sum.

77. (New) An interpolator according to claim 73, wherein the interpolator is configured to interpolate sub-pixel values for sub-pixels having co-ordinates with even values of K and L, using a weighted sum comprising first intermediate values for sub-pixels having co-ordinates with K equal to zero and L equal to an even value and intermediate values for sub-pixels having corresponding co-ordinates in immediately adjacent bounded rectangular regions to produce a second intermediate value, said second intermediate value having a dynamic range equal to the dynamic range of the first intermediate values used in said weighted sum, multiplied by a value equal to the sum of the respective weights used in said weighted sum.

78. (New) An interpolator according to claim 76, wherein the interpolator is configured to truncate the second intermediate value by mathematically dividing the second intermediate value by a second scale factor, said second scale factor having a value equal to the sum of the respective weights used in the weighted sum of claim 73 multiplied by the sum of the respective weights used in the weighted sum of claim 76, thereby forming a sub-pixel value with a dynamic range equal to the predetermined dynamic range of said pixels.

79. (New) An interpolator according to claim 77, wherein the interpolator is configured to truncate the second intermediate value by mathematically dividing the second intermediate value by a second scale factor, said second scale factor having a value equal to the sum of the respective weights used in the weighted sum of claim 73 multiplied by the sum of the respective weights used in the weighted sum of claim 77, thereby forming a sub-pixel value with a dynamic range equal to the predetermined dynamic range of said pixels.

80. (New) An interpolator according to claim 75, wherein the interpolator is configured to use a truncated first intermediate sub-pixel value when interpolating a value for a sub-pixel having co-ordinates with odd values of K and L.

81. (New) An interpolator according to claim 78, wherein the interpolator is configured to use a truncated second intermediate sub-pixel value when interpolating a value for a sub-pixel having co-ordinates with odd values of K and L.

## III. REMARKS

The claims have been amended to correct typographical errors.

Claims 62-81 are new and depend from claims 1 and 22. Applicant has taken care to avoid adding new matter

The Commissioner is hereby authorized to charge payment for any fees associated with this communication or credit any over payment to Deposit Account No. 16-1350.

Respectfully submitted,

Joseph V. Gamberdell, Jr.
Reg. No. 44,695

7 December 2010
Date

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# Electronic Patent Application Fee Transmittal

| | |
|---|---|
| **Application Number:** | 11839205 |
| **Filing Date:** | 15-Aug-2007 |
| **Title of Invention:** | METHOD FOR SUB-PIXEL VALUE INTERPOLATION |
| **First Named Inventor/Applicant Name:** | Marta Karczewicz |
| **Filer:** | Joseph V. Gamberdell |
| **Attorney Docket Number:** | 982-010567-US (C02) |

Filed as Large Entity

## Utility under 35 USC 111(a) Filing Fees

| Description | Fee Code | Quantity | Amount | Sub-Total in USD($) |
|---|---|---|---|---|
| **Basic Filing:** | | | | |
| **Pages:** | | | | |
| **Claims:** | | | | |
| Claims in excess of 20 | 1202 | 20 | 52 | 1040 |
| **Miscellaneous-Filing:** | | | | |
| **Petition:** | | | | |
| **Patent-Appeals-and-Interference:** | | | | |
| **Post-Allowance-and-Post-Issuance:** | | | | |
| **Extension-of-Time:** | | | | |

| Description | Fee Code | Quantity | Amount | Sub-Total in USD($) |
|---|---|---|---|---|
| **Miscellaneous:** | | | | |
| Request for continued examination | 1801 | 1 | 810 | 810 |
| | | **Total in USD ($)** | | **1850** |

# Electronic Acknowledgement Receipt

| | |
|---|---|
| **EFS ID:** | 8986901 |
| **Application Number:** | 11839205 |
| **International Application Number:** | |
| **Confirmation Number:** | 8091 |
| **Title of Invention:** | METHOD FOR SUB-PIXEL VALUE INTERPOLATION |
| **First Named Inventor/Applicant Name:** | Marta Karczewicz |
| **Customer Number:** | 02512 |
| **Filer:** | Joseph V. Gamberdell |
| **Filer Authorized By:** | |
| **Attorney Docket Number:** | 982-010567-US (C02) |
| **Receipt Date:** | 07-DEC-2010 |
| **Filing Date:** | 15-AUG-2007 |
| **Time Stamp:** | 19:26:29 |
| **Application Type:** | Utility under 35 USC 111(a) |

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| Submitted with Payment | yes |
| Payment Type | Deposit Account |
| Payment was successfully received in RAM | $1850 |
| RAM confirmation Number | 6112 |
| Deposit Account | 161350 |
| Authorized User | |

## File Listing:

| Document Number | Document Description | File Name | File Size(Bytes)/ Message Digest | Multi Part /.zip | Pages (if appl.) |
|---|---|---|---|---|---|

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|---|---|---|---|---|---|
| 1 | Request for Continued Examination (RCE) | sb0030e_fill_RCE.pdf | 697289<br>cb60bdce6ecb36e22049f1eefec613f21234b7cf | no | 3 |
| **Warnings:** | | | | | |
| **Information:** | | | | | |
| 2 | Amendment Submitted/Entered with Filing of CPA/RCE | AmendafterAllow101207.pdf | 1638635<br>449d05d4058c9aff161a58ac953903398ec26866 | no | 26 |
| **Warnings:** | | | | | |
| **Information:** | | | | | |
| 3 | Fee Worksheet (PTO-875) | fee-info.pdf | 32749<br>4a8850078f405e89592e66ee6a58abb6dbbf807e | no | 2 |
| **Warnings:** | | | | | |
| **Information:** | | | | | |
| | | | **Total Files Size (in bytes):** | 2368673 | |

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**New Applications Under 35 U.S.C. 111**

**If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.**

**National Stage of an International Application under 35 U.S.C. 371**

**If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.**

**New International Application Filed with the USPTO as a Receiving Office**

**If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.**

PTO/SB/06 (07-06)
Approved for use through 1/31/2007. OMB 0651-0032
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number.

# PATENT APPLICATION FEE DETERMINATION RECORD

Substitute for Form PTO-875

| Application or Docket Number | Filing Date | ☐ To be Mailed |
|---|---|---|
| 11/839,205 | 08/15/2007 | |

## APPLICATION AS FILED – PART I

| FOR | (Column 1) NUMBER FILED | (Column 2) NUMBER EXTRA | SMALL ENTITY RATE ($) | SMALL ENTITY FEE ($) | OR | OTHER THAN SMALL ENTITY RATE ($) | OTHER THAN SMALL ENTITY FEE ($) |
|---|---|---|---|---|---|---|---|
| ☐ BASIC FEE (37 CFR 1.16(a), (b), or (c)) | N/A | N/A | N/A | | | N/A | |
| ☐ SEARCH FEE (37 CFR 1.16(k), (i), or (m)) | N/A | N/A | N/A | | | N/A | |
| ☐ EXAMINATION FEE (37 CFR 1.16(o), (p), or (q)) | N/A | N/A | N/A | | | N/A | |
| TOTAL CLAIMS (37 CFR 1.16(i)) | minus 20 = | * | X $ = | | OR | X $ = | |
| INDEPENDENT CLAIMS (37 CFR 1.16(h)) | minus 3 = | * | X $ = | | | X $ = | |
| ☐ APPLICATION SIZE FEE (37 CFR 1.16(s)) | If the specification and drawings exceed 100 sheets of paper, the application size fee due is $250 ($125 for small entity) for each additional 50 sheets or fraction thereof. See 35 U.S.C. 41(a)(1)(G) and 37 CFR 1.16(s). | | | | | | |
| ☐ MULTIPLE DEPENDENT CLAIM PRESENT (37 CFR 1.16(j)) | | | | | | | |
| * If the difference in column 1 is less than zero, enter "0" in column 2. | | | TOTAL | | | TOTAL | |

## APPLICATION AS AMENDED – PART II

| AMENDMENT | 12/07/2010 | (Column 1) CLAIMS REMAINING AFTER AMENDMENT | | (Column 2) HIGHEST NUMBER PREVIOUSLY PAID FOR | (Column 3) PRESENT EXTRA | SMALL ENTITY RATE ($) | SMALL ENTITY ADDITIONAL FEE ($) | OR | OTHER THAN SMALL ENTITY RATE ($) | OTHER THAN SMALL ENTITY ADDITIONAL FEE ($) |
|---|---|---|---|---|---|---|---|---|---|---|
| | Total (37 CFR 1.16(i)) | * 85 | Minus | ** 65 | = 20 | X $ = | | OR | X $52= | 1040 |
| | Independent (37 CFR 1.16(h)) | * 13 | Minus | ***13 | = 0 | X $ = | | OR | X $220= | 0 |
| | ☐ Application Size Fee (37 CFR 1.16(s)) | | | | | | | | | |
| | ☐ FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j)) | | | | | | | OR | | |
| | | | | | | TOTAL ADD'L FEE | | OR | TOTAL ADD'L FEE | **1040** |

| AMENDMENT | | (Column 1) CLAIMS REMAINING AFTER AMENDMENT | | (Column 2) HIGHEST NUMBER PREVIOUSLY PAID FOR | (Column 3) PRESENT EXTRA | RATE ($) | ADDITIONAL FEE ($) | | RATE ($) | ADDITIONAL FEE ($) |
|---|---|---|---|---|---|---|---|---|---|---|
| | Total (37 CFR 1.16(i)) | * | Minus | ** | = | X $ = | | OR | X $ = | |
| | Independent (37 CFR 1.16(h)) | * | Minus | *** | = | X $ = | | OR | X $ = | |
| | ☐ Application Size Fee (37 CFR 1.16(s)) | | | | | | | | | |
| | ☐ FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j)) | | | | | | | OR | | |
| | | | | | | TOTAL ADD'L FEE | | OR | TOTAL ADD'L FEE | |

* If the entry in column 1 is less than the entry in column 2, write "0" in column 3.

** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 20, enter "20".

*** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 3, enter "3".

The "Highest Number Previously Paid For" (Total or Independent) is the highest number found in the appropriate box in column 1.

Legal Instrument Examiner:
/DAVINA G. BUTLER/

This collection of information is required by 37 CFR 1.16. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 12 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

*If you need assistance in completing the form, call 1-800-PTO-9199 and select option 2.*

PTO/SB/07 (07-06)
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| **MULTIPLE DEPENDENT CLAIM FEE CALCULATION SHEET**<br>Substitute for Form PTO-1360<br>(For use with Form PTO/SB/06) | Application Number 10/689,365 | Filing Date | ☐ To be Mailed |
|---|---|---|---|
| | Applicant(s) | | Page 1 of 1 |

* May be used for additional claims or amendments

| CLAIMS | AS FILED | | AFTER FIRST AMENDMENT 8-7-10 | | AFTER SEC. AMENDMENT | | * | | | * | | * | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Indep | Depend | Indep | Depend | Indep | Depend | | Indep | Depend | Indep | Depend | Indep | Depend |
| 1 | | | 1 | | | | 51 | | | | 1 | | |
| 2 | | | 1 | | | | 52 | | | | 1 | | |
| 3 | | | 1 | | | | 53 | | | 1 | | | |
| 4 | | | | 1 | | | 54 | | | 1 | | | |
| 5 | | | | 1 | | | 55 | | | 1 | | | |
| 6 | | | | 1 | | | 56 | | | | 3 | | |
| 7 | | | | 1 | | | 57 | | | | 3 | | |
| 8 | | | | 1 | | | 58 | | | | 3 | | |
| 9 | | | | 1 | | | 59 | | | | 3 | | |
| 10 | | | | 1 | | | 60 | | | 1 | | | |
| 11 | | | | 1 | | | 61 | | | 1 | | | |
| 12 | | | | 1 | | | 62 | | | | 1 | | |
| 13 | | | | 1 | | | 63 | | | | 1 | | |
| 14 | | | | 1 | | | 64 | | | | 1 | | |
| 15 | | | | 1 | | | 65 | | | | 1 | | |
| 16 | | | | 1 | | | 66 | | | | 1 | | |
| 17 | | | | 1 | | | 67 | | | | 1 | | |
| 18 | | | | 1 | | | 68 | | | | 1 | | |
| 19 | | | | 1 | | | 69 | | | | 1 | | |
| 20 | | | | 1 | | | 70 | | | | 1 | | |
| 21 | | | | 1 | | | 71 | | | | 1 | | |
| 22 | | | 1 | | | | 72 | | | | 1 | | |
| 23 | | | | 1 | | | 73 | | | | 1 | | |
| 24 | | | | 1 | | | 74 | | | | 1 | | |
| 25 | | | | 1 | | | 75 | | | | 1 | | |
| 26 | | | | 1 | | | 76 | | | | 1 | | |
| 27 | | | | 1 | | | 77 | | | | 1 | | |
| 28 | | | | 1 | | | 78 | | | | 1 | | |
| 29 | | | | 1 | | | 79 | | | | 1 | | |
| 30 | | | | 1 | | | 80 | | | | 1 | | |
| 31 | | | | 1 | | | 81 | | | | 1 | | |
| 32 | | | | 1 | | | 82 | | | | | | |
| 33 | | | | 1 | | | 83 | | | | | | |
| 34 | | | | 1 | | | 84 | | | | | | |
| 35 | | | | 1 | | | 85 | | | | | | |
| 36 | | | | 1 | | | 86 | | | | | | |
| 37 | | | | 1 | | | 87 | | | | | | |
| 38 | | | | 1 | | | 88 | | | | | | |
| 39 | | | | 1 | | | 89 | | | | | | |
| 40 | | | | 1 | | | 90 | | | | | | |
| 41 | | | | 1 | | | 91 | | | | | | |
| 42 | | | 1 | | | | 92 | | | | | | |
| 43 | | | 1 | | | | 93 | | | | | | |
| 44 | | | 1 | | | | 94 | | | | | | |
| 45 | | | 1 | | | | 95 | | | | | | |
| 46 | | | | (1) | | | 96 | | | | | | |
| 47 | | | | (1) | | | 97 | | | | | | |
| 48 | | | | 1 | | | 98 | | | | | | |
| 49 | | | | 1 | | | 99 | | | | | | |
| 50 | | | | 1 | | | 100 | | | | | | |
| Total Indep | | | 13 | | | | Total Indep | | | | | | |
| Total Depend | | | 70 | | | | Total Depend | | | | | | |
| Total Claims | | | 83 | | | | Total Claims | | | | | | |

This collection of information is required by 37 CFR 1.16. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 12 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

If you need assistance in completing the form, call 1-800-PTO-9199 and select option 2 Part of Paper No

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P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

# NOTICE OF ALLOWANCE AND FEE(S) DUE

2512 7590 12/28/2010

Perman & Green, LLP
99 Hawley Lane
Stratford, CT 06614

| EXAMINER | |
|---|---|
| AN, SHAWN S | |
| ART UNIT | PAPER NUMBER |
| 2483 | |

DATE MAILED: 12/28/2010

| APPLICATION NO. | FILING DATE | FIRST NAMED INVENTOR | ATTORNEY DOCKET NO. | CONFIRMATION NO. |
|---|---|---|---|---|
| 11/839,205 | 08/15/2007 | Marta Karczewicz | 982-010567-US (C02) | 8091 |

TITLE OF INVENTION: METHOD FOR SUB-PIXEL VALUE INTERPOLATION

| APPLN. TYPE | SMALL ENTITY | ISSUE FEE DUE | PUBLICATION FEE DUE | PREV. PAID ISSUE FEE | TOTAL FEE(S) DUE | DATE DUE |
|---|---|---|---|---|---|---|
| nonprovisional | NO | $1510 | $300 | $0 | $1810 | 03/28/2011 |

**THE APPLICATION IDENTIFIED ABOVE HAS BEEN EXAMINED AND IS ALLOWED FOR ISSUANCE AS A PATENT. PROSECUTION ON THE MERITS IS CLOSED. THIS NOTICE OF ALLOWANCE IS NOT A GRANT OF PATENT RIGHTS. THIS APPLICATION IS SUBJECT TO WITHDRAWAL FROM ISSUE AT THE INITIATIVE OF THE OFFICE OR UPON PETITION BY THE APPLICANT. SEE 37 CFR 1.313 AND MPEP 1308.**

**THE ISSUE FEE AND PUBLICATION FEE (IF REQUIRED) MUST BE PAID WITHIN THREE MONTHS FROM THE MAILING DATE OF THIS NOTICE OR THIS APPLICATION SHALL BE REGARDED AS ABANDONED. THIS STATUTORY PERIOD CANNOT BE EXTENDED. SEE 35 U.S.C. 151. THE ISSUE FEE DUE INDICATED ABOVE DOES NOT REFLECT A CREDIT FOR ANY PREVIOUSLY PAID ISSUE FEE IN THIS APPLICATION. IF AN ISSUE FEE HAS PREVIOUSLY BEEN PAID IN THIS APPLICATION (AS SHOWN ABOVE), THE RETURN OF PART B OF THIS FORM WILL BE CONSIDERED A REQUEST TO REAPPLY THE PREVIOUSLY PAID ISSUE FEE TOWARD THE ISSUE FEE NOW DUE.**

**HOW TO REPLY TO THIS NOTICE:**

I. Review the SMALL ENTITY status shown above.

If the SMALL ENTITY is shown as YES, verify your current SMALL ENTITY status:

A. If the status is the same, pay the TOTAL FEE(S) DUE shown above.

B. If the status above is to be removed, check box 5b on Part B - Fee(s) Transmittal and pay the PUBLICATION FEE (if required) and twice the amount of the ISSUE FEE shown above, or

If the SMALL ENTITY is shown as NO:

A. Pay TOTAL FEE(S) DUE shown above, or

B. If applicant claimed SMALL ENTITY status before, or is now claiming SMALL ENTITY status, check box 5a on Part B - Fee(s) Transmittal and pay the PUBLICATION FEE (if required) and 1/2 the ISSUE FEE shown above.

II. PART B - FEE(S) TRANSMITTAL, or its equivalent, must be completed and returned to the United States Patent and Trademark Office (USPTO) with your ISSUE FEE and PUBLICATION FEE (if required). If you are charging the fee(s) to your deposit account, section "4b" of Part B - Fee(s) Transmittal should be completed and an extra copy of the form should be submitted. If an equivalent of Part B is filed, a request to reapply a previously paid issue fee must be clearly made, and delays in processing may occur due to the difficulty in recognizing the paper as an equivalent of Part B.

III. All communications regarding this application must give the application number. Please direct all communications prior to issuance to Mail Stop ISSUE FEE unless advised to the contrary.

**IMPORTANT REMINDER: Utility patents issuing on applications filed on or after Dec. 12, 1980 may require payment of maintenance fees. It is patentee's responsibility to ensure timely payment of maintenance fees when due.**

## PART B - FEE(S) TRANSMITTAL

**Complete and send this form, together with applicable fee(s), to: Mail** **Mail Stop ISSUE FEE**
**Commissioner for Patents**
**P.O. Box 1450**
**Alexandria, Virginia 22313-1450**
**or Fax (571)-273-2885**

INSTRUCTIONS: This form should be used for transmitting the ISSUE FEE and PUBLICATION FEE (if required). Blocks 1 through 5 should be completed where appropriate. All further correspondence including the Patent, advance orders and notification of maintenance fees will be mailed to the current correspondence address as indicated unless corrected below or directed otherwise in Block 1, by (a) specifying a new correspondence address; and/or (b) indicating a separate "FEE ADDRESS" for maintenance fee notifications.

CURRENT CORRESPONDENCE ADDRESS (Note: Use Block 1 for any change of address)

2512 7590 12/28/2010

Perman & Green, LLP
99 Hawley Lane
Stratford, CT 06614

Note: A certificate of mailing can only be used for domestic mailings of the Fee(s) Transmittal. This certificate cannot be used for any other accompanying papers. Each additional paper, such as an assignment or formal drawing, must have its own certificate of mailing or transmission.

**Certificate of Mailing or Transmission**

I hereby certify that this Fee(s) Transmittal is being deposited with the United States Postal Service with sufficient postage for first class mail in an envelope addressed to the Mail Stop ISSUE FEE address above, or being facsimile transmitted to the USPTO (571) 273-2885, on the date indicated below.

| |
|---|
| (Depositor's name) |
| (Signature) |
| (Date) |

| APPLICATION NO. | FILING DATE | FIRST NAMED INVENTOR | ATTORNEY DOCKET NO. | CONFIRMATION NO. |
|---|---|---|---|---|
| 11/839,205 | 08/15/2007 | Marta Karczewicz | 982-010567-US (C02) | 8091 |

TITLE OF INVENTION: METHOD FOR SUB-PIXEL VALUE INTERPOLATION

| APPLN. TYPE | SMALL ENTITY | ISSUE FEE DUE | PUBLICATION FEE DUE | PREV. PAID ISSUE FEE | TOTAL FEE(S) DUE | DATE DUE |
|---|---|---|---|---|---|---|
| nonprovisional | NO | $1510 | $300 | $0 | $1810 | 03/28/2011 |

| EXAMINER | ART UNIT | CLASS-SUBCLASS |
|---|---|---|
| AN, SHAWN S | 2483 | 375-240170 |

1. Change of correspondence address or indication of "Fee Address" (37 CFR 1.363).

❑ Change of correspondence address (or Change of Correspondence Address form PTO/SB/122) attached.

❑ "Fee Address" indication (or "Fee Address" Indication form PTO/SB/47; Rev 03-02 or more recent) attached. **Use of a Customer Number is required.**

2. For printing on the patent front page, list

(1) the names of up to 3 registered patent attorneys or agents OR, alternatively, 1_____

(2) the name of a single firm (having as a member a registered attorney or agent) and the names of up to 2 registered patent attorneys or agents. If no name is listed, no name will be printed. 2_____ 3_____

3. ASSIGNEE NAME AND RESIDENCE DATA TO BE PRINTED ON THE PATENT (print or type)

PLEASE NOTE: Unless an assignee is identified below, no assignee data will appear on the patent. If an assignee is identified below, the document has been filed for recordation as set forth in 37 CFR 3.11. Completion of this form is NOT a substitute for filing an assignment.

(A) NAME OF ASSIGNEE (B) RESIDENCE: (CITY and STATE OR COUNTRY)

Please check the appropriate assignee category or categories (will not be printed on the patent) : ❑ Individual ❑ Corporation or other private group entity ❑ Government

4a. The following fee(s) are submitted:

❑ Issue Fee

❑ Publication Fee (No small entity discount permitted)

❑ Advance Order - # of Copies _____

4b. Payment of Fee(s): **(Please first reapply any previously paid issue fee shown above)**

❑ A check is enclosed.

❑ Payment by credit card. Form PTO-2038 is attached.

❑ The Director is hereby authorized to charge the required fee(s), any deficiency, or credit any overpayment, to Deposit Account Number _____ (enclose an extra copy of this form).

5. **Change in Entity Status** (from status indicated above)

❑ a. Applicant claims SMALL ENTITY status. See 37 CFR 1.27.

❑ b. Applicant is no longer claiming SMALL ENTITY status. See 37 CFR 1.27(g)(2).

NOTE: The Issue Fee and Publication Fee (if required) will not be accepted from anyone other than the applicant; a registered attorney or agent; or the assignee or other party in interest as shown by the records of the United States Patent and Trademark Office.

Authorized Signature _____ Date _____

Typed or printed name _____ Registration No. _____

This collection of information is required by 37 CFR 1.311. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 12 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, Virginia 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, Virginia 22313-1450.

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Alexandria, Virginia 22313-1450
www.uspto.gov

| APPLICATION NO. | FILING DATE | FIRST NAMED INVENTOR | ATTORNEY DOCKET NO. | CONFIRMATION NO. |
|---|---|---|---|---|
| 11/839,205 | 08/15/2007 | Marta Karczewicz | 982-010567-US (C02) | 8091 |

2512 7590 12/28/2010

Perman & Green, LLP
99 Hawley Lane
Stratford, CT 06614

| EXAMINER | |
|---|---|
| AN, SHAWN S | |
| ART UNIT | PAPER NUMBER |
| 2483 | |

DATE MAILED: 12/28/2010

**Determination of Patent Term Adjustment under 35 U.S.C. 154 (b)**
(application filed on or after May 29, 2000)

The Patent Term Adjustment to date is 0 day(s). If the issue fee is paid on the date that is three months after the mailing date of this notice and the patent issues on the Tuesday before the date that is 28 weeks (six and a half months) after the mailing date of this notice, the Patent Term Adjustment will be 0 day(s).

If a Continued Prosecution Application (CPA) was filed in the above-identified application, the filing date that determines Patent Term Adjustment is the filing date of the most recent CPA.

Applicant will be able to obtain more detailed information by accessing the Patent Application Information Retrieval (PAIR) WEB site (http://pair.uspto.gov).

Any questions regarding the Patent Term Extension or Adjustment determination should be directed to the Office of Patent Legal Administration at (571)-272-7702. Questions relating to issue and publication fee payments should be directed to the Customer Service Center of the Office of Patent Publication at 1-(888)-786-0101 or (571)-272-4200.

| Notice of Allowability | Application No. | Applicant(s) | |
|---|---|---|---|
| | 11/839,205 | KARCZEWICZ ET AL. | |
| | Examiner | Art Unit | |
| | SHAWN AN | 2483 | |

***-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address--***

All claims being allowable, PROSECUTION ON THE MERITS IS (OR REMAINS) CLOSED in this application. If not included herewith (or previously mailed), a Notice of Allowance (PTOL-85) or other appropriate communication will be mailed in due course. **THIS NOTICE OF ALLOWABILITY IS NOT A GRANT OF PATENT RIGHTS.** This application is subject to withdrawal from issue at the initiative of the Office or upon petition by the applicant. See 37 CFR 1.313 and MPEP 1308.

1. ☒ This communication is responsive to *12/07/10*.

2. ☒ The allowed claim(s) is/are *1-81*.

3. ☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).
   a) ☐ All b) ☐ Some* c) ☐ None of the:
      1. ☐ Certified copies of the priority documents have been received.
      2. ☐ Certified copies of the priority documents have been received in Application No. _____ .
      3. ☐ Copies of the certified copies of the priority documents have been received in this national stage application from the International Bureau (PCT Rule 17.2(a)).

   * Certified copies not received: _____.

Applicant has THREE MONTHS FROM THE "MAILING DATE" of this communication to file a reply complying with the requirements noted below. Failure to timely comply will result in ABANDONMENT of this application.
**THIS THREE-MONTH PERIOD IS NOT EXTENDABLE**.

4. ☐ A SUBSTITUTE OATH OR DECLARATION must be submitted. Note the attached EXAMINER'S AMENDMENT or NOTICE OF INFORMAL PATENT APPLICATION (PTO-152) which gives reason(s) why the oath or declaration is deficient.

5. ☐ CORRECTED DRAWINGS ( as "replacement sheets") must be submitted.
   (a) ☐ including changes required by the Notice of Draftsperson's Patent Drawing Review ( PTO-948) attached
      1) ☐ hereto or 2) ☐ to Paper No./Mail Date _____.
   (b) ☐ including changes required by the attached Examiner's Amendment / Comment or in the Office action of Paper No./Mail Date _____.

   **Identifying indicia such as the application number (see 37 CFR 1.84(c)) should be written on the drawings in the front (not the back) of each sheet. Replacement sheet(s) should be labeled as such in the header according to 37 CFR 1.121(d).**

6. ☐ DEPOSIT OF and/or INFORMATION about the deposit of BIOLOGICAL MATERIAL must be submitted. Note the attached Examiner's comment regarding REQUIREMENT FOR THE DEPOSIT OF BIOLOGICAL MATERIAL.

**Attachment(s)**

1. ☒ Notice of References Cited (PTO-892)
2. ☐ Notice of Draftperson's Patent Drawing Review (PTO-948)
3. ☐ Information Disclosure Statements (PTO/SB/08), Paper No./Mail Date _____
4. ☐ Examiner's Comment Regarding Requirement for Deposit of Biological Material
5. ☐ Notice of Informal Patent Application
6. ☐ Interview Summary (PTO-413), Paper No./Mail Date _____ .
7. ☐ Examiner's Amendment/Comment
8. ☒ Examiner's Statement of Reasons for Allowance
9. ☐ Other _____.

## Reasons for Allowance

**1.** The request filed on 12/07/10 for a Request for Continued Examination (RCE) under 37 CFR 1.114 based on parent Application No. 11/839,205 is acceptable and a RCE has been established. An action on the RCE follows.

**2.** As per Applicant's instruction as filed on 12/07/10, claims 1-2, 4-9, 21-28, 42-45, 53-54, and 60-61 have been amended and claims 62-81 have been newly added.

**3.** Claims 1-81 are allowed.

**4.** Claims 1-81 are allowed based on Applicant's filing of Terminal Disclaimer as filed on 5/07/10, wherein the prior art of record fails to anticipate or make obvious the claimed features as specified in independent claims 1-3, 22, 42-45, 53-55, and 60-61.

Any comments considered necessary by Applicant must be submitted no later than the payment of the issue fee and, to avoid processing delays, should preferably accompany the issue fee. Such submissions should be clearly labeled "Comments on Statement of Reasons for Allowance."

### *Conclusion*

**5.** The prior art made of record is considered pertinent to Applicant's disclosure.

A) Ito et al (6,693,960 B2), Moving picture encoder and moving picture decoder.

**6.** Any inquiry concerning this communication or earlier communications from the Examiner should be directed to *Shawn An* whose telephone number is 571-272-7324.

If attempts to reach the Examiner by telephone are unsuccessful, the Examiner's supervisor, Joseph Ustaris can be reached on 571-272-7383.

**7.** The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300.

**8.** Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see http://pair-direct.uspto.gov. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free). If you would like assistance from a USPTO Customer Service Representative or access to the automated information system, call 800-786-9199 (IN USA OR CANADA) or 571-272-1000.

/SHAWN AN/
Primary Examiner
Art Unit 2483

| Notice of References Cited | Application/Control No. 11/839,205 | Applicant(s)/Patent Under Reexamination KARCZEWICZ ET AL. | |
|---|---|---|---|
| | Examiner SHAWN AN | Art Unit 2483 | Page 1 of 1 |

**U.S. PATENT DOCUMENTS**

| * | | Document Number Country Code-Number-Kind Code | Date MM-YYYY | Name | Classification |
|---|---|---|---|---|---|
| * | A | US-6,693,960 B2 | 02-2004 | Ito et al. | 375/240.11 |
| | B | US- | | | |
| | C | US- | | | |
| | D | US- | | | |
| | E | US- | | | |
| | F | US- | | | |
| | G | US- | | | |
| | H | US- | | | |
| | I | US- | | | |
| | J | US- | | | |
| | K | US- | | | |
| | L | US- | | | |
| | M | US- | | | |

**FOREIGN PATENT DOCUMENTS**

| * | | Document Number Country Code-Number-Kind Code | Date MM-YYYY | Country | Name | Classification |
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**NON-PATENT DOCUMENTS**

| * | | Include as applicable: Author, Title Date, Publisher, Edition or Volume, Pertinent Pages) |
|---|---|---|
| | U | |
| | V | |
| | W | |
| | X | |

*A copy of this reference is not being furnished with this Office action. (See MPEP § 707.05(a).)
Dates in MM-YYYY format are publication dates. Classifications may be US or foreign.

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www.uspto.gov

# BIB DATA SHEET

**CONFIRMATION NO. 8091**

| SERIAL NUMBER | FILING or 371(c) DATE / RULE | CLASS | GROUP ART UNIT | ATTORNEY DOCKET NO. |
|---|---|---|---|---|
| 11/839,205 | 08/15/2007 | 375 | 2483 | 982-010567-US (C02) |

**APPLICANTS**

Marta Karczewicz, Irving, TX;
Antti Olli Hallapuro, Tampere, FINLAND;

**** CONTINUING DATA ***************************

This application is a CON of 11/090,717 03/25/2005 PAT 7,280,599
which is a CON of 09/954,608 09/17/2001 PAT 6,950,469

**** FOREIGN APPLICATIONS ***************************

**** IF REQUIRED, FOREIGN FILING LICENSE GRANTED ****

08/22/2007

| Foreign Priority claimed | 35 USC 119(a-d) conditions met | Verified and Acknowledged | Met after Allowance | STATE OR COUNTRY | SHEETS DRAWINGS | TOTAL CLAIMS | INDEPENDENT CLAIMS |
|---|---|---|---|---|---|---|---|
| ☐ Yes ☑ No | ☐ Yes ☑ No | /SHAWN AN/ Examiner's Signature | ☐ Initials | TX | 28 | 81 | 13 |

**ADDRESS**

Perman & Green, LLP
99 Hawley Lane
Stratford, CT 06614
UNITED STATES

**TITLE**

METHOD FOR SUB-PIXEL VALUE INTERPOLATION

| FILING FEE RECEIVED | | |
|---|---|---|
| 7022 | FEES: Authority has been given in Paper No._____ to charge/credit DEPOSIT ACCOUNT No._____ for following: | ☐ All Fees<br>☐ 1.16 Fees (Filing)<br>☐ 1.17 Fees (Processing Ext. of time)<br>☐ 1.18 Fees (Issue)<br>☐ Other _____<br>☐ Credit |

BIB (Rev. 05/07).

| Index of Claims | Application/Control No. | Applicant(s)/Patent under Reexamination |
|---|---|---|
| *11839205* | 11/839,205 | KARCZEWICZ ET AL. |
| | Examiner: SHAWN AN | Art Unit: 2483 |

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|---|---|---|---|---|---|---|---|
| √ | Rejected | – | (Through numeral) Cancelled | N | Non-Elected | A | Appeal |
| = | Allowed | ÷ | Restricted | I | Interference | O | Objected |

| Claim | | Date | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Final | Original | 12/21/10 | | | | | | | | |
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| 31 | 3 | = | | | | | | | | |
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| 42 | 32 | = | | | | | | | | |
| 43 | 33 | = | | | | | | | | |
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| 47 | 37 | = | | | | | | | | |
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| 49 | 39 | = | | | | | | | | |
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| 62 | 42 | = | | | | | | | | |
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| 64 | 48 | = | | | | | | | | |
| 68 | 49 | = | | | | | | | | |
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| Final | Original | 12/21/10 | | | | | | | | |
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| *Issue Classification* | Application/Control No. | Applicant(s)/Patent under Reexamination | |
|---|---|---|---|
| *1183920 5* | 11/839,205 | KARCZEWICZ ET AL. | |
| | Examiner | Art Unit | |
| | SHAWN AN | 2483 | |

# ISSUE CLASSIFICATION

| ORIGINAL | | | CROSS REFERENCE(S) | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| CLASS | SUBCLASS | CLASS | SUBCLASS (ONE SUBCLASS PER BLOCK) | | | | | | |
| 375 | 240.17 | 375 | 240.16 | 240.25 | 240.26 | 240.12 | | | |
| INTERNATIONAL CLASSIFICATION | | 382 | 238 | 236 | 233 | 235 | | | |
| H 0 4 B 1/66 | | | | | | | | | |
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| (Assistant Examiner) (Date) | /SHAWN AN/ 12/21/2010 | Total Claims Allowed: 81 |
| (Legal Instruments Examiner) (Date) | (Primary Examiner) (Date) | O.G. Print Claim(s): 1 / O.G. Print Fig.: 7 |

☐ Claims renumbered in the same order as presented by applicant ☐ CPA ☐ T.D. ☐ R.1.47

| Final | Original | Final | Original | Final | Original | Final | Original | Final | Original | Final | Original | Final | Original |
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| 30 | 2 | 42 | 32 | 20 | 62 | | 92 | | 122 | | 152 | | 182 |
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| 2 | 4 | 44 | 34 | 22 | 64 | | 94 | | 124 | | 154 | | 184 |
| 4 | 5 | 45 | 35 | 23 | 65 | | 95 | | 125 | | 155 | | 185 |
| 3 | 6 | 46 | 36 | 25 | 66 | | 96 | | 126 | | 156 | | 186 |
| 5 | 7 | 47 | 37 | 28 | 67 | | 97 | | 127 | | 157 | | 187 |
| 6 | 8 | 48 | 38 | 26 | 68 | | 98 | | 128 | | 158 | | 188 |
| 7 | 9 | 49 | 39 | 29 | 69 | | 99 | | 129 | | 159 | | 189 |
| 8 | 10 | 50 | 40 | 24 | 70 | | 100 | | 130 | | 160 | | 190 |
| 9 | 11 | 51 | 41 | 27 | 71 | | 101 | | 131 | | 161 | | 191 |
| 10 | 12 | 62 | 42 | 52 | 72 | | 102 | | 132 | | 162 | | 192 |
| 11 | 13 | 66 | 43 | 53 | 73 | | 103 | | 133 | | 163 | | 193 |
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| 14 | 16 | 63 | 46 | 57 | 76 | | 106 | | 136 | | 166 | | 196 |
| 15 | 17 | 67 | 47 | 60 | 77 | | 107 | | 137 | | 167 | | 197 |
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| 17 | 19 | 68 | 49 | 61 | 79 | | 109 | | 139 | | 169 | | 199 |
| 18 | 20 | 70 | 50 | 56 | 80 | | 110 | | 140 | | 170 | | 200 |
| 19 | 21 | 72 | 51 | 59 | 81 | | 111 | | 141 | | 171 | | 201 |
| 32 | 22 | 65 | 52 | | 82 | | 112 | | 142 | | 172 | | 202 |
| 33 | 23 | 73 | 53 | | 83 | | 113 | | 143 | | 173 | | 203 |
| 35 | 24 | 74 | 54 | | 84 | | 114 | | 144 | | 174 | | 204 |
| 34 | 25 | 77 | 55 | | 85 | | 115 | | 145 | | 175 | | 205 |
| 36 | 26 | 75 | 56 | | 86 | | 116 | | 146 | | 176 | | 206 |
| 37 | 27 | 78 | 57 | | 87 | | 117 | | 147 | | 177 | | 207 |
| 38 | 28 | 76 | 58 | | 88 | | 118 | | 148 | | 178 | | 208 |

| | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 39 | 29 | | 79 | 59 | | | 89 | | | 119 | | | 149 | | | 179 | | | 209 |
| 40 | 30 | | 80 | 60 | | | 90 | | | 120 | | | 150 | | | 180 | | | 210 |

| Search Notes | Application/Control No. | Applicant(s)/Patent under Reexamination | |
|---|---|---|---|
| *11839205* | 11/839,205 | KARCZEWICZ ET AL. | |
| | Examiner | Art Unit | |
| | SHAWN AN | 2483 | |

| SEARCHED | | | |
|---|---|---|---|
| Class | Subclass | Date | Examiner |
| 375 | 240.17 | 12/20/2010 | SA |
| | 240.16 | | SA |
| | 240.25 | | SA |
| | 240.26 | | SA |
| | 240.12 | | SA |
| 382 | 238 | | SA |
| | 236 | | SA |
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| | 235 | | SA |
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| INTERFERENCE SEARCHED | | | |
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| Class | Subclass | Date | Examiner |
| **375** | **240.17** | 12/20/2010 | **SA** |
| | 240.16 | | SA |
| | 240.25 | | SA |
| 382/238<br>382/236 | | | SA |

| SEARCH NOTES (INCLUDING SEARCH STRATEGY) | | |
|---|---|---|
| | DATE | EXMR |
| Search updated. | 12/20/2010 | SA |
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Alexandria, Virginia 22313-1450
www.uspto.gov

| APPLICATION NUMBER | PATENT NUMBER | GROUP ART UNIT | FILE WRAPPER LOCATION |
|---|---|---|---|
| 11/839,205 | | 2483 | 26L2 |

OC000000046587238

# Correspondence Address/Fee Address Change

**The following fields have been set to Customer Number 10868 on 02/07/2011**

- **Correspondence Address**
- **Power of Attorney Address**

**The address of record for Customer Number 10868 is:**

**10868**
**Perman & Green, LLP**
**99 Hawley Lane**
**Stratford, CT 06614**

PART 1 - ATTORNEY/APPLICANT COPY
page 1 of 1

PTO/SB/30EFS (07-09)
Approved for use through 07/31/2012. OMB 0651-0031
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it contains a valid OMB control number.

# REQUEST FOR CONTINUED EXAMINATION(RCE)TRANSMITTAL
## (Submitted Only via EFS-Web)

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Application Number | 11839205 | Filing Date | 2007-08-15 | Docket Number (if applicable) | 982-010567-US (C02) | Art Unit | 2621 |
| First Named Inventor | Marta Karczewicz | | | Examiner Name | An, Shawn S. | | |

**This is a Request for Continued Examination (RCE) under 37 CFR 1.114 of the above-identified application.**
Request for Continued Examination (RCE) practice under 37 CFR 1.114 does not apply to any utility or plant application filed prior to June 8, 1995, or to any design application. The Instruction Sheet for this form is located at WWW.USPTO.GOV

### SUBMISSION REQUIRED UNDER 37 CFR 1.114

Note: If the RCE is proper, any previously filed unentered amendments and amendments enclosed with the RCE will be entered in the order in which they were filed unless applicant instructs otherwise. If applicant does not wish to have any previously filed unentered amendment(s) entered, applicant must request non-entry of such amendment(s).

☐ Previously submitted. If a final Office action is outstanding, any amendments filed after the final Office action may be considered as a submission even if this box is not checked.

- ☐ Consider the arguments in the Appeal Brief or Reply Brief previously filed on _____
- ☐ Other _____

☒ Enclosed

- ☒ Amendment/Reply
- ☐ Information Disclosure Statement (IDS)
- ☐ Affidavit(s)/ Declaration(s)
- ☐ Other _____

### MISCELLANEOUS

☐ Suspension of action on the above-identified application is requested under 37 CFR 1.103(c) for a period of months _____ (Period of suspension shall not exceed 3 months; Fee under 37 CFR 1.17(i) required)

☐ Other _____

### FEES

☒ **The RCE fee under 37 CFR 1.17(e) is required by 37 CFR 1.114 when the RCE is filed.**
The Director is hereby authorized to charge any underpayment of fees, or credit any overpayments, to Deposit Account No 161350

### SIGNATURE OF APPLICANT, ATTORNEY, OR AGENT REQUIRED

☒ Patent Practitioner Signature

☐ Applicant Signature

PTO/SB/30EFS (07-09)
Approved for use through 07/31/2012. OMB 0651-0031
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
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| Signature of Registered U.S. Patent Practitioner | | | |
|---|---|---|---|
| Signature | /jvg44695/ | Date (YYYY-MM-DD) | 2011-03-28 |
| Name | Joseph V. Gamberdell, Jr. | Registration Number | 44695 |

This collection of information is required by 37 CFR 1.114. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.11 and 1.14. This collection is estimated to take 12 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450.

*If you need assistance in completing the form, call 1-800-PTO-9199 and select option 2.*

# Privacy Act Statement

The Privacy Act of 1974 (P.L. 93-579) requires that you be given certain information in connection with your submission of the attached form related to a patent application or patent. Accordingly, pursuant to the requirements of the Act, please be advised that: (1) the general authority for the collection of this information is 35 U.S.C. 2(b)(2); (2) furnishing of the information solicited is voluntary; and (3) the principal purpose for which the information is used by the U.S. Patent and Trademark Office is to process and/or examine your submission related to a patent application or patent. If you do not furnish the requested information, the U.S. Patent and Trademark Office may not be able to process and/or examine your submission, which may result in termination of proceedings or abandonment of the application or expiration of the patent.

The information provided by you in this form will be subject to the following routine uses:

1. The information on this form will be treated confidentially to the extent allowed under the Freedom of Information Act (5 U.S.C. 552) and the Privacy Act (5 U.S.C. 552a). Records from this system of records may be disclosed to the Department of Justice to determine whether the Freedom of Information Act requires disclosure of these records.

2. A record from this system of records may be disclosed, as a routine use, in the course of presenting evidence to a court, magistrate, or administrative tribunal, including disclosures to opposing counsel in the course of settlement negotiations.

3. A record in this system of records may be disclosed, as a routine use, to a Member of Congress submitting a request involving an individual, to whom the record pertains, when the individual has requested assistance from the Member with respect to the subject matter of the record.

4. A record in this system of records may be disclosed, as a routine use, to a contractor of the Agency having need for the information in order to perform a contract. Recipients of information shall be required to comply with the requirements of the Privacy Act of 1974, as amended, pursuant to 5 U.S.C. 552a(m).

5. A record related to an International Application filed under the Patent Cooperation Treaty in this system of records may be disclosed, as a routine use, to the International Bureau of the World Intellectual Property Organization, pursuant to the Patent Cooperation Treaty.

6. A record in this system of records may be disclosed, as a routine use, to another federal agency for purposes of National Security review (35 U.S.C. 181) and for review pursuant to the Atomic Energy Act (42 U.S.C. 218(c)).

7. A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (i.e., GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.

8. A record from this system of records may be disclosed, as a routine use, to the public after either publication of the application pursuant to 35 U.S.C. 122(b) or issuance of a patent pursuant to 35 U.S.C. 151. Further, a record may be disclosed, subject to the limitations of 37 CFR 1.14, as a routine use, to the public if the record was filed in an application which became abandoned or in which the proceedings were terminated and which application is referenced by either a published application, an application open to public inspections or an issued patent.

9. A record from this system of records may be disclosed, as a routine use, to a Federal, State, or local law enforcement agency, if the USPTO becomes aware of a violation or potential violation of law or regulation.

# Electronic Patent Application Fee Transmittal

| | |
|---|---|
| **Application Number:** | 11839205 |
| **Filing Date:** | 15-Aug-2007 |
| **Title of Invention:** | METHOD FOR SUB-PIXEL VALUE INTERPOLATION |
| **First Named Inventor/Applicant Name:** | Marta Karczewicz |
| **Filer:** | Joseph V. Gamberdell/Sarah Nadeau |
| **Attorney Docket Number:** | 982-010567-US (C02) |

Filed as Large Entity

## Utility under 35 USC 111(a) Filing Fees

| Description | Fee Code | Quantity | Amount | Sub-Total in USD($) |
|---|---|---|---|---|
| **Basic Filing:** | | | | |
| **Pages:** | | | | |
| **Claims:** | | | | |
| **Miscellaneous-Filing:** | | | | |
| **Petition:** | | | | |
| **Patent-Appeals-and-Interference:** | | | | |
| **Post-Allowance-and-Post-Issuance:** | | | | |
| **Extension-of-Time:** | | | | |

| Description | Fee Code | Quantity | Amount | Sub-Total in USD($) |
|---|---|---|---|---|
| **Miscellaneous:** | | | | |
| Request for continued examination | 1801 | 1 | 810 | 810 |
| | | **Total in USD ($)** | | **810** |

# Electronic Acknowledgement Receipt

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| **EFS ID:** | 9751327 |
| **Application Number:** | 11839205 |
| **International Application Number:** | |
| **Confirmation Number:** | 8091 |
| **Title of Invention:** | METHOD FOR SUB-PIXEL VALUE INTERPOLATION |
| **First Named Inventor/Applicant Name:** | Marta Karczewicz |
| **Customer Number:** | 10868 |
| **Filer:** | Joseph V. Gamberdell/Sarah Nadeau |
| **Filer Authorized By:** | Joseph V. Gamberdell |
| **Attorney Docket Number:** | 982-010567-US (C02) |
| **Receipt Date:** | 28-MAR-2011 |
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| **Time Stamp:** | 15:01:39 |
| **Application Type:** | Utility under 35 USC 111(a) |

## Payment information:

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| Submitted with Payment | yes |
| Payment Type | Deposit Account |
| Payment was successfully received in RAM | $810 |
| RAM confirmation Number | 1628 |
| Deposit Account | 161350 |
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| The Director of the USPTO is hereby authorized to charge indicated fees and credit any overpayment as follows: Charge any Additional Fees required under 37 C.F.R. Section 1.21 (Miscellaneous fees and charges) | |

## File Listing:

| Document Number | Document Description | File Name | File Size(Bytes)/ Message Digest | Multi Part /.zip | Pages (if appl.) |
|---|---|---|---|---|---|
| 1 | Amendment after Notice of Allowance (Rule 312) | AmendmentAfterNoticeofAllow110328a.pdf | 121359<br>dbef468338a34f14fffa0e4a302572928f64a7c3 | no | 27 |
| **Warnings:** | | | | | |
| **Information:** | | | | | |
| 2 | Request for Continued Examination (RCE) | sb0030e_fill_RCE.pdf | 697282<br>2f113504aeb8fd027c590ddabed230ad683aa14c | no | 3 |
| **Warnings:** | | | | | |
| **Information:** | | | | | |
| 3 | Fee Worksheet (PTO-875) | fee-info.pdf | 31125<br>a06e71df798f700478f953f86a4083e536b0c838 | no | 2 |
| **Warnings:** | | | | | |
| **Information:** | | | | | |
| | | **Total Files Size (in bytes):** | 849766 | | |

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**New Applications Under 35 U.S.C. 111**

**If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.**

**National Stage of an International Application under 35 U.S.C. 371**

**If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.**

**New International Application Filed with the USPTO as a Receiving Office**

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**IN THE UNITED STATES PATENT AND TRADEMARK OFFICE**

| | | | |
|---|---|---|---|
| APPLICANT(s): | Marta Karczewicz | CONF. NO.: | 8091 |
| SERIAL NO.: | 11/839,205 | ART UNIT: | 2621 |
| FILING DATE: | 08/15/2007 | EXAMINER: | An, Shawn S. |
| TITLE: | METHOD FOR SUB-PIXEL VALUE INTERPOLATION | | |
| ATTORNEY DOCKET NO.: | 982-010567-US (C02) | | |

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Alexandria VA 22313-1450

**AMENDMENT**

## I. INTRODUCTION

This is a submission included with a Request for Continued Examination for the above-identified patent application in response to the Notice of Allowance mailed December 28, 2010.

Reconsideration of the rejection of the claims is respectfully solicited in light of the following amendment and remarks.

## III. REMARKS

The claims have been amended to correct typographical errors.

Claims 82 and 83 are new and depend from claims 69 and 79, respectively. Applicant has taken care to avoid adding new matter

The Commissioner is hereby authorized to charge payment for any fees associated with this communication or credit any over payment to Deposit Account No. 16-1350.

Respectfully submitted,

/jvg44695/ March 28, 2011

Joseph V. Gamberdell, Jr. Date
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# PATENT APPLICATION FEE DETERMINATION RECORD

Substitute for Form PTO-875

| Application or Docket Number | Filing Date | ☐ To be Mailed |
|---|---|---|
| 11/839,205 | 08/15/2007 | |

## APPLICATION AS FILED – PART I

| FOR | (Column 1) NUMBER FILED | (Column 2) NUMBER EXTRA | SMALL ENTITY ☐ RATE ($) | SMALL ENTITY ☐ FEE ($) | OR | OTHER THAN SMALL ENTITY RATE ($) | OTHER THAN SMALL ENTITY FEE ($) |
|---|---|---|---|---|---|---|---|
| ☐ BASIC FEE (37 CFR 1.16(a), (b), or (c)) | N/A | N/A | N/A | | | N/A | |
| ☐ SEARCH FEE (37 CFR 1.16(k), (i), or (m)) | N/A | N/A | N/A | | | N/A | |
| ☐ EXAMINATION FEE (37 CFR 1.16(o), (p), or (q)) | N/A | N/A | N/A | | | N/A | |
| TOTAL CLAIMS (37 CFR 1.16(i)) | minus 20 = | * | X $ = | | OR | X $ = | |
| INDEPENDENT CLAIMS (37 CFR 1.16(h)) | minus 3 = | * | X $ = | | | X $ = | |
| ☐ APPLICATION SIZE FEE (37 CFR 1.16(s)) | If the specification and drawings exceed 100 sheets of paper, the application size fee due is $250 ($125 for small entity) for each additional 50 sheets or fraction thereof. See 35 U.S.C. 41(a)(1)(G) and 37 CFR 1.16(s). | | | | | | |
| ☐ MULTIPLE DEPENDENT CLAIM PRESENT (37 CFR 1.16(j)) | | | | | | | |
| * If the difference in column 1 is less than zero, enter "0" in column 2. | | | TOTAL | | | TOTAL | |

## APPLICATION AS AMENDED – PART II

| AMENDMENT | 03/28/2011 | (Column 1) CLAIMS REMAINING AFTER AMENDMENT | | (Column 2) HIGHEST NUMBER PREVIOUSLY PAID FOR | (Column 3) PRESENT EXTRA | SMALL ENTITY RATE ($) | SMALL ENTITY ADDITIONAL FEE ($) | OR | OTHER THAN SMALL ENTITY RATE ($) | OTHER THAN SMALL ENTITY ADDITIONAL FEE ($) |
|---|---|---|---|---|---|---|---|---|---|---|
| | Total (37 CFR 1.16(i)) | * 87 | Minus | ** 85 | = 2 | X $ = | | OR | X $52= | 104 |
| | Independent (37 CFR 1.16(h)) | * 13 | Minus | ***13 | = 0 | X $ = | | OR | X $220= | 0 |
| | ☐ Application Size Fee (37 CFR 1.16(s)) | | | | | | | | | |
| | ☐ FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j)) | | | | | | | OR | | |
| | | | | | | TOTAL ADD'L FEE | | OR | TOTAL ADD'L FEE | **104** |

| AMENDMENT | | (Column 1) CLAIMS REMAINING AFTER AMENDMENT | | (Column 2) HIGHEST NUMBER PREVIOUSLY PAID FOR | (Column 3) PRESENT EXTRA | RATE ($) | ADDITIONAL FEE ($) | | RATE ($) | ADDITIONAL FEE ($) |
|---|---|---|---|---|---|---|---|---|---|---|
| | Total (37 CFR 1.16(i)) | * | Minus | ** | = | X $ = | | OR | X $ = | |
| | Independent (37 CFR 1.16(h)) | * | Minus | *** | = | X $ = | | OR | X $ = | |
| | ☐ Application Size Fee (37 CFR 1.16(s)) | | | | | | | | | |
| | ☐ FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j)) | | | | | | | OR | | |
| | | | | | | TOTAL ADD'L FEE | | OR | TOTAL ADD'L FEE | |

* If the entry in column 1 is less than the entry in column 2, write "0" in column 3.

** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 20, enter "20".

*** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 3, enter "3".

The "Highest Number Previously Paid For" (Total or Independent) is the highest number found in the appropriate box in column 1.

Legal Instrument Examiner:
/Fennell A. Pearlie/

This collection of information is required by 37 CFR 1.16. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 12 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

*If you need assistance in completing the form, call 1-800-PTO-9199 and select option 2.*

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## II. CLAIM AMENDMENTS

1. (Previously Presented) A method for sub-pixel value interpolation to determine values for sub-pixels situated within a rectangular bounded region defined by four corner pixels with no intermediate pixels between the corners, the pixels and sub-pixels being configured for display in rows and columns, pixel and sub-pixel locations in the rows and columns being representable mathematically within the rectangular bounded region using the co-ordinate notation $K/2^N$, $L/2^N$, K and L being positive integers having respective values between zero and $2^N$, N being a positive integer greater than one and representing a particular degree of sub-pixel value interpolation, the method comprising causing an apparatus to:

- interpolate a sub-pixel value for a sub-pixel having co-ordinates with odd values of K and L, according to a predetermined choice of either a weighted average of the value of a nearest-neighbouring pixel and the value of the sub-pixel situated at co-ordinates 1/2, 1/2, or a weighted average of the values of a pair of diagonally-opposed sub-pixels having co-ordinates with even values of K and L, including zero, situated within a quadrant of the rectangular bounded region, the quadrant being defined by the sub-pixel having co-ordinates 1/2, 1/2 and the nearest neighbouring pixel;
- interpolate sub-pixel values for sub-pixels having co-ordinates with K equal to an even value and L equal to zero and sub-pixels having co-ordinates with K equal to zero and L equal to an even value, used in the interpolation of the sub-pixels having co-ordinates with odd values of K and L, using weighted sums of the values of pixels located in rows and columns respectively; and
- interpolate sub-pixel values for sub-pixels having co-ordinates with even values of K and L, used in the interpolation of sub-pixel values for the sub-pixels having co-ordinates with odd values of K and L, using a predetermined choice of either a weighted sum of the values of sub-pixels having co-ordinates with K equal to an even value and L equal to zero and the values of sub-pixels having corresponding co-ordinates in immediately adjacent rectangular bounded regions, or a weighted sum of the values of sub-pixels having co-ordinates with K equal to zero and L equal to an even value and the values of sub-pixels having corresponding co-ordinates in immediately adjacent rectangular bounded regions.

2. (Previously Presented) A method for quarter resolution sub-pixel value interpolation to determine values for sub-pixels situated within a rectangular bounded region defined by four corner pixels with no intermediate pixels between the corners, the pixels and sub-pixels being configured for display in rows and columns, pixel and sub-pixel locations in the rows and columns being representable mathematically within the rectangular bounded region using the co-ordinate notation K/4, L/4, K and L being positive integers having respective values between zero and 4, the method comprising causing an apparatus to:

- interpolate a sub-pixel value for a sub-pixel having co-ordinates with K and L equal to 1 or 3, according to a predetermined choice of either a weighted average of the value of a nearest-neighbouring pixel and the value of the sub-pixel situated at co-ordinates 2/4, 2/4, or a weighted average of the values of a pair of diagonally-opposed sub-pixels having co-ordinates with K and L equal to zero, 2 or 4, situated within a quadrant of the rectangular bounded region, the quadrant being defined by the sub-pixel having co-ordinates 2/4, 2/4 and the nearest neighbouring pixel;
- interpolate sub-pixel values for sub-pixels having co-ordinates with K equal to 2 and L equal to zero and sub-pixels having co-ordinates with K equal to zero and L equal to 2, used in the interpolation of the sub-pixels having co-ordinates with K and L equal to 1 or 3, using weighted sums of the values of pixels located in rows and columns respectively; and
- interpolate a sub-pixel value for the sub-pixel having co-ordinates with K and L equal to 2, used in the interpolation of sub-pixel values for the sub-pixels having co-ordinates with K and L equal to 1 or 3, using a predetermined choice of either a weighted sum of the values of the sub-pixel having co-ordinates with K equal to 2 and L equal to zero and the values of sub-pixels having corresponding co-ordinates in immediately adjacent rectangular bounded regions, or a weighted sum of the value of the sub-pixel having co-ordinates with K equal to zero and L equal to 2 and the values of sub-pixels having corresponding co-ordinates in immediately adjacent rectangular bounded regions.

3. (Previously Presented) A method for eighth resolution sub-pixel value interpolation to determine values for sub-pixels situated within a rectangular bounded region defined by four corner pixels with no intermediate pixels between the corners, the pixels and sub-pixels being configured for display in rows and columns, pixel and sub-pixel locations in the rows and columns being representable mathematically with the rectangular bounded region using the co-

ordinate notation K/8, L/8, K and L being positive integers having respective values between zero and 8, the method comprising causing an apparatus to:

- interpolate a sub-pixel value for a sub-pixel having co-ordinates with K and L equal to 1, 3, 5 or 7, according to a predetermined choice of either a weighted average of the value of a nearest-neighbouring pixel and the value of the sub-pixel situated at co-ordinates 4/8, 4/8, or a weighted average of the values of a pair of diagonally-opposed sub-pixels having co-ordinates with K and L equal to zero, 2, 4, 6 or 8, situated within a quadrant of the rectangular bounded region, the quadrant being defined by the sub-pixel having co-ordinates 4/8, 4/8 and the nearest neighbouring pixel;
- interpolate sub-pixel values for sub-pixels having co-ordinates with K equal to 2, 4 or 6 and L equal to zero and sub-pixels having co-ordinates with K equal to zero and L equal to 2, 4 or 6, used in the interpolation of the sub-pixels having co-ordinates with K and L equal to 1, 3, 5 or 7, using weighted sums of the values of pixels located in rows and columns respectively; and
- interpolate sub-pixel values for sub-pixels having co-ordinates with K and L equal to 2, 4 or 6, used in the interpolation of sub-pixel values for the sub-pixels having co-ordinates with K and L equal to 1, 3, 5 or 7, using a predetermined choice of either a weighted sum of the values of sub-pixels having co-ordinates with K equal to 2, 4 or 6 and L equal to zero and the values of sub-pixels having corresponding co-ordinates in immediately adjacent rectangular bounded regions or a weighted sum of the values of sub-pixels having co-ordinates with K equal to zero and L equal to 2, 4 or 6 and the values of sub-pixels having corresponding co-ordinates in immediately adjacent rectangular bounded regions.

4. (Previously Presented) A method according to claim 1, comprising causing the apparatus to use a first and a second weight in the weighted average chosen to interpolate the sub-pixel value for a sub-pixel having co-ordinates with odd values of K and L, wherein when the chosen weighted average is that involving the value of a nearest neighbouring pixel and the value of the sub-pixel situated at co-ordinates 1/2, 1/2, causing the apparatus to select the relative magnitudes of the first and second weights to be inversely proportional to the respective straight-line diagonal distances of the nearest-neighbouring pixel and the sub-pixel situated at co-ordinates 1/2, 1/2 to the sub-pixel having co-ordinates with odd values of K and L whose value is being interpolated.

5. (Previously Presented) A method according to claim 1, comprising causing the apparatus to use a first and a second weight in the weighted average chosen to interpolate the sub-pixel value for a sub-pixel having co-ordinates with odd values of K and L, wherein when the chosen weighted average is that involving the values of a pair of diagonally-opposed sub-pixels having co-ordinates with even values of K and L, causing the apparatus to select the relative magnitudes of the first and second weights to be inversely proportional to the respective straight-line diagonal distances of the sub-pixels having co-ordinates with even values of K and L to the sub-pixel having co-ordinates with odd values of K and L whose value is being interpolated.

6. (Previously Presented) A method according to claim 4, comprising causing the apparatus to use first and second weights with equal values when the nearest-neighbouring pixel and sub-pixel situated at co-ordinates 1/2, 1/2 are equidistant from the sub-pixel having co-ordinates with odd values of K and L whose value is being interpolated.

7. (Previously Presented) A method according to claim 5, comprising causing the apparatus to use first and second weights with equal values when the sub-pixels having co-ordinates with even values of K and L are equidistant from the sub-pixel having co-ordinates with odd values of K and L whose value is being interpolated.

8. (Previously Presented) A method according to claim 1, comprising causing the apparatus to interpolate sub-pixel values for sub-pixels having co-ordinates with even values of K and L, used in interpolation of sub-pixel values for the sub-pixels having co-ordinates with odd values of K and L, using a weighted sum of the values of sub-pixels having co-ordinates with K equal to an even value and L equal to zero and the values of sub-pixels having corresponding co-ordinates in immediately adjacent rectangular bounded regions when the value of a sub-pixel having co-ordinates with K equal to an even value and L equal to an odd value is also required.

9. (Previously Presented) A method according to claim 1, comprising causing the apparatus to interpolate sub-pixel values for sub-pixels having co-ordinates with even values of K and L, used in interpolation of sub-pixel values for the sub-pixels having co-ordinates with odd values of K and L, using a weighted sum of the values of sub-pixels having co-ordinates with K equal to

zero and L equal to an even value and the values of sub-pixels having corresponding co-ordinates in immediately adjacent rectangular bounded regions when the value of a sub-pixel having co-ordinates with K equal to an odd value and L equal to an even value is also required.

10. (Previously Presented) A method according to claim 1, comprising causing the apparatus to interpolate sub-pixel values for sub-pixels having co-ordinates with K equal to an odd value O and L equal to an even value E, not including zero or $2^N$, by taking an average of the value of a first sub-pixel having co-ordinates with K equal to the even value O - 1 and L equal to E and a second sub-pixel having co-ordinates with K equal to the even value O + 1 and L equal to E.

11. (Previously Presented) A method according to claim 1, comprising causing the apparatus to interpolate a sub-pixel value for a sub-pixel having co-ordinates with K equal to 1 and L equal to zero, by taking an average of the value of a pixel having co-ordinates with K equal to zero and L equal to zero, and a sub-pixel having co-ordinates with K equal to 2 and L equal to zero.

12. (Previously Presented) A method according to claim 1, comprising causing the apparatus to interpolate a sub-pixel value for a sub-pixel having co-ordinates with K equal to $2^N$ - 1 and L equal to zero, by taking an average of the value of a pixel having co-ordinates with K equal to $2^N$ and L equal to zero, and a sub-pixel having co-ordinates with K equal to $2^N$ - 2 and L equal to zero.

13. (Previously Presented) A method according to claim 1, comprising causing the apparatus to interpolate a sub-pixel value for a sub-pixel having co-ordinates with K equal to 1 and L equal to $2^N$, by taking an average of the value of a pixel having co-ordinates with K equal to zero and L equal to $2^N$, and a sub-pixel having co-ordinates with K equal to 2 and L equal to $2^N$.

14. (Previously Presented) A method according to claim 1, comprising causing the apparatus to interpolate a sub-pixel value for a sub-pixel having co-ordinates with K equal to $2^N$ - 1 and L equal to $2^N$, by taking an average of the value of a pixel having co-ordinates with K equal to $2^N$ and L equal to $2^N$, and a sub-pixel having co-ordinates with K equal to $2^N$ - 2 and L equal to $2^N$.

15. (Previously Presented) A method according to claim 1, comprising causing the apparatus to interpolate sub-pixel values for sub-pixels having co-ordinates with K equal to an even value

E, not including zero or $2^N$, and L equal to an odd value O, by taking an average of the value of a first sub-pixel having co-ordinates with K equal to E and L equal to the even value O - 1 and a second sub-pixel having co-ordinates with K equal to E and L equal to the even value O + 1.

16. (Previously Presented) A method according to claim 1, comprising causing the apparatus to interpolate a sub-pixel value for a sub-pixel having co-ordinates with K equal to zero and L equal to 1, by taking an average of the value of a pixel having co-ordinates with K equal to zero and L equal to zero, and a sub-pixel having co-ordinates with K equal to zero and L equal to 2.

17. (Previously Presented) A method according to claim 1, comprising causing the apparatus to interpolate a sub-pixel value for a sub-pixel having co-ordinates with K equal to $2^N$ and L equal to 1, by taking an average of the value of a pixel having co-ordinates with K equal to $2^N$ and L equal to zero, and a sub-pixel having co-ordinates with K equal to $2^N$ and L equal to 2.

18. (Currently amended) A method according to claim 1, comprising causing the apparatus to interpolate a sub-pixel value for a sub-pixel having co-ordinates with K equal to 0zero[SW1] and L equal to $2^N$ - 1, by taking an average of the value of a pixel having co-ordinates with K equal to zero and L equal to $2^N$, and a sub-pixel having co-ordinates with K equal to zero and L equal to $2^N$ - 2.

19. (Previously Presented) A method according to claim 1, comprising causing the apparatus to interpolate a sub-pixel value for a sub-pixel having co-ordinates with K equal to $2^N$ and L equal to $2^N$ - 1, by taking an average of the value of a pixel having co-ordinates with K equal to $2^N$ and L equal to $2^N$, and a sub-pixel having co-ordinates with K equal to $2^N$ and L equal to $2^N$ - 2.

20. (Previously Presented) A method according to claim 1, comprising causing the apparatus to interpolate a sub-pixel value for the sub-pixel having co-ordinates with K equal to $2^N$ - 1 and L equal to $2^N$ - 1, by taking a weighted average of the values of the four corner pixels that define the rectangular bounded region.

21. (Previously Presented) A method according to claim 1, in which N is one of the values 2, 3, and 4.

22. (Currently amended) An interpolator for sub-pixel value interpolation, the interpolator being configured to determine values for sub-pixels situated within a rectangular bounded region defined by four corner pixels with no intermediate pixels between the corners, the pixels and sub-pixels being configured for display in rows and columns, pixel and sub-pixel locations in the rows and columns being representable mathematically within the rectangular bounded region using the co-ordinate notation $K/2^N$, $L/2^N$, K and L being positive integers having respective values between zero and $2^N$, N being a positive integer greater than one and representing a particular degree of sub-pixel value interpolation, the interpolator being configured to:

- interpolate a sub-pixel value for a sub-pixel having co-ordinates with odd values of K and L, according to a predetermined choice of either a weighted average of the value of a nearest-neighbouring pixel and the value of the sub-pixel situated at co-ordinates 1/2, 1/2, or a weighted average of the values of a pair of diagonally-opposed sub-pixels having co-ordinates with even values of K and L, including zero, situated within a quadrant of the rectangular bounded region, the quadrant being defined by the sub-pixel having co-ordinates 1/2, 1/2 and the nearest neighbouring pixel;
- interpolate sub-pixel values for sub-pixels having co-ordinates with K equal to an even value and L equal to zero and sub-pixels having co-ordinates with K equal to zero and L equal to an even value, used in the interpolation of the sub-pixels having co-ordinates with odd values of K and L, using weighted sums of the values of pixels located in rows and columns respectively; and
- interpolate sub-pixel values for sub-pixels having co-ordinates with even values of K and L, used in the interpolation of sub-pixel values for the sub-pixels having co-ordinates with odd values of K and L, using a predetermined choice of either a weighted sum of the values of sub-pixels having co-ordinates with K equal to an even value and L equal to zero and the values of sub-pixels having corresponding co-ordinates in immediately adjacent rectangular bounded regions, or a weighted sum of the values of sub-pixels having co-ordinates with K equal to zero and L equal to an even value and the values of sub-pixels having corresponding co-ordinates in immediately adjacent rectangular bounded ~~rectangular~~ regions[SW2].

23. (Previously Presented) An interpolator according to claim 22, wherein the interpolator is configured to use a first and a second weight in the weighted average chosen to interpolate the sub-pixel value for a sub-pixel having co-ordinates with odd values of K and L, wherein when the chosen weighted average is that involving the value of a nearest neighbouring pixel and the value of the sub-pixel situated at co-ordinates 1/2, 1/2, the interpolator is configured to select the relative magnitudes of the first and second weights to be inversely proportional to the respective straight-line diagonal distances of the nearest-neighbouring pixel and the sub-pixel situated at co-ordinates 1/2, 1/2 to the sub-pixel having co-ordinates with odd values of K and L whose value is being interpolated.

24. (Previously Presented) An interpolator according to claim 22, wherein the interpolator is configured to use a first and a second weight in the weighted average chosen to interpolate the sub-pixel value for a sub-pixel having co-ordinates with odd values of K and L, wherein when the chosen weighted average is that involving the values of a pair of diagonally-opposed sub-pixels having co-ordinates with even values of K and L, the interpolator is configured to select the relative magnitudes of the first and second weights to be inversely proportional to the respective straight-line diagonal distances of the sub-pixels having co-ordinates with even values of K and L to the sub-pixel having co-ordinates with odd values of K and L whose value is being interpolated.

25. (Previously Presented) An interpolator according to claim 23, wherein the interpolator is configured to use first and second weights with equal values when the nearest-neighbouring pixel and sub-pixel situated at co-ordinates 1/2, 1/2 are equidistant from the sub-pixel having co-ordinates with odd values of K and L whose value is being interpolated.

26. (Previously Presented) An interpolator according to claim 24, wherein the interpolator is configured to use first and second weights with equal values when the sub-pixels having co-ordinates with even values of K and L are equidistant from the sub-pixel having co-ordinates with odd values of K and L whose value is being interpolated.

27. (Previously Presented) An interpolator according to claim 22, wherein the interpolator is configured to interpolate sub-pixel values for sub-pixels having co-ordinates with even values of K and L, used in interpolation of sub-pixel values for the sub-pixels having co-ordinates with odd

values of K and L, using a weighted sum of the values of sub-pixels having co-ordinates with K equal to an even value and L equal to zero and the values of sub-pixels having corresponding co-ordinates in immediately adjacent rectangular bounded regions when the value of a sub-pixel having co-ordinates with K equal to an even value and L equal to an odd value is also required.

28. (Previously Presented) An interpolator according to claim 22, wherein the interpolator is configured to interpolate sub-pixel values for sub-pixels having co-ordinates with even values of K and L, used in interpolation of sub-pixel values for the sub-pixels having co-ordinates with odd values of K and L, using a weighted sum of the values of sub-pixels having co-ordinates with K equal to zero and L equal to an even value and the values of sub-pixels having corresponding co-ordinates in immediately adjacent rectangular bounded regions when the value of a sub-pixel having co-ordinates with K equal to an odd value and L equal to an even value is also required.

29. (Previously Presented) An interpolator according to claim 22, wherein the interpolator is configured to interpolate sub-pixel values for sub-pixels having co-ordinates with K equal to an odd value O and L equal to an even value E, not including zero or $2^N$, by taking an average of the value of a first sub-pixel having co-ordinates with K equal to the even value O - 1 and L equal to E and a second sub-pixel having co-ordinates with K equal to the even value O + 1 and L equal to E.

30. (Previously Presented) An interpolator according to claim 22, wherein the interpolator is configured to interpolate a sub-pixel value for a sub-pixel having co-ordinates with K equal to 1 and L equal to zero, by taking an average of the value of a pixel having co-ordinates with K equal to zero and L equal to zero, and a sub-pixel having co-ordinates with K equal to 2 and L equal to zero.

31. (Previously Presented) An interpolator according to claim 22, wherein the interpolator is configured to interpolate a sub-pixel value for a sub-pixel having co-ordinates with K equal to $2^N$ - 1 and L equal to zero, by taking an average of the value of a pixel having co-ordinates with K equal to $2^N$ and L equal to zero, and a sub-pixel having co-ordinates with K equal to $2^N$ - 2 and L equal to zero.

32. (Previously Presented) An interpolator according to claim 22, wherein the interpolator is configured to interpolate a sub-pixel value for a sub-pixel having co-ordinates with K equal to 1 and L equal to $2^N$, by taking an average of the value of a pixel having co-ordinates with K equal to zero and L equal to $2^N$, and a sub-pixel having co-ordinates with K equal to 2 and L equal to $2^N$.

33. (Previously Presented) An interpolator according to claim 22, wherein the interpolator is configured to interpolate a sub-pixel value for a sub-pixel having co-ordinates with K equal to $2^N - 1$ and L equal to $2^N$, by taking an average of the value of a pixel having co-ordinates with K equal to $2^N$ and L equal to $2^N$, and a sub-pixel having co-ordinates with K equal to $2^N - 2$ and L equal to $2^N$.

34. (Previously Presented) An interpolator according to claim 22, wherein the interpolator is configured to interpolate sub-pixel values for sub-pixels having co-ordinates with K equal to an even value E, not including zero or $2^N$, and L equal to an odd value O, by taking an average of the value of a first sub-pixel having co-ordinates with K equal to E and L equal to the even value O - 1 and a second sub-pixel having co-ordinates with K equal to E and L equal to the even value O + 1.

35. (Previously Presented) An interpolator according to claim 22, wherein the interpolator is configured to interpolate a sub-pixel value for a sub-pixel having co-ordinates with K equal to zero and L equal to 1, by taking an average of the value of a pixel having co-ordinates with K equal to zero and L equal to zero, and a sub-pixel having co-ordinates with K equal to zero and L equal to 2.

36. (Currently amended) An interpolator according to claim 22, wherein the interpolator is configured to interpolate a sub-pixel value for a sub-pixel having co-ordinates with K equal to $2^N$ and L equal to 1, by taking an average of the value of a pixel having co-ordinates with K equal to $2^N$ and L equal to zero, and a sub-pixel having co-ordinates with K equal to ~~zero~~$2^N$ [SW3] and L equal to 2.

37. (Currently amended) An interpolator according to claim 22, wherein the interpolator is configured to interpolate a sub-pixel value for a sub-pixel having co-ordinates with K equal to

θzero[SW4] and L equal to $2^N$ - 1, by taking an average of the value of a pixel having co-ordinates with K equal to zero and L equal to $2^N$, and a sub-pixel having co-ordinates with K equal to zero and L equal to $2^N$ - 2.

38. (Previously Presented) An interpolator according to claim 22, wherein the interpolator is configured to interpolate a sub-pixel value for a sub-pixel having co-ordinates with K equal to $2^N$ and L equal to $2^N$ - 1, by taking an average of the value of a pixel having co-ordinates with K equal to $2^N$ and L equal to $2^N$, and a sub-pixel having co-ordinates with K equal to $2^N$ and L equal to $2^N$ - 2.

39. (Previously Presented) An interpolator according to claim 22, wherein the interpolator is configured to interpolate a sub-pixel value for the sub-pixel having co-ordinates with K equal to $2^N$ - 1 and L equal to $2^N$ - 1, by taking a weighted average of the values of the four corner pixels that define the rectangular bounded region.

40. (Previously Presented) An interpolator according to claim 22, wherein N is set equal to 2.

41. (Previously Presented) An interpolator according to claim 22, wherein N is set equal to 3.

42. (Currently amended) A video encoder comprising an interpolator for sub-pixel value interpolation, the interpolator being configured to determine values for sub-pixels situated within a rectangular bounded region defined by four corner pixels with no intermediate pixels between the corners, the pixels and sub-pixels being configured for display in rows and columns, pixel and sub-pixel locations in the rows and columns being representable mathematically within the rectangular bounded region using the co-ordinate notation $K/2^N$, $L/2^N$, K and L being positive integers having respective values between zero and $2^N$, N being a positive integer greater than one and representing a particular degree of sub-pixel value interpolation, the interpolator being configured to:

- interpolate a sub-pixel value for a sub-pixel having co-ordinates with odd values of K and L, according to a predetermined choice of either a weighted average of the value of a nearest-neighbouring pixel and the value of the sub-pixel situated at co-ordinates 1/2, 1/2, or a weighted average of the values of a pair of diagonally-opposed sub-pixels having co-ordinates with even values of K and L, including zero, situated within a quadrant of the

rectangular bounded region, the quadrant being defined by the sub-pixel having co-ordinates 1/2, 1/2 and the nearest neighbouring pixel;

- interpolate sub-pixel values for sub-pixels having co-ordinates with K equal to an even value and L equal to zero and sub-pixels having co-ordinates with K equal to zero and L equal to an even value, used in the interpolation of the sub-pixels having co-ordinates with odd values of K and L, using weighted sums of the values of pixels located in rows and columns respectively; and
- interpolate sub-pixel values for sub-pixels having co-ordinates with even values of K and L, used in the interpolation of sub-pixel values for the sub-pixels having co-ordinates with odd values of K and L, using a predetermined choice of either a weighted sum of the values of sub-pixels having co-ordinates with K equal to an even value and L equal to zero and the values of sub-pixels having corresponding co-ordinates in immediately adjacent rectangular bounded regions, or a weighted sum of the values of sub-pixels having co-ordinates with K equal to zero and L equal to an even value and the values of sub-pixels having corresponding co-ordinates in immediately adjacent rectangular bounded ~~rectangular~~ regions[SW5].

43. (Currently amended) A still image encoder comprising an interpolator for sub-pixel value interpolation, the interpolator being configured to determine values for sub-pixels situated within a rectangular bounded region defined by four corner pixels with no intermediate pixels between the corners, the pixels and sub-pixels being configured for display in rows and columns, pixel and sub-pixel locations in the rows and columns being representable mathematically within the rectangular bounded region using the co-ordinate notation $K/2^N$, $L/2^N$, K and L being positive integers having respective values between zero and $2^N$, N being a positive integer greater than one and representing a particular degree of sub-pixel value interpolation, the interpolator being configured to:

- interpolate a sub-pixel value for a sub-pixel having co-ordinates with odd values of K and L, according to a predetermined choice of either a weighted average of the value of a nearest-neighbouring pixel and the value of the sub-pixel situated at co-ordinates 1/2, 1/2, or a weighted average of the values of a pair of diagonally-opposed sub-pixels having co-ordinates with even values of K and L, including zero, situated within a quadrant of the rectangular bounded region, the quadrant being defined by the sub-pixel having co-ordinates 1/2, 1/2 and the nearest neighbouring pixel;

- interpolate sub-pixel values for sub-pixels having co-ordinates with K equal to an even value and L equal to zero and sub-pixels having co-ordinates with K equal to zero and L equal to an even value, used in the interpolation of the sub-pixels having co-ordinates with odd values of K and L, using weighted sums of the values of pixels located in rows and columns respectively; and
- interpolate sub-pixel values for sub-pixels having co-ordinates with even values of K and L, used in the interpolation of sub-pixel values for the sub-pixels having co-ordinates with odd values of K and L, using a predetermined choice of either a weighted sum of the values of sub-pixels having co-ordinates with K equal to an even value and L equal to zero and the values of sub-pixels having corresponding co-ordinates in immediately adjacent rectangular bounded regions, or a weighted sum of the values of sub-pixels having co-ordinates with K equal to zero and L equal to an even value and the values of sub-pixels having corresponding co-ordinates in immediately adjacent rectangular bounded ~~rectangular~~ regions[SW6].

44. (Currently amended) A video decoder comprising an interpolator for sub-pixel value interpolation, the interpolator being configured to determine values for sub-pixels situated within a rectangular bounded region defined by four corner pixels with no intermediate pixels between the corners, the pixels and sub-pixels being configured for display in rows and columns, pixel and sub-pixel locations in the rows and columns being representable mathematically within the rectangular bounded region using the co-ordinate notation $K/2^N$, $L/2^N$, K and L being positive integers having respective values between zero and $2^N$, N being a positive integer greater than one and representing a particular degree of sub-pixel value interpolation, the interpolator being configured to:

- interpolate a sub-pixel value for a sub-pixel having co-ordinates with odd values of K and L, according to a predetermined choice of a either weighted average of the value of a nearest-neighbouring pixel and the value of the sub-pixel situated at co-ordinates 1/2, 1/2, or a weighted average of the values of a pair of diagonally-opposed sub-pixels having co-ordinates with even values of K and L, including zero, situated within a quadrant of the rectangular bounded region, the quadrant being defined by the sub-pixel having co-ordinates 1/2, 1/2 and the nearest neighbouring pixel;
- interpolate sub-pixel values for sub-pixels having co-ordinates with K equal to an even value and L equal to zero and sub-pixels having co-ordinates with K equal to zero and L

equal to an even value, used in the interpolation of the sub-pixels having co-ordinates with odd values of K and L, using weighted sums of the values of pixels located in rows and columns respectively; and

- interpolate sub-pixel values for sub-pixels having co-ordinates with even values of K and L, used in the interpolation of sub-pixel values for the sub-pixels having co-ordinates with odd values of K and L, using a predetermined choice of either a weighted sum of the values of sub-pixels having co-ordinates with K equal to an even value and L equal to zero and the values of sub-pixels having corresponding co-ordinates in immediately adjacent rectangular bounded regions, or a weighted sum of the values of sub-pixels having co-ordinates with K equal to zero and L equal to an even value and the values of sub-pixels having corresponding co-ordinates in immediately adjacent rectangular bounded ~~rectangular~~ regions[SW7].

45. (Currently amended) A still image decoder comprising an interpolator for sub-pixel value interpolation, the interpolator being configured to determine values for sub-pixels situated within a rectangular bounded region defined by four corner pixels with no intermediate pixels between the corners, the pixels and sub-pixels being configured for display in rows and columns, pixel and sub-pixel locations in the rows and columns being representable mathematically within the rectangular bounded region using the co-ordinate notation $K/2^N$, $L/2^N$, K and L being positive integers having respective values between zero and $2^N$, N being a positive integer greater than one and representing a particular degree of sub-pixel value interpolation, the interpolator being configured to:

- interpolate a sub-pixel value for a sub-pixel having co-ordinates with odd values of K and L, according to a predetermined choice of either a weighted average of the value of a nearest-neighbouring pixel and the value of the sub-pixel situated at co-ordinates 1/2, 1/2, or a weighted average of the values of a pair of diagonally-opposed sub-pixels having co-ordinates with even values of K and L, including zero, situated within a quadrant of the rectangular bounded region, the quadrant being defined by the sub-pixel having co-ordinates 1/2, 1/2 and the nearest neighbouring pixel;
- interpolate sub-pixel values for sub-pixels having co-ordinates with K equal to an even value and L equal to zero and sub-pixels having co-ordinates with K equal to zero and L equal to an even value, used in the interpolation of the sub-pixels having co-ordinates with

odd values of K and L, using weighted sums of the values of pixels located in rows and columns respectively; and

- interpolate sub-pixel values for sub-pixels having co-ordinates with even values of K and L, used in the interpolation of sub-pixel values for the sub-pixels having co-ordinates with odd values of K and L, using a predetermined choice of either a weighted sum of the values of sub-pixels having co-ordinates with K equal to an even value and L equal to zero and the values of sub-pixels having corresponding co-ordinates in immediately adjacent rectangular bounded regions, or a weighted sum of the values of sub-pixels having co-ordinates with K equal to zero and L equal to an even value and the values of sub-pixels having corresponding co-ordinates in immediately adjacent rectangular bounded ~~rectangular~~ regions[SW8].

46. (Previously Presented) A codec comprising a video encoder according to claim 42 and a video decoder according to claim 44.

47. (Previously Presented) A codec comprising a still image encoder according to claim 43 and a still image decoder according to claim 45.

48. (Previously Presented) A communications terminal comprising a video encoder according to claim 42.

49. (Previously Presented) A communications terminal comprising a still image encoder according to claim 43.

50. (Previously Presented) A communications terminal comprising a video decoder according to claim 44.

51. (Previously Presented) A communications terminal comprising a still image decoder according to claim 45.

52. (Previously Presented) A communications terminal according to claim 48, wherein the communications terminal is a wireless terminal.

53. (Currently amended) An interpolator for sub-pixel value interpolation, the interpolator being configured to determine values for sub-pixels situated within a rectangular bounded region defined by four corner pixels with no intermediate pixels between the corners, the pixels and sub-pixels being configured for display in rows and columns, pixel and sub-pixel locations in the rows and columns being representable mathematically within the rectangular bounded region using the co-ordinate notation $K/2^N$, $L/2^N$, K and L being positive integers having respective values between zero and $2^N$, N being a positive integer greater than one and representing a particular degree of sub-pixel value interpolation, the interpolator comprising:

- circuitry configured to interpolate a sub-pixel value for a sub-pixel having co-ordinates with odd values of K and L, according to a predetermined choice of either a weighted average of the value of a nearest-neighbouring pixel and the value of the sub-pixel situated at co-ordinates 1/2, 1/2, ~~and~~or a weighted average of the values of a pair of diagonally-opposed sub-pixels having co-ordinates with even values of K and L, including zero, situated within a quadrant of the rectangular bounded region, the quadrant being defined by the sub-pixel having co-ordinates 1/2, 1/2 and the nearest neighbouring pixel;
- circuitry configured to interpolate sub-pixel values for sub-pixels having co-ordinates with K equal to an even value and L equal to zero and sub-pixels having co-ordinates with K equal to zero and L equal to an even value, used in the interpolation of the sub-pixels having co-ordinates with odd values of K and L, using weighted sums of the values of pixels located in rows and columns respectively; and
- circuitry configured to interpolate sub-pixel values for sub-pixels having co-ordinates with even values of K and L, used in the interpolation of sub-pixel values for the sub-pixels having co-ordinates with odd values of K and L, using a predetermined choice of either a weighted sum of the values of sub-pixels having co-ordinates with K equal to an even value and L equal to zero and the values of sub-pixels having corresponding co-ordinates in immediately adjacent rectangular bounded regions, or a weighted sum of the values of sub-pixels having co-ordinates with K equal to zero and L equal to an even value and the values of sub-pixels having corresponding co-ordinates in immediately adjacent rectangular bounded ~~rectangular~~ regions[SW9].

54. (Previously Presented) An interpolator for quarter resolution sub-pixel value interpolation, the interpolator being configured to determine values for sub-pixels situated within a rectangular bounded region defined by four corner pixels with no intermediate pixels between the corners,

the pixels and sub-pixels being configured for display in rows and columns, pixel and sub-pixel locations in the rows and columns being representable mathematically within the rectangular bounded region using the co-ordinate notation K/4, L/4, K and L being positive integers having respective values between zero and 4, the interpolator being configured to:

- interpolate a sub-pixel value for a sub-pixel having co-ordinates with K and L equal to 1 or 3, according to a predetermined choice of either a weighted average of the value of a nearest-neighbouring pixel and the value of the sub-pixel situated at co-ordinates 2/4, 2/4, or a weighted average of the values of a pair of diagonally-opposed sub-pixels having co-ordinates with K and L equal to zero, 2 or 4, situated within a quadrant of the rectangular bounded region, the quadrant being defined by the sub-pixel having co-ordinates 2/4, 2/4 and the nearest neighbouring pixel;
- interpolate sub-pixel values for sub-pixels having co-ordinates with K equal to 2 and L equal to zero and sub-pixels having co-ordinates with K equal to zero and L equal to 2, used in the interpolation of the sub-pixels having co-ordinates with K and L equal to 1 or 3, using weighted sums of the values of pixels located in rows and columns respectively; and
- interpolate a sub-pixel value for the sub-pixel having co-ordinates with K and L equal to 2, used in the interpolation of sub-pixel values for the sub-pixels having co-ordinates with K and L equal to 1 or 3, using a predetermined choice of either a weighted sum of the values of the sub-pixel having co-ordinates with K equal to 2 and L equal to zero and the values of sub-pixels having corresponding co-ordinates in immediately adjacent rectangular bounded regions, or a weighted sum of the value of the sub-pixel having co-ordinates with K equal to zero and L equal to 2 and the values of sub-pixels having corresponding co-ordinates in immediately adjacent rectangular bounded regions.

55. (Previously Presented) An interpolator for eighth resolution sub-pixel value interpolation, the interpolator being configured to determine values for sub-pixels situated within a rectangular bounded region defined by four corner pixels with no intermediate pixels between the corners, the pixels and sub-pixels being configured for display in rows and columns, pixel and sub-pixel locations in the rows and columns being representable mathematically with the rectangular bounded region using the co-ordinate notation K/8, L/8, K and L being positive integers having respective values between zero and 8, the interpolator being configured to:

- interpolate a sub-pixel value for a sub-pixel having co-ordinates with K and L equal to 1, 3, 5 or 7, according to a predetermined choice of either a weighted average of the value of a

nearest-neighbouring pixel and the value of the sub-pixel situated at co-ordinates 4/8, 4/8, or a weighted average of the values of a pair of diagonally-opposed sub-pixels having co-ordinates with K and L equal to zero, 2, 4, 6 or 8, situated within a quadrant of the rectangular bounded region, the quadrant being defined by the sub-pixel having co-ordinates 4/8, 4/8 and the nearest neighbouring pixel;

- interpolate sub-pixel values for sub-pixels having co-ordinates with K equal to 2, 4 or 6 and L equal to zero and sub-pixels having co-ordinates with K equal to zero and L equal to 2, 4 or 6, used in the interpolation of the sub-pixels having co-ordinates with K and L equal to 1, 3, 5 or 7, using weighted sums of the values of pixels located in rows and columns respectively; and
- interpolate sub-pixel values for sub-pixels having co-ordinates with K and L equal to 2, 4 or 6, used in the interpolation of sub-pixel values for the sub-pixels having co-ordinates with K and L equal to 1, 3, 5 or 7, using a predetermined choice of either a weighted sum of the values of sub-pixels having co-ordinates with K equal to 2, 4 or 6 and L equal to zero and the values of sub-pixels having corresponding co-ordinates in immediately adjacent rectangular bounded regions or a weighted sum of the values of sub-pixels having co-ordinates with K equal to zero and L equal to 2, 4 or 6 and the values of sub-pixels having corresponding co-ordinates in immediately adjacent rectangular bounded regions.

56. (Previously Presented) A video encoder or still image encoder comprising an interpolator according to claim 54 or 55.

57. (Previously Presented) A video decoder or still image decoder comprising an interpolator according to claim 54 or 55.

58. (Previously Presented) A communications terminal comprising a video encoder or still image encoder according to claim 56.

59. (Previously Presented) A communications terminal comprising a video decoder or still image decoder according to claim 57.

60. (Currently amended) A computer program for sub-pixel value interpolation, embodied on a computer readable storage medium ~~for sub-pixel value interpolation~~, the computer program being configured to determine values for sub-pixels situated within a rectangular bounded region defined by four corner pixels with no intermediate pixels between the corners, the pixels and sub-pixels being configured for display in rows and columns, pixel and sub-pixel locations in the rows and columns being representable mathematically within the rectangular bounded region using the co-ordinate notation $K/2^N$, $L/2^N$, K and L being positive integers having respective values between zero and $2^N$, N being a positive integer greater than one and representing a particular degree of sub-pixel value interpolation, the computer program comprising:

- computer program code for interpolating a sub-pixel value for a sub-pixel having co-ordinates with odd values of K and L, according to a predetermined choice of either a weighted average of the value of a nearest-neighbouring pixel and the value of the sub-pixel situated at co-ordinates 1/2, 1/2, or a weighted average of the values of a pair of diagonally-opposed sub-pixels having co-ordinates with even values of K and L, including zero, situated within a quadrant of the rectangular bounded region, the quadrant being defined by the sub-pixel having co-ordinates 1/2, 1/2 and the nearest neighbouring pixel;
- computer program code for interpolating sub-pixel values for sub-pixels having co-ordinates with K equal to an even value and L equal to zero and sub-pixels having co-ordinates with K equal to zero and L equal to an even value, used in the interpolation of the sub-pixels having co-ordinates with odd values of K and L, using weighted sums of the values of pixels located in rows and columns respectively; and
- computer program code for interpolating sub-pixel values for sub-pixels having co-ordinates with even values of K and L, used in the interpolation of sub-pixel values for the sub-pixels having co-ordinates with odd values of K and L, using a predetermined choice of either a weighted sum of the values of sub-pixels having co-ordinates with K equal to an even value and L equal to zero and the values of sub-pixels having corresponding co-ordinates in immediately adjacent rectangular bounded regions, or a weighted sum of the values of sub-pixels having co-ordinates with K equal to zero and L equal to an even value and the values of sub-pixels having corresponding co-ordinates in immediately adjacent rectangular bounded ~~rectangular~~ regions[SW10].

61. (Currently amended) A network apparatus comprising an interpolator for sub-pixel value interpolation, the interpolator being configured to determine values for sub-pixels situated within a rectangular bounded region defined by four corner pixels with no intermediate pixels between the corners, the pixels and sub-pixels being configured for display in rows and columns, pixel and sub-pixel locations in the rows and columns being representable mathematically within the rectangular bounded region using the co-ordinate notation $K/2^N$, $L/2^N$, K and L being positive integers having respective values between zero and $2^N$, N being a positive integer greater than one and representing a particular degree of sub-pixel value interpolation, the interpolator being configured to:

- interpolate a sub-pixel value for a sub-pixel having co-ordinates with odd values of K and L, according to a predetermined choice of either a weighted average of the value of a nearest-neighbouring pixel and the value of the sub-pixel situated at co-ordinates 1/2, 1/2, or a weighted average of the values of a pair of diagonally-opposed sub-pixels having co-ordinates with even values of K and L, including zero, situated within a quadrant of the rectangular bounded region, the quadrant being defined by the sub-pixel having co-ordinates 1/2, 1/2 and the nearest neighbouring pixel;
- interpolate sub-pixel values for sub-pixels having co-ordinates with K equal to an even value and L equal to zero and sub-pixels having co-ordinates with K equal to zero and L equal to an even value, used in the interpolation of the sub-pixels having co-ordinates with odd values of K and L, using weighted sums of the values of pixels located in rows and columns respectively; and
- interpolate sub-pixel values for sub-pixels having co-ordinates with even values of K and L, used in the interpolation of sub-pixel values for the sub-pixels having co-ordinates with odd values of K and L, using a predetermined choice of either a weighted sum of the values of sub-pixels having co-ordinates with K equal to an even value and L equal to zero and the values of sub-pixels having corresponding co-ordinates in immediately adjacent rectangular bounded regions, or a weighted sum of the values of sub-pixels having co-ordinates with K equal to zero and L equal to an even value and the values of sub-pixels having corresponding co-ordinates in immediately adjacent rectangular bounded ~~rectangular~~ regions[SW11].

62. (Previously Presented) A method according to claim 1, wherein the pixels have a predetermined dynamic range, said predetermined dynamic range corresponding to the range of values said pixels can take.

63 (Currently amended) A method according to claim 62, comprising interpolating sub-pixel values for sub-pixels having co-ordinates with K equal to an even value and L equal to zero[SW12] and for sub-pixels having co-ordinates with K equal to zero and L equal to an even value, using weighted sums of the values of pixels located in rows and columns respectively, to produce a first intermediate value, said first intermediate value having a dynamic range equal to the predetermined dynamic range of the pixels used in said weighted sum multiplied by a value equal to the sum of the respective weights used in said weighted sum.

64. (Previously Presented) A method according to claim 63, wherein the dynamic range of said first intermediate value is defined by the number of bits used to represent the respective pixels used in said weighted sum plus the number of bits required to represent the sum of the respective weights used in said weighted sum.

65. (Currently amended) A method according to claim 63, comprising truncating the first intermediate value by mathematically dividing [SW13]the first intermediate value by a first scale factor, said first scale factor having a value equal to the sum of the respective weights used in said weighted sum, thereby forming a sub-pixel value with a dynamic range equal to the predetermined dynamic range of said pixels.

66. (Currently amended) A method according to claim 63, comprising interpolating sub-pixel values for sub-pixels having co-ordinates with even values of K and L, using a weighted sum comprising first intermediate values for sub-pixels having co-ordinates with K equal to an even value and L equal to zero and corresponding first intermediate values[SW14] for sub-pixels having corresponding co-ordinates in immediately adjacent rectangular bounded regions, to produce a second intermediate value, said second intermediate value having a dynamic range equal to the dynamic range of the first intermediate values used in said weighted sum, multiplied by a value equal to the sum of the respective weights used in said weighted sum.

67. (Currently amended) A method according to claim 63, comprising interpolating sub-pixel values for sub-pixels having co-ordinates with even values of K and L, using a weighted sum comprising first intermediate values for sub-pixels having co-ordinates with K equal to zero and L equal to an even value and corresponding first intermediate values[SW15] for sub-pixels having corresponding co-ordinates in immediately adjacent rectangular bounded ~~rectangular~~ regions[SW16] to produce a second intermediate value, said second intermediate value having a dynamic range equal to the dynamic range of the first intermediate values used in said weighted sum, multiplied by a value equal to the sum of the respective weights used in said weighted sum.

68. (Previously Presented) A method according to claim 66, comprising truncating the second intermediate value by mathematically dividing the second intermediate value by a second scale factor, said second scale factor having a value equal to the sum of the respective weights used in the weighted sum of claim 63 multiplied by the sum of the respective weights used in the weighted sum of claim 66, thereby forming a sub-pixel value with a dynamic range equal to the predetermined dynamic range of said pixels.

69. (Previously Presented) A method according to claim 67, comprising truncating the second intermediate value by mathematically dividing the second intermediate value by a second scale factor, said second scale factor having a value equal to the sum of the respective weights used in the weighted sum of claim 63 multiplied by the sum of the respective weights used in the weighted sum of claim 67, thereby forming a sub-pixel value with a dynamic range equal to the dynamic range of said pixels.

70. (Previously Presented) A method according to claim 65, comprising using a truncated first intermediate sub-pixel value when interpolating a value for a sub-pixel having co-ordinates with odd values of K and L.

71. (Previously Presented) A method according to claim 68, comprising using a truncated second intermediate sub-pixel value when interpolating a value for a sub-pixel having co-ordinates with odd values of K and L.

72. (Previously Presented) An interpolator according to claim 22, wherein the pixels have a predetermined dynamic range, said predetermined dynamic range corresponding to the range of values said pixels can take.

73. (Currently amended) An interpolator according to claim 72, wherein the interpolator is configured to interpolate sub-pixel values for sub-pixels having co-ordinates with K equal to an even value and L equal to zero[SW17] and for sub-pixels having co-ordinates with K equal to zero and L equal to an even value, using weighted sums of the values of pixels located in rows and columns respectively, to produce a first intermediate value, said first intermediate value having a dynamic range equal to the predetermined dynamic range of the pixels used in said weighted sum multiplied by a value equal to the sum of the respective weights used in said weighted sum.

74. (Previously Presented) An interpolator according to claim 73, wherein the dynamic range of said first intermediate value is defined by the number of bits used to represent the respective pixels used in said weighted sum plus the number of bits required to represent the sum of the respective weights used in said weighted sum.

75. (Previously Presented) An interpolator according to claim 73, wherein the interpolator is configured to truncate the first intermediate value by mathematically dividing the first intermediate value by a first scale factor, said first scale factor having a value equal to the sum of the respective weights used in said weighted sum, thereby forming a sub-pixel value with a dynamic range equal to the predetermined dynamic range of said pixels.

76. (Currently amended) An interpolator according to claim 73, wherein the interpolator is configured to interpolate sub-pixel values for sub-pixels having co-ordinates with even values of K and L, using a weighted sum comprising first intermediate values for sub-pixels having co-ordinates with K equal to an even value and L equal to zero and corresponding first intermediate values[SW18] for sub-pixels having corresponding co-ordinates in immediately adjacent rectangular bounded regions, to produce a second intermediate value, said second intermediate value having a dynamic range equal to the dynamic range of the first intermediate values used in said weighted sum, multiplied by a value equal to the sum of the respective weights used in said weighted sum.

77. (Currently amended) An interpolator according to claim 73, wherein the interpolator is configured to interpolate sub-pixel values for sub-pixels having co-ordinates with even values of K and L, using a weighted sum comprising first intermediate values for sub-pixels having co-ordinates with K equal to zero and L equal to an even value and corresponding first intermediate values[SW19] for sub-pixels having corresponding co-ordinates in immediately adjacent rectangular bounded ~~rectangular~~ regions[SW20] to produce a second intermediate value, said second intermediate value having a dynamic range equal to the dynamic range of the first intermediate values used in said weighted sum, multiplied by a value equal to the sum of the respective weights used in said weighted sum.

78. (Previously Presented) An interpolator according to claim 76, wherein the interpolator is configured to truncate the second intermediate value by mathematically dividing the second intermediate value by a second scale factor, said second scale factor having a value equal to the sum of the respective weights used in the weighted sum of claim 73 multiplied by the sum of the respective weights used in the weighted sum of claim 76, thereby forming a sub-pixel value with a dynamic range equal to the predetermined dynamic range of said pixels.

79. (Previously Presented) An interpolator according to claim 77, wherein the interpolator is configured to truncate the second intermediate value by mathematically dividing the second intermediate value by a second scale factor, said second scale factor having a value equal to the sum of the respective weights used in the weighted sum of claim 73 multiplied by the sum of the respective weights used in the weighted sum of claim 77, thereby forming a sub-pixel value with a dynamic range equal to the predetermined dynamic range of said pixels.

80. (Previously Presented) An interpolator according to claim 75, wherein the interpolator is configured to use a truncated first intermediate sub-pixel value when interpolating a value for a sub-pixel having co-ordinates with odd values of K and L.

81. (Previously Presented) An interpolator according to claim 78, wherein the interpolator is configured to use a truncated second intermediate sub-pixel value when interpolating a value for a sub-pixel having co-ordinates with odd values of K and L.

82. (New) A method according to claim 69, comprising using a truncated second intermediate sub-pixel value when interpolating a value for a sub-pixel having co-ordinates with odd values of K and L.

83. (New) An interpolator according to claim 79, wherein the interpolator is configured to use a truncated second intermediate sub-pixel value when interpolating a value for a sub-pixel having co-ordinates with odd values of K and L.

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# NOTICE OF ALLOWANCE AND FEE(S) DUE

10868 7590 04/06/2011

Perman & Green, LLP
99 Hawley Lane
Stratford, CT 06614

| EXAMINER |
|---|
| AN, SHAWN S |

| ART UNIT | PAPER NUMBER |
|---|---|
| 2483 | |

DATE MAILED: 04/06/2011

| APPLICATION NO. | FILING DATE | FIRST NAMED INVENTOR | ATTORNEY DOCKET NO. | CONFIRMATION NO. |
|---|---|---|---|---|
| 11/839,205 | 08/15/2007 | Marta Karczewicz | 982-010567-US (C02) | 8091 |

TITLE OF INVENTION: METHOD FOR SUB-PIXEL VALUE INTERPOLATION

| APPLN. TYPE | SMALL ENTITY | ISSUE FEE DUE | PUBLICATION FEE DUE | PREV. PAID ISSUE FEE | TOTAL FEE(S) DUE | DATE DUE |
|---|---|---|---|---|---|---|
| nonprovisional | NO | $1510 | $300 | $0 | $1810 | 07/06/2011 |

**THE APPLICATION IDENTIFIED ABOVE HAS BEEN EXAMINED AND IS ALLOWED FOR ISSUANCE AS A PATENT. PROSECUTION ON THE MERITS IS CLOSED. THIS NOTICE OF ALLOWANCE IS NOT A GRANT OF PATENT RIGHTS. THIS APPLICATION IS SUBJECT TO WITHDRAWAL FROM ISSUE AT THE INITIATIVE OF THE OFFICE OR UPON PETITION BY THE APPLICANT. SEE 37 CFR 1.313 AND MPEP 1308.**

**THE ISSUE FEE AND PUBLICATION FEE (IF REQUIRED) MUST BE PAID WITHIN THREE MONTHS FROM THE MAILING DATE OF THIS NOTICE OR THIS APPLICATION SHALL BE REGARDED AS ABANDONED. THIS STATUTORY PERIOD CANNOT BE EXTENDED. SEE 35 U.S.C. 151. THE ISSUE FEE DUE INDICATED ABOVE DOES NOT REFLECT A CREDIT FOR ANY PREVIOUSLY PAID ISSUE FEE IN THIS APPLICATION. IF AN ISSUE FEE HAS PREVIOUSLY BEEN PAID IN THIS APPLICATION (AS SHOWN ABOVE), THE RETURN OF PART B OF THIS FORM WILL BE CONSIDERED A REQUEST TO REAPPLY THE PREVIOUSLY PAID ISSUE FEE TOWARD THE ISSUE FEE NOW DUE.**

**HOW TO REPLY TO THIS NOTICE:**

I. Review the SMALL ENTITY status shown above.

If the SMALL ENTITY is shown as YES, verify your current SMALL ENTITY status:

A. If the status is the same, pay the TOTAL FEE(S) DUE shown above.

B. If the status above is to be removed, check box 5b on Part B - Fee(s) Transmittal and pay the PUBLICATION FEE (if required) and twice the amount of the ISSUE FEE shown above, or

If the SMALL ENTITY is shown as NO:

A. Pay TOTAL FEE(S) DUE shown above, or

B. If applicant claimed SMALL ENTITY status before, or is now claiming SMALL ENTITY status, check box 5a on Part B - Fee(s) Transmittal and pay the PUBLICATION FEE (if required) and 1/2 the ISSUE FEE shown above.

II. PART B - FEE(S) TRANSMITTAL, or its equivalent, must be completed and returned to the United States Patent and Trademark Office (USPTO) with your ISSUE FEE and PUBLICATION FEE (if required). If you are charging the fee(s) to your deposit account, section "4b" of Part B - Fee(s) Transmittal should be completed and an extra copy of the form should be submitted. If an equivalent of Part B is filed, a request to reapply a previously paid issue fee must be clearly made, and delays in processing may occur due to the difficulty in recognizing the paper as an equivalent of Part B.

III. All communications regarding this application must give the application number. Please direct all communications prior to issuance to Mail Stop ISSUE FEE unless advised to the contrary.

**IMPORTANT REMINDER: Utility patents issuing on applications filed on or after Dec. 12, 1980 may require payment of maintenance fees. It is patentee's responsibility to ensure timely payment of maintenance fees when due.**

# PART B - FEE(S) TRANSMITTAL

**Complete and send this form, together with applicable fee(s), to: Mail** **Mail Stop ISSUE FEE**
**Commissioner for Patents**
**P.O. Box 1450**
**Alexandria, Virginia 22313-1450**
**or Fax (571)-273-2885**

INSTRUCTIONS: This form should be used for transmitting the ISSUE FEE and PUBLICATION FEE (if required). Blocks 1 through 5 should be completed where appropriate. All further correspondence including the Patent, advance orders and notification of maintenance fees will be mailed to the current correspondence address as indicated unless corrected below or directed otherwise in Block 1, by (a) specifying a new correspondence address; and/or (b) indicating a separate "FEE ADDRESS" for maintenance fee notifications.

CURRENT CORRESPONDENCE ADDRESS (Note: Use Block 1 for any change of address)

10868 7590 04/06/2011

Perman & Green, LLP
99 Hawley Lane
Stratford, CT 06614

Note: A certificate of mailing can only be used for domestic mailings of the Fee(s) Transmittal. This certificate cannot be used for any other accompanying papers. Each additional paper, such as an assignment or formal drawing, must have its own certificate of mailing or transmission.

**Certificate of Mailing or Transmission**

I hereby certify that this Fee(s) Transmittal is being deposited with the United States Postal Service with sufficient postage for first class mail in an envelope addressed to the Mail Stop ISSUE FEE address above, or being facsimile transmitted to the USPTO (571) 273-2885, on the date indicated below.

| |
|---|
| (Depositor's name) |
| (Signature) |
| (Date) |

| APPLICATION NO. | FILING DATE | FIRST NAMED INVENTOR | ATTORNEY DOCKET NO. | CONFIRMATION NO. |
|---|---|---|---|---|
| 11/839,205 | 08/15/2007 | Marta Karczewicz | 982-010567-US (C02) | 8091 |

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| APPLN. TYPE | SMALL ENTITY | ISSUE FEE DUE | PUBLICATION FEE DUE | PREV. PAID ISSUE FEE | TOTAL FEE(S) DUE | DATE DUE |
|---|---|---|---|---|---|---|
| nonprovisional | NO | $1510 | $300 | $0 | $1810 | 07/06/2011 |

| EXAMINER | ART UNIT | CLASS-SUBCLASS |
|---|---|---|
| AN, SHAWN S | 2483 | 375-240170 |

1. Change of correspondence address or indication of "Fee Address" (37 CFR 1.363).

❑ Change of correspondence address (or Change of Correspondence Address form PTO/SB/122) attached.

❑ "Fee Address" indication (or "Fee Address" Indication form PTO/SB/47; Rev 03-02 or more recent) attached. **Use of a Customer Number is required.**

2. For printing on the patent front page, list

(1) the names of up to 3 registered patent attorneys or agents OR, alternatively,

(2) the name of a single firm (having as a member a registered attorney or agent) and the names of up to 2 registered patent attorneys or agents. If no name is listed, no name will be printed.

1 _____

2 _____

3 _____

3. ASSIGNEE NAME AND RESIDENCE DATA TO BE PRINTED ON THE PATENT (print or type)

PLEASE NOTE: Unless an assignee is identified below, no assignee data will appear on the patent. If an assignee is identified below, the document has been filed for recordation as set forth in 37 CFR 3.11. Completion of this form is NOT a substitute for filing an assignment.

(A) NAME OF ASSIGNEE (B) RESIDENCE: (CITY and STATE OR COUNTRY)

Please check the appropriate assignee category or categories (will not be printed on the patent) : ❑ Individual ❑ Corporation or other private group entity ❑ Government

4a. The following fee(s) are submitted:

❑ Issue Fee

❑ Publication Fee (No small entity discount permitted)

❑ Advance Order - # of Copies _____

4b. Payment of Fee(s): **(Please first reapply any previously paid issue fee shown above)**

❑ A check is enclosed.

❑ Payment by credit card. Form PTO-2038 is attached.

❑ The Director is hereby authorized to charge the required fee(s), any deficiency, or credit any overpayment, to Deposit Account Number _____ (enclose an extra copy of this form).

5. **Change in Entity Status** (from status indicated above)

❑ a. Applicant claims SMALL ENTITY status. See 37 CFR 1.27.

❑ b. Applicant is no longer claiming SMALL ENTITY status. See 37 CFR 1.27(g)(2).

NOTE: The Issue Fee and Publication Fee (if required) will not be accepted from anyone other than the applicant; a registered attorney or agent; or the assignee or other party in interest as shown by the records of the United States Patent and Trademark Office.

Authorized Signature _____ Date _____

Typed or printed name _____ Registration No. _____

This collection of information is required by 37 CFR 1.311. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 12 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, Virginia 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, Virginia 22313-1450.

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10868 7590 04/06/2011

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| EXAMINER | |
|---|---|
| AN, SHAWN S | |

| ART UNIT | PAPER NUMBER |
|---|---|
| 2483 | |

DATE MAILED: 04/06/2011

**Determination of Patent Term Adjustment under 35 U.S.C. 154 (b)**
(application filed on or after May 29, 2000)

The Patent Term Adjustment to date is 0 day(s). If the issue fee is paid on the date that is three months after the mailing date of this notice and the patent issues on the Tuesday before the date that is 28 weeks (six and a half months) after the mailing date of this notice, the Patent Term Adjustment will be 0 day(s).

If a Continued Prosecution Application (CPA) was filed in the above-identified application, the filing date that determines Patent Term Adjustment is the filing date of the most recent CPA.

Applicant will be able to obtain more detailed information by accessing the Patent Application Information Retrieval (PAIR) WEB site (http://pair.uspto.gov).

Any questions regarding the Patent Term Extension or Adjustment determination should be directed to the Office of Patent Legal Administration at (571)-272-7702. Questions relating to issue and publication fee payments should be directed to the Customer Service Center of the Office of Patent Publication at 1-(888)-786-0101 or (571)-272-4200.

## Privacy Act Statement

**The Privacy Act of 1974 (P.L. 93-579)** requires that you be given certain information in connection with your submission of the attached form related to a patent application or patent. Accordingly, pursuant to the requirements of the Act, please be advised that: (1) the general authority for the collection of this information is 35 U.S.C. 2(b)(2); (2) furnishing of the information solicited is voluntary; and (3) the principal purpose for which the information is used by the U.S. Patent and Trademark Office is to process and/or examine your submission related to a patent application or patent. If you do not furnish the requested information, the U.S. Patent and Trademark Office may not be able to process and/or examine your submission, which may result in termination of proceedings or abandonment of the application or expiration of the patent.

The information provided by you in this form will be subject to the following routine uses:

1. The information on this form will be treated confidentially to the extent allowed under the Freedom of Information Act (5 U.S.C. 552) and the Privacy Act (5 U.S.C 552a). Records from this system of records may be disclosed to the Department of Justice to determine whether disclosure of these records is required by the Freedom of Information Act.
2. A record from this system of records may be disclosed, as a routine use, in the course of presenting evidence to a court, magistrate, or administrative tribunal, including disclosures to opposing counsel in the course of settlement negotiations.
3. A record in this system of records may be disclosed, as a routine use, to a Member of Congress submitting a request involving an individual, to whom the record pertains, when the individual has requested assistance from the Member with respect to the subject matter of the record.
4. A record in this system of records may be disclosed, as a routine use, to a contractor of the Agency having need for the information in order to perform a contract. Recipients of information shall be required to comply with the requirements of the Privacy Act of 1974, as amended, pursuant to 5 U.S.C. 552a(m).
5. A record related to an International Application filed under the Patent Cooperation Treaty in this system of records may be disclosed, as a routine use, to the International Bureau of the World Intellectual Property Organization, pursuant to the Patent Cooperation Treaty.
6. A record in this system of records may be disclosed, as a routine use, to another federal agency for purposes of National Security review (35 U.S.C. 181) and for review pursuant to the Atomic Energy Act (42 U.S.C. 218(c)).
7. A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (i.e., GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.
8. A record from this system of records may be disclosed, as a routine use, to the public after either publication of the application pursuant to 35 U.S.C. 122(b) or issuance of a patent pursuant to 35 U.S.C. 151. Further, a record may be disclosed, subject to the limitations of 37 CFR 1.14, as a routine use, to the public if the record was filed in an application which became abandoned or in which the proceedings were terminated and which application is referenced by either a published application, an application open to public inspection or an issued patent.
9. A record from this system of records may be disclosed, as a routine use, to a Federal, State, or local law enforcement agency, if the USPTO becomes aware of a violation or potential violation of law or regulation.

| Notice of Allowability | Application No. | Applicant(s) | |
|---|---|---|---|
| | 11/839,205 | KARCZEWICZ ET AL. | |
| | Examiner | Art Unit | |
| | SHAWN AN | 2483 | |

***-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address--***

All claims being allowable, PROSECUTION ON THE MERITS IS (OR REMAINS) CLOSED in this application. If not included herewith (or previously mailed), a Notice of Allowance (PTOL-85) or other appropriate communication will be mailed in due course. **THIS NOTICE OF ALLOWABILITY IS NOT A GRANT OF PATENT RIGHTS.** This application is subject to withdrawal from issue at the initiative of the Office or upon petition by the applicant. See 37 CFR 1.313 and MPEP 1308.

1. ☒ This communication is responsive to *3/28/11*.

2. ☒ The allowed claim(s) is/are *1-83*.

3. ☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).
   a) ☐ All b) ☐ Some* c) ☐ None of the:
      1. ☐ Certified copies of the priority documents have been received.
      2. ☐ Certified copies of the priority documents have been received in Application No. _____ .
      3. ☐ Copies of the certified copies of the priority documents have been received in this national stage application from the International Bureau (PCT Rule 17.2(a)).

   * Certified copies not received: _____.

Applicant has THREE MONTHS FROM THE "MAILING DATE" of this communication to file a reply complying with the requirements noted below. Failure to timely comply will result in ABANDONMENT of this application.
**THIS THREE-MONTH PERIOD IS NOT EXTENDABLE**.

4. ☐ A SUBSTITUTE OATH OR DECLARATION must be submitted. Note the attached EXAMINER'S AMENDMENT or NOTICE OF INFORMAL PATENT APPLICATION (PTO-152) which gives reason(s) why the oath or declaration is deficient.

5. ☐ CORRECTED DRAWINGS ( as "replacement sheets") must be submitted.
   (a) ☐ including changes required by the Notice of Draftsperson's Patent Drawing Review ( PTO-948) attached
      1) ☐ hereto or 2) ☐ to Paper No./Mail Date _____.
   (b) ☐ including changes required by the attached Examiner's Amendment / Comment or in the Office action of Paper No./Mail Date _____.

   **Identifying indicia such as the application number (see 37 CFR 1.84(c)) should be written on the drawings in the front (not the back) of each sheet. Replacement sheet(s) should be labeled as such in the header according to 37 CFR 1.121(d).**

6. ☐ DEPOSIT OF and/or INFORMATION about the deposit of BIOLOGICAL MATERIAL must be submitted. Note the attached Examiner's comment regarding REQUIREMENT FOR THE DEPOSIT OF BIOLOGICAL MATERIAL.

**Attachment(s)**

1. ☒ Notice of References Cited (PTO-892)
2. ☐ Notice of Draftperson's Patent Drawing Review (PTO-948)
3. ☐ Information Disclosure Statements (PTO/SB/08), Paper No./Mail Date _____
4. ☐ Examiner's Comment Regarding Requirement for Deposit of Biological Material
5. ☐ Notice of Informal Patent Application
6. ☐ Interview Summary (PTO-413), Paper No./Mail Date _____ .
7. ☐ Examiner's Amendment/Comment
8. ☒ Examiner's Statement of Reasons for Allowance
9. ☐ Other _____.

## Reasons for Allowance

**1.** The request filed on 3/28/11 for a Request for Continued Examination (RCE) under 37 CFR 1.114 based on parent Application No. 11/839,205 is acceptable and a RCE has been established. An action on the RCE follows.

**2.** As per Applicant's instruction as filed on 3/28/11, claims 18, 22, 36-37, 42-45, 53, 60-61, 63, 65-67, 73, and 76-77 have been amended, and claims 82-83 have been newly added.

**3.** Claims 1-83 are allowed.

**4.** Claims 1-83 are allowed as having incorporated substantially the same/similar allowable subject matter as previously discussed in the last Office action as filed on 12/28/10.

Any comments considered necessary by Applicant must be submitted no later than the payment of the issue fee and, to avoid processing delays, should preferably accompany the issue fee. Such submissions should be clearly labeled "Comments on Statement of Reasons for Allowance."

### *Conclusion*

**5.** The prior art made of record is considered pertinent to Applicant's disclosure.

A) Ito et al (6,693,960 B2), Moving picture encoder and moving picture decoder.

**6.** Any inquiry concerning this communication or earlier communications from the Examiner should be directed to *Shawn An* whose telephone number is 571-272-7324.

If attempts to reach the Examiner by telephone are unsuccessful, the Examiner's supervisor, Joseph Ustaris can be reached on 571-272-7383.

**7.** The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300.

**8.** Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see http://pair-direct.uspto.gov. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free). If you would like assistance from a USPTO Customer Service Representative or access to the automated information system, call 800-786-9199 (IN USA OR CANADA) or 571-272-1000.

/SHAWN AN/
Primary Examiner
Art Unit 2483

| Notice of References Cited | Application/Control No. 11/839,205 | Applicant(s)/Patent Under Reexamination KARCZEWICZ ET AL. | |
|---|---|---|---|
| | Examiner SHAWN AN | Art Unit 2483 | Page 1 of 1 |

**U.S. PATENT DOCUMENTS**

| * | | Document Number Country Code-Number-Kind Code | Date MM-YYYY | Name | Classification |
|---|---|---|---|---|---|
| * | A | US-6,693,960 B2 | 02-2004 | Ito et al. | 375/240.11 |
| | B | US- | | | |
| | C | US- | | | |
| | D | US- | | | |
| | E | US- | | | |
| | F | US- | | | |
| | G | US- | | | |
| | H | US- | | | |
| | I | US- | | | |
| | J | US- | | | |
| | K | US- | | | |
| | L | US- | | | |
| | M | US- | | | |

**FOREIGN PATENT DOCUMENTS**

| * | | Document Number Country Code-Number-Kind Code | Date MM-YYYY | Country | Name | Classification |
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| | N | | | | | |
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**NON-PATENT DOCUMENTS**

| * | | Include as applicable: Author, Title Date, Publisher, Edition or Volume, Pertinent Pages) |
|---|---|---|
| | U | |
| | V | |
| | W | |
| | X | |

*A copy of this reference is not being furnished with this Office action. (See MPEP § 707.05(a).)
Dates in MM-YYYY format are publication dates. Classifications may be US or foreign.

## Index of Claims

| Application/Control No. | Applicant(s)/Patent under Reexamination |
|---|---|
| 11/839,205 | KARCZEWICZ ET AL. |
| **Examiner** | **Art Unit** |
| SHAWN AN | 2483 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| √ | Rejected | – | (Through numeral) Cancelled | N | Non-Elected | A | Appeal |
| = | Allowed | ÷ | Restricted | I | Interference | O | Objected |

| Claim | | Date | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Final | Original | 4/2/11 | | | | | | | | |
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| 52 | 41 | = | | | | | | | | |
| 64 | 42 | = | | | | | | | | |
| 67 | 43 | = | | | | | | | | |
| 69 | 44 | = | | | | | | | | |
| 72 | 45 | = | | | | | | | | |
| 70 | 46 | = | | | | | | | | |
| 73 | 47 | = | | | | | | | | |
| 65 | 48 | = | | | | | | | | |
| 68 | 49 | = | | | | | | | | |
| 71 | 50 | = | | | | | | | | |

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|---|---|---|---|---|---|---|---|---|---|---|
| Final | Original | 4/2/11 | | | | | | | | |
| 74 | 51 | = | | | | | | | | |
| 66 | 52 | = | | | | | | | | |
| 75 | 53 | = | | | | | | | | |
| 78 | 54 | = | | | | | | | | |
| 79 | 55 | = | | | | | | | | |
| 76 | 56 | = | | | | | | | | |
| 80 | 57 | = | | | | | | | | |
| 77 | 58 | = | | | | | | | | |
| 81 | 59 | = | | | | | | | | |
| 82 | 60 | = | | | | | | | | |
| 83 | 61 | = | | | | | | | | |
| 20 | 62 | = | | | | | | | | |
| 21 | 63 | = | | | | | | | | |
| 22 | 64 | = | | | | | | | | |
| 23 | 65 | = | | | | | | | | |
| 25 | 66 | = | | | | | | | | |
| 28 | 67 | = | | | | | | | | |
| 26 | 68 | = | | | | | | | | |
| 29 | 69 | = | | | | | | | | |
| 24 | 70 | = | | | | | | | | |
| 27 | 71 | = | | | | | | | | |
| 53 | 72 | = | | | | | | | | |
| 54 | 73 | = | | | | | | | | |
| 55 | 74 | = | | | | | | | | |
| 56 | 75 | = | | | | | | | | |
| 58 | 76 | = | | | | | | | | |
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| 59 | 78 | = | | | | | | | | |
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# BIB DATA SHEET

**CONFIRMATION NO. 8091**

| SERIAL NUMBER | FILING or 371(c) DATE / RULE | CLASS | GROUP ART UNIT | ATTORNEY DOCKET NO. |
|---|---|---|---|---|
| 11/839,205 | 08/15/2007 | 375 | 2483 | 982-010567-US (C02) |

**APPLICANTS**

Marta Karczewicz, Irving, TX;
Antti Olli Hallapuro, Tampere, FINLAND;

**** CONTINUING DATA ***************************

This application is a CON of 11/090,717 03/25/2005 PAT 7,280,599
which is a CON of 09/954,608 09/17/2001 PAT 6,950,469

**** FOREIGN APPLICATIONS ***************************

**** IF REQUIRED, FOREIGN FILING LICENSE GRANTED ****

08/22/2007

| Foreign Priority claimed | 35 USC 119(a-d) conditions met | Verified and Acknowledged | Met after Allowance | STATE OR COUNTRY | SHEETS DRAWINGS | TOTAL CLAIMS | INDEPENDENT CLAIMS |
|---|---|---|---|---|---|---|---|
| ☐ Yes ☑ No | ☐ Yes ☑ No | /SHAWN AN/ Examiner's Signature | ☐ Initials | TX | 28 | 83 | 13 |

**ADDRESS**

Perman & Green, LLP
99 Hawley Lane
Stratford, CT 06614
UNITED STATES

**TITLE**

METHOD FOR SUB-PIXEL VALUE INTERPOLATION

| FILING FEE RECEIVED | | |
|---|---|---|
| 7126 | FEES: Authority has been given in Paper No._____ to charge/credit DEPOSIT ACCOUNT No._____ for following: | ☐ All Fees<br>☐ 1.16 Fees (Filing)<br>☐ 1.17 Fees (Processing Ext. of time)<br>☐ 1.18 Fees (Issue)<br>☐ Other _____<br>☐ Credit |

BIB (Rev. 05/07).

| Issue Classification | Application/Control No. | Applicant(s)/Patent under Reexamination | |
|---|---|---|---|
| | 11/839,205 | KARCZEWICZ ET AL. | |
| | Examiner | Art Unit | |
| | SHAWN AN | 2483 | |

# ISSUE CLASSIFICATION

| ORIGINAL | | | CROSS REFERENCE(S) | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| CLASS | SUBCLASS | CLASS | SUBCLASS (ONE SUBCLASS PER BLOCK) | | | | | | |
| 375 | 240.17 | 375 | 240.16 | 240.25 | 240.26 | 240.12 | | | |
| INTERNATIONAL CLASSIFICATION | | 382 | 238 | 236 | 233 | 235 | | | |
| H 0 4 B 1/66 | | | | | | | | | |
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| (Assistant Examiner) (Date) | /SHAWN AN/ 4/03/2011 | Total Claims Allowed: 83 | |
|---|---|---|---|
| (Legal Instruments Examiner) (Date) | (Primary Examiner) (Date) | O.G. Print Claim(s): 1 | O.G. Print Fig.: 7 |

☐ Claims renumbered in the same order as presented by applicant ☐ CPA ☐ T.D. ☐ R.1.47

| Final | Original | Final | Original | Final | Original | Final | Original | Final | Original | Final | Original | Final | Original |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1 | 42 | 31 | 83 | 61 | | 91 | | 121 | | 151 | | 181 |
| 31 | 2 | 43 | 32 | 20 | 62 | | 92 | | 122 | | 152 | | 182 |
| 32 | 3 | 44 | 33 | 21 | 63 | | 93 | | 123 | | 153 | | 183 |
| 2 | 4 | 45 | 34 | 22 | 64 | | 94 | | 124 | | 154 | | 184 |
| 4 | 5 | 46 | 35 | 23 | 65 | | 95 | | 125 | | 155 | | 185 |
| 3 | 6 | 47 | 36 | 25 | 66 | | 96 | | 126 | | 156 | | 186 |
| 5 | 7 | 48 | 37 | 28 | 67 | | 97 | | 127 | | 157 | | 187 |
| 6 | 8 | 49 | 38 | 26 | 68 | | 98 | | 128 | | 158 | | 188 |
| 7 | 9 | 50 | 39 | 29 | 69 | | 99 | | 129 | | 159 | | 189 |
| 8 | 10 | 51 | 40 | 24 | 70 | | 100 | | 130 | | 160 | | 190 |
| 9 | 11 | 52 | 41 | 27 | 71 | | 101 | | 131 | | 161 | | 191 |
| 10 | 12 | 64 | 42 | 53 | 72 | | 102 | | 132 | | 162 | | 192 |
| 11 | 13 | 67 | 43 | 54 | 73 | | 103 | | 133 | | 163 | | 193 |
| 12 | 14 | 69 | 44 | 55 | 74 | | 104 | | 134 | | 164 | | 194 |
| 13 | 15 | 72 | 45 | 56 | 75 | | 105 | | 135 | | 165 | | 195 |
| 14 | 16 | 70 | 46 | 58 | 76 | | 106 | | 136 | | 166 | | 196 |
| 15 | 17 | 73 | 47 | 61 | 77 | | 107 | | 137 | | 167 | | 197 |
| 16 | 18 | 65 | 48 | 59 | 78 | | 108 | | 138 | | 168 | | 198 |
| 17 | 19 | 68 | 49 | 62 | 79 | | 109 | | 139 | | 169 | | 199 |
| 18 | 20 | 71 | 50 | 57 | 80 | | 110 | | 140 | | 170 | | 200 |
| 19 | 21 | 74 | 51 | 60 | 81 | | 111 | | 141 | | 171 | | 201 |
| 33 | 22 | 66 | 52 | 30 | 82 | | 112 | | 142 | | 172 | | 202 |
| 34 | 23 | 75 | 53 | 63 | 83 | | 113 | | 143 | | 173 | | 203 |
| 36 | 24 | 78 | 54 | | 84 | | 114 | | 144 | | 174 | | 204 |
| 35 | 25 | 79 | 55 | | 85 | | 115 | | 145 | | 175 | | 205 |
| 37 | 26 | 76 | 56 | | 86 | | 116 | | 146 | | 176 | | 206 |
| 38 | 27 | 80 | 57 | | 87 | | 117 | | 147 | | 177 | | 207 |
| 39 | 28 | 77 | 58 | | 88 | | 118 | | 148 | | 178 | | 208 |
| 40 | 29 | 81 | 59 | | 89 | | 119 | | 149 | | 179 | | 209 |
| 41 | 30 | 82 | 60 | | 90 | | 120 | | 150 | | 180 | | 210 |

## Search Notes

| Application/Control No. | Applicant(s)/Patent under Reexamination |
|---|---|
| 11/839,205 | KARCZEWICZ ET AL. |
| **Examiner** | **Art Unit** |
| SHAWN AN | 2483 |

| SEARCHED | | | |
|---|---|---|---|
| Class | Subclass | Date | Examiner |
| 375 | 240.17 | 12/20/2010 | SA |
| | 240.16 | | SA |
| | 240.25 | | SA |
| | 240.26 | | SA |
| | 240.12 | | SA |
| 382 | 238 | | SA |
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| **375** | **240.17** | 12/20/2010 | **SA** |
| | 240.16 | | SA |
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| 382/238<br>382/236<br>Search updated. | | 4/1/2011 | SA |

| SEARCH NOTES (INCLUDING SEARCH STRATEGY) | | |
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IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

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|---|---|---|---|
| APPLICANT(s): | Marta Karczewicz | CONF. NO.: | 8091 |
| SERIAL NO.: | 11/839,205 | ART UNIT: | 2621 |
| FILING DATE: | 08/15/2007 | EXAMINER: | An, Shawn S. |
| TITLE: | METHOD FOR SUB-PIXEL VALUE INTERPOLATION | | |
| ATTORNEY DOCKET NO.: | 982-010567-US (C02) | | |

MAIL STOP AF
Commissioner of Patents
P.O. Box 1450
Alexandria, VA 22313-1450

**AMENDMENT AFTER ALLOWANCE UNDER**

**37 C.F.R. 1.312**

## I. INTRODUCTION

This is an amendment under 37 CFR 1.312 to correct a typographical error in claim 63.

## II. CLAIM AMENDMENTS

1. (Previously Presented) A method for sub-pixel value interpolation to determine values for sub-pixels situated within a rectangular bounded region defined by four corner pixels with no intermediate pixels between the corners, the pixels and sub-pixels being configured for display in rows and columns, pixel and sub-pixel locations in the rows and columns being representable mathematically within the rectangular bounded region using the co-ordinate notation $K/2^N$, $L/2^N$, K and L being positive integers having respective values between zero and $2^N$, N being a positive integer greater than one and representing a particular degree of sub-pixel value interpolation, the method comprising causing an apparatus to:

- interpolate a sub-pixel value for a sub-pixel having co-ordinates with odd values of K and L, according to a predetermined choice of either a weighted average of the value of a nearest-neighbouring pixel and the value of the sub-pixel situated at co-ordinates 1/2, 1/2, or a weighted average of the values of a pair of diagonally-opposed sub-pixels having co-ordinates with even values of K and L, including zero, situated within a quadrant of the rectangular bounded region, the quadrant being defined by the sub-pixel having co-ordinates 1/2, 1/2 and the nearest neighbouring pixel;
- interpolate sub-pixel values for sub-pixels having co-ordinates with K equal to an even value and L equal to zero and sub-pixels having co-ordinates with K equal to zero and L equal to an even value, used in the interpolation of the sub-pixels having co-ordinates with odd values of K and L, using weighted sums of the values of pixels located in rows and columns respectively; and
- interpolate sub-pixel values for sub-pixels having co-ordinates with even values of K and L, used in the interpolation of sub-pixel values for the sub-pixels having co-ordinates with odd values of K and L, using a predetermined choice of either a weighted sum of the values of sub-pixels having co-ordinates with K equal to an even value and L equal to zero and the values of sub-pixels having corresponding co-ordinates in immediately adjacent rectangular bounded regions, or a weighted sum of the values of sub-pixels having co-ordinates with K equal to zero and L equal to an even value and the values of sub-pixels having corresponding co-ordinates in immediately adjacent rectangular bounded regions.

2. (Previously Presented) A method for quarter resolution sub-pixel value interpolation to determine values for sub-pixels situated within a rectangular bounded region defined by four corner pixels with no intermediate pixels between the corners, the pixels and sub-pixels being configured for display in rows and columns, pixel and sub-pixel locations in the rows and columns being representable mathematically within the rectangular bounded region using the co-ordinate notation K/4, L/4, K and L being positive integers having respective values between zero and 4, the method comprising causing an apparatus to:

- interpolate a sub-pixel value for a sub-pixel having co-ordinates with K and L equal to 1 or 3, according to a predetermined choice of either a weighted average of the value of a nearest-neighbouring pixel and the value of the sub-pixel situated at co-ordinates 2/4, 2/4, or a weighted average of the values of a pair of diagonally-opposed sub-pixels having co-ordinates with K and L equal to zero, 2 or 4, situated within a quadrant of the rectangular bounded region, the quadrant being defined by the sub-pixel having co-ordinates 2/4, 2/4 and the nearest neighbouring pixel;
- interpolate sub-pixel values for sub-pixels having co-ordinates with K equal to 2 and L equal to zero and sub-pixels having co-ordinates with K equal to zero and L equal to 2, used in the interpolation of the sub-pixels having co-ordinates with K and L equal to 1 or 3, using weighted sums of the values of pixels located in rows and columns respectively; and
- interpolate a sub-pixel value for the sub-pixel having co-ordinates with K and L equal to 2, used in the interpolation of sub-pixel values for the sub-pixels having co-ordinates with K and L equal to 1 or 3, using a predetermined choice of either a weighted sum of the values of the sub-pixel having co-ordinates with K equal to 2 and L equal to zero and the values of sub-pixels having corresponding co-ordinates in immediately adjacent rectangular bounded regions, or a weighted sum of the value of the sub-pixel having co-ordinates with K equal to zero and L equal to 2 and the values of sub-pixels having corresponding co-ordinates in immediately adjacent rectangular bounded regions.

3. (Previously Presented) A method for eighth resolution sub-pixel value interpolation to determine values for sub-pixels situated within a rectangular bounded region defined by four corner pixels with no intermediate pixels between the corners, the pixels and sub-pixels being configured for display in rows and columns, pixel and sub-pixel locations in the rows and

columns being representable mathematically with the rectangular bounded region using the co-ordinate notation K/8, L/8, K and L being positive integers having respective values between zero and 8, the method comprising causing an apparatus to:

- interpolate a sub-pixel value for a sub-pixel having co-ordinates with K and L equal to 1, 3, 5 or 7, according to a predetermined choice of either a weighted average of the value of a nearest-neighbouring pixel and the value of the sub-pixel situated at co-ordinates 4/8, 4/8, or a weighted average of the values of a pair of diagonally-opposed sub-pixels having co-ordinates with K and L equal to zero, 2, 4, 6 or 8, situated within a quadrant of the rectangular bounded region, the quadrant being defined by the sub-pixel having co-ordinates 4/8, 4/8 and the nearest neighbouring pixel;
- interpolate sub-pixel values for sub-pixels having co-ordinates with K equal to 2, 4 or 6 and L equal to zero and sub-pixels having co-ordinates with K equal to zero and L equal to 2, 4 or 6, used in the interpolation of the sub-pixels having co-ordinates with K and L equal to 1, 3, 5 or 7, using weighted sums of the values of pixels located in rows and columns respectively; and
- interpolate sub-pixel values for sub-pixels having co-ordinates with K and L equal to 2, 4 or 6, used in the interpolation of sub-pixel values for the sub-pixels having co-ordinates with K and L equal to 1, 3, 5 or 7, using a predetermined choice of either a weighted sum of the values of sub-pixels having co-ordinates with K equal to 2, 4 or 6 and L equal to zero and the values of sub-pixels having corresponding co-ordinates in immediately adjacent rectangular bounded regions or a weighted sum of the values of sub-pixels having co-ordinates with K equal to zero and L equal to 2, 4 or 6 and the values of sub-pixels having corresponding co-ordinates in immediately adjacent rectangular bounded regions.

4. (Previously Presented) A method according to claim 1, comprising causing the apparatus to use a first and a second weight in the weighted average chosen to interpolate the sub-pixel value for a sub-pixel having co-ordinates with odd values of K and L, wherein when the chosen weighted average is that involving the value of a nearest neighbouring pixel and the value of the sub-pixel situated at co-ordinates 1/2, 1/2, causing the apparatus to select the relative magnitudes of the first and second weights to be inversely proportional to the respective

straight-line diagonal distances of the nearest-neighbouring pixel and the sub-pixel situated at co-ordinates 1/2, 1/2 to the sub-pixel having co-ordinates with odd values of K and L whose value is being interpolated.

5. (Previously Presented) A method according to claim 1, comprising causing the apparatus to use a first and a second weight in the weighted average chosen to interpolate the sub-pixel value for a sub-pixel having co-ordinates with odd values of K and L, wherein when the chosen weighted average is that involving the values of a pair of diagonally-opposed sub-pixels having co-ordinates with even values of K and L, causing the apparatus to select the relative magnitudes of the first and second weights to be inversely proportional to the respective straight-line diagonal distances of the sub-pixels having co-ordinates with even values of K and L to the sub-pixel having co-ordinates with odd values of K and L whose value is being interpolated.

6. (Previously Presented) A method according to claim 4, comprising causing the apparatus to use first and second weights with equal values when the nearest-neighbouring pixel and sub-pixel situated at co-ordinates 1/2, 1/2 are equidistant from the sub-pixel having co-ordinates with odd values of K and L whose value is being interpolated.

7. (Previously Presented) A method according to claim 5, comprising causing the apparatus to use first and second weights with equal values when the sub-pixels having co-ordinates with even values of K and L are equidistant from the sub-pixel having co-ordinates with odd values of K and L whose value is being interpolated.

8. (Previously Presented) A method according to claim 1, comprising causing the apparatus to interpolate sub-pixel values for sub-pixels having co-ordinates with even values of K and L, used in interpolation of sub-pixel values for the sub-pixels having co-ordinates with odd values of K and L, using a weighted sum of the values of sub-pixels having co-ordinates with K equal to an even value and L equal to zero and the values of sub-pixels having corresponding co-

ordinates in immediately adjacent rectangular bounded regions when the value of a sub-pixel having co-ordinates with K equal to an even value and L equal to an odd value is also required.

9. (Previously Presented) A method according to claim 1, comprising causing the apparatus to interpolate sub-pixel values for sub-pixels having co-ordinates with even values of K and L, used in interpolation of sub-pixel values for the sub-pixels having co-ordinates with odd values of K and L, using a weighted sum of the values of sub-pixels having co-ordinates with K equal to zero and L equal to an even value and the values of sub-pixels having corresponding co-ordinates in immediately adjacent rectangular bounded regions when the value of a sub-pixel having co-ordinates with K equal to an odd value and L equal to an even value is also required.

10. (Previously Presented) A method according to claim 1, comprising causing the apparatus to interpolate sub-pixel values for sub-pixels having co-ordinates with K equal to an odd value O and L equal to an even value E, not including zero or $2^N$, by taking an average of the value of a first sub-pixel having co-ordinates with K equal to the even value O - 1 and L equal to E and a second sub-pixel having co-ordinates with K equal to the even value O + 1 and L equal to E.

11. (Previously Presented) A method according to claim 1, comprising causing the apparatus to interpolate a sub-pixel value for a sub-pixel having co-ordinates with K equal to 1 and L equal to zero, by taking an average of the value of a pixel having co-ordinates with K equal to zero and L equal to zero, and a sub-pixel having co-ordinates with K equal to 2 and L equal to zero.

12. (Previously Presented) A method according to claim 1, comprising causing the apparatus to interpolate a sub-pixel value for a sub-pixel having co-ordinates with K equal to $2^N$ - 1 and L equal to zero, by taking an average of the value of a pixel having co-ordinates with K equal to $2^N$ and L equal to zero, and a sub-pixel having co-ordinates with K equal to $2^N$ - 2 and L equal to zero.

13. (Previously Presented) A method according to claim 1, comprising causing the apparatus to interpolate a sub-pixel value for a sub-pixel having co-ordinates with K equal to 1 and L equal to $2^N$, by taking an average of the value of a pixel having co-ordinates with K equal to zero and L equal to $2^N$, and a sub-pixel having co-ordinates with K equal to 2 and L equal to $2^N$.

14. (Previously Presented) A method according to claim 1, comprising causing the apparatus to interpolate a sub-pixel value for a sub-pixel having co-ordinates with K equal to $2^N$ - 1 and L equal to $2^N$, by taking an average of the value of a pixel having co-ordinates with K equal to $2^N$ and L equal to $2^N$, and a sub-pixel having co-ordinates with K equal to $2^N$ - 2 and L equal to $2^N$.

15. (Previously Presented) A method according to claim 1, comprising causing the apparatus to interpolate sub-pixel values for sub-pixels having co-ordinates with K equal to an even value E, not including zero or $2^N$, and L equal to an odd value O, by taking an average of the value of a first sub-pixel having co-ordinates with K equal to E and L equal to the even value O - 1 and a second sub-pixel having co-ordinates with K equal to E and L equal to the even value O + 1.

16. (Previously Presented) A method according to claim 1, comprising causing the apparatus to interpolate a sub-pixel value for a sub-pixel having co-ordinates with K equal to zero and L equal to 1, by taking an average of the value of a pixel having co-ordinates with K equal to zero and L equal to zero, and a sub-pixel having co-ordinates with K equal to zero and L equal to 2.

17. (Previously Presented) A method according to claim 1, comprising causing the apparatus to interpolate a sub-pixel value for a sub-pixel having co-ordinates with K equal to $2^N$ and L equal to 1, by taking an average of the value of a pixel having co-ordinates with K equal to $2^N$ and L equal to zero, and a sub-pixel having co-ordinates with K equal to $2^N$ and L equal to 2.

18. (Previously Presented) A method according to claim 1, comprising causing the apparatus to interpolate a sub-pixel value for a sub-pixel having co-ordinates with K equal to zero and L equal to $2^N$ - 1, by taking an average of the value of a pixel having co-ordinates with K equal to

zero and L equal to $2^N$, and a sub-pixel having co-ordinates with K equal to zero and L equal to $2^N - 2$.

19. (Previously Presented) A method according to claim 1, comprising causing the apparatus to interpolate a sub-pixel value for a sub-pixel having co-ordinates with K equal to $2^N$ and L equal to $2^N - 1$, by taking an average of the value of a pixel having co-ordinates with K equal to $2^N$ and L equal to $2^N$, and a sub-pixel having co-ordinates with K equal to $2^N$ and L equal to $2^N - 2$.

20. (Previously Presented) A method according to claim 1, comprising causing the apparatus to interpolate a sub-pixel value for the sub-pixel having co-ordinates with K equal to $2^N - 1$ and L equal to $2^N - 1$, by taking a weighted average of the values of the four corner pixels that define the rectangular bounded region.

21. (Previously Presented) A method according to claim 1, in which N is one of the values 2, 3, and 4.

22. (Previously Presented) An interpolator for sub-pixel value interpolation, the interpolator being configured to determine values for sub-pixels situated within a rectangular bounded region defined by four corner pixels with no intermediate pixels between the corners, the pixels and sub-pixels being configured for display in rows and columns, pixel and sub-pixel locations in the rows and columns being representable mathematically within the rectangular bounded region using the co-ordinate notation $K/2^N$, $L/2^N$, K and L being positive integers having respective values between zero and $2^N$, N being a positive integer greater than one and representing a particular degree of sub-pixel value interpolation, the interpolator being configured to:

- interpolate a sub-pixel value for a sub-pixel having co-ordinates with odd values of K and L, according to a predetermined choice of either a weighted average of the value of a nearest-neighbouring pixel and the value of the sub-pixel situated at co-ordinates 1/2, 1/2, or a weighted average of the values of a pair of diagonally-opposed sub-pixels having co-

ordinates with even values of K and L, including zero, situated within a quadrant of the rectangular bounded region, the quadrant being defined by the sub-pixel having co-ordinates 1/2, 1/2 and the nearest neighbouring pixel;

- interpolate sub-pixel values for sub-pixels having co-ordinates with K equal to an even value and L equal to zero and sub-pixels having co-ordinates with K equal to zero and L equal to an even value, used in the interpolation of the sub-pixels having co-ordinates with odd values of K and L, using weighted sums of the values of pixels located in rows and columns respectively; and
- interpolate sub-pixel values for sub-pixels having co-ordinates with even values of K and L, used in the interpolation of sub-pixel values for the sub-pixels having co-ordinates with odd values of K and L, using a predetermined choice of either a weighted sum of the values of sub-pixels having co-ordinates with K equal to an even value and L equal to zero and the values of sub-pixels having corresponding co-ordinates in immediately adjacent rectangular bounded regions, or a weighted sum of the values of sub-pixels having co-ordinates with K equal to zero and L equal to an even value and the values of sub-pixels having corresponding co-ordinates in immediately adjacent rectangular bounded regions.

23. (Previously Presented) An interpolator according to claim 22, wherein the interpolator is configured to use a first and a second weight in the weighted average chosen to interpolate the sub-pixel value for a sub-pixel having co-ordinates with odd values of K and L, wherein when the chosen weighted average is that involving the value of a nearest neighbouring pixel and the value of the sub-pixel situated at co-ordinates 1/2, 1/2, the interpolator is configured to select the relative magnitudes of the first and second weights to be inversely proportional to the respective straight-line diagonal distances of the nearest-neighbouring pixel and the sub-pixel situated at co-ordinates 1/2, 1/2 to the sub-pixel having co-ordinates with odd values of K and L whose value is being interpolated.

24. (Previously Presented) An interpolator according to claim 22, wherein the interpolator is configured to use a first and a second weight in the weighted average chosen to interpolate the sub-pixel value for a sub-pixel having co-ordinates with odd values of K and L, wherein when

the chosen weighted average is that involving the values of a pair of diagonally-opposed sub-pixels having co-ordinates with even values of K and L, the interpolator is configured to select the relative magnitudes of the first and second weights to be inversely proportional to the respective straight-line diagonal distances of the sub-pixels having co-ordinates with even values of K and L to the sub-pixel having co-ordinates with odd values of K and L whose value is being interpolated.

25. (Previously Presented) An interpolator according to claim 23, wherein the interpolator is configured to use first and second weights with equal values when the nearest-neighbouring pixel and sub-pixel situated at co-ordinates 1/2, 1/2 are equidistant from the sub-pixel having co-ordinates with odd values of K and L whose value is being interpolated.

26. (Previously Presented) An interpolator according to claim 24, wherein the interpolator is configured to use first and second weights with equal values when the sub-pixels having co-ordinates with even values of K and L are equidistant from the sub-pixel having co-ordinates with odd values of K and L whose value is being interpolated.

27. (Previously Presented) An interpolator according to claim 22, wherein the interpolator is configured to interpolate sub-pixel values for sub-pixels having co-ordinates with even values of K and L, used in interpolation of sub-pixel values for the sub-pixels having co-ordinates with odd values of K and L, using a weighted sum of the values of sub-pixels having co-ordinates with K equal to an even value and L equal to zero and the values of sub-pixels having corresponding co-ordinates in immediately adjacent rectangular bounded regions when the value of a sub-pixel having co-ordinates with K equal to an even value and L equal to an odd value is also required.

28. (Previously Presented) An interpolator according to claim 22, wherein the interpolator is configured to interpolate sub-pixel values for sub-pixels having co-ordinates with even values of K and L, used in interpolation of sub-pixel values for the sub-pixels having co-ordinates with odd values of K and L, using a weighted sum of the values of sub-pixels having co-ordinates with K equal to zero and L equal to an even value and the values of sub-pixels having corresponding

co-ordinates in immediately adjacent rectangular bounded regions when the value of a sub-pixel having co-ordinates with K equal to an odd value and L equal to an even value is also required.

29. (Previously Presented) An interpolator according to claim 22, wherein the interpolator is configured to interpolate sub-pixel values for sub-pixels having co-ordinates with K equal to an odd value O and L equal to an even value E, not including zero or $2^N$, by taking an average of the value of a first sub-pixel having co-ordinates with K equal to the even value O - 1 and L equal to E and a second sub-pixel having co-ordinates with K equal to the even value O + 1 and L equal to E.

30. (Previously Presented) An interpolator according to claim 22, wherein the interpolator is configured to interpolate a sub-pixel value for a sub-pixel having co-ordinates with K equal to 1 and L equal to zero, by taking an average of the value of a pixel having co-ordinates with K equal to zero and L equal to zero, and a sub-pixel having co-ordinates with K equal to 2 and L equal to zero.

31. (Previously Presented) An interpolator according to claim 22, wherein the interpolator is configured to interpolate a sub-pixel value for a sub-pixel having co-ordinates with K equal to $2^N$ - 1 and L equal to zero, by taking an average of the value of a pixel having co-ordinates with K equal to $2^N$ and L equal to zero, and a sub-pixel having co-ordinates with K equal to $2^N$ - 2 and L equal to zero.

32. (Previously Presented) An interpolator according to claim 22, wherein the interpolator is configured to interpolate a sub-pixel value for a sub-pixel having co-ordinates with K equal to 1 and L equal to $2^N$, by taking an average of the value of a pixel having co-ordinates with K equal to zero and L equal to $2^N$, and a sub-pixel having co-ordinates with K equal to 2 and L equal to $2^N$.

33. (Previously Presented) An interpolator according to claim 22, wherein the interpolator is configured to interpolate a sub-pixel value for a sub-pixel having co-ordinates with K equal to $2^N - 1$ and L equal to $2^N$, by taking an average of the value of a pixel having co-ordinates with K equal to $2^N$ and L equal to $2^N$, and a sub-pixel having co-ordinates with K equal to $2^N - 2$ and L equal to $2^N$.

34. (Previously Presented) An interpolator according to claim 22, wherein the interpolator is configured to interpolate sub-pixel values for sub-pixels having co-ordinates with K equal to an even value E, not including zero or $2^N$, and L equal to an odd value O, by taking an average of the value of a first sub-pixel having co-ordinates with K equal to E and L equal to the even value O - 1 and a second sub-pixel having co-ordinates with K equal to E and L equal to the even value O + 1.

35. (Previously Presented) An interpolator according to claim 22, wherein the interpolator is configured to interpolate a sub-pixel value for a sub-pixel having co-ordinates with K equal to zero and L equal to 1, by taking an average of the value of a pixel having co-ordinates with K equal to zero and L equal to zero, and a sub-pixel having co-ordinates with K equal to zero and L equal to 2.

36. (Previously Presented) An interpolator according to claim 22, wherein the interpolator is configured to interpolate a sub-pixel value for a sub-pixel having co-ordinates with K equal to $2^N$ and L equal to 1, by taking an average of the value of a pixel having co-ordinates with K equal to $2^N$ and L equal to zero, and a sub-pixel having co-ordinates with K equal to $2^N$ and L equal to 2.

37. (Previously Presented) An interpolator according to claim 22, wherein the interpolator is configured to interpolate a sub-pixel value for a sub-pixel having co-ordinates with K equal to zero and L equal to $2^N - 1$, by taking an average of the value of a pixel having co-ordinates with K equal to zero and L equal to $2^N$, and a sub-pixel having co-ordinates with K equal to zero and L equal to $2^N - 2$.

38. (Previously Presented) An interpolator according to claim 22, wherein the interpolator is configured to interpolate a sub-pixel value for a sub-pixel having co-ordinates with K equal to $2^N$ and L equal to $2^N$ - 1, by taking an average of the value of a pixel having co-ordinates with K equal to $2^N$ and L equal to $2^N$, and a sub-pixel having co-ordinates with K equal to $2^N$ and L equal to $2^N$ - 2.

39. (Previously Presented) An interpolator according to claim 22, wherein the interpolator is configured to interpolate a sub-pixel value for the sub-pixel having co-ordinates with K equal to $2^N$ - 1 and L equal to $2^N$ - 1, by taking a weighted average of the values of the four corner pixels that define the rectangular bounded region.

40. (Previously Presented) An interpolator according to claim 22, wherein N is set equal to 2.

41. (Previously Presented) An interpolator according to claim 22, wherein N is set equal to 3.

42. (Previously Presented) A video encoder comprising an interpolator for sub-pixel value interpolation, the interpolator being configured to determine values for sub-pixels situated within a rectangular bounded region defined by four corner pixels with no intermediate pixels between the corners, the pixels and sub-pixels being configured for display in rows and columns, pixel and sub-pixel locations in the rows and columns being representable mathematically within the rectangular bounded region using the co-ordinate notation $K/2^N$, $L/2^N$, K and L being positive integers having respective values between zero and $2^N$, N being a positive integer greater than one and representing a particular degree of sub-pixel value interpolation, the interpolator being configured to:

- interpolate a sub-pixel value for a sub-pixel having co-ordinates with odd values of K and L, according to a predetermined choice of either a weighted average of the value of a nearest-neighbouring pixel and the value of the sub-pixel situated at co-ordinates 1/2, 1/2, or a weighted average of the values of a pair of diagonally-opposed sub-pixels having co-

ordinates with even values of K and L, including zero, situated within a quadrant of the rectangular bounded region, the quadrant being defined by the sub-pixel having co-ordinates 1/2, 1/2 and the nearest neighbouring pixel;

- interpolate sub-pixel values for sub-pixels having co-ordinates with K equal to an even value and L equal to zero and sub-pixels having co-ordinates with K equal to zero and L equal to an even value, used in the interpolation of the sub-pixels having co-ordinates with odd values of K and L, using weighted sums of the values of pixels located in rows and columns respectively; and
- interpolate sub-pixel values for sub-pixels having co-ordinates with even values of K and L, used in the interpolation of sub-pixel values for the sub-pixels having co-ordinates with odd values of K and L, using a predetermined choice of either a weighted sum of the values of sub-pixels having co-ordinates with K equal to an even value and L equal to zero and the values of sub-pixels having corresponding co-ordinates in immediately adjacent rectangular bounded regions, or a weighted sum of the values of sub-pixels having co-ordinates with K equal to zero and L equal to an even value and the values of sub-pixels having corresponding co-ordinates in immediately adjacent rectangular bounded regions.

43. (Previously Presented) A still image encoder comprising an interpolator for sub-pixel value interpolation, the interpolator being configured to determine values for sub-pixels situated within a rectangular bounded region defined by four corner pixels with no intermediate pixels between the corners, the pixels and sub-pixels being configured for display in rows and columns, pixel and sub-pixel locations in the rows and columns being representable mathematically within the rectangular bounded region using the co-ordinate notation $K/2^N$, $L/2^N$, K and L being positive integers having respective values between zero and $2^N$, N being a positive integer greater than one and representing a particular degree of sub-pixel value interpolation, the interpolator being configured to:

- interpolate a sub-pixel value for a sub-pixel having co-ordinates with odd values of K and L, according to a predetermined choice of either a weighted average of the value of a nearest-neighbouring pixel and the value of the sub-pixel situated at co-ordinates 1/2, 1/2, or a weighted average of the values of a pair of diagonally-opposed sub-pixels having co-

ordinates with even values of K and L, including zero, situated within a quadrant of the rectangular bounded region, the quadrant being defined by the sub-pixel having co-ordinates 1/2, 1/2 and the nearest neighbouring pixel;

- interpolate sub-pixel values for sub-pixels having co-ordinates with K equal to an even value and L equal to zero and sub-pixels having co-ordinates with K equal to zero and L equal to an even value, used in the interpolation of the sub-pixels having co-ordinates with odd values of K and L, using weighted sums of the values of pixels located in rows and columns respectively; and
- interpolate sub-pixel values for sub-pixels having co-ordinates with even values of K and L, used in the interpolation of sub-pixel values for the sub-pixels having co-ordinates with odd values of K and L, using a predetermined choice of either a weighted sum of the values of sub-pixels having co-ordinates with K equal to an even value and L equal to zero and the values of sub-pixels having corresponding co-ordinates in immediately adjacent rectangular bounded regions, or a weighted sum of the values of sub-pixels having co-ordinates with K equal to zero and L equal to an even value and the values of sub-pixels having corresponding co-ordinates in immediately adjacent rectangular bounded regions.

44. (Previously Presented) A video decoder comprising an interpolator for sub-pixel value interpolation, the interpolator being configured to determine values for sub-pixels situated within a rectangular bounded region defined by four corner pixels with no intermediate pixels between the corners, the pixels and sub-pixels being configured for display in rows and columns, pixel and sub-pixel locations in the rows and columns being representable mathematically within the rectangular bounded region using the co-ordinate notation $K/2^N$, $L/2^N$, K and L being positive integers having respective values between zero and $2^N$, N being a positive integer greater than one and representing a particular degree of sub-pixel value interpolation, the interpolator being configured to:

- interpolate a sub-pixel value for a sub-pixel having co-ordinates with odd values of K and L, according to a predetermined choice of a either weighted average of the value of a nearest-neighbouring pixel and the value of the sub-pixel situated at co-ordinates 1/2, 1/2, or a weighted average of the values of a pair of diagonally-opposed sub-pixels having co-

ordinates with even values of K and L, including zero, situated within a quadrant of the rectangular bounded region, the quadrant being defined by the sub-pixel having co-ordinates 1/2, 1/2 and the nearest neighbouring pixel;

- interpolate sub-pixel values for sub-pixels having co-ordinates with K equal to an even value and L equal to zero and sub-pixels having co-ordinates with K equal to zero and L equal to an even value, used in the interpolation of the sub-pixels having co-ordinates with odd values of K and L, using weighted sums of the values of pixels located in rows and columns respectively; and
- interpolate sub-pixel values for sub-pixels having co-ordinates with even values of K and L, used in the interpolation of sub-pixel values for the sub-pixels having co-ordinates with odd values of K and L, using a predetermined choice of either a weighted sum of the values of sub-pixels having co-ordinates with K equal to an even value and L equal to zero and the values of sub-pixels having corresponding co-ordinates in immediately adjacent rectangular bounded regions, or a weighted sum of the values of sub-pixels having co-ordinates with K equal to zero and L equal to an even value and the values of sub-pixels having corresponding co-ordinates in immediately adjacent rectangular bounded regions.

45. (Previously Presented) A still image decoder comprising an interpolator for sub-pixel value interpolation, the interpolator being configured to determine values for sub-pixels situated within a rectangular bounded region defined by four corner pixels with no intermediate pixels between the corners, the pixels and sub-pixels being configured for display in rows and columns, pixel and sub-pixel locations in the rows and columns being representable mathematically within the rectangular bounded region using the co-ordinate notation $K/2^N$, $L/2^N$, K and L being positive integers having respective values between zero and $2^N$, N being a positive integer greater than one and representing a particular degree of sub-pixel value interpolation, the interpolator being configured to:

- interpolate a sub-pixel value for a sub-pixel having co-ordinates with odd values of K and L, according to a predetermined choice of either a weighted average of the value of a nearest-neighbouring pixel and the value of the sub-pixel situated at co-ordinates 1/2, 1/2, or a weighted average of the values of a pair of diagonally-opposed sub-pixels having co-

ordinates with even values of K and L, including zero, situated within a quadrant of the rectangular bounded region, the quadrant being defined by the sub-pixel having co-ordinates 1/2, 1/2 and the nearest neighbouring pixel;

- interpolate sub-pixel values for sub-pixels having co-ordinates with K equal to an even value and L equal to zero and sub-pixels having co-ordinates with K equal to zero and L equal to an even value, used in the interpolation of the sub-pixels having co-ordinates with odd values of K and L, using weighted sums of the values of pixels located in rows and columns respectively; and
- interpolate sub-pixel values for sub-pixels having co-ordinates with even values of K and L, used in the interpolation of sub-pixel values for the sub-pixels having co-ordinates with odd values of K and L, using a predetermined choice of either a weighted sum of the values of sub-pixels having co-ordinates with K equal to an even value and L equal to zero and the values of sub-pixels having corresponding co-ordinates in immediately adjacent rectangular bounded regions, or a weighted sum of the values of sub-pixels having co-ordinates with K equal to zero and L equal to an even value and the values of sub-pixels having corresponding co-ordinates in immediately adjacent rectangular bounded regions.

46. (Previously Presented) A codec comprising a video encoder according to claim 42 and a video decoder according to claim 44.

47. (Previously Presented) A codec comprising a still image encoder according to claim 43 and a still image decoder according to claim 45.

48. (Previously Presented) A communications terminal comprising a video encoder according to claim 42.

49. (Previously Presented) A communications terminal comprising a still image encoder according to claim 43.

50. (Previously Presented) A communications terminal comprising a video decoder according to claim 44.

51. (Previously Presented) A communications terminal comprising a still image decoder according to claim 45.

52. (Previously Presented) A communications terminal according to claim 48, wherein the communications terminal is a wireless terminal.

53. (Previously Presented) An interpolator for sub-pixel value interpolation, the interpolator being configured to determine values for sub-pixels situated within a rectangular bounded region defined by four corner pixels with no intermediate pixels between the corners, the pixels and sub-pixels being configured for display in rows and columns, pixel and sub-pixel locations in the rows and columns being representable mathematically within the rectangular bounded region using the co-ordinate notation $K/2^N$, $L/2^N$, K and L being positive integers having respective values between zero and $2^N$, N being a positive integer greater than one and representing a particular degree of sub-pixel value interpolation, the interpolator comprising:

- circuitry configured to interpolate a sub-pixel value for a sub-pixel having co-ordinates with odd values of K and L, according to a predetermined choice of either a weighted average of the value of a nearest-neighbouring pixel and the value of the sub-pixel situated at co-ordinates 1/2, 1/2, or a weighted average of the values of a pair of diagonally-opposed sub-pixels having co-ordinates with even values of K and L, including zero, situated within a quadrant of the rectangular bounded region, the quadrant being defined by the sub-pixel having co-ordinates 1/2, 1/2 and the nearest neighbouring pixel;
- circuitry configured to interpolate sub-pixel values for sub-pixels having co-ordinates with K equal to an even value and L equal to zero and sub-pixels having co-ordinates with K equal to zero and L equal to an even value, used in the interpolation of the sub-pixels having co-ordinates with odd values of K and L, using weighted sums of the values of pixels located in rows and columns respectively; and

- circuitry configured to interpolate sub-pixel values for sub-pixels having co-ordinates with even values of K and L, used in the interpolation of sub-pixel values for the sub-pixels having co-ordinates with odd values of K and L, using a predetermined choice of either a weighted sum of the values of sub-pixels having co-ordinates with K equal to an even value and L equal to zero and the values of sub-pixels having corresponding co-ordinates in immediately adjacent rectangular bounded regions, or a weighted sum of the values of sub-pixels having co-ordinates with K equal to zero and L equal to an even value and the values of sub-pixels having corresponding co-ordinates in immediately adjacent rectangular bounded regions.

54. (Previously Presented) An interpolator for quarter resolution sub-pixel value interpolation, the interpolator being configured to determine values for sub-pixels situated within a rectangular bounded region defined by four corner pixels with no intermediate pixels between the corners, the pixels and sub-pixels being configured for display in rows and columns, pixel and sub-pixel locations in the rows and columns being representable mathematically within the rectangular bounded region using the co-ordinate notation K/4, L/4, K and L being positive integers having respective values between zero and 4, the interpolator being configured to:

- interpolate a sub-pixel value for a sub-pixel having co-ordinates with K and L equal to 1 or 3, according to a predetermined choice of either a weighted average of the value of a nearest-neighbouring pixel and the value of the sub-pixel situated at co-ordinates 2/4, 2/4, or a weighted average of the values of a pair of diagonally-opposed sub-pixels having co-ordinates with K and L equal to zero, 2 or 4, situated within a quadrant of the rectangular bounded region, the quadrant being defined by the sub-pixel having co-ordinates 2/4, 2/4 and the nearest neighbouring pixel;
- interpolate sub-pixel values for sub-pixels having co-ordinates with K equal to 2 and L equal to zero and sub-pixels having co-ordinates with K equal to zero and L equal to 2, used in the interpolation of the sub-pixels having co-ordinates with K and L equal to 1 or 3, using weighted sums of the values of pixels located in rows and columns respectively; and
- interpolate a sub-pixel value for the sub-pixel having co-ordinates with K and L equal to 2, used in the interpolation of sub-pixel values for the sub-pixels having co-ordinates with K and L equal to 1 or 3, using a predetermined choice of either a weighted sum of the

values of the sub-pixel having co-ordinates with K equal to 2 and L equal to zero and the values of sub-pixels having corresponding co-ordinates in immediately adjacent rectangular bounded regions, or a weighted sum of the value of the sub-pixel having co-ordinates with K equal to zero and L equal to 2 and the values of sub-pixels having corresponding co-ordinates in immediately adjacent rectangular bounded regions.

55. (Previously Presented) An interpolator for eighth resolution sub-pixel value interpolation, the interpolator being configured to determine values for sub-pixels situated within a rectangular bounded region defined by four corner pixels with no intermediate pixels between the corners, the pixels and sub-pixels being configured for display in rows and columns, pixel and sub-pixel locations in the rows and columns being representable mathematically with the rectangular bounded region using the co-ordinate notation K/8, L/8, K and L being positive integers having respective values between zero and 8, the interpolator being configured to:

- interpolate a sub-pixel value for a sub-pixel having co-ordinates with K and L equal to 1, 3, 5 or 7, according to a predetermined choice of either a weighted average of the value of a nearest-neighbouring pixel and the value of the sub-pixel situated at co-ordinates 4/8, 4/8, or a weighted average of the values of a pair of diagonally-opposed sub-pixels having co-ordinates with K and L equal to zero, 2, 4, 6 or 8, situated within a quadrant of the rectangular bounded region, the quadrant being defined by the sub-pixel having co-ordinates 4/8, 4/8 and the nearest neighbouring pixel;
- interpolate sub-pixel values for sub-pixels having co-ordinates with K equal to 2, 4 or 6 and L equal to zero and sub-pixels having co-ordinates with K equal to zero and L equal to 2, 4 or 6, used in the interpolation of the sub-pixels having co-ordinates with K and L equal to 1, 3, 5 or 7, using weighted sums of the values of pixels located in rows and columns respectively; and
- interpolate sub-pixel values for sub-pixels having co-ordinates with K and L equal to 2, 4 or 6, used in the interpolation of sub-pixel values for the sub-pixels having co-ordinates with K and L equal to 1, 3, 5 or 7, using a predetermined choice of either a weighted sum of the values of sub-pixels having co-ordinates with K equal to 2, 4 or 6 and L equal to zero and the values of sub-pixels having corresponding co-ordinates in immediately adjacent rectangular bounded regions or a weighted sum of the values of sub-pixels

having co-ordinates with K equal to zero and L equal to 2, 4 or 6 and the values of sub-pixels having corresponding co-ordinates in immediately adjacent rectangular bounded regions.

56. (Previously Presented) A video encoder or still image encoder comprising an interpolator according to claim 54 or 55.

57. (Previously Presented) A video decoder or still image decoder comprising an interpolator according to claim 54 or 55.

58. (Previously Presented) A communications terminal comprising a video encoder or still image encoder according to claim 56.

59. (Previously Presented) A communications terminal comprising a video decoder or still image decoder according to claim 57.

60. (Previously Presented) A computer program for sub-pixel value interpolation, embodied on a computer readable storage medium, the computer program being configured to determine values for sub-pixels situated within a rectangular bounded region defined by four corner pixels with no intermediate pixels between the corners, the pixels and sub-pixels being configured for display in rows and columns, pixel and sub-pixel locations in the rows and columns being representable mathematically within the rectangular bounded region using the co-ordinate notation $K/2^N$, $L/2^N$, K and L being positive integers having respective values between zero and $2^N$, N being a positive integer greater than one and representing a particular degree of sub-pixel value interpolation, the computer program comprising:

- computer program code for interpolating a sub-pixel value for a sub-pixel having co-ordinates with odd values of K and L, according to a predetermined choice of either a weighted average of the value of a nearest-neighbouring pixel and the value of the sub-pixel situated at co-ordinates 1/2, 1/2, or a weighted average of the values of a pair of

diagonally-opposed sub-pixels having co-ordinates with even values of K and L, including zero, situated within a quadrant of the rectangular bounded region, the quadrant being defined by the sub-pixel having co-ordinates 1/2, 1/2 and the nearest neighbouring pixel;

- computer program code for interpolating sub-pixel values for sub-pixels having co-ordinates with K equal to an even value and L equal to zero and sub-pixels having co-ordinates with K equal to zero and L equal to an even value, used in the interpolation of the sub-pixels having co-ordinates with odd values of K and L, using weighted sums of the values of pixels located in rows and columns respectively; and
- computer program code for interpolating sub-pixel values for sub-pixels having co-ordinates with even values of K and L, used in the interpolation of sub-pixel values for the sub-pixels having co-ordinates with odd values of K and L, using a predetermined choice of either a weighted sum of the values of sub-pixels having co-ordinates with K equal to an even value and L equal to zero and the values of sub-pixels having corresponding co-ordinates in immediately adjacent rectangular bounded regions, or a weighted sum of the values of sub-pixels having co-ordinates with K equal to zero and L equal to an even value and the values of sub-pixels having corresponding co-ordinates in immediately adjacent rectangular bounded regions.

61. (Previously Presented) A network apparatus comprising an interpolator for sub-pixel value interpolation, the interpolator being configured to determine values for sub-pixels situated within a rectangular bounded region defined by four corner pixels with no intermediate pixels between the corners, the pixels and sub-pixels being configured for display in rows and columns, pixel and sub-pixel locations in the rows and columns being representable mathematically within the rectangular bounded region using the co-ordinate notation $K/2^N$, $L/2^N$, K and L being positive integers having respective values between zero and $2^N$, N being a positive integer greater than one and representing a particular degree of sub-pixel value interpolation, the interpolator being configured to:

- interpolate a sub-pixel value for a sub-pixel having co-ordinates with odd values of K and L, according to a predetermined choice of either a weighted average of the value of a nearest-neighbouring pixel and the value of the sub-pixel situated at co-ordinates 1/2, 1/2, or a weighted average of the values of a pair of diagonally-opposed sub-pixels having co-

ordinates with even values of K and L, including zero, situated within a quadrant of the rectangular bounded region, the quadrant being defined by the sub-pixel having co-ordinates 1/2, 1/2 and the nearest neighbouring pixel;

- interpolate sub-pixel values for sub-pixels having co-ordinates with K equal to an even value and L equal to zero and sub-pixels having co-ordinates with K equal to zero and L equal to an even value, used in the interpolation of the sub-pixels having co-ordinates with odd values of K and L, using weighted sums of the values of pixels located in rows and columns respectively; and
- interpolate sub-pixel values for sub-pixels having co-ordinates with even values of K and L, used in the interpolation of sub-pixel values for the sub-pixels having co-ordinates with odd values of K and L, using a predetermined choice of either a weighted sum of the values of sub-pixels having co-ordinates with K equal to an even value and L equal to zero and the values of sub-pixels having corresponding co-ordinates in immediately adjacent rectangular bounded regions, or a weighted sum of the values of sub-pixels having co-ordinates with K equal to zero and L equal to an even value and the values of sub-pixels having corresponding co-ordinates in immediately adjacent rectangular bounded regions.

62. (Previously Presented) A method according to claim 1, wherein the pixels have a predetermined dynamic range, said predetermined dynamic range corresponding to the range of values said pixels can take.

63 (Currently Amended) A method according to claim 62, comprising interpolating sub-pixel values for sub-pixels having co-ordinates with K equal to an even value and L equal to zero and for sub-pixels having co-ordinates with K equal to zero and L equal to an even value, using weighted sums of the values of pixels located in rows and columns respectively, to produce a first intermediate value, said first intermediate value having a dynamic range equal to the predetermined dynamic range of the pixels used in said weighted sum multiplied by a value equal to the sum of the respective weights used in said weighted sum.

64. (Previously Presented) A method according to claim 63, wherein the dynamic range of said first intermediate value is defined by the number of bits used to represent the respective pixels used in said weighted sum plus the number of bits required to represent the sum of the respective weights used in said weighted sum.

65. (Previously Presented) A method according to claim 63, comprising truncating the first intermediate value by mathematically dividing the first intermediate value by a first scale factor, said first scale factor having a value equal to the sum of the respective weights used in said weighted sum, thereby forming a sub-pixel value with a dynamic range equal to the predetermined dynamic range of said pixels.

66. (Previously Presented) A method according to claim 63, comprising interpolating sub-pixel values for sub-pixels having co-ordinates with even values of K and L, using a weighted sum comprising first intermediate values for sub-pixels having co-ordinates with K equal to an even value and L equal to zero and corresponding first intermediate values for sub-pixels having corresponding co-ordinates in immediately adjacent rectangular bounded regions, to produce a second intermediate value, said second intermediate value having a dynamic range equal to the dynamic range of the first intermediate values used in said weighted sum, multiplied by a value equal to the sum of the respective weights used in said weighted sum.

67. (Previously Presented) A method according to claim 63, comprising interpolating sub-pixel values for sub-pixels having co-ordinates with even values of K and L, using a weighted sum comprising first intermediate values for sub-pixels having co-ordinates with K equal to zero and L equal to an even value and corresponding first intermediate values for sub-pixels having corresponding co-ordinates in immediately adjacent rectangular bounded regions to produce a second intermediate value, said second intermediate value having a dynamic range equal to the dynamic range of the first intermediate values used in said weighted sum, multiplied by a value equal to the sum of the respective weights used in said weighted sum.

68. (Previously Presented) A method according to claim 66, comprising truncating the second intermediate value by mathematically dividing the second intermediate value by a second scale factor, said second scale factor having a value equal to the sum of the respective weights used

in the weighted sum of claim 63 multiplied by the sum of the respective weights used in the weighted sum of claim 66, thereby forming a sub-pixel value with a dynamic range equal to the predetermined dynamic range of said pixels.

69. (Previously Presented) A method according to claim 67, comprising truncating the second intermediate value by mathematically dividing the second intermediate value by a second scale factor, said second scale factor having a value equal to the sum of the respective weights used in the weighted sum of claim 63 multiplied by the sum of the respective weights used in the weighted sum of claim 67, thereby forming a sub-pixel value with a dynamic range equal to the dynamic range of said pixels.

70. (Previously Presented) A method according to claim 65, comprising using a truncated first intermediate sub-pixel value when interpolating a value for a sub-pixel having co-ordinates with odd values of K and L.

71. (Previously Presented) A method according to claim 68, comprising using a truncated second intermediate sub-pixel value when interpolating a value for a sub-pixel having co-ordinates with odd values of K and L.

72. (Previously Presented) An interpolator according to claim 22, wherein the pixels have a predetermined dynamic range, said predetermined dynamic range corresponding to the range of values said pixels can take.

73. (Previously Presented) An interpolator according to claim 72, wherein the interpolator is configured to interpolate sub-pixel values for sub-pixels having co-ordinates with K equal to an even value and L equal to zero and for sub-pixels having co-ordinates with K equal to zero and L equal to an even value, using weighted sums of the values of pixels located in rows and columns respectively, to produce a first intermediate value, said first intermediate value having a dynamic range equal to the predetermined dynamic range of the pixels used in said weighted sum multiplied by a value equal to the sum of the respective weights used in said weighted sum.

74. (Previously Presented) An interpolator according to claim 73, wherein the dynamic range of said first intermediate value is defined by the number of bits used to represent the respective pixels used in said weighted sum plus the number of bits required to represent the sum of the respective weights used in said weighted sum.

75. (Previously Presented) An interpolator according to claim 73, wherein the interpolator is configured to truncate the first intermediate value by mathematically dividing the first intermediate value by a first scale factor, said first scale factor having a value equal to the sum of the respective weights used in said weighted sum, thereby forming a sub-pixel value with a dynamic range equal to the predetermined dynamic range of said pixels.

76. (Previously Presented) An interpolator according to claim 73, wherein the interpolator is configured to interpolate sub-pixel values for sub-pixels having co-ordinates with even values of K and L, using a weighted sum comprising first intermediate values for sub-pixels having co-ordinates with K equal to an even value and L equal to zero and corresponding first intermediate values for sub-pixels having corresponding co-ordinates in immediately adjacent rectangular bounded regions, to produce a second intermediate value, said second intermediate value having a dynamic range equal to the dynamic range of the first intermediate values used in said weighted sum, multiplied by a value equal to the sum of the respective weights used in said weighted sum.

77. (Previously Presented) An interpolator according to claim 73, wherein the interpolator is configured to interpolate sub-pixel values for sub-pixels having co-ordinates with even values of K and L, using a weighted sum comprising first intermediate values for sub-pixels having co-ordinates with K equal to zero and L equal to an even value and corresponding first intermediate values for sub-pixels having corresponding co-ordinates in immediately adjacent rectangular bounded regions to produce a second intermediate value, said second intermediate value having a dynamic range equal to the dynamic range of the first intermediate values used in said weighted sum, multiplied by a value equal to the sum of the respective weights used in said weighted sum.

78. (Previously Presented) An interpolator according to claim 76, wherein the interpolator is configured to truncate the second intermediate value by mathematically dividing the second intermediate value by a second scale factor, said second scale factor having a value equal to the sum of the respective weights used in the weighted sum of claim 73 multiplied by the sum of the respective weights used in the weighted sum of claim 76, thereby forming a sub-pixel value with a dynamic range equal to the predetermined dynamic range of said pixels.

79. (Previously Presented) An interpolator according to claim 77, wherein the interpolator is configured to truncate the second intermediate value by mathematically dividing the second intermediate value by a second scale factor, said second scale factor having a value equal to the sum of the respective weights used in the weighted sum of claim 73 multiplied by the sum of the respective weights used in the weighted sum of claim 77, thereby forming a sub-pixel value with a dynamic range equal to the predetermined dynamic range of said pixels.

80. (Previously Presented) An interpolator according to claim 75, wherein the interpolator is configured to use a truncated first intermediate sub-pixel value when interpolating a value for a sub-pixel having co-ordinates with odd values of K and L.

81. (Previously Presented) An interpolator according to claim 78, wherein the interpolator is configured to use a truncated second intermediate sub-pixel value when interpolating a value for a sub-pixel having co-ordinates with odd values of K and L.

82. (Previously Presented) A method according to claim 69, comprising using a truncated second intermediate sub-pixel value when interpolating a value for a sub-pixel having co-ordinates with odd values of K and L.

83. (Previously Presented) An interpolator according to claim 79, wherein the interpolator is configured to use a truncated second intermediate sub-pixel value when interpolating a value for a sub-pixel having co-ordinates with odd values of K and L.

## III. REMARKS

Claim 63 has been amended to add a space between the words "zero" and "and" in line 2. Applicant respectfully requests entry of the claim amendment.

The amendment is needed to correct a typographical error introduced in the previous amendment.

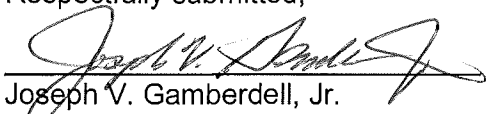
The proposed amended claim requires no additional search or examination because it includes no new subject matter and is only amended to correct a typographical error.

The claims are patentable because they have been allowed and the amendment does not change their scope.

The amendment was not presented earlier because the typographical error was only recently discovered.

The Commissioner is hereby authorized to charge payment for any fees associated with this communication or credit any over payment to Deposit Account No. 16-1350.

Respectfully submitted,



Joseph V. Gamberdell, Jr.
Reg. No. 44,695



Date

Perman & Green, LLP
99 Hawley Lane
Stratford, CT 06614
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Customer No.: 2512

# Electronic Acknowledgement Receipt

| | |
|---|---|
| **EFS ID:** | 10359428 |
| **Application Number:** | 11839205 |
| **International Application Number:** | |
| **Confirmation Number:** | 8091 |
| **Title of Invention:** | METHOD FOR SUB-PIXEL VALUE INTERPOLATION |
| **First Named Inventor/Applicant Name:** | Marta Karczewicz |
| **Customer Number:** | 10868 |
| **Filer:** | Joseph V. Gamberdell/Maureen Silveira |
| **Filer Authorized By:** | Joseph V. Gamberdell |
| **Attorney Docket Number:** | 982-010567-US (C02) |
| **Receipt Date:** | 22-JUN-2011 |
| **Filing Date:** | 15-AUG-2007 |
| **Time Stamp:** | 13:27:54 |
| **Application Type:** | Utility under 35 USC 111(a) |

## Payment information:

| | |
|---|---|
| Submitted with Payment | no |

## File Listing:

| Document Number | Document Description | File Name | File Size(Bytes)/ Message Digest | Multi Part /.zip | Pages (if appl.) |
|---|---|---|---|---|---|
| 1 | Amendment after Notice of Allowance (Rule 312) | AmendmentAfterNoticeofAllow110622_Cute.pdf | 3960788<br>cab3a908ab8da8739b23193f2b8d271d98de0deb | no | 28 |

| | |
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| **Warnings:** | |
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**New Applications Under 35 U.S.C. 111**
**If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.**

**National Stage of an International Application under 35 U.S.C. 371**
**If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.**

**New International Application Filed with the USPTO as a Receiving Office**
**If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.**

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| APPLICATION NO. | FILING DATE | FIRST NAMED INVENTOR | ATTORNEY DOCKET NO. | CONFIRMATION NO. |
|---|---|---|---|---|
| 11/839,205 | 08/15/2007 | Marta Karczewicz | 982-010567-US (C02) | 8091 |

10868 7590 07/01/2011

Perman & Green, LLP
99 Hawley Lane
Stratford, CT 06614

| EXAMINER | |
|---|---|
| AN, SHAWN S | |
| ART UNIT | PAPER NUMBER |
| 2483 | |
| MAIL DATE | DELIVERY MODE |
| 07/01/2011 | PAPER |

**Please find below and/or attached an Office communication concerning this application or proceeding.**

The time period for reply, if any, is set in the attached communication.

| Response to Rule 312 Communication | Application No. | Applicant(s) |
|---|---|---|
| | 11/839,205 | KARCZEWICZ ET AL. |
| | Examiner | Art Unit |
| | SHAWN AN | 2483 |

*-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address –*

1. ☒ The amendment filed on *22 June 2011* under 37 CFR 1.312 has been considered, and has been:

   a) ☐ entered.

   b) ☒ entered as directed to matters of form not affecting the scope of the invention.

   c) ☐ disapproved because the amendment was filed after the payment of the issue fee.
   Any amendment filed after the date the issue fee is paid must be accompanied by a petition under 37 CFR 1.313(c)(1) and the required fee to withdraw the application from issue.

   d) ☐ disapproved. See explanation below.

   e) ☐ entered in part. See explanation below.

6/28/11

/SHAWN AN/
Primary Examiner, Art Unit 2483

# PART B - FEE(S) TRANSMITTAL

**Complete and send this form, together with applicable fee(s), to: Mail** **Mail Stop ISSUE FEE**
**Commissioner for Patents**
**P.O. Box 1450**
**Alexandria, Virginia 22313-1450**
**or Fax (571) 273-2885**

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CURRENT CORRESPONDENCE ADDRESS (Note: Use Block 1 for any change of address)

PERMAN & GREEN LLP
99 HAWLEY LANE
STRATFORD, CT 06614

Note: A certificate of mailing can only be used for domestic mailings of the Fee(s) Transmittal. This certificate cannot be used for any other accompanying papers. Each additional paper, such as an assignment or formal drawing, must have its own certificate of mailing or transmission.

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I hereby certify that this Fee(s) Transmittal is being deposited with the United States Postal Service with sufficient postage for first class mail in an envelope addressed to the Mail Stop ISSUE FEE address above, or being facsimile transmitted to the USPTO (571) 273-2885, on the date indicated below.

| (Depositor's name) |
|---|
| (Signature) |
| (Date) |

| APPLICATION NO. | FILING DATE | FIRST NAMED INVENTOR | ATTORNEY DOCKET NO. | CONFIRMATION NO. |
|---|---|---|---|---|
| 11/839,205 | 08/15/2007 | Marta Karczewicz | 982-010567-US (C02) | 8091 |

TITLE OF INVENTION:

| APPLN. TYPE | SMALL ENTITY | ISSUE FEE | PUBLICATION FEE | TOTAL FEE(S) DUE | DATE DUE |
|---|---|---|---|---|---|
| nonprovisional | NO | $1510 | $300 | $1810 | 07/06/2011 |

| EXAMINER | ART UNIT | CLASS-SUBCLASS |
|---|---|---|
| | | |

1. Change of correspondence address or indication of "Fee Address" (37 CFR 1.363).

☐ Change of correspondence address (or Change of Correspondence Address form PTO/SB/122) attached.

☐ "Fee Address" indication (or "Fee Address" Indication form PTO/SB/47; Rev 03-02 or more recent) attached. **Use of a Customer Number is required.**

2. For printing on the patent front page, list

(1) the names of up to 3 registered patent attorneys or agents OR, alternatively,

(2) the name of a single firm (having as a member a registered attorney or agent) and the names of up to 2 registered patent attorneys or agents. If no name is listed, no name will be printed.

1 PERMAN & GREEN, LLP
2
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3. ASSIGNEE NAME AND RESIDENCE DATA TO BE PRINTED ON THE PATENT (print or type)

PLEASE NOTE: Unless an assignee is identified below, no assignee data will appear on the patent. If an assignee is identified below, the document has been filed for recordation as set forth in 37 CFR 3.11. Completion of this form is NOT a substitute for filing an assignment.

| (A) NAME OF ASSIGNEE | (B) RESIDENCE: (CITY and STATE OR COUNTRY) |
|---|---|
| Nokia Corporation | Espoo, FINLAND |

Please check the appropriate assignee category or categories (will not be printed on the patent) : ☐ Individual ☑ Corporation or other private group entity ☐ Government

4a. The following fee(s) are enclosed:

☑ Issue Fee
☑ Publication Fee (No small entity discount permitted)
☐ Advance Order - # of Copies _

4b. Payment of Fee(s):

☐ A check in the amount of the fee(s) is enclosed.
☐ Payment by credit card. Form PTO-2038 is attached.
☑ The Director is hereby authorized by charge the required fee(s), or credit any overpayment, to Deposit Account Number 16-1350 .

5. **Change in Entity Status** (from status indicated above)

☐ a. Applicant claims SMALL ENTITY status. See 37 CFR 1.27.
☐ b. Applicant is no longer claiming SMALL ENTITY status. See 37 CFR 1.27(g)(2).

The Director of the USPTO is requested to apply the Issue Fee and Publication Fee (if any) or to re-apply any previously paid issue fee to the application identified above.
NOTE: The Issue Fee and Publication Fee (if required) will not be accepted from anyone other than the applicant; a registered attorney or agent; or the assignee or other party in interest as shown by the records of the United States Patent and Trademark Office.

Authorized Signature /jvg44695/ Date 2011-07-06

Typed or printed name Joseph V. Gamberdell, Jr. Registration No. 44,695

This collection of information is required by 37 CFR 1.311. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 12 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, Virginia 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, Virginia 22313-1450.

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The information provided by you in this form will be subject to the following routine uses:

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3. A record in this system of records may be disclosed, as a routine use, to a Member of Congress submitting a request involving an individual, to whom the record pertains, when the individual has requested assistance from the Member with respect to the subject matter of the record.
4. A record in this system of records may be disclosed, as a routine use, to a contractor of the Agency having need for the information in order to perform a contract. Recipients of information shall be required to comply with the requirements of the Privacy Act of 1974, as amended, pursuant to 5 U.S.C. 552a(m).
5. A record related to an International Application filed under the Patent Cooperation Treaty in this system of records may be disclosed, as a routine use, to the International Bureau of the World Intellectual Property Organization, pursuant to the Patent Cooperation Treaty.
6. A record in this system of records may be disclosed, as a routine use, to another federal agency for purposes of National Security review (35 U.S.C. 181) and for review pursuant to the Atomic Energy Act (42 U.S.C. 218(c)).
7. A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (i.e., GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.
8. A record from this system of records may be disclosed, as a routine use, to the public after either publication of the application pursuant to 35 U.S.C. 122(b) or issuance of a patent pursuant to 35 U.S.C. 151. Further, a record may be disclosed, subject to the limitations of 37 CFR 1.14, as a routine use, to the public if the record was filed in an application which became abandoned or in which the proceedings were terminated and which application is referenced by either a published application, an application open to public inspection or an issued patent.
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# Electronic Patent Application Fee Transmittal

| | |
|---|---|
| **Application Number:** | 11839205 |
| **Filing Date:** | 15-Aug-2007 |
| **Title of Invention:** | METHOD FOR SUB-PIXEL VALUE INTERPOLATION |
| **First Named Inventor/Applicant Name:** | Marta Karczewicz |
| **Filer:** | Joseph V. Gamberdell/Maureen Silveira |
| **Attorney Docket Number:** | 982-010567-US (C02) |

Filed as Large Entity

## Utility under 35 USC 111(a) Filing Fees

| Description | Fee Code | Quantity | Amount | Sub-Total in USD($) |
|---|---|---|---|---|
| **Basic Filing:** | | | | |
| **Pages:** | | | | |
| **Claims:** | | | | |
| **Miscellaneous-Filing:** | | | | |
| **Petition:** | | | | |
| **Patent-Appeals-and-Interference:** | | | | |
| **Post-Allowance-and-Post-Issuance:** | | | | |
| Utility Appl issue fee | 1501 | 1 | 1510 | 1510 |
| Publ. Fee- early, voluntary, or normal | 1504 | 1 | 300 | 300 |

| Description | Fee Code | Quantity | Amount | Sub-Total in USD($) |
|---|---|---|---|---|
| **Extension-of-Time:** | | | | |
| **Miscellaneous:** | | | | |
| | | | **Total in USD ($)** | **1810** |

# Electronic Acknowledgement Receipt

| | |
|---|---|
| **EFS ID:** | 10451426 |
| **Application Number:** | 11839205 |
| **International Application Number:** | |
| **Confirmation Number:** | 8091 |
| **Title of Invention:** | METHOD FOR SUB-PIXEL VALUE INTERPOLATION |
| **First Named Inventor/Applicant Name:** | Marta Karczewicz |
| **Customer Number:** | 10868 |
| **Filer:** | Joseph V. Gamberdell/Maureen Silveira |
| **Filer Authorized By:** | Joseph V. Gamberdell |
| **Attorney Docket Number:** | 982-010567-US (C02) |
| **Receipt Date:** | 06-JUL-2011 |
| **Filing Date:** | 15-AUG-2007 |
| **Time Stamp:** | 11:30:02 |
| **Application Type:** | Utility under 35 USC 111(a) |

## Payment information:

| | |
|---|---|
| Submitted with Payment | yes |
| Payment Type | Deposit Account |
| Payment was successfully received in RAM | $1810 |
| RAM confirmation Number | 9064 |
| Deposit Account | 161350 |
| Authorized User | |
| The Director of the USPTO is hereby authorized to charge indicated fees and credit any overpayment as follows:<br>Charge any Additional Fees required under 37 C.F.R. Section 1.20 (Post Issuance fees) | |

## File Listing:

| Document Number | Document Description | File Name | File Size(Bytes)/ Message Digest | Multi Part /.zip | Pages (if appl.) |
|---|---|---|---|---|---|
| 1 | Issue Fee Payment (PTO-85B) | IssueFeeTransmittal_PTOL85B.pdf | 232107<br>b8b23ebdec6e89022cfb0a4678f249976c576a1e | no | 2 |
| **Warnings:** | | | | | |
| **Information:** | | | | | |
| 2 | Fee Worksheet (SB06) | fee-info.pdf | 32570<br>36ded42136f70b3848db0a2e14b93a2123ea2b39 | no | 2 |
| **Warnings:** | | | | | |
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| APPLICATION NO. | FILING DATE | FIRST NAMED INVENTOR | ATTORNEY DOCKET NO. | CONFIRMATION NO. |
|---|---|---|---|---|
| 11/839,205 | 08/15/2007 | Marta Karczewicz | 982-010567-US (C02) | 8091 |

10868 7590 08/15/2011

Perman & Green, LLP
99 Hawley Lane
Stratford, CT 06614

| EXAMINER | |
|---|---|
| AN, SHAWN S | |
| ART UNIT | PAPER NUMBER |
| 2483 | |
| MAIL DATE | DELIVERY MODE |
| 08/15/2011 | PAPER |

**Please find below and/or attached an Office communication concerning this application or proceeding.**

The time period for reply, if any, is set in the attached communication.

| Supplemental Notice of Allowability | Application No. 11/839,205 | Applicant(s) KARCZEWICZ ET AL. | |
|---|---|---|---|
| | Examiner SHAWN AN | Art Unit 2483 | |

***-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address--***

All claims being allowable, PROSECUTION ON THE MERITS IS (OR REMAINS) CLOSED in this application. If not included herewith (or previously mailed), a Notice of Allowance (PTOL-85) or other appropriate communication will be mailed in due course. **THIS NOTICE OF ALLOWABILITY IS NOT A GRANT OF PATENT RIGHTS.** This application is subject to withdrawal from issue at the initiative of the Office or upon petition by the applicant. See 37 CFR 1.313 and MPEP 1308.

1. ☐ This communication is responsive to _____.

2. ☒ The allowed claim(s) is/are *1-83*.

3. ☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).
   a) ☐ All b) ☐ Some* c) ☐ None of the:
      1. ☐ Certified copies of the priority documents have been received.
      2. ☐ Certified copies of the priority documents have been received in Application No. _____ .
      3. ☐ Copies of the certified copies of the priority documents have been received in this national stage application from the International Bureau (PCT Rule 17.2(a)).

   * Certified copies not received: _____.

Applicant has THREE MONTHS FROM THE "MAILING DATE" of this communication to file a reply complying with the requirements noted below. Failure to timely comply will result in ABANDONMENT of this application.
**THIS THREE-MONTH PERIOD IS NOT EXTENDABLE**.

4. ☐ A SUBSTITUTE OATH OR DECLARATION must be submitted. Note the attached EXAMINER'S AMENDMENT or NOTICE OF INFORMAL PATENT APPLICATION (PTO-152) which gives reason(s) why the oath or declaration is deficient.

5. ☐ CORRECTED DRAWINGS ( as "replacement sheets") must be submitted.
   (a) ☐ including changes required by the Notice of Draftsperson's Patent Drawing Review ( PTO-948) attached
      1) ☐ hereto or 2) ☐ to Paper No./Mail Date _____.
   (b) ☐ including changes required by the attached Examiner's Amendment / Comment or in the Office action of Paper No./Mail Date _____.

   **Identifying indicia such as the application number (see 37 CFR 1.84(c)) should be written on the drawings in the front (not the back) of each sheet. Replacement sheet(s) should be labeled as such in the header according to 37 CFR 1.121(d).**

6. ☐ DEPOSIT OF and/or INFORMATION about the deposit of BIOLOGICAL MATERIAL must be submitted. Note the attached Examiner's comment regarding REQUIREMENT FOR THE DEPOSIT OF BIOLOGICAL MATERIAL.

**Attachment(s)**

1. ☐ Notice of References Cited (PTO-892)
2. ☐ Notice of Draftperson's Patent Drawing Review (PTO-948)
3. ☐ Information Disclosure Statements (PTO/SB/08), Paper No./Mail Date _____
4. ☐ Examiner's Comment Regarding Requirement for Deposit of Biological Material
5. ☐ Notice of Informal Patent Application
6. ☐ Interview Summary (PTO-413), Paper No./Mail Date _____ .
7. ☒ Examiner's Amendment/Comment
8. ☐ Examiner's Statement of Reasons for Allowance
9. ☐ Other _____.

## Supplemental reasons for Allowance

### EXAMINER'S AMENDMENT

**I.** An Examiner's amendment to the record appears below. Should the changes and/or additions be unacceptable to Applicant, an amendment may be filed as provided by 37 CFR 1.312. To ensure consideration of such an amendment, it MUST be submitted no later than the payment of the issue fee.

**IN THE CLAIMS:**

**A)** Please amend claims 46-47 and 56-57 as follows:

46. (Currently Amended) A codec comprising a video encoder according to claim 42 and a video decoder ~~according to claim 44~~ comprising an interpolator for sub-pixel value interpolation, the interpolator being configured to determine values for sub-pixels situated within a rectangular bounded region defined by four corner pixels with no intermediate pixels between the corners, the pixels and sub-pixels being configured for display in rows and columns, pixel and sub-pixel locations in the rows and columns being representable mathematically within the rectangular bounded region using the co-ordinate notation $K/2^N$, $L/2^N$, K and L being positive integers having respective values between zero and $2^N$, N being a positive integer greater than one and representing a particular degree of sub-pixel value interpolation, the interpolator being configured to:

- interpolate a sub-pixel value for a sub-pixel having co-ordinates with odd values of K and L, according to a predetermined choice of a either weighted average of the value of a nearest-neighbouring pixel and the value of the sub-pixel situated at co-ordinates 1/2, 1/2, or a weighted average of the values of a pair of

diagonally-opposed sub-pixels having co-ordinates with even values of K and L, including zero, situated within a quadrant of the rectangular bounded region, the quadrant being defined by the sub-pixel having co- ordinates 1/2, 1/2 and the nearest neighbouring pixel;

- interpolate sub-pixel values for sub-pixels having co-ordinates with K equal to an even value and L equal to zero and sub-pixels having co-ordinates with K equal to zero and L equal to an even value, used in the interpolation of the sub-pixels having co-ordinates with odd values of K and L, using weighted sums of the values of pixels located in rows and columns respectively; and
- interpolate sub-pixel values for sub-pixels having co-ordinates with even values of K and L, used in the interpolation of sub-pixel values for the sub-pixels having co-ordinates with odd values of K and L, using a predetermined choice of either a weighted sum of the values of sub-pixels having co-ordinates with K equal to an even value and L equal to zero and the values of sub-pixels having corresponding co-ordinates in immediately adjacent rectangular bounded regions, or a weighted sum of the values of sub-pixels having co-ordinates with K equal to zero and L equal to an even value and the values of sub-pixels having corresponding co-ordinates in immediately adjacent rectangular bounded regions.

47. (Currently Amended) A codec comprising a still image encoder according to claim 43 and a still image decoder ~~according to claim 45~~ comprising an interpolator for sub-pixel value interpolation, the interpolator being configured to determine values for sub-pixels situated within a rectangular bounded region defined by four corner pixels with no intermediate pixels between the corners, the pixe!s and sub-pixels being configured for display in rows and columns, pixel and sub-pixel locations in the rows and columns being representable mathematically within the rectangular bounded region using the co-ordinate notation $K/2^N$, $L/2^N$, K and L being positive integers having respective values

between zero and $2^N$, N being a positive integer greater than one and representing a particular degree of sub-pixel value interpolation, the interpolator being configured to:

- interpolate a sub-pixel value for a sub-pixel having co-ordinates with odd values of K and L, according to a predetermined choice of either a weighted average of the value of a nearest-neighbouring pixel and the value of the sub-pixel situated at co-ordinates 1/2, 1/2, or a weighted average of the values of a pair of diagonally-opposed sub-pixels having co-ordinates with even values of K and L, including zero, situated within a quadrant of the rectangular bounded region, the quadrant being defined by the sub-pixel having co- ordinates 1/2, 1/2 and the nearest neighbouring pixel;
- interpolate sub-pixel values for sub-pixels having co-ordinates with K equal to an even value and L equal to zero and sub-pixels having co-ordinates with K equal to zero and L equal to an even value, used in the interpolation of the sub-pixels having co-ordinates with odd values of K and L, using weighted sums of the values of pixels located in rows and columns respectively; and
- interpolate sub-pixel values for sub-pixels having co-ordinates with even values of K and L, used in the interpolation of sub-pixel values for the sub-pixels having co-ordinates with odd values of K and L, using a predetermined choice of either a weighted sum of the values of sub-pixels having co-ordinates with K equal to an even value and L equal to zero and the values of sub-pixels having corresponding co-ordinates in immediately adjacent rectangular bounded regions, or a weighted sum of the values of sub-pixels having co-ordinates with K equal to zero and L equal to an even value and the values of sub-pixels having corresponding co-ordinates in immediately adjacent rectangular bounded regions.

56. (Previously Presented) A video encoder or still image encoder comprising an interpolator according to claim 54 ~~or 55~~.

57. (Previously Presented) A video decoder or still image decoder comprising an interpolator according to claim ~~54 or~~ 55.

**REMARKS:**

**II.** Claims 46-47 and 56-57 have been amended as discussed above, as authorized by Applicant's attorney/representative, Joseph V. Gamberdell, Jr. on August 10, 2011.

**III.** Any inquiry concerning this communication or earlier communications from the Examiner should be directed to *Shawn An* whose telephone number is 571-272-7324.

/SHAWN AN/
Primary Examiner, Art Unit 2483

| Issue Classification | Application/Control No. | Applicant(s)/Patent under Reexamination | |
|---|---|---|---|
| | 11/839,205 | KARCZEWICZ ET AL. | |
| | Examiner | Art Unit | |
| | SHAWN AN | 2483 | |

# ISSUE CLASSIFICATION

| ORIGINAL | | | CROSS REFERENCE(S) | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| CLASS | SUBCLASS | CLASS | SUBCLASS (ONE SUBCLASS PER BLOCK) | | | | | | |
| 375 | 240.17 | 375 | 240.16 | 240.25 | 240.26 | 240.12 | | | |
| INTERNATIONAL CLASSIFICATION | | 382 | 238 | 236 | 233 | 235 | | | |
| H 0 4 B 1/66 | | | | | | | | | |
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| (Assistant Examiner) (Date) | /SHAWN AN/ 8/11/2011 (Primary Examiner) (Date) | Total Claims Allowed: 83 | |
|---|---|---|---|
| (Legal Instruments Examiner) (Date) | | O.G. Print Claim(s): 1 | O.G. Print Fig.: 7 |

☐ Claims renumbered in the same order as presented by applicant ☐ CPA ☐ T.D. ☐ R.1.47

| Final | Original | Final | Original | Final | Original | Final | Original | Final | Original | Final | Original | Final | Original |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1 | 42 | 31 | 83 | 61 | | 91 | | 121 | | 151 | | 181 |
| 31 | 2 | 43 | 32 | 20 | 62 | | 92 | | 122 | | 152 | | 182 |
| 32 | 3 | 44 | 33 | 21 | 63 | | 93 | | 123 | | 153 | | 183 |
| 2 | 4 | 45 | 34 | 22 | 64 | | 94 | | 124 | | 154 | | 184 |
| 4 | 5 | 46 | 35 | 23 | 65 | | 95 | | 125 | | 155 | | 185 |
| 3 | 6 | 47 | 36 | 25 | 66 | | 96 | | 126 | | 156 | | 186 |
| 5 | 7 | 48 | 37 | 28 | 67 | | 97 | | 127 | | 157 | | 187 |
| 6 | 8 | 49 | 38 | 26 | 68 | | 98 | | 128 | | 158 | | 188 |
| 7 | 9 | 50 | 39 | 29 | 69 | | 99 | | 129 | | 159 | | 189 |
| 8 | 10 | 51 | 40 | 24 | 70 | | 100 | | 130 | | 160 | | 190 |
| 9 | 11 | 52 | 41 | 27 | 71 | | 101 | | 131 | | 161 | | 191 |
| 10 | 12 | 64 | 42 | 53 | 72 | | 102 | | 132 | | 162 | | 192 |
| 11 | 13 | 68 | 43 | 54 | 73 | | 103 | | 133 | | 163 | | 193 |
| 12 | 14 | 71 | 44 | 55 | 74 | | 104 | | 134 | | 164 | | 194 |
| 13 | 15 | 73 | 45 | 56 | 75 | | 105 | | 135 | | 165 | | 195 |
| 14 | 16 | 65 | 46 | 58 | 76 | | 106 | | 136 | | 166 | | 196 |
| 15 | 17 | 69 | 47 | 61 | 77 | | 107 | | 137 | | 167 | | 197 |
| 16 | 18 | 66 | 48 | 59 | 78 | | 108 | | 138 | | 168 | | 198 |
| 17 | 19 | 70 | 49 | 62 | 79 | | 109 | | 139 | | 169 | | 199 |
| 18 | 20 | 72 | 50 | 57 | 80 | | 110 | | 140 | | 170 | | 200 |
| 19 | 21 | 74 | 51 | 60 | 81 | | 111 | | 141 | | 171 | | 201 |
| 33 | 22 | 67 | 52 | 30 | 82 | | 112 | | 142 | | 172 | | 202 |
| 34 | 23 | 75 | 53 | 63 | 83 | | 113 | | 143 | | 173 | | 203 |
| 36 | 24 | 76 | 54 | | 84 | | 114 | | 144 | | 174 | | 204 |
| 35 | 25 | 79 | 55 | | 85 | | 115 | | 145 | | 175 | | 205 |
| 37 | 26 | 77 | 56 | | 86 | | 116 | | 146 | | 176 | | 206 |
| 38 | 27 | 80 | 57 | | 87 | | 117 | | 147 | | 177 | | 207 |
| 39 | 28 | 78 | 58 | | 88 | | 118 | | 148 | | 178 | | 208 |
| 40 | 29 | 81 | 59 | | 89 | | 119 | | 149 | | 179 | | 209 |
| 41 | 30 | 82 | 60 | | 90 | | 120 | | 150 | | 180 | | 210 |

## Index of Claims

| Application/Control No. | Applicant(s)/Patent under Reexamination |
|---|---|
| 11/839,205 | KARCZEWICZ ET AL. |
| **Examiner** | **Art Unit** |
| SHAWN AN | 2483 |

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|---|---|---|---|---|---|---|---|
| √ | Rejected | – | (Through numeral) Cancelled | N | Non-Elected | A | Appeal |
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| Claim | | Date | | | | | | | | |
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| Final | Original | 8/11/11 | | | | | | | | |
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| 42 | 31 | = | | | | | | | | |
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| 64 | 42 | = | | | | | | | | |
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UNITED STATES PATENT AND TRADEMARK OFFICE

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United States Patent and Trademark Office
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Alexandria, Virginia 22313-1450
www.uspto.gov

| APPLICATION NO. | ISSUE DATE | PATENT NO. | ATTORNEY DOCKET NO. | CONFIRMATION NO. |
|---|---|---|---|---|
| 11/839,205 | 10/11/2011 | 8036273 | 982-010567-US (C02) | 8091 |

10868 7590 09/21/2011

Perman & Green, LLP
99 Hawley Lane
Stratford, CT 06614

# ISSUE NOTIFICATION

The projected patent number and issue date are specified above.

**Determination of Patent Term Adjustment under 35 U.S.C. 154 (b)**
(application filed on or after May 29, 2000)

The Patent Term Adjustment is 0 day(s). Any patent to issue from the above-identified application will include an indication of the adjustment on the front page.

If a Continued Prosecution Application (CPA) was filed in the above-identified application, the filing date that determines Patent Term Adjustment is the filing date of the most recent CPA.

Applicant will be able to obtain more detailed information by accessing the Patent Application Information Retrieval (PAIR) WEB site (http://pair.uspto.gov).

Any questions regarding the Patent Term Extension or Adjustment determination should be directed to the Office of Patent Legal Administration at (571)-272-7702. Questions relating to issue and publication fee payments should be directed to the Application Assistance Unit (AAU) of the Office of Data Management (ODM) at (571)-272-4200.

APPLICANT(s) (Please see PAIR WEB site http://pair.uspto.gov for additional applicants):

Marta Karczewicz, Irving, TX;
Antti Olli Hallapuro, Tampere, FINLAND;

PTO/SB/44 (09-07)
Approved for use through 08/31/2010. OMB 0651-0033
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
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(Also Form PTO-1050)

# UNITED STATES PATENT AND TRADEMARK OFFICE
## CERTIFICATE OF CORRECTION



PATENT NO. : 8,036,273

APPLICATION NO .: 11/839,205

ISSUE DATE : October 11, 2011

INVENTOR(S) : Karczewicz et al.

It is certified that an error appears or errors appear in the above-identified patent and that said Letters Patent is hereby corrected as shown below:

Column 1, line 2, in the Second Inventor's Name, delete -- Antti Hallapuro -- and insert --Antti Olli Hallapuro -- therefor.

Column 1, line 2, in the Second Inventor's Residence, delete -- FL (US) -- and insert -- (FI) -- therefor.

Column 51, line 61, in Claim 3, after -- pixel -- delete -- pixel --.

Column 55, line 22, in Claim 31, after -- with -- delete -- both --.

Column 57, line 66, in Claim 42, delete -- $2^N$31 2 -- and insert -- $2^N$-2 – therefor.

Column 59, line 1, in Claim 54, delete -- equal -- and insert -- equal to -- therefor.

Column 59, line 60, in Claim 61, delete -- region -- and insert -- regions -- therefor.

Column 59, line 2, in Claim 62, delete -- truncated -- and insert -- truncate -- therefor.

Column 60, line 55-56, in Claim 64, delete -- bounded rectangular regions -- and insert -- rectangular bounded regions -- therefor.

Column 61, line 6, in Claim 65, delete -- of a either -- and insert -- of either a -- therefor.

Column 61, line 13, in Claim 65, delete -- co- ordinates -- and insert -- co-ordinates -- therefor.

Column 61, line 54, in Claim 68, after -- of -- delete -- both --.

Column 62, line 41, in Claim 69, delete -- co- ordinates -- and insert -- co-ordinates -- therefor.

MAILING ADDRESS OF SENDER (Please do not use customer number below):

Perman & Green, LLP
99 Hawley Lane
Stratford, CT 06614

This collection of information is required by 37 CFR 1.322, 1.323, and 1.324. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 1.0 hour to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the Individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Attention Certificate of Corrections Branch, Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

*If you need assistance in completing the form, call 1-800-PTO-9199 and select option 2.*

PTO/SB/44 (09-07)
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(Also Form PTO-1050)

# UNITED STATES PATENT AND TRADEMARK OFFICE
## CERTIFICATE OF CORRECTION



PATENT NO. : 8,036,273

APPLICATION NO.: 11/839,205

ISSUE DATE : October 11, 2011

INVENTOR(S) : Karczewicz et al.

It is certified that an error appears or errors appear in the above-identified patent and that said Letters Patent is hereby corrected as shown below:

Column 62, line 66, in Claim 71, delete -- encoder -- and insert -- decoder -- therefor.

Column 63, line 43, in Claim 71, delete -- region -- and insert -- regions -- therefor.

Column 65, line 34, in Claim 76, after -- with -- delete -- both --.

Column 65, line 36, in Claim 76, after -- with -- delete -- both --.

Column 65, line 67, in Claim 79, after -- with -- delete -- both --.

Column 66, line 9, in Claim 79, after -- with -- delete -- both --.

Column 66, line 44, in Claim 82, after -- of -- delete -- both --.

Column 66, line 49, in Claim 82, after -- of -- delete -- both --.

Column 57, line 46-53, delete Claim 40 and insert -- An interpolator according to claim 33, wherein the interpolator is configured to interpolate sub-pixel values for sub-pixels having co-ordinates with K equal to an odd value O and L equal to an even value E, not including zero or $2^N$, by taking an average of the value of a first sub-pixel having co-ordinates with K equal to the even value O – 1 and L equal to E and a second sub-pixel having co-ordinates with K equal to the even value O + 1 and L equal to E. -- therefor.

MAILING ADDRESS OF SENDER (Please do not use customer number below):

Perman & Green, LLP
99 Hawley Lane
Stratford, CT 06614

This collection of information is required by 37 CFR 1.322, 1.323, and 1.324. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 1.0 hour to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the Individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Attention Certificate of Corrections Branch, Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

*If you need assistance in completing the form, call 1-800-PTO-9199 and select option 2.*

# Electronic Acknowledgement Receipt

| | |
|---|---|
| **EFS ID:** | 11841305 |
| **Application Number:** | 11839205 |
| **International Application Number:** | |
| **Confirmation Number:** | 8091 |
| **Title of Invention:** | METHOD FOR SUB-PIXEL VALUE INTERPOLATION |
| **First Named Inventor/Applicant Name:** | Marta Karczewicz |
| **Customer Number:** | 10868 |
| **Filer:** | Joseph V. Gamberdell/Maureen Silveira |
| **Filer Authorized By:** | Joseph V. Gamberdell |
| **Attorney Docket Number:** | 982-010567-US (C02) |
| **Receipt Date:** | 16-JAN-2012 |
| **Filing Date:** | 15-AUG-2007 |
| **Time Stamp:** | 12:41:36 |
| **Application Type:** | Utility under 35 USC 111(a) |

## Payment information:

| | |
|---|---|
| Submitted with Payment | no |

## File Listing:

| Document Number | Document Description | File Name | File Size(Bytes)/ Message Digest | Multi Part /.zip | Pages (if appl.) |
|---|---|---|---|---|---|
| 1 | Miscellaneous Incoming Letter | RequestforCertificateofCorrPTO 120116_Cute.pdf | 253913<br>85d703c1eebc323dda51c2c0f0f46f9b509026cd | no | 3 |

| | |
|---|---|
| **Warnings:** | |
| **Information:** | |

| | | | | | |
|---|---|---|---|---|---|
| 2 | Request for Certificate of Correction | SB44CertificateofCorrPTO120116_Cute.pdf | 313449<br>e0986763a68635f4abb0ab5d180fb6fa7595ee4 | no | 2 |

| | |
|---|---|
| **Warnings:** | |
| **Information:** | |
| **Total Files Size (in bytes):** | 567362 |

**This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.**

**New Applications Under 35 U.S.C. 111**

**If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.**

**National Stage of an International Application under 35 U.S.C. 371**

**If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.**

**New International Application Filed with the USPTO as a Receiving Office**

**If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.**

**IN THE UNITED STATES PATENT AND TRADEMARK OFFICE**

| | |
|---|---|
| PATENT NO.: | 8,036,273 |
| ISSUED: | October 11, 2011 |
| PATENTEE: | Karczewicz et al. |
| TITLE: | METHOD FOR SUB-PIXEL VALUE INTERPOLATION |
| ATTORNEY DOCKET NO.: | 982-010567-US (C02) |

Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

ATTENTION: Decision and Certificate of Correction
Branch of the Patent Issue Division

**REQUEST FOR CERTIFICATE OF CORRECTION OF PATENT FOR PTO MISTAKE (37 C.F.R. 1.322(a))**

1. Attached, in duplicate, is Form PTO-1050, with at least one copy being suitable for printing.

2. The exact page and line number where the errors are shown correctly in the application file are:

In the Declaration as filed on August 15, 2007, page 4, line 1 reads "Antti Olli Hallapuro"

In the Declaration as filed on August 15, 2007, page 4, line 1 reads "FI"

In the amendment filed on June 22, 2011, page 5, claim 6, line 3, reads "pixel"

In the amendment filed on June 22, 2011, page 3, claim 2, line 19, reads "with"

In the amendment filed on June 22, 2011, page 11, claim 31, line 4, reads "$2^N$-2"

In the amendment filed on June 22, 2011, page 25, claim 73, line 3, reads "equal to"

In the amendment filed on June 22, 2011, page 26, claim 77, line 6, reads "regions"

In the amendment filed on June 22, 2011, page 27, claim 79, line 2, reads "truncate"

In the amendment filed on June 22, 2011, page 27, claim 79, line 2, reads "truncate"

In the Supplemental Notice of Allowance filed on August 15, 2011, page 2, claim 46, line 12, reads "of either a"

In the Supplemental Notice of Allowance filed on August 15, 2011, page 3, claim 46, line 3, reads "co-ordinates"

In the amendment filed on June 22, 2011, page 14, claim 43, line 10, reads "of"

In the Supplemental Notice of Allowance filed on August 15, 2011, page 4, claim 47, line 9, reads "co-ordinates"

In the amendment filed on June 22, 2011, page 15, claim 44, line 1, reads "decoder"

In the amendment filed on June 22, 2011, page 15, claim 44, line 17, reads "regions."

In the amendment filed on June 22, 2011, page 19, claim 54, line 19, reads "with"

In the amendment filed on June 22, 2011, page 19, claim 54, line 20, reads "with"

In the amendment filed on June 22, 2011, page 20, claim 55, line 12, reads "with"

In the amendment filed on June 22, 2011, page 20, claim 55, line 17, reads "with"

In the amendment filed on June 22, 2011, page 21, claim 60, line 11, reads "of"

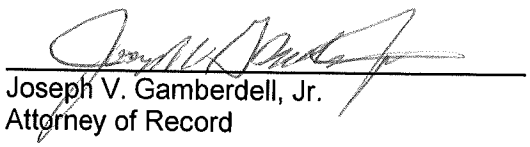
In the amendment filed on June 22, 2011, page 22, claim 60, line 1, reads "of"

In the amendment filed on June 22, 2011, page 11, claim 29, reads "An interpolator according to claim 33, wherein the interpolator is configured to interpolate sub-pixel values for sub-pixels having co-ordinates with K equal to an odd value O and L equal to an even value E, not including zero or $2^N$, by taking an average of the value of a first sub-pixel having co-ordinates with K equal to the even value O – 1 and L equal to E and a second sub-pixel having co-ordinates with K equal to the even value O + 1 and L equal to E."

3. Please send the Certificate to:

Name: Joseph V. Gamberdell, Jr.
Address: Customer No. 2512

Respectfully submitted,



Joseph V. Gamberdell, Jr.
Attorney of Record

Reg. No. 44,695
Perman & Green, LLP
99 Hawley Lane
Stratford, CT 06614
(203) 259-1800
Customer No.: 2512

UNITED STATES PATENT AND TRADEMARK OFFICE

# CERTIFICATE OF CORRECTION



PATENT NO. : 8,036,273 B2
APPLICATION NO. : 11/839205
DATED : October 11, 2011
INVENTOR(S) : Karczewicz et al.

It is certified that error appears in the above-identified patent and that said Letters Patent is hereby corrected as shown below:

Title Page, item (75); Column 1, line 2, in the Second Inventor's Name, delete "Antti Hallapuro" and insert -- Antti Olli Hallapuro -- therefor.

Column 1, line 2, in the Second Inventor's Residence, delete "FL (US)" and insert -- (FI) -- therefor.

Column 51, line 64, in Claim 3, after -- pixel -- delete "pixel".

Column 55, line 22, in Claim 31, after -- with -- delete "both".

Column 57, line 46-53, delete Claim 40 and insert -- An interpolator according to claim 33, wherein the interpolator is configured to interpolate sub-pixel values for sub-pixels having co-ordinates with K equal to an odd value O and L equal to an even value E, not including zero or $2^N$, by taking an average of the value of a first sub-pixel having co-ordinates with K equal to the even value O – 1 and L equal to E and a second sub-pixel having co-ordinates with K equal to the even value O + 1 and L equal to E. -- therefor.

Column 57, line 66, in Claim 42, delete "$2^N$31 2" and insert -- $2^N$-2 -- therefor.

Column 59, line 1, in Claim 54, delete "equal" and insert -- equal to -- therefor.

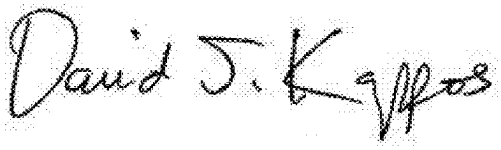
Column 59, line 60, in Claim 61, delete "region" and insert -- regions -- therefor.

Column 59, line 67, in Claim 62, delete "truncated" and insert -- truncate -- therefor.

Column 60, line 55-56, in Claim 64, delete "bounded rectangular regions" and insert -- rectangular bounded regions -- therefor.

Column 61, line 6, in Claim 65, delete "of a either" and insert -- of either a -- therefor.

Signed and Sealed this
Sixth Day of March, 2012



David J. Kappos
*Director of the United States Patent and Trademark Office*

Column 61, line 13, in Claim 65, delete "co- ordinates" and insert -- co-ordinates -- therefor.

Column 61, line 54, in Claim 68, after -- of -- delete "both".

Column 62, line 41, in Claim 69, delete "co- ordinates" and insert -- co-ordinates -- therefor.

Column 62, line 66, in Claim 71, delete "encoder" and insert -- decoder -- therefor.

Column 63, line 43, in Claim 71, delete "region" and insert -- regions -- therefor.

Column 65, line 34, in Claim 76, after -- with -- delete "both".

Column 65, line 36, in Claim 76, after -- with -- delete "both".

Column 65, line 67, in Claim 79, after -- with -- delete "both".

Column 66, line 9, in Claim 79, after -- with -- delete "both".

Column 66, line 44, in Claim 82, after -- of -- delete "both".

Column 66, line 49, in Claim 82, after -- of -- delete "both".

PTO/SB/47 (03-09)
Approved for use through 03/31/2012. OMB 0651-0016
U.S. Patent and Trademark Office; U. S. DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number.

# "FEE ADDRESS" INDICATION FORM

**Address to:**
**Mail Stop M Correspondence**
**Commissioner for Patents**
**P.O. Box 1450**
**Alexandria, VA 22313-1450**

**- OR -**

**Fax to:**
**571-273-6500**

**INSTRUCTIONS:** The issue fee must have been paid for application(s) listed on this form. In addition, only an address represented by a Customer Number can be established as the fee address for maintenance fee purposes (hereafter, fee address). A fee address should be established when correspondence related to maintenance fees should be mailed to a different address than the correspondence address for the application. **When to check the first box below**: If you have a Customer Number to represent the fee address. **When to check the second box below**: If you have no Customer Number representing the desired fee address, in which case a completed Request for Customer Number (PTO/SB/125) must be attached to this form. For more information on Customer Numbers, see the Manual of Patent Examining Procedure (MPEP) § 403.

For the following listed application(s), please recognize as the "Fee Address" under the provisions of 37 CFR 1.363 the address associated with:

☑ Customer Number: 00197

***OR***

☐ The attached Request for Customer Number (PTO/SB/125) form.

| PATENT NUMBER (if known) | APPLICATION NUMBER |
|---|---|
| 8,036,273 | 11/839,205 |

Completed by (check one):

☐ Applicant/Inventor — /jvg44695/ (Signature)

☑ Attorney or Agent of record 44695 (Reg. No.) — Joseph V. Gamberdell, Jr. (Typed or printed name)

☐ Assignee of record of the entire interest. See 37 CFR 3.71. Statement under 37 CFR 3.73(b) is enclosed. (Form PTO/SB/96) — 203-259-1800 Ext. 225 (Requester's telephone number)

☐ Assignee recorded at Reel _____ Frame_____ — 14 March 2012 (Date)

NOTE: Signatures of all the inventors or assignees of record of the entire interest or their representative(s) are required. Submit multiple forms if more that one signature is required, see below*.

☐ *** Total of _____forms are submitted.**

This collection of information is required by 37 CFR 1.363. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1. 11 and 1.14. This collection is estimated to take 5 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313- 1450. DO NOT SEND COMPLETED FORMS TO THIS ADDRESS.
**SEND TO: Mail Stop M Correspondence, Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**
*If you need assistance in completing the form, call 1-800-PTO-9199 and select option 2.*

# Privacy Act Statement

The **Privacy Act of 1974 (P.L. 93-579)** requires that you be given certain information in connection with your submission of the attached form related to a patent application or patent. Accordingly, pursuant to the requirements of the Act, please be advised that: (1) the general authority for the collection of this information is 35 U.S.C. 2(b)(2); (2) furnishing of the information solicited is voluntary; and (3) the principal purpose for which the information is used by the U.S. Patent and Trademark Office is to process and/or examine your submission related to a patent application or patent. If you do not furnish the requested information, the U.S. Patent and Trademark Office may not be able to process and/or examine your submission, which may result in termination of proceedings or abandonment of the application or expiration of the patent.

The information provided by you in this form will be subject to the following routine uses:

1. The information on this form will be treated confidentially to the extent allowed under the Freedom of Information Act (5 U.S.C. 552) and the Privacy Act (5 U.S.C 552a). Records from this system of records may be disclosed to the Department of Justice to determine whether disclosure of these records is required by the Freedom of Information Act.
2. A record from this system of records may be disclosed, as a routine use, in the course of presenting evidence to a court, magistrate, or administrative tribunal, including disclosures to opposing counsel in the course of settlement negotiations.
3. A record in this system of records may be disclosed, as a routine use, to a Member of Congress submitting a request involving an individual, to whom the record pertains, when the individual has requested assistance from the Member with respect to the subject matter of the record.
4. A record in this system of records may be disclosed, as a routine use, to a contractor of the Agency having need for the information in order to perform a contract. Recipients of information shall be required to comply with the requirements of the Privacy Act of 1974, as amended, pursuant to 5 U.S.C. 552a(m).
5. A record related to an International Application filed under the Patent Cooperation Treaty in this system of records may be disclosed, as a routine use, to the International Bureau of the World Intellectual Property Organization, pursuant to the Patent Cooperation Treaty.
6. A record in this system of records may be disclosed, as a routine use, to another federal agency for purposes of National Security review (35 U.S.C. 181) and for review pursuant to the Atomic Energy Act (42 U.S.C. 218(c)).
7. A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (*i.e.*, GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.
8. A record from this system of records may be disclosed, as a routine use, to the public after either publication of the application pursuant to 35 U.S.C. 122(b) or issuance of a patent pursuant to 35 U.S.C. 151. Further, a record may be disclosed, subject to the limitations of 37 CFR 1.14, as a routine use, to the public if the record was filed in an application which became abandoned or in which the proceedings were terminated and which application is referenced by either a published application, an application open to public inspection or an issued patent.
9. A record from this system of records may be disclosed, as a routine use, to a Federal, State, or local law enforcement agency, if the USPTO becomes aware of a violation or potential violation of law or regulation.

# Electronic Acknowledgement Receipt

| | |
|---|---|
| **EFS ID:** | 12302346 |
| **Application Number:** | 11839205 |
| **International Application Number:** | |
| **Confirmation Number:** | 8091 |
| **Title of Invention:** | METHOD FOR SUB-PIXEL VALUE INTERPOLATION |
| **First Named Inventor/Applicant Name:** | Marta Karczewicz |
| **Customer Number:** | 10868 |
| **Filer:** | Joseph V. Gamberdell/Maureen Silveira |
| **Filer Authorized By:** | Joseph V. Gamberdell |
| **Attorney Docket Number:** | 982-010567-US (C02) |
| **Receipt Date:** | 14-MAR-2012 |
| **Filing Date:** | 15-AUG-2007 |
| **Time Stamp:** | 16:12:54 |
| **Application Type:** | Utility under 35 USC 111(a) |

## Payment information:

| | |
|---|---|
| Submitted with Payment | no |

## File Listing:

| Document Number | Document Description | File Name | File Size(Bytes)/ Message Digest | Multi Part /.zip | Pages (if appl.) |
|---|---|---|---|---|---|
| 1 | Change of Address | SB47_FeeAddressIndicationForm.pdf | 312495<br>a52ee8549af03ef8927378c7082911b7e451a89a | no | 2 |

| | |
|---|---|
| **Warnings:** | |
| **Information:** | |

| | |
|---|---|
| **Total Files Size (in bytes):** | 312495 |

**This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.**

**New Applications Under 35 U.S.C. 111**
**If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.**

**National Stage of an International Application under 35 U.S.C. 371**
**If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.**

**New International Application Filed with the USPTO as a Receiving Office**
**If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.**

AO 120 (Rev. 08/10)

| TO: | REPORT ON THE FILING OR DETERMINATION OF AN ACTION REGARDING A PATENT OR TRADEMARK |
|---|---|
| Mail Stop 8<br>Director of the U.S. Patent and Trademark Office<br>P.O. Box 1450<br>Alexandria, VA 22313-1450 | |

In Compliance with 35 U.S.C. § 290 and/or 15 U.S.C. § 1116 you are hereby advised that a court action has been filed in the U.S. District Court Eastern District of Texas on the following

☐ Trademarks or ☑ Patents. ( ☐ the patent action involves 35 U.S.C. § 292.):

| DOCKET NO. | DATE FILED | U.S. DISTRICT COURT |
|---|---|---|
| 2:16-cv-1440 | 12/21/2016 | Eastern District of Texas |

| PLAINTIFF | DEFENDANT |
|---|---|
| Nokia Technologies OY and Alcatel-Lucent USA Inc. | Apple Inc. |

| | PATENT OR TRADEMARK NO. | DATE OF PATENT OR TRADEMARK | HOLDER OF PATENT OR TRADEMARK |
|---|---|---|---|
| 1 | 6,680,974 | 1/20/2004 | Alcatel-Lucent USA Inc. |
| 2 | 6,711,211 | 3/23/2004 | Nokia Technologies Oy |
| 3 | 6,856,701 | 2/15/2005 | Nokia Technologies Oy |
| 4 | 6,950,469 | 9/27/2005 | Nokia Technologies Oy |
| 5 | 6,968,005 | 11/22/2005 | Nokia Technologies Oy |

In the above—entitled case, the following patent(s)/ trademark(s) have been included:

| DATE INCLUDED | INCLUDED BY ☐ Amendment ☐ Answer ☐ Cross Bill ☐ Other Pleading | |
|---|---|---|
| PATENT OR TRADEMARK NO. | DATE OF PATENT OR TRADEMARK | HOLDER OF PATENT OR TRADEMARK |
| 1 7,532,808 | 5/12/2009 | Nokia Technologies Oy |
| 2 8,036,273 | 10/11/2011 | Nokia Technologies Oy |
| 3 8,144,764 | 3/27/2012 | Nokia Technologies Oy |
| 4 | | |
| 5 | | |

In the above—entitled case, the following decision has been rendered or judgement issued:

| DECISION/JUDGEMENT | | |
|---|---|---|
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**Copy 1—Upon initiation of action, mail this copy to Director** **Copy 3—Upon termination of action, mail this copy to Director**
**Copy 2—Upon filing document adding patent(s), mail this copy to Director** **Copy 4—Case file copy**

AO 120 (Rev. 08/10)

| TO: | REPORT ON THE FILING OR DETERMINATION OF AN ACTION REGARDING A PATENT OR TRADEMARK |
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In Compliance with 35 U.S.C. § 290 and/or 15 U.S.C. § 1116 you are hereby advised that a court action has been filed in the U.S. District Court Eastern District of Texas on the following

☐ Trademarks or ☑ Patents. ( ☐ the patent action involves 35 U.S.C. § 292.):

| DOCKET NO. | DATE FILED | U.S. DISTRICT COURT |
|---|---|---|
| 2:16-cv-1440 | 12/21/2016 | Eastern District of Texas |

| PLAINTIFF | DEFENDANT |
|---|---|
| Nokia Technologies OY and Alcatel-Lucent USA Inc. | Apple Inc. |

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|---|---|---|---|
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| 2 | 6,711,211 | 3/23/2004 | Nokia Technologies Oy |
| 3 | 6,856,701 | 2/15/2005 | Nokia Technologies Oy |
| 4 | 6,950,469 | 9/27/2005 | Nokia Technologies Oy |
| 5 | 6,968,005 | 11/22/2005 | Nokia Technologies Oy |

In the above—entitled case, the following patent(s)/ trademark(s) have been included:

| DATE INCLUDED | INCLUDED BY ☐ Amendment ☐ Answer ☐ Cross Bill ☐ Other Pleading | |
|---|---|---|
| PATENT OR TRADEMARK NO. | DATE OF PATENT OR TRADEMARK | HOLDER OF PATENT OR TRADEMARK |
| 1 7,532,808 | 5/12/2009 | Nokia Technologies Oy |
| 2 8,036,273 | 10/11/2011 | Nokia Technologies Oy |
| 3 8,144,764 | 3/27/2012 | Nokia Technologies Oy |
| 4 | | |
| 5 | | |

In the above—entitled case, the following decision has been rendered or judgement issued:

| DECISION/JUDGEMENT |
|---|
| |

| CLERK | (BY) DEPUTY CLERK | DATE |
|---|---|---|
| | | |

**Copy 1—Upon initiation of action, mail this copy to Director Copy 3—Upon termination of action, mail this copy to Director**
**Copy 2—Upon filing document adding patent(s), mail this copy to Director Copy 4—Case file copy**

AO 120 (Rev. 08/10)

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In Compliance with 35 U.S.C. § 290 and/or 15 U.S.C. § 1116 you are hereby advised that a court action has been filed in the U.S. District Court Eastern District of North Carolina on the following

☐ Trademarks or ☑ Patents. ( ☐ the patent action involves 35 U.S.C. § 292.):

| DOCKET NO. | DATE FILED | U.S. DISTRICT COURT |
|---|---|---|
| 5:19-CV-427-BO | 9/25/2019 | Eastern District of North Carolina |

| PLAINTIFF | DEFENDANT |
|---|---|
| Nokia Technologies Oy | Lenovo (Shanghai) Electronics Technology Co., Ltd. et al |

| | PATENT OR TRADEMARK NO. | DATE OF PATENT OR TRADEMARK | HOLDER OF PATENT OR TRADEMARK |
|---|---|---|---|
| 1 | 6,856,701 | | |
| 2 | 6,950,469 | | |
| 3 | 6,968,005 | | |
| 4 | 7,263,125 | | |
| 5 | 7,280,599 | | |

In the above—entitled case, the following patent(s)/ trademark(s) have been included:

| DATE INCLUDED | INCLUDED BY ☐ Amendment ☐ Answer ☐ Cross Bill ☐ Other Pleading | |
|---|---|---|
| PATENT OR TRADEMARK NO. | DATE OF PATENT OR TRADEMARK | HOLDER OF PATENT OR TRADEMARK |
| 1 7,532,808 | | |
| 2 7,724,818 | | |
| 3 8,036,273 | | |
| 4 8,144,764 | | |
| 5 9,800,891 | | |

In the above—entitled case, the following decision has been rendered or judgement issued:

| DECISION/JUDGEMENT |
|---|
| |

| CLERK | (BY) DEPUTY CLERK | DATE |
|---|---|---|
| PETER A. MOORE, JR. | Joanna Rudd, Deputy | 9/26/2019 |

**Copy 1—Upon initiation of action, mail this copy to Director** **Copy 3—Upon termination of action, mail this copy to Director**
**Copy 2—Upon filing document adding patent(s), mail this copy to Director** **Copy 4—Case file copy**

AO 120 (Rev. 08/10)

| TO: | REPORT ON THE FILING OR DETERMINATION OF AN ACTION REGARDING A PATENT OR TRADEMARK |
|---|---|
| Mail Stop 8<br>Director of the U.S. Patent and Trademark Office<br>P.O. Box 1450<br>Alexandria, VA 22313-1450 | |

In Compliance with 35 U.S.C. § 290 and/or 15 U.S.C. § 1116 you are hereby advised that a court action has been filed in the U.S. District Court Eastern District of North Carolina on the following

☐ Trademarks or ☑ Patents. ( ☐ the patent action involves 35 U.S.C. § 292.):

| DOCKET NO. | DATE FILED | U.S. DISTRICT COURT |
|---|---|---|
| 5:19-CV-427-BO | 9/25/2019 | Eastern District of North Carolina |

| PLAINTIFF | DEFENDANT |
|---|---|
| Nokia Technologies Oy | Lenovo (Shanghai) Electronics Technology Co., Ltd. et al |

| | PATENT OR TRADEMARK NO. | DATE OF PATENT OR TRADEMARK | HOLDER OF PATENT OR TRADEMARK |
|---|---|---|---|
| 1 | 6,856,701 | | |
| 2 | 6,950,469 | | |
| 3 | 6,968,005 | | |
| 4 | 7,263,125 | | |
| 5 | 7,280,599 | | |

In the above—entitled case, the following patent(s)/ trademark(s) have been included:

| DATE INCLUDED | INCLUDED BY ☐ Amendment ☐ Answer ☐ Cross Bill ☐ Other Pleading | |
|---|---|---|
| PATENT OR TRADEMARK NO. | DATE OF PATENT OR TRADEMARK | HOLDER OF PATENT OR TRADEMARK |
| 1 7,532,808 | | |
| 2 7,724,818 | | |
| 3 8,036,273 | | |
| 4 8,144,764 | | |
| 5 9,800,891 | | |

In the above—entitled case, the following decision has been rendered or judgement issued:

| DECISION/JUDGEMENT |
|---|
| |

| CLERK | (BY) DEPUTY CLERK | DATE |
|---|---|---|
| PETER A. MOORE, JR. | Joanna Ruth, Deputy | 9/26/2019 |

**Copy 1—Upon initiation of action, mail this copy to Director** **Copy 3—Upon termination of action, mail this copy to Director**
**Copy 2—Upon filing document adding patent(s), mail this copy to Director** **Copy 4—Case file copy**