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*February 09, 2024*

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Certified by

Kathi

Performing the Functions and Duties of the
Under Secretary of Commerce
for Intellectual Property
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Patent and Trademark Office

***IN THE UNITED STATES PATENT AND TRADEMARK OFFICE***

Applicant: Jani Lainema

Title: SPATIALLY ENHANCED TRANSFORM CODING

Appl. No.: Unknown

Filing Date: Herewith

Examiner: Unknown

Art Unit: Unknown

**UTILITY PATENT APPLICATION TRANSMITTAL**

Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Sir:

Transmitted herewith for filing under 37 C.F.R. § 1.53(b) is the nonprovisional utility patent application of:

Jani Lainema
Kisakentäkatu 12 B 6
Tampere
FIN-33230
Finland

[ ] Applicant claims small entity status under 37 CFR 1.27.

Enclosed are:

[ **X** ] Description, Claim(s), and Abstract (20 pages).

[ **X** ] Formal drawings (9 sheets, Figures 1, 2a, 2b, 2c, 3, 4, 5, 6, 7, 8, 9).

[ **X** ] Unexecuted Declaration and Power of Attorney (3 pages).

[ ] Assignment of the invention to Nokia Corporation.

[ ] Assignment Recordation Cover Sheet.

[ ] Small Entity statement.

[ ] Request for application not to be published with certification under 35 USC 122(b)(2)(B)(i).

[ ] Information Disclosure Statement.

[ ] Form PTO/SB/08 with copies of ___ listed reference(s).

[ **X** ] Application Data Sheet (37 CFR 1.76).

[ ] Claim for Convention Priority.

The adjustment to the number of sheets for EFS-Web filing follows:

| **Number of Sheets** | | **EFS-Web Adjustment** | **Number of Sheets for EFS-Web** |
|---|---|---|---|
| 29 | x | 75% | 22 |

The filing fee is calculated below:

| | **Number Filed** | | **Included in Basic Fee** | | **Extra** | | Rate | | Fee Totals |
|---|---|---|---|---|---|---|---|---|---|
| Basic Filing Fee | | | | | | | $310.00 | = | $310.00 |
| Search Fee | | | | | | | $510.00 | | $510.00 |
| Examination Fee | | | | | | | $210.00 | | $210.00 |
| Size Fee | 22 | - | 100 | = | 0 | x | $260.00 | | $0.00 |
| Total Claims: | 39 | - | 20 | = | 19 | x | $50.00 | = | $950.00 |
| Independents: | 5 | - | 3 | = | 2 | x | $210.00 | = | $420.00 |
| If any Multiple Dependent Claim(s) present: | | | | | | + | $370.00 | = | $0.00 |
| Surcharge under 37 CFR 1.16(f) for late filing of Executed Declaration | | | | | | + | $130.00 | = | $130.00 |
| | | | | | | | SUBTOTAL: | = | $2530.00 |

| | | | | |
|---|---|---|---|---|
| [ ] | Small Entity Fees Apply (subtract ½ of above): | | = | 0 |
| | Basic Filing Fee Reduction for Filing via EFS-Web | | | $0.00 |
| | TOTAL FILING FEE: | | = | $2530.00 |
| Assignment Recordation Fee: | | + | = | $0.00 |
| Processing Fee under 37 CFR 1.17(i) for Late Filing of English Translation of Application: | | + $130.00 | = | |
| TOTAL FEE | | | = | $2530.00 |

The above-identified fees of $2530.00 are being paid by credit card via EFS-Web.

The Commissioner is hereby authorized to charge any additional fees which may be required regarding this application under 37 C.F.R. §§ 1.16-1.17, or credit any overpayment, to Deposit Account No. 19-0741. Should no proper payment be enclosed herewith, as by the credit card payment instructions in EFS-Web being incorrect or absent, resulting in a rejected or incorrect credit card transaction, the Commissioner is authorized to charge the unpaid amount to Deposit Account No. 19-0741.

Please direct all correspondence to the undersigned attorney or agent at the address indicated below.

Respectfully submitted,

Date: April 10, 2008

By /G. Peter Albert, Jr./

FOLEY & LARDNER LLP
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G. Peter Albert Jr.
Attorney for Applicant
Registration No. 37,268

***IN THE UNITED STATES PATENT AND TRADEMARK OFFICE***

Applicant: Jani Lainema

Title: SPATIALLY ENHANCED TRANSFORM CODING

Appl. No.: Unknown

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Examiner: Unknown

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| Surcharge under 37 CFR 1.16(f) for late filing of Executed Declaration | | | | | | + | $130.00 | = | $130.00 |
| | | | | | | | SUBTOTAL: | = | $2530.00 |

| | | | | |
|---|---|---|---|---|
| [ ] | Small Entity Fees Apply (subtract ½ of above): | | = | 0 |
| | Basic Filing Fee Reduction for Filing via EFS-Web | | | $0.00 |
| | TOTAL FILING FEE: | | = | $2530.00 |
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| Processing Fee under 37 CFR 1.17(i) for Late Filing of English Translation of Application: | | + $130.00 | = | |
| TOTAL FEE | | | = | $2530.00 |

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G. Peter Albert Jr.
Attorney for Applicant
Registration No. 37,268

## Application Data Sheet

### Application Information

| | |
|---|---|
| **Application Type::** | Regular |
| **Subject Matter::** | Utility |
| **Suggested classification::** | |
| **Suggested Group Art Unit::** | |
| **CD-ROM or CD-R?::** | None |
| **Computer Readable Form (CRF)?::** | No |
| **Title::** | SPATIALLY ENHANCED TRANSFORM CODING |
| **Attorney Docket Number::** | 037145-7826 |
| **Request for Early Publication?::** | No |
| **Request for Non-Publication?::** | No |
| **Suggested Drawing Figure::** | 1 |
| **Total Drawing Sheets::** | 9 |
| **Small Entity?::** | No |
| **Petition included?::** | No |
| **Secrecy Order in Parent Appl.?::** | No |

### Applicant Information

| | |
|---|---|
| **Applicant Authority Type::** | Inventor |
| **Primary Citizenship Country::** | Finland |
| **Status::** | Full Capacity |
| **Given Name::** | Jani |
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**Correspondence Information**

**Correspondence Customer Number::** 30542

**E-Mail address::** PTOMailSanDiegoNorth@foley.com

**Representative Information**

| | | |
|---|---|---|
| **Representative Customer Number::** | 30542 | |

**Domestic Priority Information**

| **Application::** | **Continuity Type::** | **Parent Application::** | **Parent Filing Date::** |
|---|---|---|---|
| This Application | An application claiming the benefit under 35 USC 119(e) | 60/911,480 | 4/12/2007 |

**Foreign Priority Information**

| **Country::** | **Application number::** | **Filing Date::** | **Priority Claimed::** |
|---|---|---|---|
| | | | |

**Assignee Information**

**Assignee Name::** Nokia Corporation

# DECLARATION AND POWER OF ATTORNEY

As a below named inventor, I HEREBY DECLARE:

THAT my residence, post office address, and citizenship are as stated below next to my name;

THAT I believe I am the original, first, and sole inventor (if only one inventor is named below) or an original, first, and joint inventor (if plural inventors are named below or in an attached Declaration) of the subject matter which is claimed and for which a patent is sought on the invention entitled

SPATIALLY ENHANCED TRANSFORM CODING

(Attorney Docket No. 037145-7826)

the specification of which (check one)

___ is attached hereto.

____ was filed on _____ as United States Application Number _____ .

THAT I do not know and do not believe that the same invention was ever known or used by others in the United States of America, or was patented or described in any printed publication in any country, before I (we) invented it;

THAT I do not know and do not believe that the same invention was patented or described in any printed publication in any country, or in public use or on sale in the United States of America, for more than one year prior to the filing date of this United States application;

THAT I do not know and do not believe that the same invention was first patented or made the subject of an inventor's certificate that issued in any country foreign to the United States of America before the filing date of this United States application if the foreign application was filed by me (us), or by my (our) legal representatives or assigns, more than twelve months (six months for design patents) prior to the filing date of this United States application;

THAT I have reviewed and understand the contents of the above-identified specification, including the claim(s), as amended by any amendment specifically referred to above;

THAT I believe that the above-identified specification contains a written description of the invention, and of the manner and process of making and using it, in such full, clear, concise, and exact terms as to enable any person skilled in the art to which it pertains, or with

which it is most nearly connected, to make and use the invention, and sets forth the best mode contemplated by me of carrying out the invention; and

THAT I acknowledge the duty to disclose to the U.S. Patent and Trademark Office all information known to me to be material to patentability as defined in Title 37, Code of Federal Regulations, §1.56.

I HEREBY CLAIM foreign priority benefits under Title 35, United States Code §119(a)-(d) or § 365(b) of any foreign application(s) for patent or inventor's certificate, or §365(a) of any PCT international application which designated at least one country other than the United States of America, listed below and have also identified below any foreign application for patent or inventor's certificate or of any PCT international application having a filing date before that of the application on which priority is claimed.

| Prior Foreign Application Number | Country | Foreign Filing Date | Priority Claimed? | Certified Copy Attached? |
|---|---|---|---|---|
| | | | | |
| | | | | |
| | | | | |

I HEREBY CLAIM the benefit under Title 35, United States Code § 119(e) of any United States provisional application(s) listed below.

| U.S. Provisional Application Number | Filing Date |
|---|---|
| 60/911,480 | 4/12/2007 |
| | |
| | |

I HEREBY CLAIM the benefit under Title 35, United States Code, §120 of any United States application(s), or § 365(c) of any PCT international application designating the United States of America, listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States or PCT International application in the manner provided by the first paragraph of Title 35, United States Code, § 112, I acknowledge the duty to disclose information which is material to patentability as defined in Title 37, Code of Federal Regulations, § 1.56 which became available between the filing date of the prior application and the national or PCT international filing date of this application.

| U.S. Parent Application Number | PCT Parent Application Number | Parent Filing Date | Parent Patent Number |
|---|---|---|---|
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I HEREBY APPOINT the registered attorneys and agents at Customer Number

**30542**

to have full power to prosecute this application and any continuations, divisions, reissues, and reexaminations thereof, to receive the patent, and to transact all business in the United States Patent and Trademark Office connected therewith.

I request that all correspondence be directed to:

G. Peter Albert Jr.
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Customer Number: 30542

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Facsimile: (858) 792-6773

I UNDERSTAND AND AGREE THAT the foregoing attorneys and agents appointed by me to prosecute this application do not personally represent me or my legal interests, but instead represent the interests of the legal owner(s) of the invention described in this application.

I FURTHER 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 issuing thereon.

| | |
|---|---|
| Name of first inventor | Jani Lainema |
| Residence | Tampere, Finland |
| Citizenship Country | Finland |
| Post Office Address | Kisakentäkatu 12 B 6<br>Tampere<br>FIN-33230<br>Finland |
| Inventor's signature | |
| Date | |

# SPATIALLY ENHANCED TRANSFORM CODING

## FIELD OF THE INVENTION

**[0001]** The present invention relates to the coding and decoding of digital video material. More particularly, the present invention relates to prediction error coding in both frequency and spatial domains.

## BACKGROUND OF THE INVENTION

**[0002]** This section is intended to provide a background or context to the invention that is recited in the claims. The description herein may include concepts that could be pursued, but are not necessarily ones that have been previously conceived or pursued. Therefore, unless otherwise indicated herein, what is described in this section is not prior art to the description and claims in this application and is not admitted to be prior art by inclusion in this section.

**[0003]** A video codec comprises an encoder that transforms input video into a compressed representation suited for storage and/or transmission and a decoder that can uncompress the compressed video representation back into a viewable form. Typically, the encoder discards some information in the original video sequence in order to represent the video in a more compact form, i.e., at a lower bitrate.

**[0004]** Typical hybrid video codecs, for example ITU-T H.263 and H.264, encode video information in two phases. In the first phase, pixel values in a certain picture area or "block" are predicted. These pixel values can be predicted, for example, by motion compensation mechanisms, which involve finding and indicating an area in one of the previously coded video frames that corresponds closely to the block being coded. Additionally, pixel values can be predicted via by spatial mechanisms, which involve using the pixel values around the block to be coded in a specified manner. The second phase involves coding the prediction error, i.e. the difference between the predicted block of pixels and the original block of pixels. This is typically

accomplished by transforming the difference in pixel values using a specified transform (e.g., a Discreet Cosine Transform (DCT) or a variant thereof), quantizing the coefficients, and entropy coding the quantized coefficients. By varying the fidelity of the quantization process, the encoder can control the balance between the accuracy of the pixel representation (i.e., the picture quality) and the size of the resulting coded video representation (i.e., the file size or transmission bitrate).

**[0005]** The decoder reconstructs output video by applying prediction mechanisms that are similar to those used by the encoder in order to form a predicted representation of the pixel blocks (using motion or spatial information created by the encoder and stored in the compressed representation) and prediction error decoding (the inverse operation of the prediction error coding, recovering the quantized prediction error signal in the spatial pixel domain). After applying prediction and prediction error decoding processes, the decoder sums up the prediction and prediction error signals (i.e., the pixel values) to form the output video frame. The decoder (and encoder) can also apply additional filtering processes in order to improve the quality of the output video before passing it for display and/or storing it as a prediction reference for the forthcoming frames in the video sequence.

**[0006]** In typical video codecs, the motion information is indicated with motion vectors associated with each motion-compensated image block. Each of these motion vectors represents the displacement of the image block in the picture to be coded (in the encoder side) or decoded (in the decoder side) and the prediction source block in one of the previously coded or decoded pictures. In order to represent motion vectors efficiently, motion vectors are typically coded differentially with respect to block specific predicted motion vectors. In a typical video codec, the predicted motion vectors are created in a predefined way, for example by calculating the median of the encoded or decoded motion vectors of the adjacent blocks.

**[0007]** Typical video encoders utilize Lagrangian cost functions to find optimal coding modes, e.g., the desired macroblock mode and associated motion vectors. This kind of cost function uses a weighting factor $\lambda$ to tie together the exact or

estimated image distortion due to lossy coding methods and the exact or estimated amount of information that is required to represent the pixel values in an image area:

$$C = D + \lambda R \qquad (1)$$

**[0008]** In Eq. (1), C is the Lagrangian cost to be minimized, D is the image distortion (e.g., the mean squared error) with the mode and motion vectors considered, and R the number of bits needed to represent the required data to reconstruct the image block in the decoder (including the amount of data to represent the candidate motion vectors).

**[0009]** Transform coding of the prediction error signal in video or image compression system typically comprises DCT-based linear transform, quantization of the transformed DCT coefficients, and context based entropy coding of the quantized coefficients. However, the transform can efficiently pack energy of the prediction error signal only under certain statistics, and the coding performance deteriorates when the prediction error to be transformed becomes less correlated. This causes suboptimal performance, especially in modern video and image coding systems employing advanced motion compensation and spatial prediction processes in order to achieve good quality predictions for the image blocks to be coded (thus, minimizing and decorrelating the prediction error signal).

**[0010]** To address some of the above issues, a number of hybrid video coding schemes have been developed. These hybrid systems typically comprise a hybrid of two redundancy reduction techniques--prediction and transformation. Prediction can take the form of inter-picture prediction, which is used to remove temporal redundancies in the signal. Intra-picture prediction may also be used in the H.264/Advanced Video Coding (AVC) standard where spatial redundancies are removed by exploiting the similarities between neighboring regions within a picture frame. As a consequence of these inter-picture and intra-picture prediction techniques, a residual/error signal is formed by removing the predicated picture frame from the original. This prediction error signal is then typically block transform coded using an 8x8 DCT transform in order to reduce spatial redundancies in the signal.

## SUMMARY OF THE INVENTION

**[0011]** Various embodiments of the present invention provide a system and method for representing the prediction error signal as a weighted sum of different basis functions of a selected transform and quantized spatial samples. The basis functions of the selected transform may comprise an orthogonal set of basis vectors, or the basis functions may not comprise an orthogonal set. According to various embodiments, the prediction error signal for a single image block is constructed using both transform basis functions and spatial samples (i.e., pixel values), thereby combining the desired features of both the transform and spatial coding approaches discussed previously. This allows for the utilization of those selected transform basis functions that give good overall representation of the image block with minimal amount of transform coefficients (representing the component of prediction error signal that is well correlated with the basis functions). Additionally, various embodiments of the present invention allow for the efficient spatial representation of those components of the prediction error signal of the same image block that are not well correlated with the basis functions of the applied transform (such as certain types of sensor noise, high frequency texture and edge information).

**[0012]** According to various embodiments of the present invention, a system and method of encoding a prediction error signal for a block of data comprises calculating a difference signal representing differences between sample values of a predicted block of data and values for an original input block. Transform coding and spatial coding are both performed to the difference signal, thereby creating a first and second representations of first and second components of the difference signal. The first and second representations are then combined to provide the prediction error signal.

**[0013]** Various embodiments of the present invention also provide a system and method of decoding a prediction error signal for a block of data, comprising receiving a coded prediction error signal, the coded prediction error signal including a plurality of transform coefficients and a plurality of spatial samples. The plurality of transformed coefficients are decoded into decoded transform information, and the plurality of spatial samples are decoded into decoded spatial information. The

decoded transform information, the decoded spatial information, and a reconstructed prediction of the block of data are then added, thereby forming a decoded representation of the block of data.

**[0014]** The implementations of various embodiments of the present invention serve to improve the compression efficiency of modern video and image codecs. Although a certain amount of increased computational complexity of encoding may be needed, fast algorithms can be applied in order to lower the encoding complexity that approaches the complexity level for traditional transform based coding. Any effect on the complexity for a decoder is negligible when implementing various embodiments of the present invention.

**[0015]** These and other advantages and features of the invention, together with the organization and manner of operation thereof, will become apparent from the following detailed description when taken in conjunction with the accompanying drawings, wherein like elements have like numerals throughout the several drawings described below.

## BRIEF DESCRIPTION OF THE DRAWINGS

**[0016]** Figure. 1 shows an example of basis functions of a Hadamard transform that can be used to encode image data;

**[0017]** Figure 2(a) is an example of four scalar values that are to be coded or decoded and representing the prediction error signal between the original image and the prediction image; Figure 2(b) shows the four weighted basis functions from Figure 1 being summed to the prediction error signal; and Figure 2(c) shows how the same prediction error signal can be reconstructed by summing up only the first basis function and a single spatial sample represented by an arrow;

**[0018]** Figure 3 is a block diagram of a video encoder constructed in accordance with one embodiment of the present invention;

**[0019]** Figure 4 is a flow chart showing one encoder algorithm which may be used in an embodiment of the present invention;

**[0020]** Figure 5 is a flow chart showing one decoder algorithm which may be used in various embodiments of the present invention;

**[0021]** Figure 6 is a block diagram of a video decoder constructed in accordance with one embodiment of the present invention;

**[0022]** Figure 7 is an overview diagram of a system within which various embodiments of the present invention may be implemented;

**[0023]** Figure 8 is a perspective view of an electronic device that can be used in conjunction with the implementation of various embodiments of the present invention; and

**[0024]** Figure 9 is a schematic representation of the circuitry which may be included in the electronic device of Figure 8.

## DETAILED DESCRIPTION OF VARIOUS EMBODIMENTS

**[0025]** Various embodiments of the present invention provide a system and method for representing the prediction error signal as a weighted sum of different basis functions of a selected transform and quantized spatial samples. According to various embodiments, the prediction error signal for a single image block is constructed using both transform basis functions and spatial samples (i.e., pixel values), thereby combining the desired features of both the transform and spatial coding approaches discussed previously. This allows for the utilization of those selected transform basis functions that give good overall representation of the image block with minimal amount of transform coefficients (representing the component of prediction error signal that is well correlated with the basis functions). Additionally, various embodiments of the present invention allow for the efficient spatial representation of those components of the prediction error signal of the same image block that are not well correlated with the basis functions of the applied transform (such as certain types of sensor noise, high frequency texture and edge information).

**[0026]** Figures 1 and 2 show a simplified example of how various embodiments of the present invention are operable in one dimension. Figure 1 shows an example of basis functions of a one-dimensional linear transform that can be used to encode

image data (namely a Hadamard transform). The weighted sum of these four basis functions can be used to represent any four samples. Figure 2(a) is an example of four scalar values that are to be coded or decoded and representing the prediction error signal between the original image and the prediction image. In Figure 2(b), the four weighted basis functions from Figure 1 are summed to the prediction error signal (1.5 times the first, 0.5 times the second, -0.5 times the third and -0.5 times the fourth basis function). In Figure 2(c) it is demonstrated how the same prediction error signal can be reconstructed by summing up only the first basis function and a single spatial sample represented by an arrow. In this example, compression efficiency improvement can be expected, as the signal is represented by a single transform coefficient and a single spatial sample instead of four transform coefficients weighting the four Hadamard basis functions (as shown in Figure 2(b)).

**[0027]** Figure 3 is a block diagram of a video encoder constructed in accordance with one embodiment of the present invention. More particularly, Figure 3 shows how an image to be encoded 300 undergoes pixel prediction 302, prediction error coding 303 and prediction error decoding 304. For pixel prediction 302, the image 300 undergoes both inter-prediction 306 and intra-prediction 308 which, after mode selection 310, results in prediction representation of an image block 312. A preliminary reconstructed image 314 is also used for intra-prediction 308. Once all of the image blocks are processed, the preliminary reconstructed image 314 undergoes filtering at 316 to create a final reconstructed image 340, which is sent to a reference frame memory 318 and is also used for inter-prediction 306 of future frames.

**[0028]** The prediction representation of the image block 312, as well as the image to be encoded 300, are used together to define a prediction error signal 320 which is used for prediction error coding 303. In prediction error coding 303, the prediction error signal 320 undergoes feature selection 322 and spatial quantization 324, as well as transform 326 and quantization 328 (both after feature selection 322). The data describing prediction error and predicted representation of the image block 312 (e.g., motion vectors, mode information and quantized DCT+spatial samples) are passed to entropy coding 330. The prediction error decoding 304 is substantially the opposite of the prediction error coding 303, with the prediction error decoding including an

inverse spatial quantizer 332, an inverse transform 334 and an inverse quantization 336. The result of the prediction error decoding 304 is a reconstructed prediction error signal 338, which is used in combination with the predicted representation of the image block 312 to create the preliminary reconstructed image 314.

**[0029]** Figure 4 is a flow chart showing one encoder algorithm which may be used in an embodiment of the present invention. However, as discussed below, a variety of different algorithms may be used according to principles of the present invention. At 400 in Figure 4, the difference between sample values of a predicted block and an original input block is calculated. It should be noted that "values" and "outlier values" as used herein are intended to refer to these difference values. At 410, outlier values are found. In this case, the amplitude depends on the expected accuracy of the coded representation; smaller amplitude representations qualify as outliers if one is targeting high bitrate good quality representation, and only high amplitude representations qualify if one is targeting a lower bitrate, lower quality representation. At 420, the modified prediction error signal is transform coded (involving transform, quantization and entropy coding), with the outlier values being substituted by interpolated representations of those values, e.g., by averaging the neighboring prediction error values. At 430, the modified prediction error signals are transform decoded back to the spatial domain. At 440, spatial coding is applied (involving quantization and entropy coding without transform) to the difference between the original outlier values and the transform decoded outlier values. At 450, the final coded representation of the prediction error signal is formed by joining the transform coded data and the spatial coded data. In an alternative embodiment, the spatial coding occurs before transform coding.

**[0030]** When considering the one-dimensional example depicted in Figures 2(a)-2(c), the algorithm outlined in Figure 4 would process the relevant data as follows. As discussed previously, Figure 2(a) represents the difference signal [1 1 3 1] to be coded. In this case, [3] is an outlier. Therefore, the prediction error signal is modified by substituting the [3] with an average of the second and fourth samples, making the signal [1 1 1 1]. The difference between the original outlier sample ([3]) and the transform coded outlier value ([1]) is then spatial coded, making the spatial coded

signal [0 0 2 0]. The entropy coded representations of the transform coded and spatial coded signals are then written to the bitstream. Thereafter, the decoder can recover the coded signal by adding up the inverse transformed data [1 1 1 1] and the inverse spatial coded data [0 0 2 0] (together with the prediction samples of the image block).

**[0031]** When considering the above example, it is important to note that the choice of Hadamard basis vectors for the transform is only intended to be exemplary in nature. In fact, the various methods and techniques described herein can be applied to any transform employing basis functions, and the basis functions do not necessarily need to be orthogonal.

**[0032]** A video or image codec, according to various embodiments the present invention, can be implemented in various ways. In the case of an encoder, the encoder can use different strategies to find the desired transform coefficients and spatial samples. For example, an encoder can first transform code the signal and apply spatial coding to the residual. The encoder can also first apply spatial coding to the signal, followed by transform coding of the residual. Additionally, some or all of the transform coefficients can be set to zero in order to improve the coding performance. Some or all spatial samples can also be set to zero in order to improve the coding performance. An encoder can also iteratively modify transform coefficients and/or spatial samples in order to improve the coding performance until a desired performance or a maximum defined number of iterations is achieved.

**[0033]** In terms of quantization and dequantization, the quantization and dequantization of transform coefficients and spatial samples can be tied together (e.g., a quantization step size for both transform coefficients and spatial samples can be derived from a single parameter). Alternatively, different quantizations and dequantizations can be applied to transform coefficients and spatial samples.

**[0034]** For the coding and decoding of spatial samples, such coding and decoding can depend on transform coefficients and vice versa. Alternatively, the coding and decoding of spatial samples, transform coefficients or both can depend on the prediction signal, on the other transform coefficients and spatial samples in the same image or in other images.

**[0035]** In addition to the above, it can be indicated that there are no transform coefficients or spatial samples for a specific image area or image. It can also be indicated that only spatial coding or only transform coding is used for a specific image area or image. The number of spatial samples can be coded and decoded as one unit, for example representing certain patterns of textures. Pre- and/or post-processing mechanisms can be applied to the prediction signal, prediction error signal reconstructed signal or any combination thereof. The method can be used to code and decode other information instead or in addition to the prediction error signals. The codec can limit the usage of either transform coefficients (e.g., allow only low frequency transform coefficients to be present in the coded representation of the signal) or spatial samples.

**[0036]** Figure 5 shows a decoding process according to various embodiments of the present invention. At 500 in Figure 5, a video decoder receives a coded prediction error signal which comprises both transformed coefficients and spatial samples. At 510, both the transformed coefficients and the spatial samples are decoded. At 520, the decoded transform information, the decoded spatial information and reconstructed prediction of the image block are added together to form decoded representation of the image block.

**[0037]** Figure 6 is a block diagram of a video decoder constructed in accordance with one embodiment of the present invention. As shown in Figure 6, entropy decoding 600 is followed by both prediction error decoding 602 and pixel prediction 604. In prediction error decoding 602, in addition to an inverse transform 606 and inverse quantization 608, an inverse spatial quantizer 610 is used as discussed herein, ultimately resulting in a reconstructed prediction error signal 612. For pixel prediction 604, either intra-prediction or inter-prediction occurs at 614 to create a predicted representation of an image block 616. The predicted representation of the image block 616 is used in conjunction with the reconstructed prediction error signal 612 to create a preliminary reconstructed image 618, which in turn can be used both for prediction 614. Once all of the image blocks have been processed, the preliminary reconstructed image 618 is passed for filtering 620. The filtered image can also be stored in reference frame memory 624, making it usable for prediction 614 as well.

**[0038]** Figure 7 shows a system 10 in which various embodiments of the present invention can be utilized, comprising multiple communication devices that can communicate through one or more networks. The system 10 may comprise any combination of wired or wireless networks including, but not limited to, a mobile telephone network, a wireless Local Area Network (LAN), a Bluetooth personal area network, an Ethernet LAN, a token ring LAN, a wide area network, the Internet, etc. The system 10 may include both wired and wireless communication devices.

**[0039]** For exemplification, the system 10 shown in Figure 7 includes a mobile telephone network 11 and the Internet 28. Connectivity to the Internet 28 may include, but is not limited to, long range wireless connections, short range wireless connections, and various wired connections including, but not limited to, telephone lines, cable lines, power lines, and the like.

**[0040]** The exemplary communication devices of the system 10 may include, but are not limited to, an electronic device 50, a combination personal digital assistant (PDA0 and mobile telephone 14, a PDA 16, an integrated messaging device (IMD) 18, a desktop computer 20, a notebook computer 22, etc. The communication devices may be stationary or mobile as when carried by an individual who is moving. The communication devices may also be located in a mode of transportation including, but not limited to, an automobile, a truck, a taxi, a bus, a train, a boat, an airplane, a bicycle, a motorcycle, etc. Some or all of the communication devices may send and receive calls and messages and communicate with service providers through a wireless connection 25 to a base station 24. The base station 24 may be connected to a network server 26 that allows communication between the mobile telephone network 11 and the Internet 28. The system 10 may include additional communication devices and communication devices of different types.

**[0041]** The communication devices may communicate using various transmission technologies including, but not limited to, Code Division Multiple Access (CDMA), Global System for Mobile Communications (GSM), Universal Mobile Telecommunications System (UMTS), Time Division Multiple Access (TDMA), Frequency Division Multiple Access (FDMA), Transmission Control Protocol/Internet Protocol (TCP/IP), Short Messaging Service (SMS), Multimedia

Messaging Service (MMS), e-mail, Instant Messaging Service (IMS), Bluetooth, IEEE 802.11, etc. A communication device involved in implementing various embodiments of the present invention may communicate using various media including, but not limited to, radio, infrared, laser, cable connection, and the like.

**[0042]** Figures 8 and 9 show one representative electronic device 50 within which the present invention may be implemented. It should be understood, however, that the present invention is not intended to be limited to one particular type of device. The electronic device 50 of Figures 8 and 9 includes a housing 30, a display 32 in the form of a liquid crystal display, a keypad 34, a microphone 36, an ear-piece 38, a battery 40, an infrared port 42, an antenna 44, a smart card 46 in the form of a UICC according to one embodiment of the invention, a card reader 48, radio interface circuitry 52, codec circuitry 54, a controller 56 and a memory 58. Individual circuits and elements are all of a type well known in the art, for example in the Nokia range of mobile telephones.

**[0043]** The various embodiments of the present invention described herein is described in the general context of method steps or processes, which may be implemented in one embodiment by a computer program product, embodied in a computer-readable medium, including computer-executable instructions, such as program code, executed by computers in networked environments. Generally, program modules may include routines, programs, objects, components, data structures, etc. that perform particular tasks or implement particular abstract data types. Computer-executable instructions, associated data structures, and program modules represent examples of program code for executing steps of the methods disclosed herein. The particular sequence of such executable instructions or associated data structures represents examples of corresponding acts for implementing the functions described in such steps or processes.

**[0044]** Software and web implementations of various embodiments of the present invention can be accomplished with standard programming techniques with rule-based logic and other logic to accomplish various database searching steps or processes, correlation steps or processes, comparison steps or processes and decision steps or processes. It should be noted that the words "component" and "module," as

used herein and in the following claims, is intended to encompass implementations using one or more lines of software code, and/or hardware implementations, and/or equipment for receiving manual inputs.

**[0045]** The foregoing description of embodiments of the present invention have been presented for purposes of illustration and description. The foregoing description is not intended to be exhaustive or to limit embodiments of the present invention to the precise form disclosed, and modifications and variations are possible in light of the above teachings or may be acquired from practice of various embodiments of the present invention. The embodiments discussed herein were chosen and described in order to explain the principles and the nature of various embodiments of the present invention and its practical application to enable one skilled in the art to utilize the present invention in various embodiments and with various modifications as are suited to the particular use contemplated.

**WHAT IS CLAIMED IS:**

1. A method of encoding a prediction error signal for a block of data, comprising:

calculating a difference signal representing differences between sample values of a predicted block of data and values for an original input block;

performing transform coding to the difference signal, thereby creating a first representation of a first component of the difference signal;

performing spatial coding to the difference signal, thereby creating a second representation of a first component of the difference signal; and

joining the first and second representations.

2. The method of claim 1, further comprising, before performing transform coding and spatial coding, substituting outlier values in the difference signal with non-outlier values to create a modified prediction error signal.

3. The method of claim 2, wherein transform coding is applied to the modified prediction error signal and spatial coding is applied to a residual thereof.

4. The method of claim 2, wherein spatial coding is applied to the modified prediction error signal and transform coding is applied to a residual thereof.

5. The method of claim 1, wherein, for transform coding, at least one transform coefficient is set to zero.

6. The method of claim 1, wherein, for spatial coding, at least one spatial sample is set to zero.

7. The method of claim 2, wherein the non-outlier values used to replace the outlier values comprise an average of neighboring prediction error values.

8. The method of claim 1, further comprising providing an indication that no transform coefficients exist in the block of data if appropriate.

9. The method of claim 1, further comprising providing an indication that no spatial samples exist in the block of data if appropriate.

10. The method of claim 1, wherein for the transform coding, a transform coefficient is formed, the transform coefficient comprising a weighting coefficient of a discrete transform basis vector.

11. The method of claim 10, wherein the discrete transform comprises a discrete orthogonal transform.

12. A computer program product, embodied in a computer-readable medium, comprising computer code configured to perform the implemented the processes of claim 1.

13. An apparatus, comprising:

a processor; and

a memory unit communicatively connected to a controller and comprising:

computer code for performing transform coding to the difference signal, thereby creating a first representation of a first component of the difference signal;

computer code for performing spatial coding to the difference signal, thereby creating a second representation of a first component of the difference signal; and

computer code for joining the first and second representations.

14. The apparatus of claim 13, wherein the memory unit further comprises computer code for, before performing transform coding and spatial coding, substituting outlier values in the difference signal with non-outlier values to create a modified prediction error signal.

15. The apparatus of claim 14, wherein transform coding is applied to the modified prediction error signal and spatial coding is applied to a residual thereof.

16. The apparatus of claim 14, wherein spatial coding is applied to the modified prediction error signal and transform coding is applied to a residual thereof.

17. The apparatus of claim 13, wherein, for transform coding, at least one transform coefficient is set to zero.

18. The apparatus of claim 13, wherein, for spatial coding, at least one spatial sample is set to zero.

19. The apparatus of claim 13, wherein the non-outlier values used to replace the outlier values comprise an average of neighboring prediction error values.

20. The apparatus of claim 13, further comprising providing an indication that no transform coefficients exist in the block of data if appropriate.

21. The apparatus of claim 13, further comprising providing an indication that no spatial samples exist in the block of data if appropriate.

22. A method of decoding a prediction error signal for a block of data, comprising:

receiving a coded prediction error signal, the coded prediction error signal including a plurality of transform coefficients and a plurality of spatial samples;

decoding the plurality of transformed coefficients into decoded transform information;

decoding the plurality of spatial samples into decoded spatial information; and

adding the decoded transform information, the decoded spatial information, and a reconstructed prediction of the block of data, thereby forming a decoded representation of the block of data.

23. The method of claim 22, wherein an indication is provided that no transform coefficients exist in the block of data if appropriate.

24. The method of claim 22, wherein an indication is provided that that no spatial samples exist in the block of data if appropriate.

25. The method of claim 22, wherein the decoding of the plurality of transformed coefficients and spatial samples includes dequantization of each, and wherein the dequantization of transformed coefficients and spatial samples are related to each other.

26. The method of claim 22, wherein the decoding of the plurality of transformed coefficients and spatial samples includes dequantization of each, and wherein the dequantization of transformed coefficients and spatial samples are different from each other.

27. The method of claim 22, wherein the decoding of the spatial samples is dependent upon the decoding of the transformed coefficients.

28. The method of claim 22, wherein the decoding of the transformed coefficients is dependent upon the decoding of the spatial samples.

29. The method of claim 22, wherein at least some of the plurality of spatial samples are decoded as a single unit.

30. A computer program product, embodied in a computer-readable medium, comprising computer code configured to perform the processes of claim 19.

31. An apparatus, comprising:

a processor; and

a memory unit communicatively connected to the processor and including:

computer code for processing a received coded prediction error signal, the coded prediction error signal including a plurality of transformed coefficients and a plurality of spatial samples;

computer code for decoding the plurality of transformed coefficients into decoded transform information;

computer code for decoding the plurality of spatial samples into decoded spatial information; and

computer code for adding the decoded transform information, the decoded spatial information, and a reconstructed prediction of the block of data, thereby forming a decoded representation of the block of data.

32. The apparatus of claim 31, wherein an indication is provided that no transform coefficients exist in the block of data if appropriate.

33. The apparatus of claim 31, wherein an indication is provided that that no spatial samples exist in the block of data if appropriate.

34. The apparatus of claim 31, wherein the decoding of the plurality of transformed coefficients and spatial samples includes dequantization of each, and wherein the dequantization of transformed coefficients and spatial samples are related to each other.

35. The apparatus of claim 31, wherein the decoding of the plurality of transformed coefficients and spatial samples includes dequantization of each, and wherein the dequantization of transformed coefficients and spatial samples are different from each other.

36. The apparatus of claim 31, wherein the decoding of the spatial samples is dependent upon the decoding of the transformed coefficients.

37. The apparatus of claim 31, wherein the decoding of the transformed coefficients is dependent upon the decoding of the spatial samples.

38. The apparatus of claim 31, wherein at least some of the plurality of spatial samples are decoded as a single unit.

39. A method of encoding a prediction error signal for a block of data, comprising:

calculating a difference signal representing differences between sample values of a predicted block of data and values for an original input block;

substituting outlier values in the difference signal with non-outlier values to create a modified prediction error signal;

performing one of transform coding and spatial coding to the modified prediction error signal, creating one of a transform coded data and spatial coded data

performing an inverse of the one of transform coding and spatial coding;

applying the other of transform coding and spatial coding to a residual from the inverse transform or spatial decoding, creating the other of transform coded data and spatial coded data; and

joining the transform coded data and the spatial coded data.

## ABSTRACT

A system and method for improving prediction error coding performance of various video compression algorithms. Various embodiments combine the energy compaction features of transform coding with localization properties of spatial coding. In various embodiments, the effects of pixel "outliers" are removed from the transform and are coded separately as a spatially coded pixel prediction, thereby improving the coding gain of the transform.

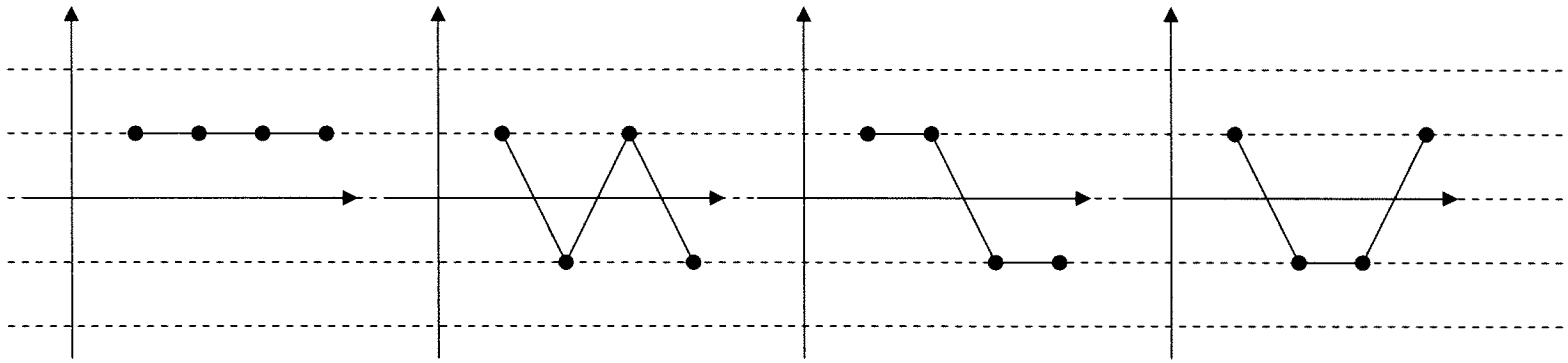

FIG. 1

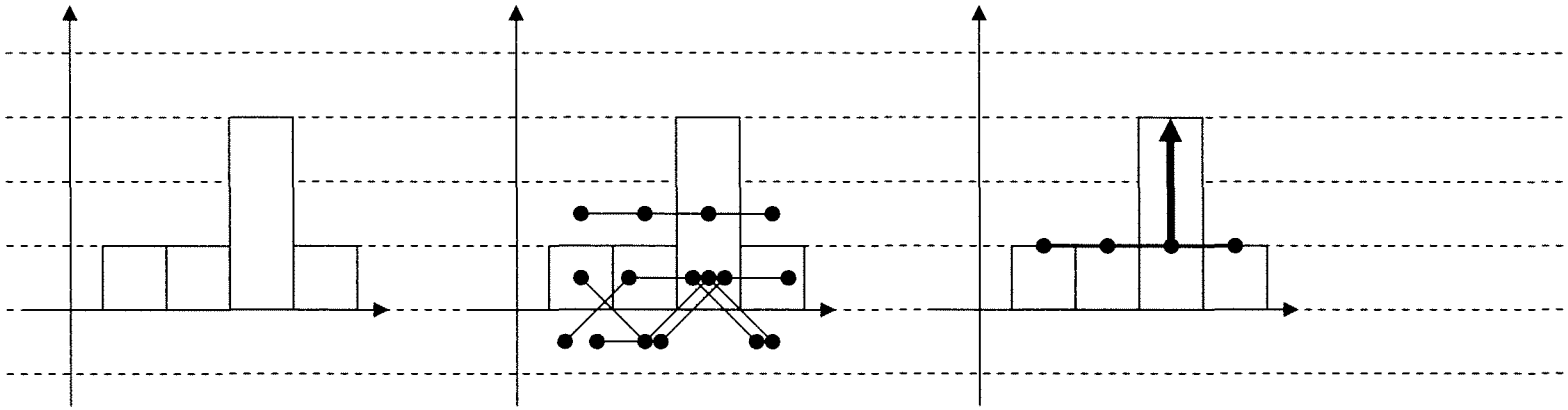

FIG. 2(a) FIG. 2(b) FIG. 2(c)

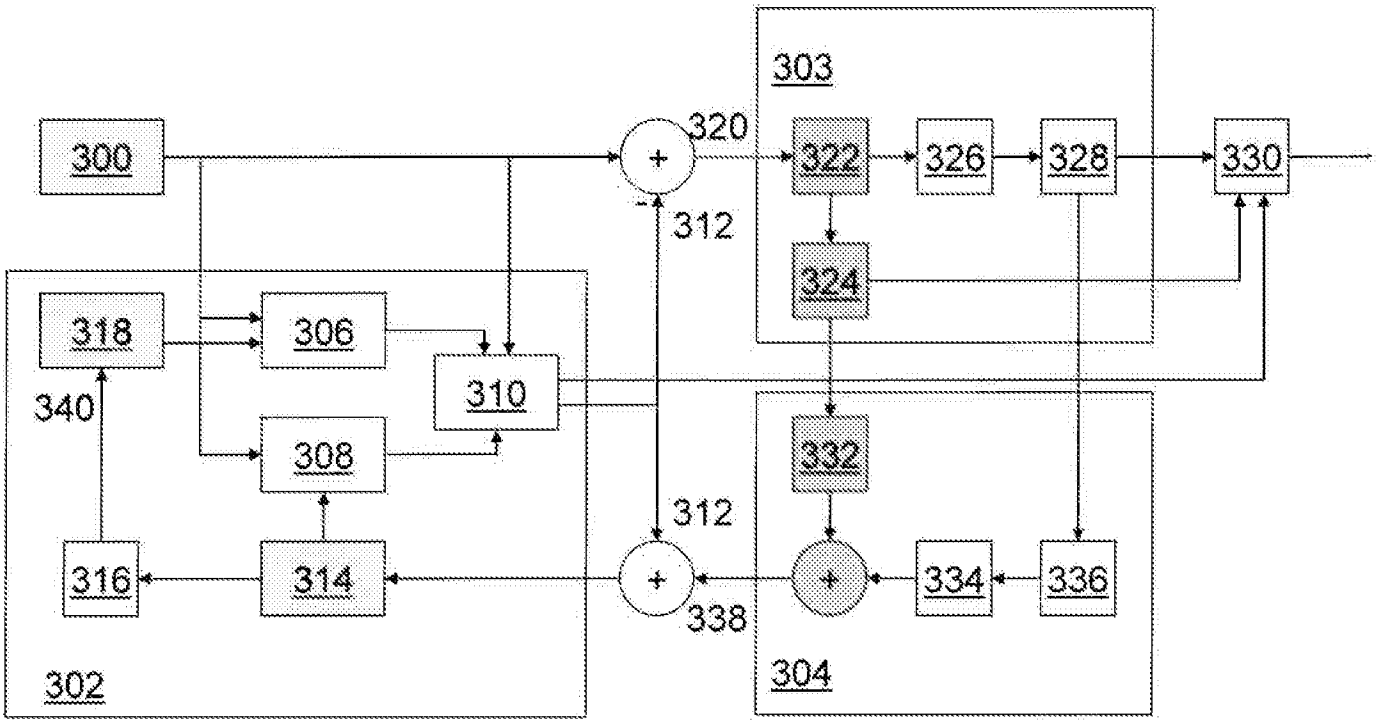
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FIG. 3

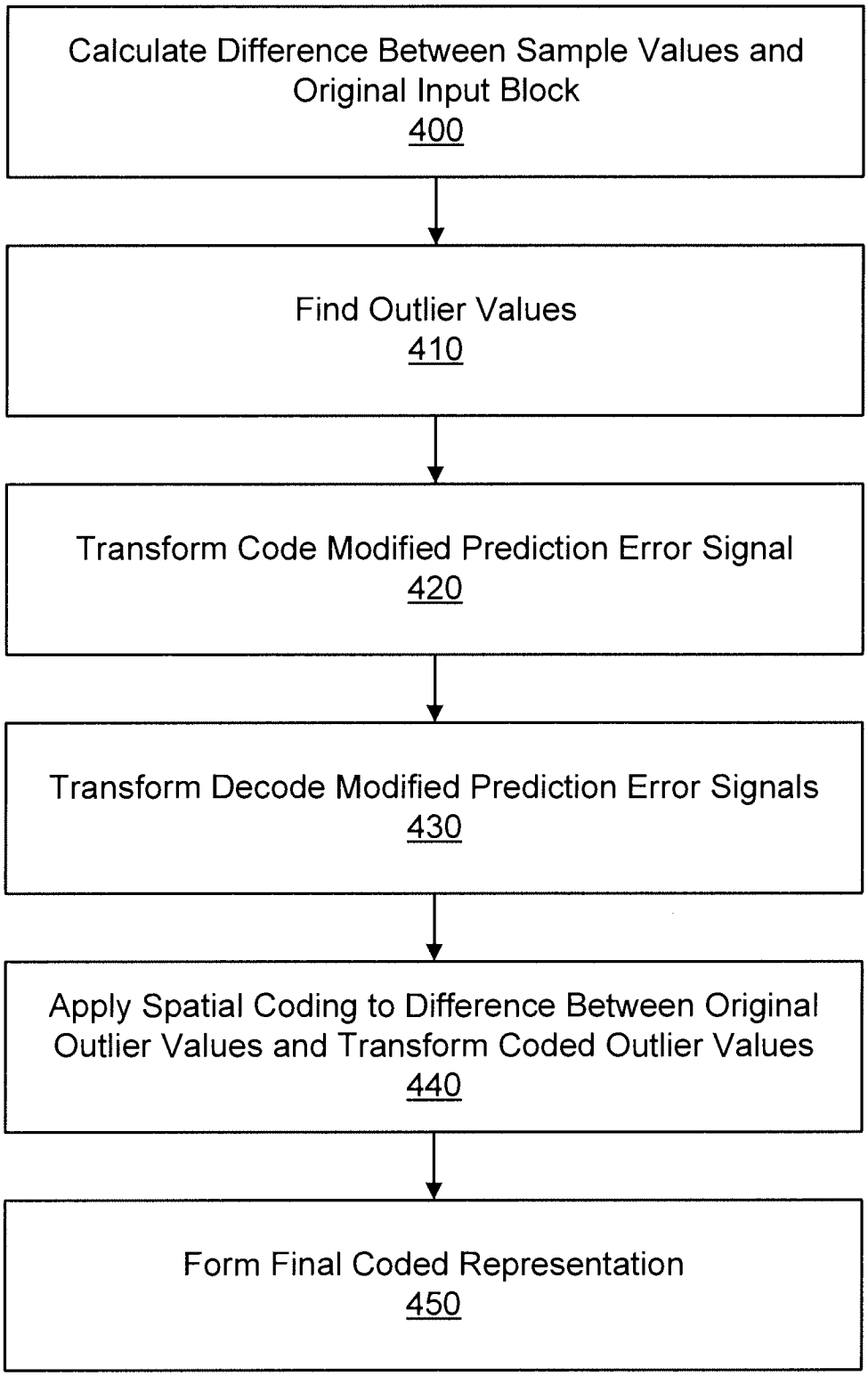
Calculate Difference Between Sample Values and Original Input Block
400
Find Outlier Values
410
Transform Code Modified Prediction Error Signal
420
Transform Decode Modified Prediction Error Signals
430
Apply Spatial Coding to Difference Between Original Outlier Values and Transform Coded Outlier Values
440
Form Final Coded Representation
450

FIG. 4

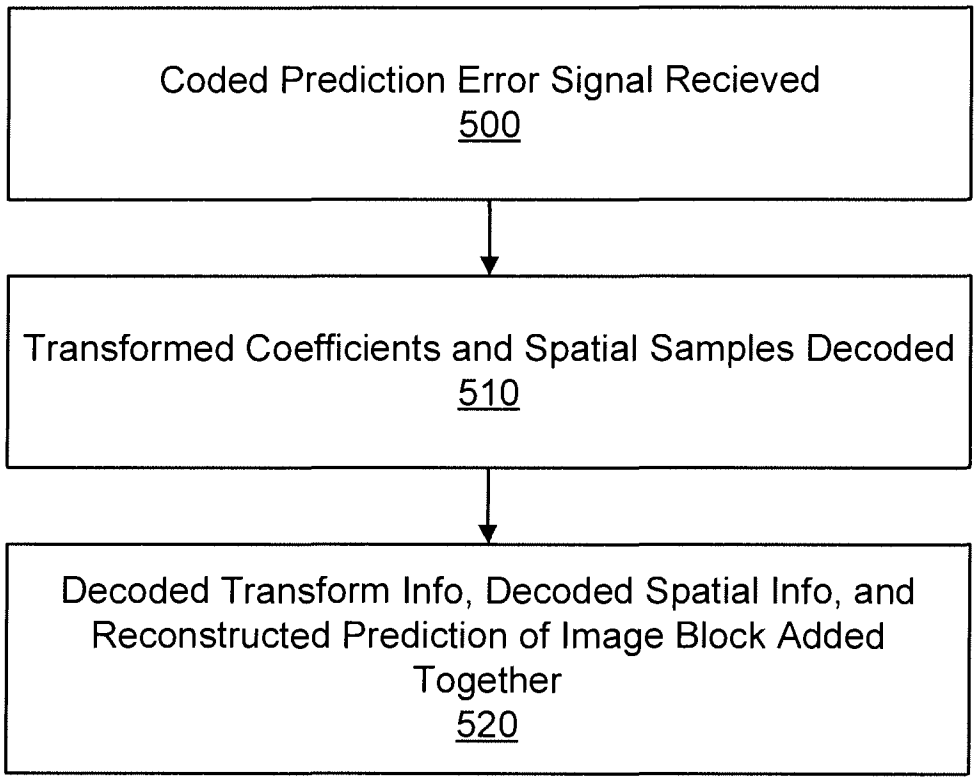
Coded Prediction Error Signal Recieved
500
Transformed Coefficients and Spatial Samples Decoded
510
Decoded Transform Info, Decoded Spatial Info, and Reconstructed Prediction of Image Block Added Together
520

FIG. 5

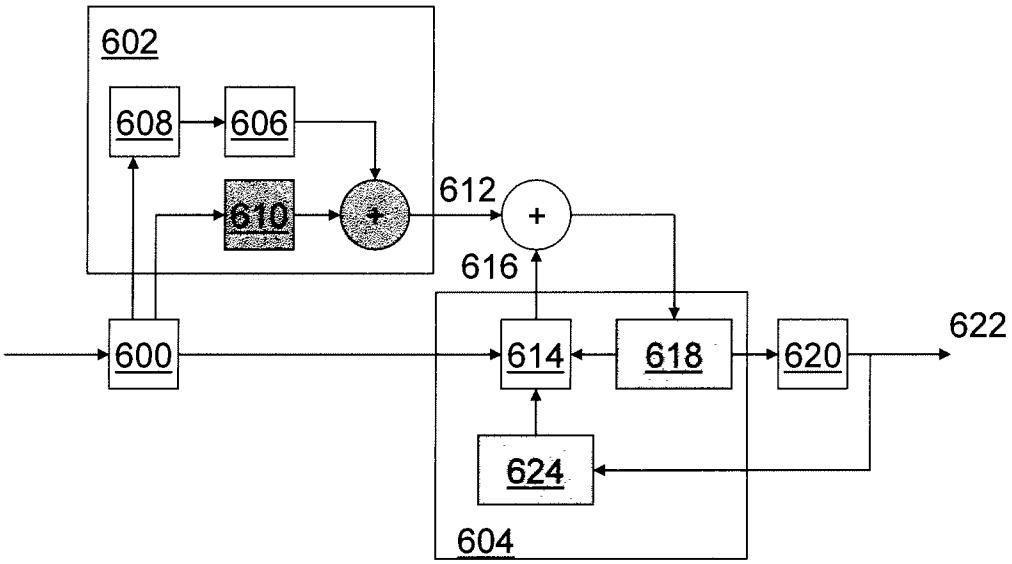


FIG. 6

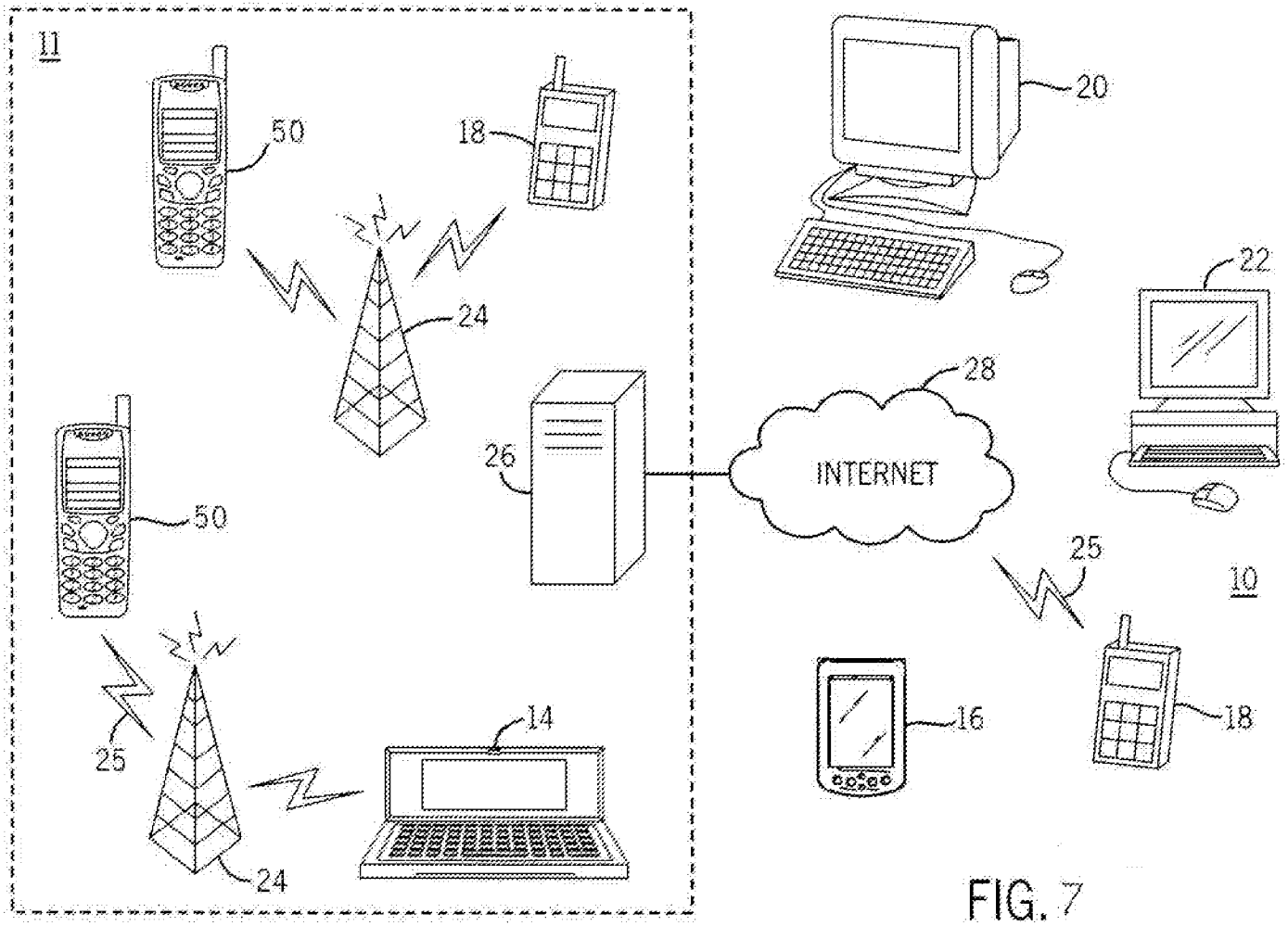


FIG. 7

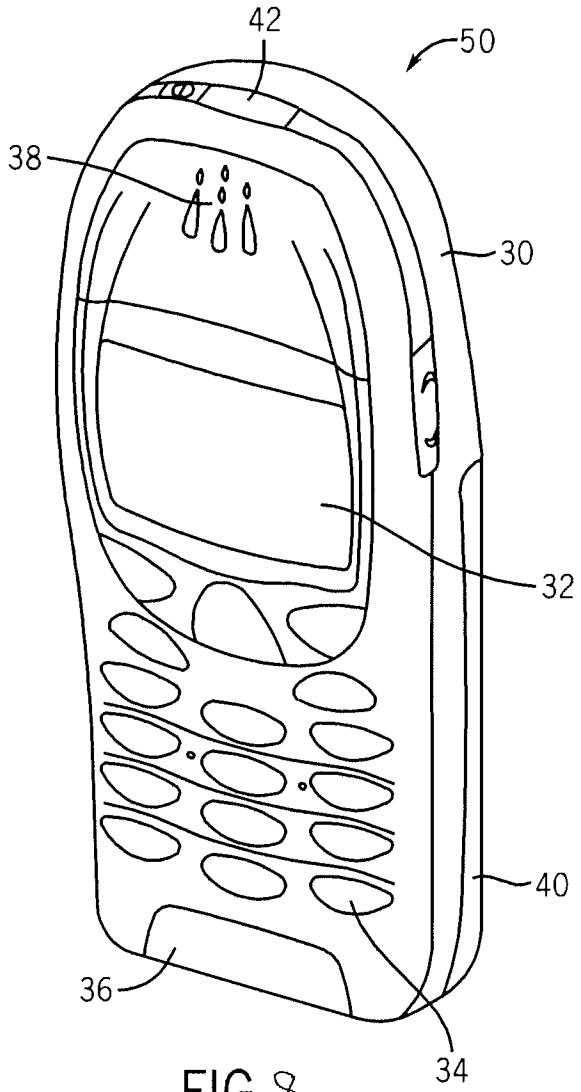


FIG. 8

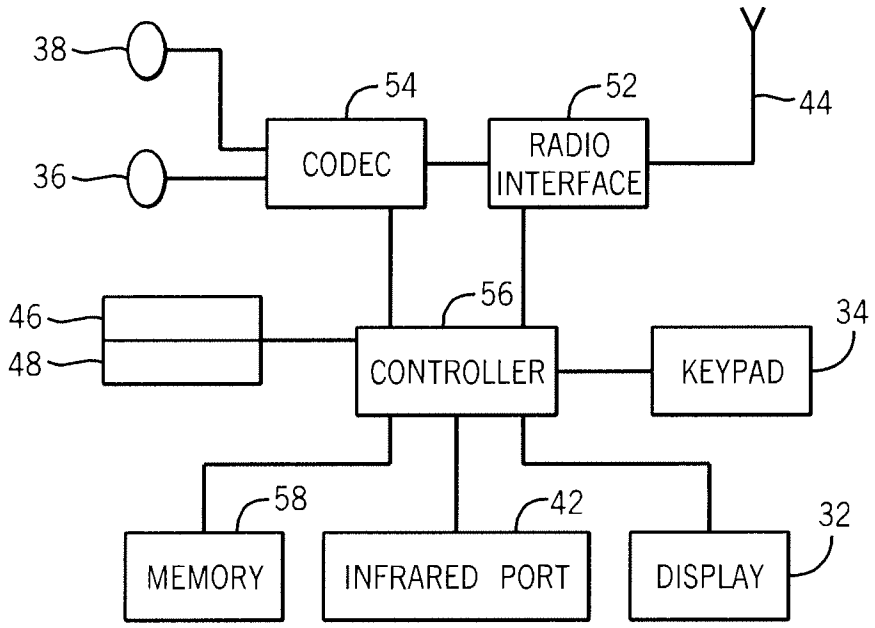
38
36
54
CODEC
52
RADIO INTERFACE
44
46
48
56
CONTROLLER
KEYPAD
34
58
MEMORY
42
INFRARED PORT
DISPLAY
32

FIG. 9

# Electronic Patent Application Fee Transmittal

| | |
|---|---|
| **Application Number:** | |
| **Filing Date:** | |
| **Title of Invention:** | SPATIALLY ENHANCED TRANSFORM CODING |
| First Named Inventor/Applicant Name: | Jani Lainema |
| **Filer:** | Glenn Peter Albert Jr./Marisol Moretto |
| **Attorney Docket Number:** | 037145-7826 |

Filed as Large Entity

## Utility Filing Fees

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|---|---|---|---|---|
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| Utility application filing | 1011 | 1 | 310 | 310 |
| Utility Search Fee | 1111 | 1 | 510 | 510 |
| Utility Examination Fee | 1311 | 1 | 210 | 210 |
| **Pages:** | | | | |
| **Claims:** | | | | |
| Claims in excess of 20 | 1202 | 19 | 50 | 950 |
| Independent claims in excess of 3 | 1201 | 2 | 210 | 420 |
| **Miscellaneous-Filing:** | | | | |

| Description | Fee Code | Quantity | Amount | Sub-Total in USD($) |
|---|---|---|---|---|
| Late filing fee for oath or declaration | 1051 | 1 | 130 | 130 |
| **Petition:** | | | | |
| **Patent-Appeals-and-Interference:** | | | | |
| Post-Allowance-and-Post-Issuance: | | | | |
| **Extension-of-Time:** | | | | |
| **Miscellaneous:** | | | | |
| | | | **Total in USD ($)** | **2530** |

# Electronic Acknowledgement Receipt

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|---|---|
| **EFS ID:** | 3136844 |
| **Application Number:** | 12101019 |
| **International Application Number:** | |
| **Confirmation Number:** | 7368 |
| **Title of Invention:** | SPATIALLY ENHANCED TRANSFORM CODING |
| **First Named Inventor/Applicant Name:** | Jani Lainema |
| **Customer Number:** | 30542 |
| **Filer:** | Glenn Peter Albert Jr./Marisol Moretto |
| **Filer Authorized By:** | Glenn Peter Albert Jr. |
| **Attorney Docket Number:** | 037145-7826 |
| **Receipt Date:** | 10-APR-2008 |
| **Filing Date:** | |
| **Time Stamp:** | 19:03:01 |
| **Application Type:** | Utility under 35 USC 111(a) |

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|---|---|---|---|---|---|
| 1 | Transmittal of New Application | 7826-UtilityTransmittal-10APR2008.pdf | 107841<br>e0f5615c6363b38d4e3c4853bb1ba3259690ef73 | no | 3 |
| **Warnings:** | | | | | |
| **Information:** | | | | | |
| 2 | Application Data Sheet | 7826-ADS-10APR2008.pdf | 59956<br>244e2c80a67de875b330cf0ccac5a0cd6d56f04f | no | 2 |
| **Warnings:** | | | | | |
| **Information:** | | | | | |
| This is not an USPTO supplied ADS fillable form | | | | | |
| 3 | Oath or Declaration filed | 7826-Declaration-10APR2008.pdf | 82235<br>3c44fad3a8fc416eb2660963625d252b7431209a | no | 3 |
| **Warnings:** | | | | | |
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| 4 | Specification | 7826-Specification-10APR2008.pdf | 132155<br>f03e8f2616de8c4d8c21c628fa1730574e843539 | no | 13 |
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| **Information:** | | | | | |
| 5 | Claims | 7826-Claims-10APR2008.pdf | 92166<br>38139aae22f2dbb34f60cd340ac1e004e760c010 | no | 6 |
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| 6 | Abstract | 7826-Abstract-10APR2008.pdf | 58938<br>6168ac5ecc26832a503624c1febdee00e4b04709 | no | 1 |
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| 7 | Drawings-only black and white line drawings | 7826-Drawings-10APR2008.pdf | 171124<br>d9706a27321d44a2ca980d1c35dc98c840f1011c | no | 9 |
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| **Information:** | | | | | |
| 8 | Fee Worksheet (PTO-06) | fee-info.pdf | 8718<br>4f3a4d9355f236666c4c352147336eb04d6ba97b | no | 2 |
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|---|---|---|---|---|---|---|
| 12/101,019 | 04/10/2008 | 2621 | 2530 | 037145-7826 | 39 | 5 |

**CONFIRMATION NO. 7368**

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P.O. BOX 80278
SAN DIEGO, CA 92138-0278

**FILING RECEIPT**

*OC000000029622056*

Date Mailed: 04/29/2008

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)**
Jani Lainema, Tampere, FINLAND;

**Assignment For Published Patent Application**
Nokia Corporation

**Power of Attorney:** None

**Domestic Priority data as claimed by applicant**
This appln claims benefit of 60/911,480 04/12/2007

**Foreign Applications**

**If Required, Foreign Filing License Granted:** 04/28/2008

The country code and number of your priority application, to be used for filing abroad under the Paris Convention, is **US 12/101,019**

**Projected Publication Date:** To Be Determined - pending completion of Missing Parts

**Non-Publication Request:** No

**Early Publication Request:** No



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**Title**

SPATIALLY ENHANCED TRANSFORM CODING

**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).

## LICENSE FOR FOREIGN FILING UNDER

## Title 35, United States Code, Section 184

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

**GRANTED**

The applicant has been granted a license under 35 U.S.C. 184, if the phrase "IF REQUIRED, FOREIGN FILING LICENSE GRANTED" followed by a date appears on this form. Such licenses are issued in all applications where the conditions for issuance of a license have been met, regardless of whether or not a license may be required as



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set forth in 37 CFR 5.15. The scope and limitations of this license are set forth in 37 CFR 5.15(a) unless an earlier license has been issued under 37 CFR 5.15(b). The license is subject to revocation upon written notification. The date indicated is the effective date of the license, unless an earlier license of similar scope has been granted under 37 CFR 5.13 or 5.14.

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 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 | FIRST NAMED APPLICANT | ATTY. DOCKET NO./TITLE |
|---|---|---|---|
| 12/101,019 | 04/10/2008 | Jani Lainema | 037145-7826 |

**CONFIRMATION NO. 7368**

30542
FOLEY & LARDNER LLP
P.O. BOX 80278
SAN DIEGO, CA 92138-0278

**FORMALITIES LETTER**

*OC000000029622057*

Date Mailed: 04/29/2008

# NOTICE TO FILE MISSING PARTS OF NONPROVISIONAL APPLICATION

**FILED UNDER 37 CFR 1.53(b)**

***Filing Date Granted***

**Items Required To Avoid Abandonment:**

An application number and filing date have been accorded to this application. The item(s) indicated below, however, are missing. Applicant is given **TWO MONTHS** from the date of this Notice within which to file all required items and pay any fees required below to avoid abandonment. 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 oath or declaration is unsigned.

Replies should be mailed to:

Mail Stop Missing Parts
Commissioner for Patents
P.O. Box 1450
Alexandria VA 22313-1450

Registered users of EFS-Web may alternatively submit their reply to this notice via EFS-Web.
https://sportal.uspto.gov/authenticate/AuthenticateUserLocalEPF.html

For more information about EFS-Web please call the USPTO Electronic Business Center at **1-866-217-9197** or visit our website at http://www.uspto.gov/ebc.

If you are not using EFS-Web to submit your reply, you must include a copy of this notice.

/rerry/

Office of Data Management, Application Assistance Unit (571) 272-4000, or (571) 272-4200, or 1-888-786-0101



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**Filing Date:** **04/10/08**

Approved for use through 7/31/2006. 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: 12/101,019

### 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 | 310 |
| SEARCH FEE (37 CFR 1.16(k), (i), or (m)) | N/A | N/A | N/A | | | N/A | 510 |
| EXAMINATION FEE (37 CFR 1.16(o), (p), or (q)) | N/A | N/A | N/A | | | N/A | 210 |
| TOTAL CLAIMS (37 CFR 1.16(i)) | 39 minus 20 = | 19 | X$ 25 | | OR | X$50 | 950 |
| INDEPENDENT CLAIMS (37 CFR 1.16(h)) | 5 minus 3 = | * 2 | X$105 | | | X$210 | 420 |
| APPLICATION SIZE FEE (37 CFR 1.16(s)) | If the specification and drawings exceed 100 sheets of paper, the application size fee due is $260 ($130 for small entity) for each additional 50 sheets or fraction thereof. See 35 U.S.C. 41(a)(1)(G) and 37 CFR | | | | | | |
| MULTIPLE DEPENDENT CLAIM PRESENT (37 CFR 1.16(j)) | | | 185 | | | 370 | |
| * If the difference in column 1 is less than zero, enter "0" in column 2. | | | TOTAL | 0 | | TOTAL | 2400 |

### APPLICATION AS AMENDED – PART II

AMENDMENT A

| | (Column 1) CLAIMS REMAINING AFTER AMENDMENT | | (Column 2) HIGHEST NUMBER PREVIOUSLY PAID FOR | (Column 3) PRESENT EXTRA | SMALL ENTITY RATE ($) | SMALL ENTITY ADDI-TIONAL FEE ($) | OR | OTHER THAN SMALL ENTITY RATE ($) | OTHER THAN SMALL ENTITY ADDI-TIONAL FEE ($) |
|---|---|---|---|---|---|---|---|---|---|
| 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) CLAIMS REMAINING AFTER AMENDMENT | | (Column 2) HIGHEST NUMBER PREVIOUSLY PAID FOR | (Column 3) PRESENT EXTRA | RATE ($) | ADDI-TIONAL FEE ($) | OR | 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.*

***IN THE UNITED STATES PATENT AND TRADEMARK OFFICE***

Applicant: Jani Lainema

Title: SPATIALLY ENHANCED TRANSFORM CODING

Appl. No.: 12/101019

Filing Date: 4/10/2008

Examiner: Unassigned

Art Unit: 2621

Confirmation Number: 7368

**TRANSMITTAL OF MISSING PARTS OF PATENT APPLICATION**

Mail Stop Missing Parts
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Sir:

In response to the Notice to File Missing Parts of Application mailed April 29, 2008, in the above-identified patent application, transmitted herewith are the missing parts to complete the filing of the subject patent application.

Enclosed are:

[ X ] Declaration and Power of Attorney (3 pages)

Any attached specification is a copy of the specification and any amendments thereto which were filed in the U.S. Patent and Trademark Office in order to obtain a filing date for the application.

[ ] Return Copy of Notice to File Missing Parts

[ ] Translation

[ ] Drawings

[ ] Preliminary Amendment

[ ] Claim for Convention Priority and certified copy of priority documents

[ ] Information Disclosure Statement

[ ] Applicant hereby petitions for an extension of time under 37 C.F.R. §1.136(a) for the total number of months checked below:

[ ] Extension for response filed within the first month
[ ] Extension for response filed within the second month
[ ] Extension for response filed within the third month
[ ] Extension for response filed within the fourth month
[ ] Extension for response filed within the fifth month

The adjustment to the number of sheets for EFS-Web filing follows:

| **Number of Sheets** | | **EFS-Web Adjustment** | **Number of Sheets for EFS-Web** |
|---|---|---|---|
| 29 | x | 75% | 22 |

The filing fee is calculated below:

| | Claims as Filed | | Included in Basic Fee | | Extra Claims | | Rate | | Fee Totals |
|---|---|---|---|---|---|---|---|---|---|
| Basic Filing Fee, Search Fee & Examination Fee | | | | | | | $1,030.00 | | $1,030.00 |
| Size Fee | 22 | - | 100 | = | 0 | x | $260.00 | = | $0.00 |
| Total Claims: | 39 | - | 20 | = | 19 | x | $50.00 | = | $950.00 |
| Independents: | 5 | - | 3 | = | 2 | x | $210.00 | = | $420.00 |
| If any Multiple Dependent Claim(s) present: | | | | | | + | $370.00 | = | $0.00 |
| Surcharge under 37 CFR 1.16(f) for late filing of Executed Declaration | | | | | | + | $130.00 | = | $130.00 |
| Extension fee for response filed within the MONTH month: | | | | | | + | | = | $0.00 |
| | | | | | | | SUBTOTAL: | = | $2,530.00 |
| [ ] Small Entity Fees Apply (subtract ½ of above): | | | | | | | | = | 0 |
| Basic Filing Fee Reduction for Filing via EFS-Web | | | | | | | | | $0.00 |
| | | | | | | | TOTAL FILING FEE: | = | $2,530.00 |
| Processing Fee under 37 CFR 1.17(i) for Late Filing | | | | | | + | $130.00 | = | $0.00 |

| | | | |
|---|---|---|---|
| of English Translation of Application: | | | |
| | TOTAL FEE | = | $2,530.00 |
| Difference to pay: | - $2,530.00 | - | $0.00 |

If any extensions of time are needed for timely acceptance of papers submitted herewith, applicant hereby petitions for such extension under 37 C.F.R. §1.136 and authorizes payment of any such extensions fees to Deposit Account No. 19-0741.

Respectfully submitted,

Date June 30, 2008

By /G. Peter Albert Jr./

FOLEY & LARDNER LLP
Customer Number: 30542
Telephone: (858) 847-6735
Facsimile: (858) 792-6773

G. Peter Albert Jr.
Attorney for Applicant
Registration No. 37,268

# DECLARATION AND POWER OF ATTORNEY

As a below named inventor, I HEREBY DECLARE:

THAT my residence, post office address, and citizenship are as stated below next to my name;

THAT I believe I am the original, first, and sole inventor (if only one inventor is named below) or an original, first, and joint inventor (if plural inventors are named below or in an attached Declaration) of the subject matter which is claimed and for which a patent is sought on the invention entitled

SPATIALLY ENHANCED TRANSFORM CODING

(Attorney Docket No. 037145-7826)

the specification of which (check one)

___ is attached hereto.

__X__ was filed on __April 10, 2008__ as United States Application Number __12/101,019__ .

THAT I do not know and do not believe that the same invention was ever known or used by others in the United States of America, or was patented or described in any printed publication in any country, before I (we) invented it;

THAT I do not know and do not believe that the same invention was patented or described in any printed publication in any country, or in public use or on sale in the United States of America, for more than one year prior to the filing date of this United States application;

THAT I do not know and do not believe that the same invention was first patented or made the subject of an inventor's certificate that issued in any country foreign to the United States of America before the filing date of this United States application if the foreign application was filed by me (us), or by my (our) legal representatives or assigns, more than twelve months (six months for design patents) prior to the filing date of this United States application;

THAT I have reviewed and understand the contents of the above-identified specification, including the claim(s), as amended by any amendment specifically referred to above;

THAT I believe that the above-identified specification contains a written description of the invention, and of the manner and process of making and using it, in such full, clear, concise, and exact terms as to enable any person skilled in the art to which it pertains, or with



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which it is most nearly connected, to make and use the invention, and sets forth the best mode contemplated by me of carrying out the invention; and

THAT I acknowledge the duty to disclose to the U.S. Patent and Trademark Office all information known to me to be material to patentability as defined in Title 37, Code of Federal Regulations, §1.56.

I HEREBY CLAIM foreign priority benefits under Title 35, United States Code §119(a)-(d) or § 365(b) of any foreign application(s) for patent or inventor's certificate, or §365(a) of any PCT international application which designated at least one country other than the United States of America, listed below and have also identified below any foreign application for patent or inventor's certificate or of any PCT international application having a filing date before that of the application on which priority is claimed.

| Prior Foreign Application Number | Country | Foreign Filing Date | Priority Claimed? | Certified Copy Attached? |
|---|---|---|---|---|
| | | | | |
| | | | | |
| | | | | |

I HEREBY CLAIM the benefit under Title 35, United States Code § 119(e) of any United States provisional application(s) listed below.

| U.S. Provisional Application Number | Filing Date |
|---|---|
| 60/911,480 | 4/12/2007 |
| | |
| | |

I HEREBY CLAIM the benefit under Title 35, United States Code, §120 of any United States application(s), or § 365(c) of any PCT international application designating the United States of America, listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States or PCT International application in the manner provided by the first paragraph of Title 35, United States Code, § 112, I acknowledge the duty to disclose information which is material to patentability as defined in Title 37, Code of Federal Regulations, § 1.56 which became available between the filing date of the prior application and the national or PCT international filing date of this application.

| U.S. Parent Application Number | PCT Parent Application Number | Parent Filing Date | Parent Patent Number |
|---|---|---|---|
| | | | |
| | | | |



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| | | | |
|---|---|---|---|
| | | | |

I HEREBY APPOINT the registered attorneys and agents at Customer Number

**30542**

to have full power to prosecute this application and any continuations, divisions, reissues, and reexaminations thereof, to receive the patent, and to transact all business in the United States Patent and Trademark Office connected therewith.

I request that all correspondence be directed to:

G. Peter Albert Jr.
FOLEY & LARDNER LLP
Customer Number: 30542

Telephone: (858) 847-6735
Facsimile: (858) 792-6773

I UNDERSTAND AND AGREE THAT the foregoing attorneys and agents appointed by me to prosecute this application do not personally represent me or my legal interests, but instead represent the interests of the legal owner(s) of the invention described in this application.

I FURTHER 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 issuing thereon.

| | |
|---|---|
| Name of first inventor | Jani Lainema |
| Residence | Tampere, Finland |
| Citizenship Country | Finland |
| Post Office Address | Kisakentäkatu 12 B 6<br>Tampere<br>FIN-33230<br>Finland |
| Inventor's signature | |
| Date | 12.05.2008 |



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# Electronic Acknowledgement Receipt

| | |
|---|---|
| **EFS ID:** | 3546015 |
| **Application Number:** | 12101019 |
| **International Application Number:** | |
| **Confirmation Number:** | 7368 |
| **Title of Invention:** | SPATIALLY ENHANCED TRANSFORM CODING |
| **First Named Inventor/Applicant Name:** | Jani Lainema |
| **Customer Number:** | 30542 |
| **Filer:** | Glenn Peter Albert Jr./Jessica Harvey |
| **Filer Authorized By:** | Glenn Peter Albert Jr. |
| **Attorney Docket Number:** | 037145-7826 |
| **Receipt Date:** | 30-JUN-2008 |
| **Filing Date:** | 10-APR-2008 |
| **Time Stamp:** | 19:53:07 |
| **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 | 7826-MissingPartsTransmittal-30JUN2008.pdf | 107440<br>f73fbbc350cc987f59b475f2acfd9d218c217bf3 | no | 3 |

**Warnings:**

**Information:**

| | | | | | |
|---|---|---|---|---|---|
| 2 | Oath or Declaration filed | 7826-ExecutedDecPOA-30JUN2008.pdf | 164318<br>210c11a65859b7c84230c3e406b314bd0f85e1d2 | no | 3 |

**Warnings:**

**Information:**

| | |
|---|---|
| **Total Files Size (in bytes):** | 271758 |

**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.**

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 |
|---|---|---|---|---|---|---|
| 12/101,019 | 04/10/2008 | 2621 | 2530 | 037145-7826 | 39 | 5 |

**CONFIRMATION NO. 7368**

**UPDATED FILING RECEIPT**

30542
FOLEY & LARDNER LLP
P.O. BOX 80278
SAN DIEGO, CA 92138-0278

*OC000000030964203*

Date Mailed: 07/17/2008

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 submit a written request for a Filing Receipt Correction. 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)**

Jani Lainema, Tampere, FINLAND;

**Assignment For Published Patent Application**

Nokia Corporation

**Power of Attorney:** The patent practitioners associated with Customer Number 30542

**Domestic Priority data as claimed by applicant**

This appln claims benefit of 60/911,480 04/12/2007

**Foreign Applications**

**If Required, Foreign Filing License Granted:** 04/28/2008

The country code and number of your priority application, to be used for filing abroad under the Paris Convention, is **US 12/101,019**

**Projected Publication Date:** 10/23/2008

**Non-Publication Request:** No

**Early Publication Request:** No



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**Title**

SPATIALLY ENHANCED TRANSFORM CODING

**Preliminary Class**

375

## PROTECTING YOUR INVENTION OUTSIDE THE UNITED STATES

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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).

## LICENSE FOR FOREIGN FILING UNDER

## Title 35, United States Code, Section 184

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

**GRANTED**

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|---|---|
| Applicant: | Jani Lainema |
| Title: | SPATIALLY ENHANCED TRANSFORM CODING |
| Appl. No.: | 12/101019 |
| Filing Date: | 4/10/2008 |
| Examiner: | Unassigned |
| Art Unit: | 2621 |
| Confirmation Number: | 7368 |

**INFORMATION DISCLOSURE STATEMENT UNDER 37 CFR §1.56**

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Sir:

Submitted herewith on Form PTO/SB/08 is a listing of documents known to Applicant in order to comply with Applicant's duty of disclosure pursuant to 37 CFR §1.56.

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The submission of any document herewith, which is not a statutory bar, is not intended as an admission that such document constitutes prior art against the claims of the present application or that such document is considered material to patentability as defined in 37 CFR §1.56(b). Applicant does not waive any rights to take any action which would be appropriate to antedate or otherwise remove as a competent reference any document which is determined to be a *prima facie* art reference against the claims of the present application.

## TIMING OF THE DISCLOSURE

The listed documents are being submitted in compliance with 37 CFR §1.97(b), before the mailing date of the first Office Action on the merits, and within three (3) months of the mailing date of the foreign search report.

## RELEVANCE OF EACH DOCUMENT

All of the documents are in English and were cited in the International Search Report for PCT Patent Application No. PCT/IB2008/051351.

Applicant respectfully requests that each listed document be considered by the Examiner and be made of record in the present application and that an initialed copy of Form PTO/SB/08 be returned in accordance with MPEP §609.

Although Applicant believes that no fee is required for this Request, the Commissioner is hereby authorized to charge any additional fees which may be required for this Request to Deposit Account No. 19-0741.

Respectfully submitted,

Date 15 OCTOBER 2008

By

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| Date Submitted: October 10, 2008 | | | | **Filing Date** | 4/10/2008 |
| | | | | **First Named Inventor** | Jani Lainema |
| | | | | Art Unit | 2621 |
| *(use as many sheets as necessary)* | | | | Examiner Name | Unassigned |
| Sheet | 1 | of | 1 | Attorney Docket Number | 037145-7826 |

**U.S. PATENT DOCUMENTS**

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| | A6 | Copy of the International Search Report PCT Application No. PCT/IB2008/051351 | |

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# On transform coding of motion-compensated difference images

E p. 372-376

H04N 7/13H4
H04N 7/137D8

XP 000305103

*Indexing terms: Motion compensation, Videophone, Transform coding*

**Abstract:** Motion-compensated interframe transform coding has been recommended as an efficient method of coding image sequences at low bit rates. The paper considers the effect of employing a variety of different transform and motion compensation techniques on the operation of the algorithm and also the interrelation between the predictive and transform parts of the scheme in terms of the spectral properties of the signal to be transformed. It is shown that, for a wide variety of source material, there is a complex interaction between the specific transform and motion compensation scheme employed, and that the efficiency of the motion-compensated predictive operation strongly influences the performance of the subsequent transform step.

## 1 Introduction

In recent years there has been much activity in the field of low bit-rate image coding, a primary objective being to achieve good quality reproduction of head and shoulder sequences at a rate of 64 kb/s for videophone applications. For the coding of still pictures, exhaustive tests and comparisons have shown that two-dimensional intraframe coding using the discrete cosine transform (DCT) is the most effective technique which is at the moment mature enough for practical applications [1]. For coding image sequences, present opinion favours the same intraframe operation carried out on frames which are constructed by taking pointwise differences between the picture element values in consecutive frames and those in a set of corresponding prediction frames formed through the operation of a conventional predictive coding loop. Such a system nowadays almost always includes a motion compensation operation which significantly reduces the variance of the error signal so produced. Owing to the differencing and motion compensation operations, however, the inter-element correlation of the frame to be transform coded is also greatly decreased, and this has led several workers to question the efficiency of the following transform process.

This paper briefly reviews the basic structure of the predictive coding mechanism and gives measurements for several different image sources and motion compensation algorithms that confirm the efficacy of the system in terms of the reduction in the variance of the error (difference) signal. Three different transform operations are introduced into the coding algorithm, and comparisons again made for different types of input material and motion compensation technique. While it is to be expected that coding results will vary with source material the measurements also indicate, in the present application, clear differences in the efficiencies of the particular motion compensation algorithms used. Depending on the source material employed, in some cases the type of transform used has an influence on the results also. It is concluded, therefore, that the use of the discrete cosine transform, together with motion compensation using the block matching technique does produce the best results, if only by a small margin, for the motion-compensated hybrid coding operation as formulated in the draft standard [2]. Finally, to gain more insight into the mutual influence of motion compensation and transform operations, spectral domain characteristics are examined in each case in terms of the so-called 'spectral flatness' measure, which indicates in an information-theoretic sense how easy any given spectral distribution will be to code. These results serve to confirm, in general, the view that an efficient motion compensation scheme produces a significant amount of spectral flattening of the interframe difference signal and seriously reduces any marked degree of coding gain which would otherwise be introduced by the subsequent transform coding operation.

## 2 The difference frame and motion compensation

The basic predictive coding loop is shown in Fig. 1. In the simplest case, the prediction for an element in the

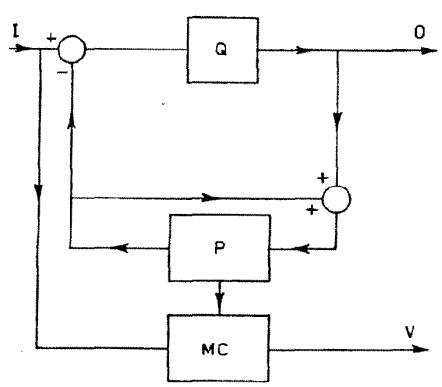


**Fig. 1** *Predictive coding with forward acting motion compensation*

I video input
O output to channel coder
Q quantiser
P predictor
MC motion compensation
V displacement vectors

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present frame is just the value of the element at the same location in the previously reconstructed frame (this having been produced by adding the previous prediction error to the reconstructed frame before that, and so on). When motion compensation is included, the prediction will not necessarily be the value at the same location in the previous frame but at such a location as to minimise some function of the error signal. Depending on the type of motion compensation used, displacement vectors may need to be transmitted to the decoder, as shown in the diagram.

Intuitively, one might propose three properties of the (motion compensated) difference signal which may subsequently require confirmation. First, since even image sequences which contain significant amounts of motion also have large areas in which motion is minimal or even absent, one expects the energy (mean square value) of the difference signal to be only a small fraction of that of the input signal itself. Secondly, since the function of the motion compensation algorithm is to produce a better prediction (i.e. one whose value is closer to that being predicted than otherwise would be the case), its inclusion should result in a further significant drop in the prediction error (difference signal) energy. (These two propositions will be seen to be amply borne out by experiment.) Thirdly, the difference signal will have, at least in part, a fragmentary or ill-defined contour and this will have consequences for its efficient coding in the spectral domain. Furthermore, these properties will be intensified by the inclusion of an efficient motion compensation scheme which will reduce the difference image to a structure consisting of fine, broken, lines.

Many motion estimation/compensation schemes have been described in the literature over the past 10–15 years (for a brief review see Reference 3). The present study compares the following algorithms:

(*a*) block-matching using the mean absolute error criterion [2]

(*b*) a Wiener estimator-based pel-recursive technique [4]

(*c*) an hierarchical technique based on a pyramid structure [5]

with the results obtained when no motion compensation is used. In brief, the block-matching technique searches over a predefined window in the previous frame for a minimum in the mean absolute difference between a block in the present frame and its counterpart in the search window. One motion vector is so determined per (typically) 8 × 8 block and is transmitted to the decoder as in Fig. 1. The pel-recursive algorithm operates on a single element (or small block of elements) and attempts to minimise the interframe difference signal by one of a number of gradient search techniques. In a similar way, the pyramid approach carried out a coarse/fine search over successive levels of the pyramid at different resolutions: 16 × 16, 64 × 64, 256 × 256 (i.e. single picture-element level), using values obtained at a higher level as initial values for the lower level (higher resolution) searches.

Table 1 lists the various energy terms for the four different motion compensation possibilities when applied to three different commonly used images (256 × 256, quantised with 8 bit resolution). MISSA (Miss America) is a relatively low contrast source, somewhat noisy and with a small degree of motion; CLAIRE is a high contrast substantially noise-free image with a moderate amount of motion, while TREVOR has rather better contrast than MISSA but contains substantial degrees of motion. Table 2 contains corresponding entropy values. The first two conjectures advanced are well demonstrated by the measurements: roughly speaking difference signal energies are no more than approximately 1% of their counterparts in the data domain. Inclusion of motion compensation brings a further energy reduction by a factor of, on average, just over three. As far as entropy values are concerned, the derivation of difference values from originally highly correlated data brings, as is well known, a significant reduction, together with the characteristic very highly peaked distribution. Even without motion compensation, for example, the difference signal distribution for CLAIRE shows that only 10% of the element values lie outside the range ±12. In all cases the entropy is now approximately 4 bits per sample, and motion compensation brings a further reduction, on average, of just over 0.5 bit per sample. There is no question, therefore, that motion compensation of any form, and over a wide range of data types, will improve the performance of a predictive coding scheme as applied to image sequences.

**Table 1: Average data and difference signal energy/element for various image sources and motion compensation schemes**

| Image | Data | Difference signal | | | |
|---|---|---|---|---|---|
| | | (a) | (b) | (c) | (d) |
| MISSA | 5668 | 17.2 | 9.4 | 11.1 | 8.4 |
| CLAIRE | 14393 | 153.3 | 35.3 | 58.4 | 30.5 |
| TREVOR | 6445 | 73.8 | 19.2 | 22.6 | 17.7 |

(a) No motion compensation
(b) Block matching
(c) Pel recursion
(d) Pyramid scheme

**Table 2: Entropy values (bits per element) for the combinations detailed in Table 1**

| Image | Data | Difference signal | | | |
|---|---|---|---|---|---|
| | | (a) | (b) | (c) | (d) |
| MISSA | 5.86 | 3.93 | 3.46 | 3.64 | 3.33 |
| CLAIRE | 6.62 | 3.81 | 3.31 | 3.43 | 3.05 |
| TREVOR | 6.58 | 4.02 | 3.52 | 3.51 | 3.40 |

(a) No motion compensation
(b) Block matching
(c) Pel recursion
(d) Pyramid scheme

## 3 Hybrid coding

Hybrid predictive/transform coding has an extensive history as an image coding technique in one of three possible formats: first, as an intraframe operation in which successive lines of an image frame are transformed and the coefficients obtained subsequently predictively coded in a vertical direction [6]; second as an interframe operation in which successive frames are subjected to a two-dimensional block transform and coefficients predictively coded along the temporal axis; and third, since motion compensation is a more complicated operation in the transform domain, in the format that has been adopted for the draft picturephone standard [2] and is discussed here — intraframe two-dimensional block coding of the interframe (motion compensated) difference signal. The equivalent intraframe operation, with a one-dimensional predictive coding procedure carried out in a vertical direction prior to transformation of the resulting error



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signal, does not seem to have been reported, although it is important to point out that, since transformation is a linear operation, in the absence of quantisation effects transformation of a difference signal and taking the difference between transforms of successive data segments are equivalent (see Reference 7 for a more extended discussion).

The coding algorithm studied here is shown in Fig. 2 and forms the basis (with many added refinements) of the

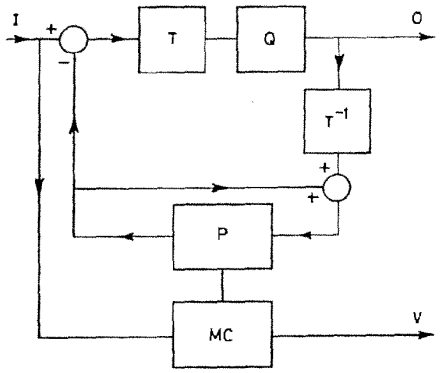


**Fig. 2** *Hybrid interframe transform coding with forward acting motion compensation*

As Fig. 1 but with
T forward transform
$T^{-1}$ inverse transform (and rescaling)

draft audiovisual service standard. Comparison with Fig. 1 indicates that most features of the two algorithms are the same with the exception that quantisation (and subsequent channel coding) is carried out on the motion-compensated interframe difference signal after that signal has been subjected to a two-dimensional discrete cosine transform with a block size of 8 × 8.

It is thus the resulting quantised transform coefficients which form the transmitted signal. Since, however, the predictor input signal is the sum of the previous prediction frame and the spatial interframe difference signal, it is necessary to include an inverse transformation ($T^{-1}$) in the prediction loop. (The draft audiovisual standard makes provision for an intraframe transform operation to be applied directly to the input video signal; the properties of such a procedure are well known [8] and are not studied further here.) It has been suggested by Girod [9] and Strobach *et al.* [10] that the efficiency of the transform operation as applied to motion-compensated intraframe difference signals is open to question. Since the draft standard is based on just such an approach, however, this paper concentrates on differences in performance between transforms and motion compensation schemes over the spread of data sources studied; see Section 5 for further discussion.

The experimental format for all test schemes is as follows: difference frames (motion compensated where appropriate) are transformed in the manner described and the resulting coefficients rounded to the nearest integral value. Methods of data rate control are not explicitly defined in the audiovisual standard; here the transform coefficients are thresholded (i.e. including a central 'dead zone' as in the recommendation) and those below the chosen value set to zero. The resulting coefficient set is then inverse transformed and the regenerated interframe difference signal added back to the prediction to form the reconstructed frame, which can then be compared with the original. Results are displayed in terms of error energy as a percentage of that of the original data as a function of average percentage of coefficients transmitted.

In addition to the combinations of image data and motion compensation scheme referred to in Section 2, three different orthogonal transforms are employed in the present experiments:

(*a*) Discrete cosine transform (DCT): most efficient of the range of orthogonal transforms commonly investigated for image processing applications when applied to data of reasonably high correlation coefficient [11].

(*b*) Walsh–Hadamard transform (WHT): a transform with, in many respects, the poorest performance in the range but having a very simple implementation [12].

(*c*) High correlation transform (HCT): a transform developed with the aim of obtaining a performance approaching that of the DCT while retaining an implementational complexity similar to that of the WHT [13].

Comparisons between the results obtained with the DCT and WHT indicate the sensitivity of the hybrid coding scheme to the spread of efficiencies obtainable from the range of available orthogonal transforms. It has been suggested that, since the interframe difference signal is substantially zero mean, the Discrete Sine Transform (DST) might be an appropriate transform to employ (see Reference 14 for discussion). Tests carried out with the DST for various combinations of images and motion compensation schemes, however, produced results little better than those for the WHT, and they have thus not been included here.

## 4 Hybrid coding results

Fig. 3 shows the results obtained for the MISSA image source, having low contrast and some noise and a small

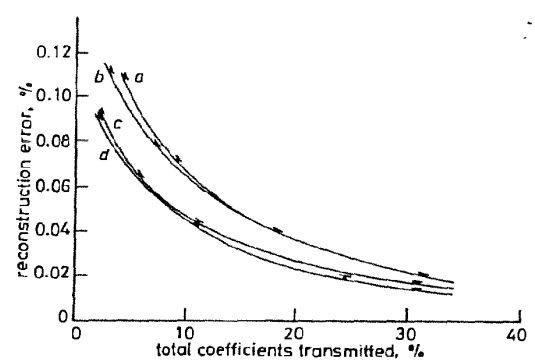


**Fig. 3** *Hybrid transform coding of image source MISSA*

*a* no motion compensation
*b* pel recursion
*c* pyramid scheme
*d* block matching
Solid curve: best results (DCT)
spread of results over all transforms used

degree of motion. There are several points of interest. First, block matching motion compensation gives the best result, with the pyramid scheme only slightly worse. Secondly, the inclusion of the pel recursive scheme is only beneficial at very low data rates, and there is a clear distinction between block matching and pyramid schemes on the one hand, and the pel-recursive scheme and no motion compensation on the other. It is also obvious that, for this image, there is little to choose between different transforms.



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The results for CLAIRE (high contrast, noise free, moderate degree of motion) are shown in Fig. 4. Again, the best result is obtained with block matching motion compensation, but in this case neither of the other schemes is clearly better than no motion compensation at

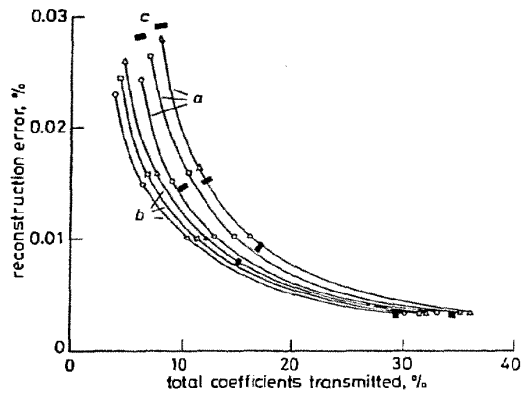


**Fig. 4** *Hybrid transform coding of image source CLAIRE*
*a* no motion compensation
*b* block matching
○ DCT
□ HCT
△ WHT
*c* ▬ total spread of results over all transforms for
(1) to the left-pyramid scheme
(2) to the right-pel recursion

all. A further interesting result is that, for both no motion compensation and block matching cases, there are clear differences between the results obtained with different transforms, with the DCT best, WHT worst, and HCT in between. For the other two cases, intertransform differences are much smaller.

Much the same results are evident for TREVOR (moderate contrast, substantial motion), Fig. 5. Here the

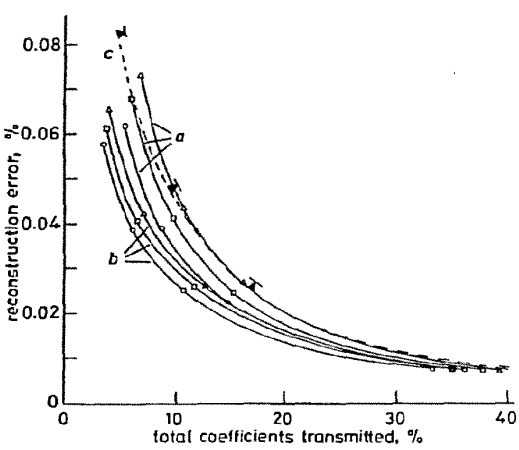


**Fig. 5** *Hybrid transform coding of image source TREVOR*
*a* and *b* as Fig. 4
*c* best results and total results spread ▬ for pel recursion and the pyramid scheme, all transforms

performance of pyramid and pel recursive algorithms is identical, and the best result is obtained using block matching motion compensation and the DCT. Fig. 6 presents the best results obtained in each case with and without motion compensation. Subjectively, as might be expected, there is little visible difference between the use of different transforms in this application. Specifically, picture quality is virtually unaffected if the DCT is replaced by the WHT.

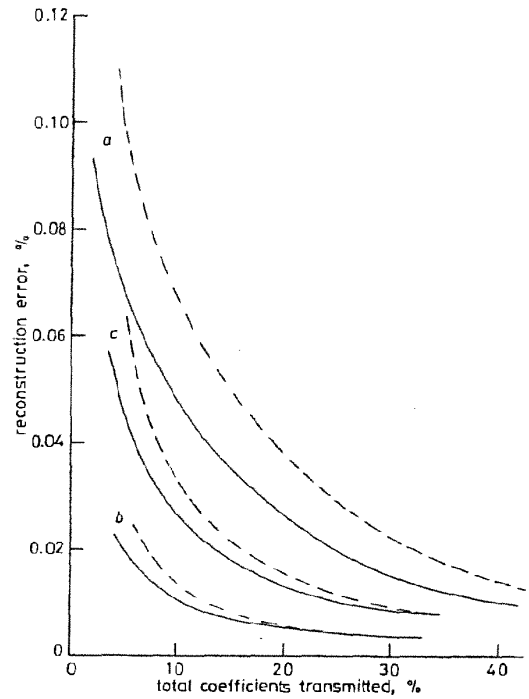


**Fig. 6** *Hybrid interframe transform coding of the three image sources*
——— best result
– – – – no motion compensation
*a* MISSA
*b* CLAIRE
*c* TREVOR

## 5 Spectral domain

Traditionally, transform coding has proved to be an effective technique for data compression when applied to original image data of high correlation [8]. Its application to the processing of interframe difference images, particularly if motion compensated, represents a departure from this, which this paper examines. Such images are likely to contain strong edge or line detail, often of a fragmentary nature, and thus be difficult to code using any technique. To the extent that one motion compensation technique is better than another, it will be more effective in reducing the amount of coherent detail remaining, and so exacerbate the coding problem — a paradox indeed! This section considers the relevant properties of the difference signal when transformed to the spectral domain in terms of the ease with which the coefficients may be coded, compared with an equivalent measure applied to original image frames themselves.

A suitable comparison measure for the present purpose is the so-called 'spectral flatness measure' [15], which for $N$ samples of a spectral process $S$ is the ratio of the geometric and arithmetic means of the spectral samples

$$\gamma_x^2 = \frac{\left(\prod_{n=1}^{N} S_n\right)^{1/N}}{\frac{1}{N}\sum_{n=1}^{N} S_n}$$



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The maximum value of $\gamma_x^2$ is unity and is achieved when all $S_n$ are equal. The spectrum is then uniformly flat and corresponds to a white noise process, for which no data compression is possible. The extent to which $\gamma_x^{-2}$ is greater than unity then, indicates the predictability or ease of coding of the data, or alternatively, the benefit to be obtained by the application of any further correlation or redundancy reducing operation. Table 3 contains

**Table 3: Values of $\gamma_x^{-2}$ for data and transform coefficients, all transforms and motion compensation schemes**

| Image | Data | No motion compensation | | | Block matching | | |
|---|---|---|---|---|---|---|---|
| | | DCT | WHT | HCT | DCT | WHT | HCT |
| MISSA | 53.0 | 1.76 | 1.75 | 1.81 | 1.89 | 1.75 | 1.89 |
| CLAIRE | 168.9 | 11.41 | 8.29 | 12.33 | 4.21 | 3.46 | 4.78 |
| TREVOR | 63.3 | 7.98 | 7.32 | 8.78 | 3.55 | 3.19 | 3.69 |

| Image | Pel recursion | | | Pyramid scheme | | |
|---|---|---|---|---|---|---|
| | DCT | WHT | HCT | DCT | WHT | HCT |
| MISSA | 1.16 | 1.18 | 1.18 | 1.22 | 1.21 | 1.24 |
| CLAIRE | 3.29 | 3.30 | 3.48 | 2.14 | 2.15 | 2.25 |
| TREVOR | 2.63 | 2.59 | 2.66 | 1.73 | 1.85 | 1.77 |

values of $\gamma_x^{-2}$ for the original data and for the prediction error sequences, using all transforms and types of motion compensation. As expected, the original data in all cases has a high value of $\gamma_x^{-2}$, indicating its amenability to data compression. CLAIRE is particularly suitable in this context. (Intuitively MISSA might be thought easiest to code, but this image has, on inspection, an appreciable noise content which naturally tends to reduce $\gamma_x^{-2}$.) TREVOR, a spatially-active image with a high degree of motion, nevertheless still shows potential for a significant degree of data compression. The situation is somewhat different when we consider difference frames, however. For these, $\gamma_x^{-2}$ is much lower than for the original data, even in the absence of motion compensation. As far as the different transforms are concerned, the results bear out these obtained earlier — that there is little to choose between those selected for this experiment (save that, interestingly enough, in several instances the HCT provides the largest value of $\gamma_x^{-2}$). If the small differences between transforms are averaged out, it can be seen that in general there is a gradual increase in spectral flattening as one moves from no motion compensation through block matching and pel-recursive techniques to the pyramid scheme. (The results for MISSA are something of an anomaly in this context and may be due to the presence of noise, as mentioned earlier.) For CLAIRE and TREVOR, data improvements over the omission of motion compensation are approximately $2\frac{1}{2}$, 3 and $4\frac{1}{2}$–5 times for block matching, pel-recursive and pyramid schemes respectively.

## 6 Conclusions

This paper has reported experiments carried out on the hybrid coding of motion-compensated interframe difference signals by varying both the transform and type of motion compensation used. It is demonstrated that the interframe prediction operation is in all cases very effective in reducing the variance of the signal to be coded, and the efficiency of this operation is improved (albeit to differing degrees) by the inclusion of motion compensation. It is further shown that, depending on the image source, there is some benefit to be gained by the use of the DCT and block matching motion compensation compared with any other combination. Results for the spectral flatness measure, however, show a marked increase in flattening as the efficiency of the motion compensation scheme improves, and it is known that in such a situation the benefit derived from any further coding of the data is very small. It is thus finally concluded that the employment of a not particularly efficient motion compensation technique (block matching) is actually beneficial in that the degree of correlation remaining in the signal to be transformed is great enough for the efficiency of the DCT subsequently to outweigh the poor motion compensation performance. If this conjecture is borne out by more wide-ranging experiments, it follows that the development of more efficient motion compensation techniques will require the associated development of coding algorithms, other than those dependent on transform operations, if their improved efficiency is to be fully realised.

## 7 Acknowledgments

British Telecom Research Laboratories supplied the image sequences on which these experiments were based. Wang Qi generated the motion compensated data used in these experiments.

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# Using Convex Set Techniques for Combined Pixel and Frequency Domain Coding of Time-Varying Images

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*Abstract*—**Projection onto convex sets has recently been suggested as an approach to time-varying image compression. In this paper, an image coding technique based on such an approach is developed. In particular, pixel and frequency domain information is combined in order to improve image quality over standard transform coding at given bit rates. The use of nonintersecting convex sets is shown to be optimum for two sets and a given error measure. Convex sets and projections are discussed in general and then in the context of image compression. Simulation results are presented for single frame images as well as for image sequences.**

## I. Introduction

TIME-VARYING image compression has received much attention, and many techniques have been shown to give good bandwidth reduction and image fidelity. Among these are transform coders, motion compensation coders, and lpc coders. The coding method described in this paper is actually a generalization of transform coding where the basis functions are replaced by convex sets. The signal to be transmitted is described to be in the intersection of certain convex sets, and the method of alternating projections is then used to locate a signal in the intersection of the sets. The sets utilized define combined frequency and spatial domain information.

Since the procedure used by this coder is the method of alternating projections onto convex sets, this topic is reviewed first as it pertains to the coding problem. Following the discussion of convex sets, the new coder is described. An optimal solution in the sense of a minimum least squares error which uses the technique of alternating projections onto nonintersecting convex sets is then given for the coder. Finally, coding results are presented which show the relative improvement for the convex set coder versus a simple transform coder.

## II. Convex Sets

Convex sets and functions have received much attention in image restoration and optimization problems [3], [13]. In the research, convex sets offer a way of utilizing or visualizing information much as in image restoration problems. For image coding, these sets may be employed at the receiver to invoke *a priori* information in order to reduce distortion in the received image. An extension of this procedure, which proves more useful, is that of transmitting information about convex sets which contain the desired image.

A convex set is defined in the following way [6]. Let $V$ be a vector space and let $C \subset V$. $C$ is convex if for every $x, y \in C$, it is also true that $[\alpha x + (1 - \alpha)y] \in C$ for $0 \le \alpha \le 1$, $\alpha$ a real. Less formally, $C$ is convex if the line segment connecting any two elements in $C$ is also in $C$ (see Fig. 1). Following are some examples of convex sets.

1) All vectors in $R^n$ (real digital signals with $n$ components) such that all of the components of the vectors are nonnegative.

$$C_P = \{x \in R^n | x_i \ge 0\} \tag{1}$$

where $x_i$ is the $i$th component of $x$.

2) All vectors in $R^n$ which have bounded energy.

$$C_B = \{x \in R^n | x^t x \le k\} \tag{2}$$

where $x^t$ is the transpose of $x$. This set defines an $n$-dimensional ball centered at the origin.

3) All vectors in $R^n$ with some given components equal to known values.

$$C_E = \{x \in R^n | x_i = k_i, i \in I\} \tag{3}$$

where the $k_i$ are known constants and $I$ is a given index set.

4) All vectors in $C^n$ with some transform coefficients equal to known values.

$$C_T = \{x \in R^n | [Tx]_i = z_i, i \in I\} \tag{4}$$

where $T$ is a linear transform, $[Tx]_i$ is the $i$th transform coefficient, the $z_i$ are known constants, perhaps complex, and $I$ is a given index set.

It is not difficult to see that $C_T$ in the last example is related to transform coding. If $m$ out of $n$ possible coefficients are transmitted, all of the signals with these $m$ coefficients form a closed convex set. The receiver, then, must accept any member of this set as feasible given no additional information. Typically, the unknown coefficients are assigned the value of zero. An alternative solution is to project the previous frame onto this set in

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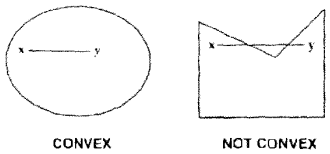


Fig. 1. Convexity in two space.

which case the untransmitted coefficients are assigned the same values as for the previous frame [10].

## III. Projections

The projection of a given vector onto a closed convex set is the vector in the set closest to this given vector. More formally, let $x$ be in the vector space $V$ and let $K$ be a closed convex subset of $V$. The projection of $x$ onto $K$ is the solution to the following problem.

$$\text{minimize } \|x - y\|^2 \quad \text{for all } y \in K. \tag{5}$$

The minimizing vector $y$ is indicated by $[Px]$. $P$ is a mapping from $V$ into $K$, i.e., $P: V \to K$, and is referred to as the projector onto $K$.

Referring to the examples of the convex sets already given, it is informative now to give the projectors onto these sets.

1) Let $P_P$ be the projector onto $C_P$.

$$[P_P x]_i = \begin{cases} x_i, & x_i \geq 0 \\ 0, & x_i \leq 0. \end{cases} \tag{6}$$

That is, if a component of $x$ is already nonnegative, leave it alone; otherwise, assign it to the nearest nonnegative value, which is clearly zero.

2) Let $P_B$ be the projector onto $C_B$.

$$P_B x = \begin{cases} x, & x'x \leq k \\ \dfrac{k^2}{x'x} x, & x'x > k. \end{cases} \tag{7}$$

The energy set defines an $n$-dimensional ball with center at the origin and radius $k$. If $x$ is inside the ball, then the projection is itself. Otherwise, the projection is the closest vector to $x$ on the surface of the ball.

3) Let $P_E$ be the projector onto $C_E$.

$$[P_E x]^i = \begin{cases} k_i, & i \in I \\ x_i, & \text{otherwise}. \end{cases} \tag{8}$$

If the value of the component is known, then assign this value; otherwise, leave it alone.

4) Let $P_T$ be the projector onto $C_T$.

$$[P_T Tx]_i = \begin{cases} z_i, & i \in I \\ [Tx]_i, & \text{otherwise}. \end{cases} \tag{9}$$

If the transform coefficient is known, then assign this value; otherwise, leave it alone.

## IV. Method of Alternating Projections

Suppose that various characteristics are known about a certain image which is to be transmitted. If these properties define convex sets, then there is a procedure to determine an image which exhibits all of these attributes. In short, an image must be found which is in the intersection of these convex sets. The procedure for accomplishing this was first given by Bregman [1] and is described next.

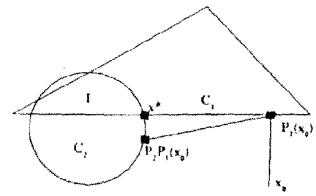


Fig. 2. Method of successive projections.

Let $C_1, C_2, \cdots, C_n$ be closed convex sets in a finite dimensional vector space $V$ with $P_1, P_2, \cdots, P_n$ their respective projectors. Then the iterative procedure

$$x_{n+1} = P_1 P_2 \cdots P_n [x_n] \tag{10}$$

converges to a vector $x^* \in C_I = \bigcap_{i=1}^{n} C_i$. The starting vector $x_0$ may be any member of $V$. This procedure is called the method of alternating projections and is depicted graphically in Fig. 2. It is interesting to note that $C_I$ will also be a closed convex set.

This theory has been used to good advantage in restoration problems where *a priori* information can be employed to constrain the size of the feasible solution set [3], [13]. In image coding, the convex set information can be transmitted and used by the receiver. This is much the same as transform coding in which the convex sets are hyperplanes. In the case of transform coding, the solution found by alternating projections onto convex sets (POCS) is also the least squares solution in the following sense.

$$x^* \text{ minimizes } \|x_0 - y\| \quad \text{for all } y \in \bigcap_{i=1}^{n} C_i. \tag{11}$$

That is, $x^*$ is the projection of $x_0$ onto the intersection of the given sets. Therefore, if $x_0$ is the zero vector, the alternating projections solution is identical to that obtained by the usual transform methods when the sets are members of an orthogonal basis set for $V$. Better results may be obtained by using the previous image as the starting estimate, at least for a short time within a sequence [10].

## V. Convex Set Coders

A general convex set coder, shown in Fig. 3, has been presented by Santago and Rajala [10]. An initial problem for this type of coder is to determine what constitutes the description of a convex set. As stated in [6], a convex set can be completely defined within closure by its support functional. Since the main concern here is with closed sets, this functional completely defines the set. Although this form of a convex set could be used, a definition which is more easily visualized is given next.

This alternative representation for convex sets is via the Minkowski functional associated with the set [6]. The Minkowski functional defines a type of distance measure from an interior point of the set to any vector in the space.

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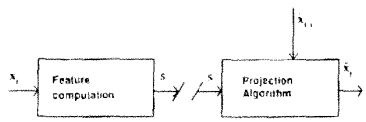


Fig. 3. Convex coder. ($S$ contains convex set information.)

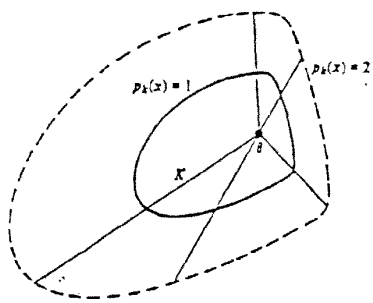


Fig. 4. The Minkowski functional $p_k(x)$ for convex set $K$ relative to point $\theta$.

As presented in [6], this point is the origin, but can be modified by simple coordinate translation. The Minkowski functional can also be viewed as the amount of expansion of the convex set necessary to include a given vector in the set (see Fig. 4). In the case of linear hyperplanes, the functional gives the amount of translation needed to contain the vector in the desired hyperplane.

As an example, if the set is the unit ball, then the Minkowski functional is the Euclidean or two-norm relative to the center of the ball. In any case, it is unlikely that these functionals would be transmitted. This would be analogous to a transform coder transmitting the basis vectors as well as the coefficients. A more likely approach would be for the receiver and the transmitter to agree on the convex set shapes and to indicate the size necessary to include the desired image via the Minkowski functional.

Finding convex sets in general is not a difficult problem. Selecting the best sets in the sense of compression capability and image quality is not, however, so easy. In the case of transform coders, the optimal representation via an orthogonal basis, given by the Karhunen–Loeve transform, is well defined, as are the projectors. In the case of projectors for general convex sets, the forms may be quite different from set to set. It was initially thought that using $n$-dimensional balls with different centers, i.e., translated energy sets, might prove enlightening. In fact, finding the optimum $n$-dimensional balls is extremely difficult and is being studied at this time.

Another view for comparing general convex sets to linear ones, e.g., transform bases, is to assume that a convex set boundary can be approximated by a finite number of hyperplanes. This can be envisioned in two dimensions by approximating a circle with a finite number of straight lines. The projection of a vector onto such a set is approximately given by the projection onto one of these hyperplanes. How closely this approaches the actual projection is a function of set shape and the number of hyperplanes used.

This approach is related to the problem of transform coding with a mixed basis. That is, given a number of possible basis sets for the signal space, choose the set for the current signal which gives the lowest error, assuming, of course, that only some of the coefficients will be transmitted. This can be extended to choosing a mixed set of basis vectors from the various bases for the current signal. The possible bases are defined by the hyperplanes which enclose the sets. In this research, a mixed basis set is used, but the bases are chosen *a priori*, i.e., pixel and frequency sets. The general problem remains open.

## VI. Difference Pictures

Since the convex set coder is designed from examination of difference pictures, it is appropriate here to discuss this topic as well as the actual sequences and models used for this paper.

The two black and white sequences coded are called BOB and MAP. BOB is a 60 frame head-and-shoulder scene of a newscaster recorded at 30 frames per second. The MAP sequence shows an individual using a pointer while lecturing in front of a wall map and also contains 60 frames. Both sequences contain frames which are 256 $\times$ 320 pixels with intensity values ranging in gray scale intensity from 0 to 255. The percent of motion in the sequences was determined by counting the number of pixels which had an absolute change of more than 3 between frames and dividing this by the number of pixels in the frame. The noise variance in both sequences was calculated to be about 1.55 and the noise densities are Gaussian [12].

In addition to actual sequences, it was desirable to code synthetic images derived from image sequence models. Initially, a three-dimensional Gauss–Markov field model was used. The coder did not perform well on this model. Since the coder did work well for the actual images, it was decided that a more realistic model was needed.

The difference pictures were then described via a composite model, a detailed description of which can be found in [12]. A binary image is made from the difference picture by assigning the value zero, black, to changed (moving) pixels and 255, white, to unchanged pixels. This binary image is known as the difference picture mask. The second part of the model uses statistics of the moving regions in order to assign values to the moving pixels. A rate distortion function was then derived for this model as well as a method for producing synthetic images which agree with the model.

## VII. Description of the Implemented Coder

The new convex set coder design is based on various attributes of interframe difference pictures as described by the composite model. First is the fact that large zero re-

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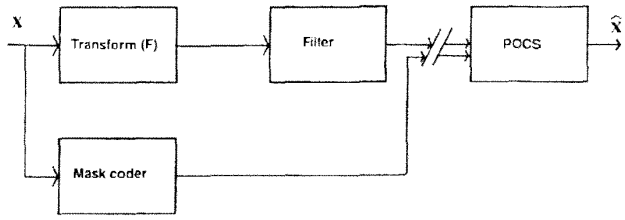


Fig. 5. Simple mixed coder using POCS.

gions or areas of unchanged pixels may allow the transmission of many pixel values with very little bandwidth requirement. This can be seen by examining the rate distortion function derived for the mask given in [9] and [12]. Second, there may be regions of uniform intensity which can also be transmitted with little bandwidth requirement. In this research, however, the major concerns are with transmitting the mask and the values of the changed regions as indicated by the mask.

As will be shown, it is possible to combine this pixel domain description of the difference picture with transform coding in order to improve received image quality. Transform coding is a robust and easily implemented coding technique. However, the information content of the coefficients is typically reduced for higher frequencies. Given this, it may then be possible to utilize the bits normally assigned to these higher frequencies more efficiently by transmitting pixel domain information directly in order to achieve reduced image error or improved subjective quality. This may be particularly applicable in the higher bandwidth systems where additional frequency coefficients or more finely quantized coefficients do not add significantly to image quality.

The previous discussion suggests that information about the image can be transmitted in two different domains. The problem then is to utilize these data to reconstruct an image at the receiver. If the information defines convex sets, then the method of alternating projections, POCS, can be employed to recover an image which is consistent with the received data. This is the case for the mixed pixel and frequency domain values as defined above. In fact, using these values defines a combination of two separate bases for two distinct transform coders. Frequency values form the basis for transform coding as we normally think of it. Pixel values are nothing more than coefficients for a standard basis, a standard basis being defined as a vector with a single entry of the value one and all others being zero.

A coder which implements this technique is given in Fig. 5. The image is segmented into fixed size blocks and each block is coded separately. This allows more flexible operation as well as the possibility of utilizing parallel processing elements in a dedicated coder system. The pixels whose values have not changed from frame to frame are referred to as the region of support (ROS). These values can be transmitted via a bit pattern which indicates whether the value of an image pixel has changed from the previous frame in the sequence. This is, in effect, transmitting the mask.

Coding the mask, which represents set $C_E$, involves simply coding a binary image. In early experiments, one bit per pixel was sent to indicate the mask [10], [4]. Even at this uncompressed rate, mean-square error reductions were shown over transform coding alone. The transform coder used for comparison utilized bit assignments based on the log-variance relation of the coefficients [8]. Uniform quantization was employed and the size of the coded blocks was the same as for the POCS coder. Some rate reduction has been effected by subsampling the mask bits [10]. As stated in [8], however, compression rates of as high as ten to one have been achieved for binary images using two-dimensional variations of run length coding for binary images. By eliminating isolated changes as well as thresholding the changes, compressions of up to seven to one have been achieved at NCSU.

In this research, experiments using Huffman coding were performed. These experiments coded vertical runs of mask pixels, corresponding to frame columns, with a maximum length of 128. Reductions of about four to one were typical, giving a value of 0.25 bits per pixel to send the mask. This compression rate is well below the rate distortion expectations for the model presented; and it is probable that further reductions could be achieved using more sophisticated techniques. Results showing the effects of up to an 8 : 1 reduction in coding the mask are given later. Once the mask and the coefficients are received, POCS may be used to reconstruct the frame.

The transform coefficients which are to be transmitted, representing set $C_T$, may be selected and quantized in any manner desired by the coder. For this research, it was determined that complex selection techniques are not of critical importance as long as reasonable methods are used. For the implemented coder, a bit assignment for each FFT coefficient based on the variance of the coefficient is used. The variances of the coefficients were determined by collecting data over a ten-frame sequence of BOB. In a real coder, these statistics may be based on a reference frame and perhaps updated periodically. Since both the transform coder and the new coder use the same assignments, the comparison should be fair as is. The bit assignments were done using the following formula [8]:

$$N_B(u, v) = \frac{N_T}{N^2} + 2 \log_{10} \left[ V(u, v) \right] - \frac{2}{N^2} \sum_{a=1}^{N} \sum_{b=1}^{N} \log_{10} \left[ V(a, b) \right] \quad (12)$$

where the image is $N \times N$, $N_T$ is the desired total number



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of bits, and $N_B(u, v)$ is the number of bits assigned to the $(u, v)$ coefficient (real and imaginary parts are assigned separately). The coefficient variances are contained in $V(u, v)$. The decision levels assume a uniform quantizer.

When coding the coefficients, various adaptive schemes can be used to reduce the bit requirement for the coder. The purpose here is to compare the new coder to the transform; thus, these methods were not implemented since the reduction would apply to both coders. However, by ignoring these techniques completely, the new coder can give results which are, in a sense, artificially much better than the transform coder. This is especially true when there are very few changes in a block and it is possible to transmit the block via conditional replenishment. The problem is discussed more thoroughly when the coding results are presented.

The previous form of the convex set coder produces improved quality and reduced error, but additional options could produce even better results. One possibility is to send the sign of the changed pixels along with the mask. This is not used here, but shows some promise of improved image quality [4].

Before describing the final form of the implemented coder, an optimal solution for two convex sets is derived and explained.

## VIII. Optimal Solution for Two Convex Sets

In this section, a new solution using a variation of POCS is developed which makes the new coder more realizable and gives a better theoretical basis for the technique. Consider a transform coder as previously described which transmits $m$ frequency coefficients out of $n$ possible coefficients. Assume, also, that the transmitter and receiver have knowledge of the values of a subset of the pixels via the mask transmission or for any other reason. These known pixels are defined, as before, to be the region of support (ROS).

Since components of the signal to be transmitted which are in the ROS will be assigned their exact values at the receiver, they become free variables or DON'T CARE elements when performing the transform at the transmitter. Therefore, the transmitter can assign values to these components so that when the transform is performed, and only a subset of the coefficients is chosen for transmission, the signal recovered by the receiver has the error minimized only for the non-ROS components. It should be noted that this algorithm is appropriate for use with transform coders which operate on fixed size blocks. If a variable number of noncontiguous pixels is allowed to be transformed coded, then the ROS pixels can be left out since they simply constitute unneeded constraints in a system of linear equations. This may not necessarily be the case, however, if the sets are not also subspaces as they are here.

Allowing the ROS values to be DON'T CARES can be defined by the following constrained minimization problem:

$$\text{minimize } \|A(Hx - x)\| \text{ w.r.t } x \text{ subject to } Ax = b \quad (13)$$

where $H$ is a mapping from $R^n$ to $R^n$ which includes a transform, filter, and an inverse transform. $Hx$ is the received signal. For example, $H = F^*LF$ where $F$ and $F^*$ are the transform and its inverse, and $L$ is a low-pass filter. $A$ is a mapping from $R^n$ to $R^k$, $k = n - m$, with $n$ and $m$ as before and it forms a vector whose components are those not in the ROS. That is, $A$ is a selection operator which alters the cost function to only measure the error in the non-ROS components. The $b$ vector is constant and contains the correct non-ROS values. The constraint equation forces the non-ROS components of the solution to be correct, while the ROS elements are allowed to vary. This constrained problem can certainly be solved, but a simple problem which leads to an optimal solution is given next.

On closer examination, there is no need to force the solution to retain exact values in the non-ROS components, only that the received signal has minimum error in this region. This may be stated as the following unconstrained minimization problem:

$$\text{minimize } \|AHx - b\| \text{ w.r.t. } x \quad (14)$$

where $A$, $H$, and $b$ are as before. This can also be seen mathematically by distributing $A$ over both terms and noting that $Ax = b$. The solution involves solving for a generalized inverse. However, an iterative solution can be obtained by applying the method of successive projections for two nonintersecting convex sets, NPOCS. The theorem describing this algorithm was first presented and proven by Cheney and Goldstein [2]. A formal statement of a similar theorem, which may be more applicable to the problem at hand, and its proof are also given in [12]. More recent work with some extensions can be found in [14]. A less formal, and hopefully more informative, description follows.

Assume a transform coder is available which transmits $m$ out of $n$ coefficients. Without loss of generality, it can be assumed that these are the $m$ low-pass coefficients and that the receiver will assign zeros to the untransmitted coefficients. Define a set $C_T$ to be all $x \in R^n$ such that the $m$ low-pass transform coefficients are bounded in magnitude, and the $m - n$ remaining coefficients have assumed values, typically zero. $C_T$ is a closed, bounded, convex set. The magnitude bounds for the $m$ transmitted coefficients can be any real numbers reasonable for the application. The $m - n$ untransmitted coefficients need not be zero, but the values which they are assumed to have must be known by the transmitter and the receiver.

Define another set $C_E$ to be all $x \in R^n$ such that $x$ has correct values in the non-ROS components, and the remaining components are bounded. $C_E$ is also closed, bounded, and convex, and the bounds for the ROS components can be any real numbers reasonable for the application.

Any received signal which is a member of $C_E$ has zero error since the ROS will be assigned exact values. Further, any signal in $C_T$ can be transmitted. The problem, then, is to find a signal $x^* \in C_T$ which is closest to $C_E$. This idea can be more readily visualized by referring to Fig. 6.

By the theorem mentioned for successive projections

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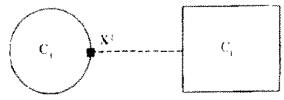

Fig. 6. Method of successive projections for two nonintersecting convex sets.

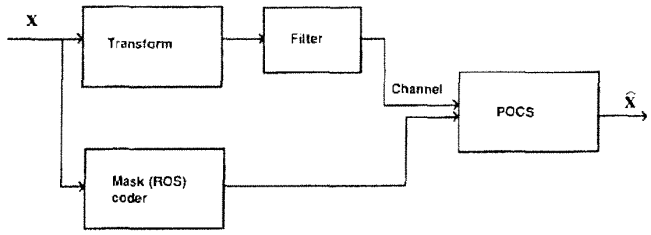


Fig. 7. Implemented mixed coder using POCS.

onto nonintersecting convex sets, the signal $x^*$ in Fig. 6 can be found by using the following method of successive projections for nonintersecting convex sets. Let $P_T$ and $P_E$ be the projectors onto $C_T$ and $C_E$, respectively. Then the iterative procedure

$$x_{k+1} = P_T P_E(x_k) \tag{15}$$

will converge to a vector in $C_T$ closest to $C_E$ ($x^*$ in the case of Fig. 6) with any $x_0 \in R^n$. This fixed point actually solves the problem:

$$\text{minimize } f(x) = \|x - P_E(x)\|, \qquad \text{for all } x \in C_T. \tag{16}$$

It should be noted that $x^*$ may not be unique and $C_T \cap C_E$ need not be empty. The transmitter sends $x^*$ and the receiver projects this signal onto $C_E$ by assigning the ROS values.

This procedure is optimum in the sense given. That is, the reconstructed signal using only the $m$ transmitted coefficients as determined by (15) will have minimum error between the reconstruction and the original signal in the non-ROS components. In all of the simulations comparing this optimal method to simple POCS, both solutions gave the same error. If the intersection of $C_T$ and $C_E$ is nonnull, then both methods give zero error. Further, the convergence rates of the two methods were practically identical. This is also shown in [11] which contains some additional examples of the use of the nonintersecting method.

The primary distinction between the POCS coder and the NPOCS coder is that for NPOCS, the iteration is performed before transmission. This is explained by the fact that the transform coefficients which give minimum error for only the non-ROS pixels can be determined before transmission. Thus, at the receiver, all that is left to do is to inverse transform and assign the ROS pixel values which were transmitted by the mask.

A coder using simple POCS is shown in Fig. 7. The coder for which results are presented in this paper is given in Fig. 8. This coder uses the NPOCS technique and two

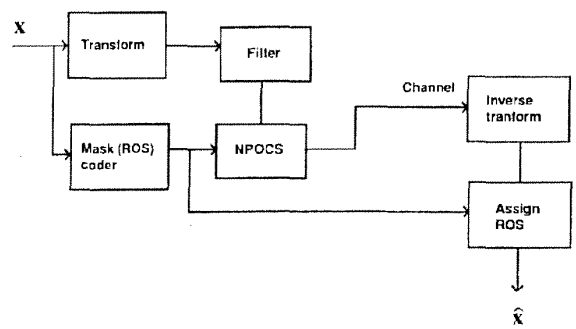


Fig. 8. Implemented mixed coder using NPOCS.

convex sets, one for the frequency domain $C_T$ information and the other for the difference picture mask $C_E$.

The method of alternating projections onto nonintersecting convex sets also converges for more than two convex sets as shown in [12]. The significance of the fixed point in this case is that all paths of fixed points with the same projection composition have the same length [14]. This path length is defined as the combined distances of each point to its projection. The usefulness of this fact needs further investigation. For the two-set case, the procedure does provide an optimal solution in the sense given and only necessitates iteration at the transmitter. Further, by using NPOCS, more decisions, such as number of iterations and allowable error in certain pixels, can be made by the transmitter before any transmission is performed [11].

## IX. Coding Results

This section contains the results of various coding simulations. Presented first are coding results for single frame-difference pictures. Following these, coding simulations for comparable synthetic images are given and the results are compared to the rate distortion function derived. Finally, results are given which show the effects of error propagation over two short sequences of a time-varying imagery.

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Some general statements should be made first which apply to all of the simulations. First, the only comparisons are among the transform coder alone, the NPOCS coder, and the rate distortion bound. The rate distortion function comparison is included only for interest since the primary goal is to relate the NPOCS coder with the ordinary transform coder. For the NPOCS algorithm, five iterations were used in all cases since additional iterations did not provide significant error reduction. Often, fewer iterations could have been used. This adaptation is easily implemented by the NPOCS algorithm since the receiver can make the decision to stop at any point. The NPOCS algorithm was chosen over ordinary POCS since both were shown, experimentally, to provide the same error and convergence rates. Finally, the coders operated on fixed size blocks of $8 \times 16$ pixels. Changes in block size do not appear to give any significant error improvement [4].

### A. Real Single Frame-Difference Coding

The first coded image is a frame-difference picture from BOB with 18.1 percent motion. The error values are not plotted since, as will be discussed shortly, the results are meaningless. In fact, some of the MSE errors exceed the variance of the difference picture itself. The MSE $\epsilon$ is defined to be

$$\epsilon = \frac{1}{N} \sum_{i=1}^{N} (x_i - \hat{x}_i)^2 \tag{17}$$

where $N$ is the number of pixels in the frame, $x_i$ is the $i$th pixel of the original frame, and $\hat{x}_i$ is the $i$th pixel of the reconstructed or received frame.

Note that for 1.0 bpp, the NPOCS method uses no frequency information. Although these rates may seem high when compared to other coders, recall that no compression is assumed for the coefficient information. That is, there is no attempt to compress the coefficient information beyond the bit assignment already discussed. A method such as hybrid transform/DPCM interframe coding could prove useful for further compression [7]. In any event, both the transform and NPOCS coders may take advantage of any additional coefficient compression using these techniques.

The NPOCS method has significant MSE improvement in all cases. One reason for the improvement is that there are many blocks to be coded which have very few changed pixels. The transform coder performs poorly for these blocks, while the convex set coder produces practically no error. The reason for this is that all changes in many of these blocks could have been transmitted via conditional replenishment. Also, for very small numbers of changes, it may be better to send no frequency coefficients at all. It was thought that this situation could be traced to the fact that coefficient bit assignments were based on statistics of all of the blocks in the image. However, when new bit assignments were calculated using only those blocks with more than 20 changes per block, the assignments were practically identical. Further, the NPOCS coder does have an advantage for coding low change blocks in that these blocks are handled automatically without changing the coding scheme.

Another method to eliminate some of the low change block problems is to median filter the difference before coding since some of the changes in these blocks are due to high noise pixels rather than motion. This technique would also allow more mask compression since isolated pixels would be eliminated, thereby producing more long runs of unchanged pixel locations.

In order to produce a more realistic comparison between the transform and NPOCS coders, simulations were performed which allow low change blocks to be transmitted exactly for both the transform and convex set coder. A reasonable number of changes would seem to be around 20 since this is where the NPOCS coder improvement begins to reduce below 100 percent. A simple justification for this number is given next.

It was assumed that these blocks could be sent via conditional replenishment and that the locations (addresses) of the nonzero errors could be sent with the same number of bits as the mask. Thus, the conditional replenishment technique would take advantage of the same amount of compression as the NPOCS coder. Also assumed was that the pixel error values could be sent with six bits on average. This may be slightly high, but even at four bits, the results are not changed much. Finally, assume that the coefficient bits could be compressed with a four-to-one ratio. This could possibly be achieved, as suggested at the beginning of this section, with both the transform and NPOCS coders making use of the compression.

Now a breakeven point must be found above which the number of bits for conditional replenishment will exceed the number of coefficient bits. This number of changes is given by

$$\text{breakeven} = \frac{\text{coefficient bits} - \text{address bits}}{\text{bits per error value}}. \tag{18}$$

For the coding cases used here, the highest breakeven is for 512 coefficient bits, a four-to-one mask and coefficient compression and 6 bits per pixel error value. The breakeven for these values is 16 changed pixels. Thus, the value of 20 changes seems valid to use for coding comparison which certainly is more than fair to the transform coder.

The results for the 18.1 percent motion BOB image using mask compression rates of 1 : 1, 2 : 1, 4 : 1, and 8 : 1, and a breakeven of 20 are given in Fig. 9. A ratio of 4 : 1 should be easily attainable as discussed previously. Note that for mask compression rates of 1 : 1 and 2 : 1, the transform coder is given even more of an advantage at this breakeven yet the NPOCS still performs better.

For high change blocks, the NPOCS performs better as well, but not in such a dramatic fashion. Fig. 10 shows the percent improvement in MSE for the NPOCS coder for various numbers of changes per block. (The improvement is not shown for fewer than 20 changes per block since, as discussed, it is artificially high.) Even for moderately high changes, the NPOCS coder has a consistently

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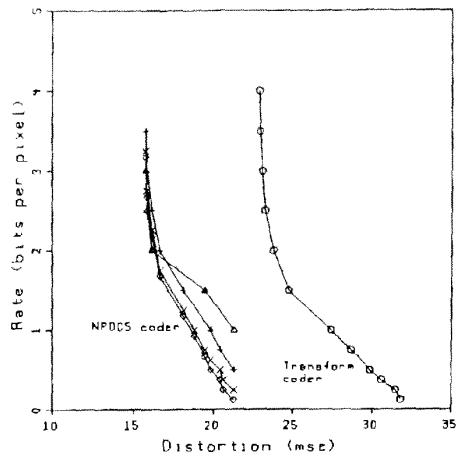
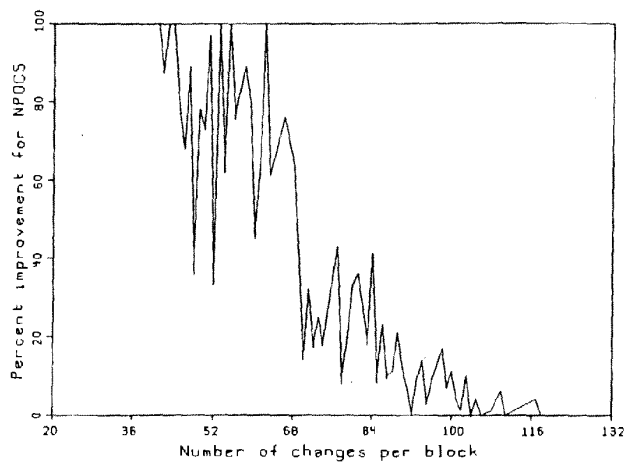
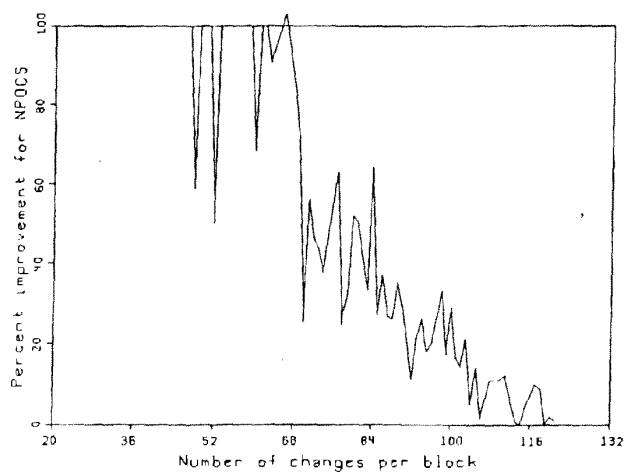



Fig. 9. Coder comparisons for BOB with 18.1 percent motion. Mask compressions of 1:1, 2:1, 4:1, 8:1.




(a)




(b)

Fig. 10. (a) Improvement for NPOCS over transform for BOB with 18.1 percent motion. Mask compression of 1:1 and 1.5 bpp. (b) Improvement for NPOCS over transform for BOBSJOB with 18.1 percent motion. Mask compression of 2:1 and 1.0 bpp.

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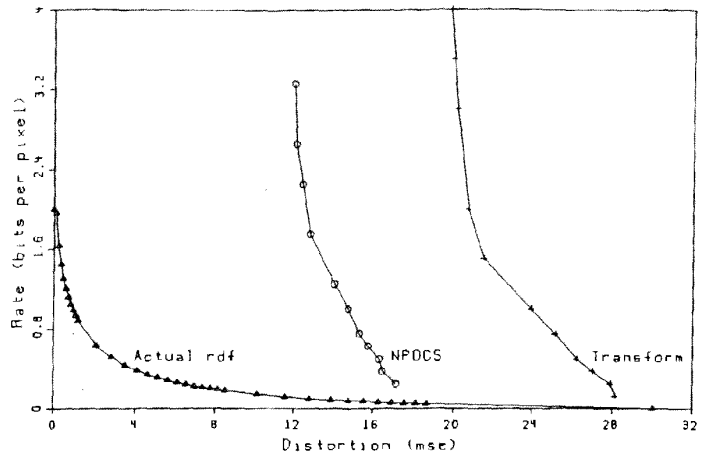


Fig. 11. Coding comparison with actual rdf. Mask compression of 4 : 1.

lower MSE error. These percent improvement values are typical for all coding runs.

The number of pixels in error is not plotted since the number remains consistent throughout the various transmission rates. Without using the breakeven for exact transmission, the number of errors greater than zero was around 76 000 over the entire frame for the transform coder and 63 000 for the NPOCS coder. Again, many of the high error counts can be traced to low change blocks. However, for high change blocks, the NPOCS method still has a reduction in the number of errors greater than 3 of about two to one. For the number of errors greater than 3, the value was about 50 000 for the transform coder and 10 000 for the NPOCS coder. This statistic is important since it is somewhat indicative of the number of pixels which must be corrected if this is desirable, perhaps for periodic update. It also has an effect on error propagation in sequences, as will be shown in the next section. For the simulations using the breakeven of 20 changes per block, there is only a significant improvement for the NPOCS coder for errors greater than 3.

The idea of reduced bit rate for error correction can also be seen in the zero order entropy of the error image for both coders. For the NPOCS coder using the breakeven, the entropy was consistently at least 1.5 bits below the transform. The first order entropy $H$ is defined as

$$H = \sum_{i=0}^{255} p(i) \log_2 p(i) \tag{19}$$

where $p(i)$ is the probability of an intensity value $i$.

### B. Synthetic Single Frame Coding

This section compares coding results for a synthetic image corresponding to 18.1 percent motion to the rate distortion bound for the composite model. The low change block problem is still evident for these images, as is the MSE improvement for the NPOCS coder (see also Fig. 10).

Figs. 11 and 12 compare the coding error for both methods to the rate distortion function using 4 : 1 mask compression. At very low bit rates, the actual coding approaches the rate distortion function. This is misleading since the error would quickly be maximized for actual coding at these rates. Also, at these levels, the rate distortion function calculation is not very robust due to numeric error in the integration with the high correlation values for the mask [12].

Examination of the images themselves shows more blurring for the simple transform coder. In addition, the transform coder produces more of a blocking effect, i.e., boundaries between the coded blocks are more obvious. This suggests that POCS or NPOCS may be useful for eliminating this effect in other transform coders. Perhaps this could be accomplished by overlapping coded blocks and forcing boundary conditions with POCS or NPOCS.

From this comparison, a few observations can be made. First, the shape of the actual coding rate distortion function suggests that, at the higher bit rates, the additional bandwidth is not used very effectively. This could be improved by implementing a hybrid, per-block transform coder which would shift the curves for both coders toward the rate distortion function, leaving the comparison results basically intact.

Second, the rate distortion function may be a bit optimistic, a possibility which can probably be traced to a moving region correlation which is too high. Also, the mask rate distortion function is probably not completely realistic. This is maybe evident from the synthetic versus the actual masks. The synthetic mask, although in good statistical agreement with the actual mask [12], has fewer and larger moving clusters. More research is needed in designing and analyzing composite models of this type in order to make completely general statements.

### C. Real Sequence Coding Results

Two sequences were coded using both the transform and the NPOCS coders. Each coder assumed a correct

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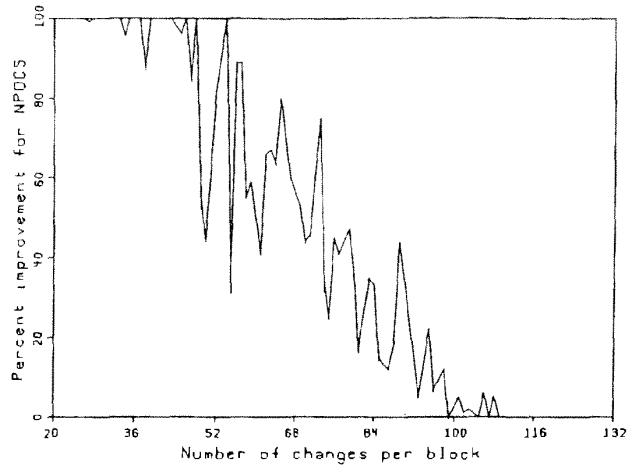
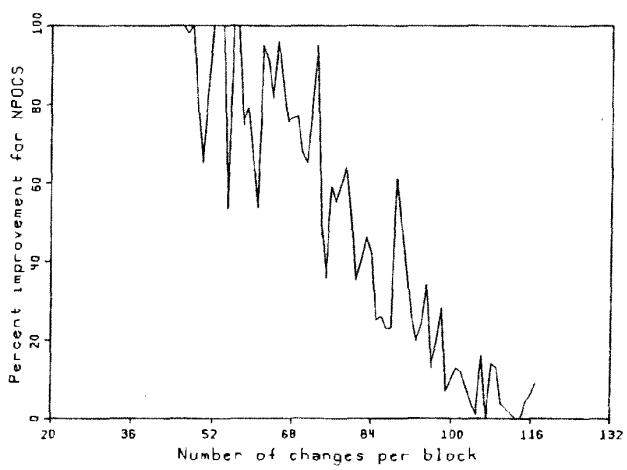



(a)




(b)

Fig. 12. (a) Improvement of NPOCS over transform for synthetic image with no mask compression and 1.5 bpp. (b) Improvement of NPOCS over transform for synthetic image with 2 : 1 mask compression and 1.0 bpp.

reference frame for a starting estimate. The first sequence contains 20 frames of BOB with the motion percentages varying from 17 to 21 percent. Compression assumed for the mask is 4 : 1 and the bit rate for each coder is 1.0 bpp. Conditional replenishment is assumed for the transform coder on the low change blocks. The error comparison is given in Fig. 13. The NPOCS coder has about one half of the MSE as the transform coder alone, and also converges more rapidly though not significantly. Fig. 14 contains the final scene from the sequence comparing the original to the coded versions.

The second sequence contains the first 17 frames of MAP sequence. The total bit rate is the same as for the first, 1.0 bpp, but the mask compression is only 2 : 1. The frames contain motion varying from 13 to 30 percent. Error comparisons are given in Fig. 15 and the final image from the sequence is shown in Fig. 16.

The large jumps at frames six and eight are due to ten rows of these frames which have incorrect data. The reason for these errors is unknown, but the sequence was used in any event since this situation may well represent a realistic possibility. Both coders recovered well from the problem. The improvement for the NPOCS coder is not as great as for the BOB sequence, which is to be expected since, with the assumed compression, the mask required more bandwidth for MAP.

For the sequence coding, the MSE improvement is greater after convergence. For the BOB sequence, a 50 percent improvement is achieved, while for MAP, around 30 percent is shown. These differences are due to many

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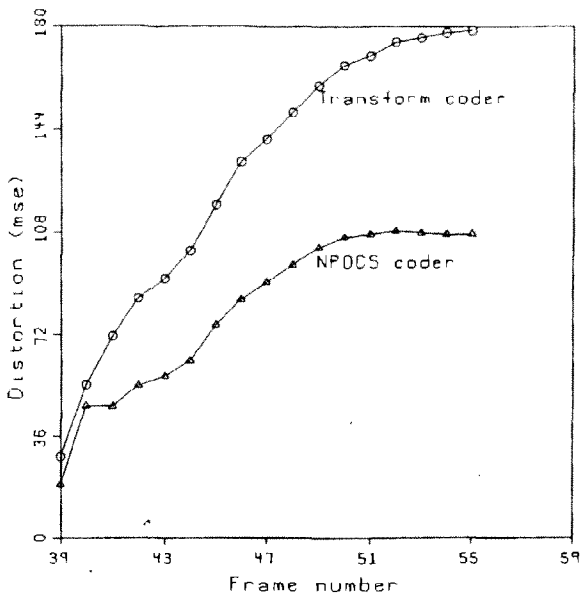



Fig. 13. BOB sequence coding error.

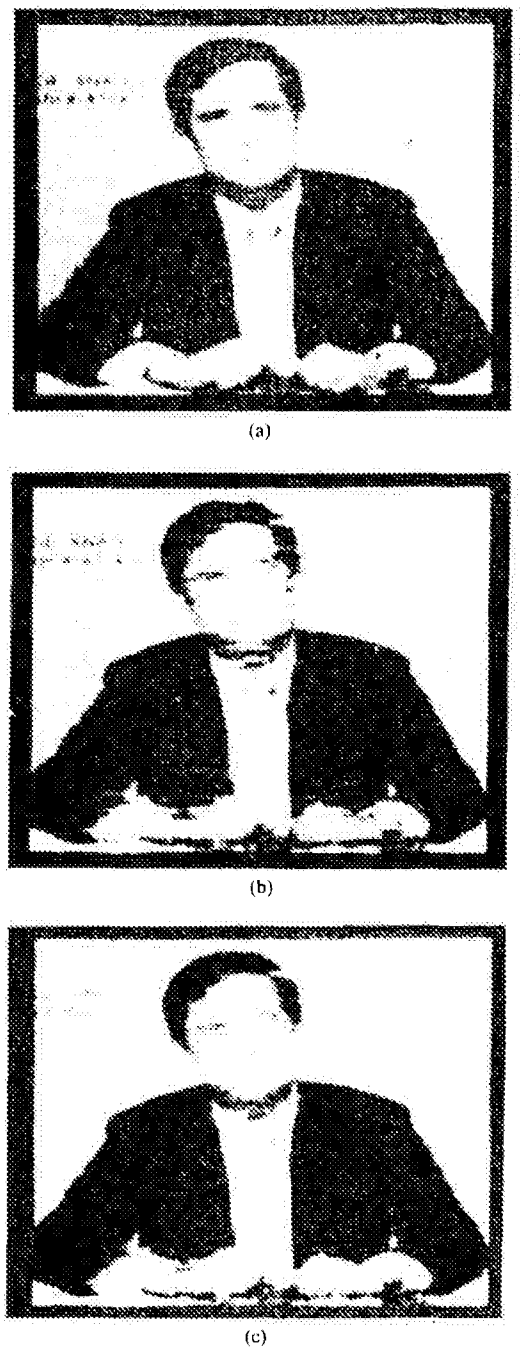
factors which include the type of moving objects, the percent of motion, and different mask compressions. Generally, the NPOCS coded frames have better detail in the moving regions. In particular, moving edges are not as noisy.

## X. Summary

The use of convex sets and the method of alternating projections provides a useful alternative to simple nonadaptive transform coding alone. In adaptive transform coding, both the transform coder and the NPOCS coder could take advantage of any further coefficient compression; the results herein may also be valid.

Projection onto convex sets (POCS) provides a technique for finding signals which must satisfy a number of constraints. For image coding, various forms of information may be transmitted which are easily formed or efficiently convey much of the image structure. POCS can be used at the receiver to recombine the transmitted information and determine an image which satisfies all of the characteristics defined by the transmitted convex sets. For two convex sets, the nonintersecting set method, NPOCS, can be employed, with the advantages of only transmitter iteration and better fidelity control.

The convex set coder studied in this paper exhibits improved mean-square error and better subjective image quality than a simple nonadaptive transform at the same bit rate. It is also probable that additional improvement would be achieved if higher mask compressions were attained. This suggests the possibility of allowing errors in the transmitted in order to increase mask compression. The transform coefficients could then be optimized for the actual mask sent using either POCS or NPOCS. Since transform coding would also be used, the error introduced by the mask would distribute of the entire block. This would hopefully produce better visual quality.



(a)

(b)

(c)

Fig. 14. (a) BOB sequence original frame 20. (b) BOB sequence frame 20 transform coded at 1.0 bpp. (c) BOB sequence frame 20 NPOCS coded at 1.0 bpp and 4 : 1 mask compression.

The most likely system to compare to the one presented in this paper was described by Pearlman and Jakatdar [7]. They used a hybrid transform/DPCM interframe coder with very good results. In comparison to other transform coders, the images received by their coder were at least as good subjectively and the SNR is close and often better.

A fair comparison between the NPOCS coder and Pearlman's is difficult to produce. It seems that their im-

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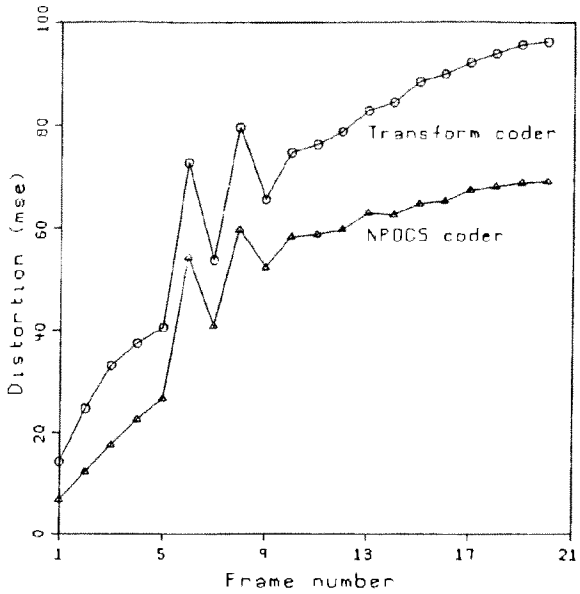


Fig. 15. MAP sequence coding error.

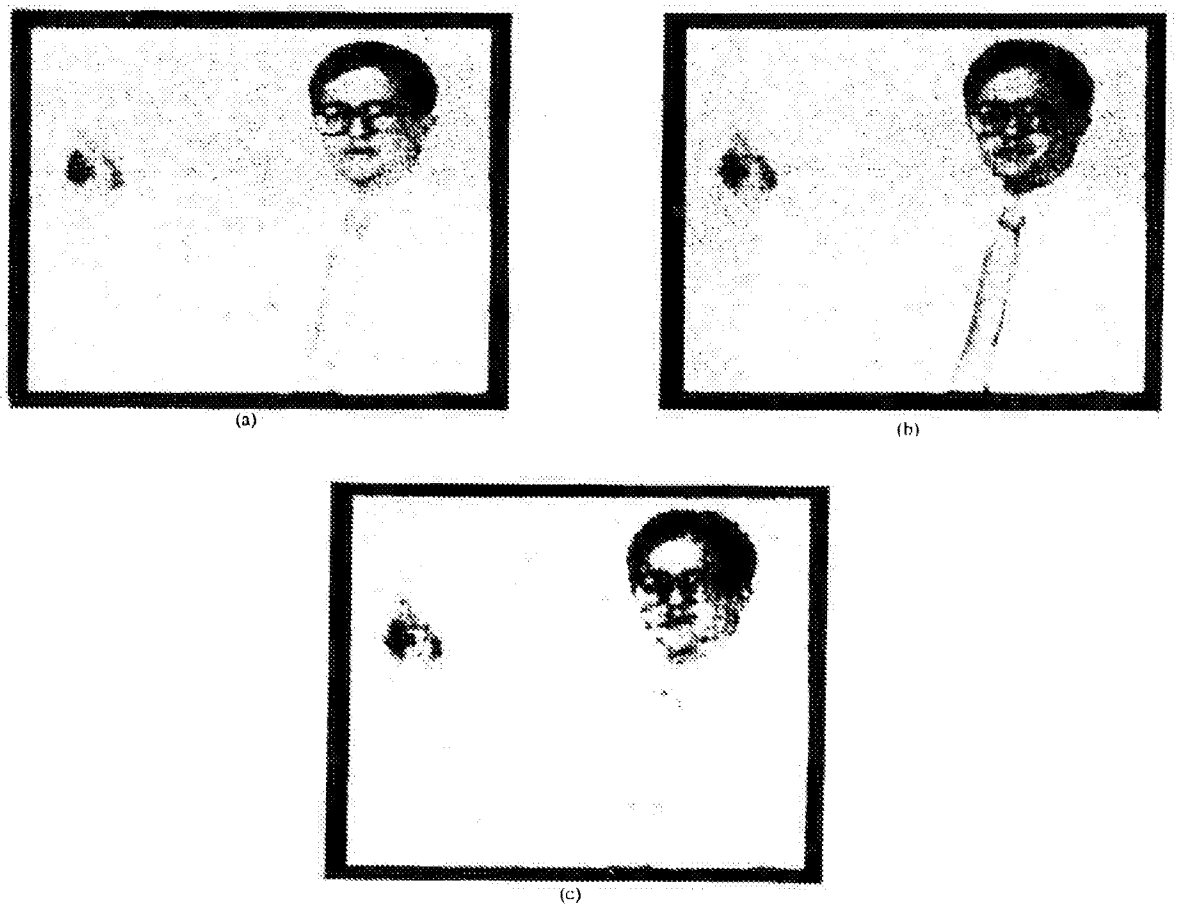


Fig. 16. (a) MAP sequence original frame 17. (b) MAP sequence frame 17 transform coded at 1.0 bpp. (c) MAP sequence frame 17 NPOCS coded at 1.0 bpp and 2:1 mask compression.

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age quality and SNR is better than NPOCS. However, they utilized a full-frame transform and their coefficient bit assignment was optimal. Further, neither the motion percentages were given nor the $\sigma_x$ for the SNR calculation. Ideally, the hybrid coder should be implemented and then the NPOCS procedure incorporated with it. It is very possible that this new coder could give some gains. The improvement for the hybrid coder improvement from 0.75 to 1.00 bits/pixel is 1.56 dB. It could prove to be more efficient to use the additional 0.25 bits/pixel to transmit the mask with a four-to-one compression.

Continued research is needed to establish the expected results of various convex sets and to determine which sets are most useful. What the POCS coder does provide is a step toward a nonlinear representation of signals and a technique for incorporating some types of information into the reconstruction process at the receiver.

In addition to questions raised about the POCS and NPOCS described in this paper, the fact that the mask indicates the location of the changed pixels requires a comparison of these methods to conditional replenishment techniques. Some analysis of this situation is being done now at NCSU. In particular, mask encoding is being studied [5]. POCS is also computer intensive, requiring iteration on large data structures for coding and decoding. It is not clear whether or not the complexity and cost can produce image fidelity gains which are in line with this procedure.

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Dr. Santago is a member of Sigma Xi.

**Sarah A. Rajala,** (S'73–M'79–SM'84), for a photograph and biography, see this issue, p. 1114.


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# Pre- and Post-Processing Algorithms for Compressed Video Enhancement

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## Abstract

*Standards-based video compression algorithms are rapidly becoming the preferred method for transmitting image sequences. Prominent examples include the MPEG and ITU family of standards. However, it is important to realize that these standards are not bit-exact, in that only the operation of the decoder is defined by the specification. Development of the rate-control mechanism and pre- and post-processing procedures is completely controlled by the system designer, and these components can introduce discernible differences between two standards compliant realizations. In this paper, we survey the fields of pre- and post-processing techniques for video compression. We then discuss our current work on compression enhancement algorithms. These algorithms are applicable to any compression standard but are discussed within the context of MPEG-2.*

## 1. Introduction

Digital video compression algorithms are a fundamental component of a video communication system. The goal of these algorithms is to represent a video sequence with a reduced number of bits, as compared to simply utilizing the intensity values of each pixel in the sequence. If the number of bits is reduced sufficiently, then transmitting and storing the video sequence becomes feasible with modern communication channels. These medias include Internet and Intranet delivery, wireless and satellite communications systems as well as DVD or hard disk storage devices.

Compressed video sequences are usually imperfect descriptions of the original imagery, in that some of the visual data of the original sequence is discarded while encoding. Eliminating information reduces the number of bits required for the compressed representation. Unfortunately, it can also lead to visible errors in the decoded imagery. In this context, the overall visual quality of the decoded sequence then becomes a critical factor in the design and comparison of video compression systems. Many variables affect this quality. For example, rate-control algorithms allocate available bits to different parts of an image sequence, which can introduce a visible difference between similar compression algorithms. In the same way, the design and implementation of pre- and post-processing mechanisms often differentiates one product from another.

In this paper, we survey the field of pre- and post-processing algorithms for digital video compression and then discuss our current work in the area. For both types of algorithms, the goal of the operation is to reduce the severity of coding artifacts within the reconstructed video sequence. Pre-processing algorithms realize this goal by filtering the original images before (or during) compression. This improves performance by simplifying the image content that must be encoded. Post-processing algorithms operate after a sequence is compressed and do not have knowledge of the original image data. Instead, these algorithms identify and attenuate coding artifacts that were introduced by the encoder.

## 2. Background

Pre- and post-processing algorithms are usually designed within the framework of a successful video standard. At the current time, these standards include the ITU and MPEG compression mechanisms. In these methods, each frame of a video sequence is coded with a combination of a block-wise transformation with the Discrete Cosine Transform (DCT) and motion compensation. Compression is realized by quantizing the transform coefficients. Unfortunately, this quantization can introduce visible errors in the reconstructed video sequence. These artifacts are typically classified as blocking, ringing or temporal flicker.

The independent processing of each block results in the first class of coding artifacts. These blocking errors dominate low bit-rate applications, where the encoder typically removes all high-frequency information. The result is a series of piece-wise constant image blocks, with sharp transitions at the block boundaries. Increasing the bit-rate of the compression system helps in reducing the blocking artifacts. However, higher bit-rate applications are still plagued by the visible "grid-like" structure in the decompressed data.

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Higher bit-rate applications also suffer from ringing artifacts. At these bit-rates, more mid-frequency information is transmitted to the decoder. However, high-frequency information is still removed from the compressed representation. This introduces a strong oscillation, or ringing, in the vicinity of significant image discontinuities. Ringing becomes more complicated in dynamic image sequences, as the oscillation may change from frame to frame. When this occurs, it is sometimes referred to as a "mosquito" or "corona" artifact.

The final artifact appearing with current compression standards is temporal flicker. Temporal flicker is introduced by local decisions within a rate-control algorithm. These algorithms allocate available bits in an attempt to maximize the resulting image quality. Unfortunately, computational complexity and finite resources often restrict the measurement of quality to the current frame of interest. Thus, there is no attempt to maintain temporal fidelity across the entire image sequence, which results in temporally varying image quality.

## 3. Post-processing

Previous work in the area of post-processing is easily divided into two types of algorithms, image enhancement and image recovery techniques. The first class of algorithms defines a heuristic procedure (or set of filters) to process the compressed imagery. The second class of algorithm relies on a rigorous model for the original image sequence and compression mechanism, utilizing optimization techniques to find the best solution. In this section, we summarize the various methods available for post-processing. Then, we discuss our current work within the area. This work focuses on higher-rate compression systems. However, our methods are applicable to any bit-rate scenario.

### 3.1. Enhancement Approaches

Designing an image enhancement algorithm typically relies on a two-step procedure. First, objectionable distortions are identified and modeled within the decompressed video sequence. Then, an operator is constructed to attenuate the distortion. For low-bit applications, enhancement techniques primarily remove blocking artifacts. For example, filtering the decoded image with a low-pass filter attenuates blocking [14]. Of coarse, excessive smoothing also removes important high-frequency content. Several techniques adjust the amount of smoothing to address this problem. For example, filtering may be restricted to the block boundaries and reduced when significant intensity differences are detected between neighboring blocks [4]. This preserves significant region boundaries. Alternatively, the visibility of each block boundary may be estimated through the use of a human visual system model. The boundary is then smoothed until it is no longer visible [1].

The design of an enhancement algorithm changes as the bit-rate of the compression system increases. At higher bit-rates, ringing artifacts become a significant distortion. Removing this artifact also requires low-pass filtering. However, the filter must contain a parameter of directionality, so that it filters parallel to edges. This removes the oscillations of the artifact without eliminating the underlying edge information. In practice this is a difficult task, as it requires the estimation and detection of every edge and its orientation within the decoded image. Improved results are attainable though. For example, morphological operators are utilized in [9], while gradient operators appear in [5, 16].

Modern video compression systems are typically prone to both ringing and blocking artifacts, as the rate-control mechanism may encode the image with spatially varying quality. In these situations, an artifact identification procedure must preclude any filtering. One approach to this problem is presented in [12]. In the approach, each block in the decompressed data is classified as "ringing", "blocking" or "none". This identification is accomplished by looking at the structure of the DCT coefficients. Significant mid-frequency information suggests that ringing artifacts are present, while the total absence of mid-frequency and high-frequency data suggests that blocking artifacts may appear. Each of these two classes of blocks is then processed with the appropriate de-blocking or de-ringing filter, while the rest of the image is unfiltered.

### 3.2. Recovery Methods

As an alternative approach to improving the visual quality of compressed video, post-processing algorithms can be expressed as recovery problems. In this context, an enhanced image must satisfy some measurement of "goodness". This metric attempts to quantify traits of the original image sequence. For example, most image sequences do not contain the blocking and ringing artifacts that appear after compression. Also, the original imagery rarely exhibits a temporal flicker.

Expressing these traits can be accomplished with either deterministic or stochastic models [19]. In the first method, an algorithm reduces compression artifacts by finding a solution that remains faithful to the decoded result while also satisfying a definition of smoothness. These definitions can include linear models within a Lagrangian approach [15, 21] or non-linear models within a projection onto convex sets (POCS) methodology [22].

In the Lagrangian techniques, one attempts to minimize the function

$$J(f) = \|\mathbf{f} - \mathbf{g}\|^2 + \lambda \|\mathbf{C}\mathbf{f}\|^2, \qquad (1)$$

where $\mathbf{f}$ denotes the post-processed image, stored row by row in a one-dimensional vector, $\mathbf{g}$ denotes the observation provided by the compressed bit-stream, $\mathbf{C}$ is an operator (or filter) that defines the measurement of goodness, and $\lambda$ is a multiplier that controls the influence of the regularizing constraint. In most realizations, $\mathbf{C}$ is a high-pass filter that enforces a smoothness constraint at the block boundaries.

In some applications, it may be more convenient to express the ideal properties of the post-processed image as a



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combination of closed and convex sets of solutions. For example, instead of penalizing high-frequency content, we could say that the energy across the block boundaries is less than some threshold. If all of the ideal properties describe the original image sequence, a solution is guaranteed to exist within the union of the set of constraints. To find the solution, a projection operator is first defined for each set. These operators map solutions outside of the constraint into the allowable set of solutions. Then, the projection operators are applied with the iteration

$$\mathbf{f}^{k+1} = P_1 P_2 \cdots P_{n-1} P_n \mathbf{f}^k, \tag{2}$$

where $P_i$ is the projection operator for the $i^{th}$ set. The algorithm continues until $\mathbf{f}^{k+1}$ and $\mathbf{f}^k$ are very close, which denotes that the solution is within the intersection of the sets.

While the Lagrangian and POCS approaches provide a method for incorporating deterministic models into the recovery procedure, stochastic definitions of image "goodness" are also allowable [7, 8, 10]. In these methods, the post-processed solution corresponds to the maximum *a posteriori* (MAP) estimate of the image sequence provided to the encoder. Thus, after applying Bayes' rule, the post-processed image must satisfy

$$\mathbf{f} = \arg \min_{\mathbf{f}_{Allowable}} \log p(\mathbf{f}_{Allowable}), \tag{3}$$

where $\mathbf{f}_{Allowable}$ denotes the set of images represented by the compressed result and $p$ is a probability distribution. In most applications, the distributions used for post-processing penalize images with significant high-frequency information, such as the expression

$$p(\mathbf{f}) = \frac{1}{Z} \exp\left\{-\frac{1}{\beta} \sum_c \varphi(d_c(\mathbf{f}))\right\}, \tag{4}$$

where $Z$ is a normalizing constant, $\beta$ is a non-negative number, $d_c$ returns the simple difference between the pixel of interest and the neighbor in the $c^{th}$ direction and $\varphi$ is a potential function that returns large numbers for large differences.

### 3.3. Current Work

In the majority of the previous work, the blocking artifact is assumed to be the dominant distortion. Our work attempts to extend the methods of image recovery to higher bit-rate applications, specifically MPEG-2 encoders operating at broadcast quality data rates. In these applications, ringing artifacts become quite important. Also, temporal flickering increases.

Working within the framework of (1), we pose the post-processing algorithm as the minimization of

$$J(f) = P_{DCT}\left(\|\mathbf{f}-\mathbf{g}\|^2 + \lambda_1\|C_1\mathbf{f}\|^2 + \lambda_2\|C_2\mathbf{f}\|^2 + \lambda_3\|C_3\mathbf{f}\|^2 + \lambda_4\|\mathbf{f}-\mathbf{f}_{MC}\|^2\right), \tag{5}$$

where $\mathbf{f}$ denotes the post-processed image, $\mathbf{g}$ denotes the observation provided by the compressed bit-stream, $C_1$ and $C_2$ are operators (or filters) that enforce smoothness across the horizontal and vertical block boundaries, respectively, $C_3$ is an operator that enforces smoothness within a block, $\mathbf{f}_{MC}$ is the observation provided by the motion compensated prediction, $P_{DCT}$ is a projection operator that restricts the solution to the transmitted set of DCT coefficients, and $\lambda_1$, $\lambda_2$, $\lambda_3$ and $\lambda_4$ express the relative importance of each constraint.

The method of successive approximations provides a solution to (5) and results in the iteration

$$\mathbf{f}^{k+1} = P_{DCT}\left(\mathbf{f}^k - \alpha\left\{\mathbf{f}^k - \mathbf{g} + \lambda_1 C_1^T C_1 \mathbf{f}^k + \lambda_2 C_2^T C_2 \mathbf{f}^k + \lambda_3 C_3^T C_3 \mathbf{f}^k + \lambda_4(\mathbf{f}^k - \mathbf{f}_{MC})\right\}\right), \tag{6}$$

where $\alpha$ determines the convergence and rate of convergence of the algorithm, and $\mathbf{f}^k$ and $\mathbf{f}^{k+1}$ denote the post-processed solution at iteration $k$ and $k+1$, respectively.

Close inspection of (5) reveals that each of the major compression artifacts is addressed in the method. For example, increasing the parameters $\lambda_1$ and $\lambda_2$ reduces blocking artifacts. Changing the value of $\lambda_3$ removes ringing artifacts, and raising the value of $\lambda_4$ diminishes the amount of temporal flicker. Selecting values for these parameters is

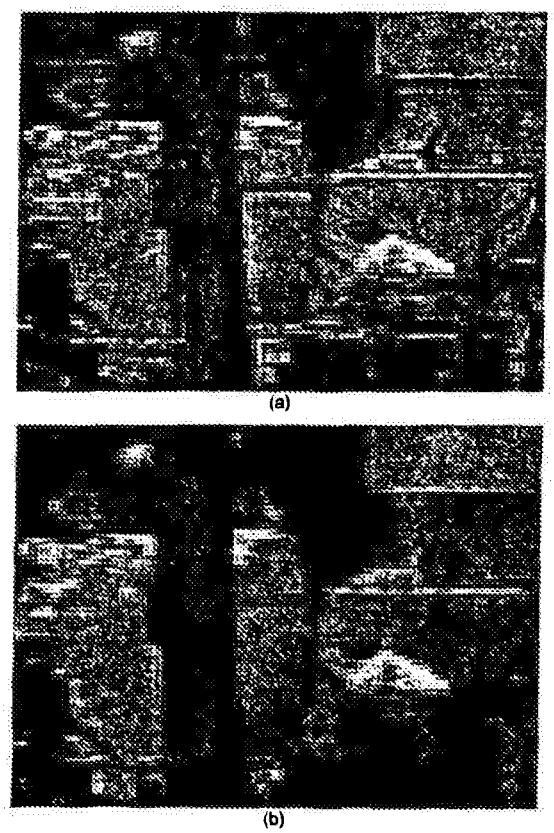


**Figure 1.** Example of post-processing algorithm: (a) portion of original CCIR601 mage coded with MPEG-2 at 3.5Mbps; (b) post-processed result by minimizing (5).



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critical for the success of the algorithm. Ideally, these parameters should vary relative to the compressed bit-stream, reflecting changes in the coding mode and bit-rate assigned to each block. Techniques that incorporate the bit-stream into the parameter selection procedure are discussed in [17, 20]. An example of the method is shown in Figure 1.

## 4. Pre-Processing

Pre-processing is commonly utilized in video compression systems, though it is not widely discussed in the literature. The goal of a pre-processing algorithm is to remove noise and small features from a video sequence, while preserving salient information. This affects the visual quality of the decoded sequence in two ways. First, the noise component of the original imagery is not transmitted to the decoder. Second, bits previously allocated to the noise are reassigned to more critical image areas.

### 4.1. Previous Work

Pre-processing algorithms appear at different locations within a video compression system. Perhaps the most obvious is to position the pre-processing algorithm before the encoding procedure. In this location, the pre-processor operates directly on the intensity data of the original image sequence. For example, applying a low-pass filter to the original imagery usually improves the quality of the encoded representation, as it removes additive noise. Heuristic methods are often employed to design the filter. However, a more sound technique is to pose the pre-processing algorithm as an operational rate-distortion problem [6]. Design of the filter then attempts to maximize the resulting image quality, given a pre-defined bit-rate.

An alternative method for pre-processing moves the procedure inside the encoder. In this approach, the motion compensated prediction is modified. Thus, the values for the transmitted error residual are changed, which requires that both the encoder and decoder implement the pre-processing method. For standards compatible encoding, only two compression formats support this type of pre-filtering. In H.261, the prediction is processed with a low-pass filter before calculating the error residual [2]. The operation is called *loop filtering*. In H.263+, the decoder filters the block boundaries of the intensity data [3], with the amount of smoothing varying relative to the quantization parameter.

Pre-processing techniques also appear after the quantization procedure. In these methods, filtering is no longer preformed on intensity data. Instead, the quantized DCT coefficients are directly modified [13]. The goal of the operation is still to remove insignificant features from the compressed bit-stream. However, the definition for insignificance exploits the structure of the variable length codes that are utilized by the encoder. Small changes in the DCT coefficient may introduce significant savings in the bits required for the representation. If the visual impact of these changes is negligible, then the pre-processing operation should adjust the quantized coefficients.

### 4.2. Current Work

Modifying the intensities within a video sequence before compression provides a very intuitive approach to the pre-filtering problem. Unfortunately, current video compression standards utilize a myriad of predictive coding techniques, which complicates the choice of the smoothing kernel. Under-smoothing the original video sequence may result in excessive coding artifacts at a given bit-rate. Alternatively, over-smoothing the video data may remove information that could be represented at the current bit-rate.

In an ideal application, selection of the pre-filter would be an iterative procedure, with the minimum amount of smoothing found so that coding artifacts are removed. Unfortunately, practical applications rarely have the luxury of the iterative approach. Changing the amount of smoothing in the original video data requires the complete re-encoding of the current frame. For inter-frame coding techniques, this necessitates the recalculation of the motion vectors – a requirement that precludes time-sensitive applications.

In our work, we are exploring pre-filtering procedures that operate on the residual between the predicted and current frames. This allows us to delay the smoothing decision and not effect the calculation of the motion vectors. Additionally, adjusting the smoothing parameter to minimize coding artifacts becomes feasible even in time-sensitive applications. Adapting the response of the filter to the underlying signal is an important component of the operation. A method is presented for adaptive processing in [11]. Higher bit-rate applications and non-linear filters are explored in [18].

Even a simple pre-processing approach can remove both additive noise and quantization errors. Figure 2 illustrates the improvement. In the illustration, an image is corrupted by additive, Gaussian white noise (SNR=20dB). The noisy image is then encoded with a traditional MPEG-2 compression algorithm. The result is plagued by a number of spurious DCT coefficients. Re-encoding the noisy image with a three-by-three averaging operation as the pre-filter improves the result. As can be seen in the figure, the spurious DCT coefficients are removed.

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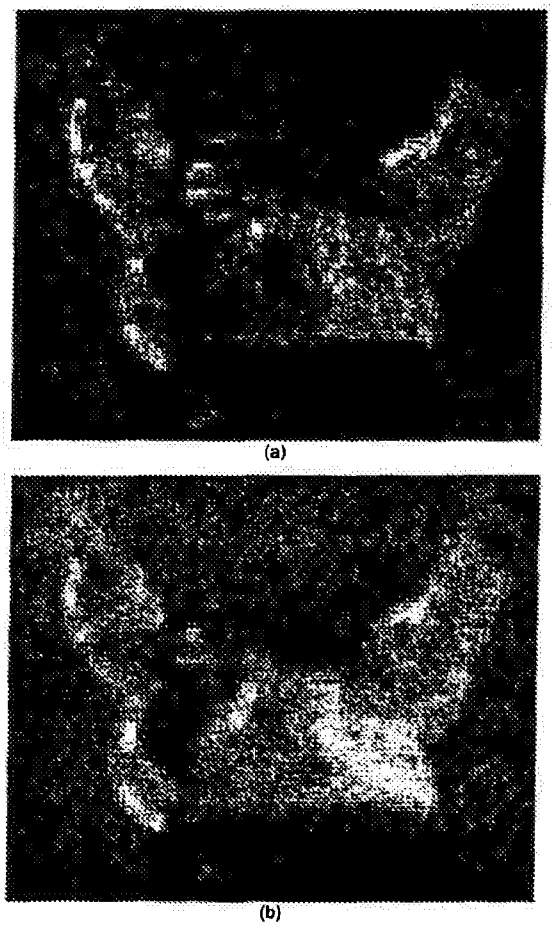

(a)

(b)

**Figure 2.** Example of current pre-processing algorithm: (a) portion of original image corrupted by noise and coded without pre-processing; (b) same image coded after filtering the residual error.

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# JOINT ADAPTIVE SPACE AND FREQUENCY BASIS SELECTION

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**ABSTRACT**

*We develop a new method for building a representation of an image from a library of basis elements that is facilitated by a joint adaptive space and frequency (JASF) graph. The JASF graph combines partitionable frequency expansion and spatial segmentation of the image, symmetrically. We demonstrate by using a rate-distortion framework for basis selection that the JASF graph improves compression performance over recent wavelet packet and double-tree methods by offering exponentially more bases in which to represent the images.*

## 1. INTRODUCTION

In this paper, we present a method for the jointly-adaptive, space and frequency selection of an image basis. The joint adaptive space and frequency (JASF) graph provides a symmetric decomposition of the image into a library of spatially and frequency localized basis elements. By performing the frequency expansions in a partitionable-form, the JASF graph provides a commutativity in the frequency and spatial operations which allows the basis elements to be more efficiently indexed by a graph.

### 1.1. Adaptive image decomposition

Recent methods have been developed for adaptively compressing images using space- or frequency-based image decompositions that involve tree structured basis selection methods [1, 3, 2]. The objective is to derive a segmentation or filter bank that is customized to the image. The two extreme approaches decompose the images either by frequency, such as wavelet packets (WP) [1], or spatially, such as quad-tree (QT) segmentation. Hybrid approaches such as the double-tree (DT) incorporate both segmentation and frequency expansion, but do so asymmetrically [2].

John R. Smith performed this work in part at Columbia University.

The JASF graph, illustrated in Figure 1, treats the space and frequency operations symmetrically in a graph structured cascade [4]. The WP-tree, QT and DT are embedded within the JASF graph. Since the JASF graph provides a more complete decomposition of the image and generates a larger number of alternative bases, the JASF graph improves image compression performance over these methods.

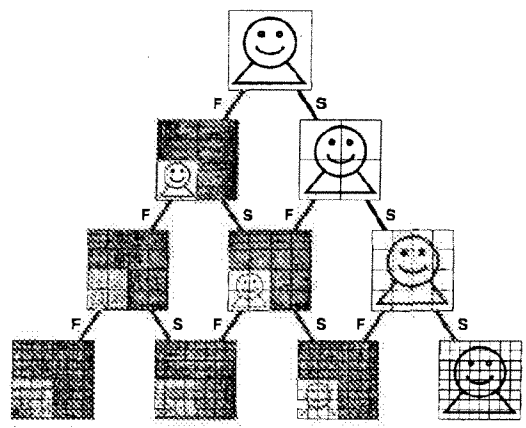


Figure 1: The JASF graph generates a joint space and frequency decomposition of the image.

In general, the tree- and graph-based decompositions generate libraries of basis elements. A *basis element* consists of a set of *basis functions* that is generated and coded as a group; each basis element corresponds to one node in the tree or graph. The objective of the search for the best basis is to select the set of basis elements that have the least total coding cost and provide a "complete" set of basis functions. The completeness requirement guarantees perfect reconstruction in the absence of quantization.

### 1.2. Outline

We present the JASF graph and the JASF basis generation and selection system. We present the framework



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for *partitionable* frequency expansions, which are fundamental to the JASF graph. We show that by using partitionable expansions, the generation of the basis elements and the reconstruction of the image may follow a number of equivalent paths. We demonstrate examples of image coding by extending the fast minimum rate-distortion cost basis selection method developed in [3]. We demonstrate that the JASF graph provides approximately $10^{20}$ more bases than the DT which generates a basis element library the same size as the JASF graph and improves compression by 0.5 to 0.9dB.

## 2. PARTITIONABLE EXPANSIONS

In order to provide commutativity in the frequency and segmentation operations in the JASF graph, the frequency expansions are performed in a partitionable form. In general, any orthonormal expansion produced by filter banks is not partitionable but may be made partitionable as we explain shortly. Producing the JASF graph expansion of depth $M$, requires frequency analysis matrices $\mathbf{H}_0$ and $\mathbf{H}_1$ that are at least $(M-1)$-partitionable.

### 2.1. 1-partitionable expansion

We define the 1-partitionable frequency expansion (1-PFE) as follows:

**Definition 1** *A frequency expansion matrix* $\mathbf{H}$ *is 1-partitionable if and only if it has only zeros in the upper right and lower left quadrants.*

If the frequency expansion matrix set $\{\mathbf{H}_0, \mathbf{H}_1\}$ generates a 1-PFE then the expansion is comprised of separate expansions over the two half-length signals, which we now illustrate. First, observe that for QMF filter banks the finite-signal frequency expansion matrices $\mathbf{H}_i$, $i \in \{0,1\}$, can be written in the following form [4]:

$$\mathbf{H}_i = \begin{pmatrix} \mathcal{H}_i^a & \mathcal{H}_i^b \\ \mathcal{H}_i^b & \mathcal{H}_i^a \end{pmatrix}. \tag{1}$$

We construct the 1-PFE from $\mathbf{H}_i$ by $\mathcal{H}_i = \mathcal{H}_i^a + \mathcal{H}_i^b$ as follows, note that for a length $N$ signal, this corresponds to circular convolution of period $N/2$:

$$\mathbf{H}_i^{(1)} = \begin{pmatrix} \mathcal{H}_i & \mathbf{0} \\ \mathbf{0} & \mathcal{H}_i \end{pmatrix} = \begin{pmatrix} \mathcal{H}_i^a + \mathcal{H}_i^b & \mathbf{0} \\ \mathbf{0} & \mathcal{H}_i^a + \mathcal{H}_i^b \end{pmatrix}. \tag{2}$$

We now state the following useful results and definition: if the original frequency expansion set $\{\mathbf{H}_0, \mathbf{H}_1\}$ satisfies the condition of perfect reconstruction and orthonormality, that is $\mathbf{H}_0^T\mathbf{H}_0 + \mathbf{H}_1^T\mathbf{H}_1 = \mathbf{I}^N$, then the 1-PFE set $\{\mathbf{H}_0^{(1)}, \mathbf{H}_1^{(1)}\}$ is orthonormal and the set $\{\mathcal{H}_0, \mathcal{H}_1\}$ generates an orthonormal expansion of length $N/2$.

**Definition 2** *The 1-partitionable frequency expansion (1-PFE) matrix set* $\{\mathbf{H}_0^{(1)}, \mathbf{H}_1^{(1)}\}$, *as constructed above is 1-partitionable and orthonormal if and only if* $\{\mathbf{H}_0, \mathbf{H}_1\}$ *satisfies the perfect reconstruction condition. For proof, see [4].*

The 1-PFE and segmentation are combined into a joint space and frequency expansion using a graph of depth = 2 as follows: in each of the four decomposition and reconstruction paths depicted in Figure 2: start from $x$, generate $v_{ij}$'s, and resynthesize $x$, we have perfect reconstruction of $x$. That is,

$$v_{ij} = \mathbf{S}_j^{N/2}\mathbf{H}_i^{(1)}x \text{ and } v_{ij} = \mathbf{H}_i^{(1)}\mathbf{S}_j^N x, \text{ and}$$

$$\begin{aligned} x &= \mathbf{G}_0^{(1)}v_{00} + \mathbf{G}_1^{(1)}v_{10} + \mathbf{G}_0^{(1)}v_{01} + \mathbf{G}_1^{(1)}v_{11}, \text{ and} \\ x &= \mathbf{G}_0^{(1)}(v_{00} + v_{01}) + \mathbf{G}_1^{(1)}(v_{10} + v_{11}), \end{aligned} \tag{3}$$

where $\mathbf{G}_i = \mathbf{H}_i^T$, and $\mathbf{S}^N$ is an $N \times N$ segmentation matrix [4].

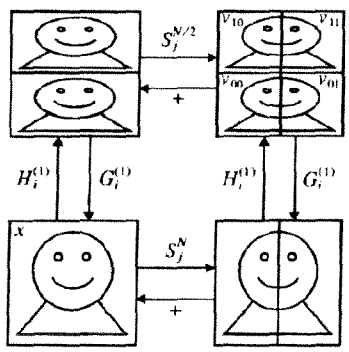


Figure 2: JASF graph of depth = 2: 1-partitionable frequency expansions (1-PFE) ($H_i, i \in \{0,1\}$) and segmentations ($S_j, j \in \{0,1\}$).

### 2.2. $M$-partitionable expansion

In order to construct the JASF graph of depth $\geq 2$, we generalize the 1-PFE to the $M$-partitionable frequency expansion (M-PFE) as follows:

**Definition 3** *A frequency expansion matrix* $\mathbf{H}_i$ *is* $M$*-partitionable if and only if the upper left and lower right quadrants are* $(M-1)$*-partitionable.*

The M-PFE analysis transform matrices $\mathbf{H}_i^{(M)}$ for $i \in \{0,1\}$ are described recursively as follows:

$$\mathbf{H}_i^{(M)} = \begin{pmatrix} \mathbf{H}_i^{(M-1)} & \mathbf{0} \\ \mathbf{0} & \mathbf{H}_i^{(M-1)} \end{pmatrix}. \tag{4}$$



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As a result, we have that, in general, $\mathbf{H}_i^{(M)}$ are block diagonal with $2^M$ partitions, as follows:

$$\mathbf{H}_i^{(M)} = \underbrace{\left(\begin{array}{c|c|c|c} \begin{array}{c|c} \mathcal{H}_i & 0 \\ \hline 0 & \mathcal{H}_i \end{array} & \ddots & \mathbf{0} \\ \hline \mathbf{0} & \ddots & \mathbf{0} \\ \hline \mathbf{0} & \ddots & \begin{array}{c|c} \mathcal{H}_i & 0 \\ \hline 0 & \mathcal{H}_i \end{array} \end{array}\right)}_{2^M \text{ partitions}} . \quad (5)$$

**Definition 4** *The M-PFE matrix set* $\{\mathbf{H}_0^{(M)}, \mathbf{H}_1^{(M)}\}$ *is M-partitionable and orthonormal if and only if the matrix set* $\{\mathbf{H}_0, \mathbf{H}_1\}$ *satisfies the perfect reconstruction condition (follows from Eq 4 and proof in [4] for 1-PFE case).*

## 3. TREE AND GRAPH EXPANSIONS

The tree- and graph-based decompositions differ in the sizes of their basis element libraries and/or the number of bases they provide. The results are summarized in Table 1 for a depth = 6 image decomposition. Examples of bases from the WP, QT, DT and JASF graph image decompositions are illustrated in Figure 3.

| | QT | WP | DT | JASF | RSFT |
|---|---|---|---|---|---|
| # basis elements | 1365 | 1365 | 7737 | 7737 | 37449 |
| # bases | $10^{78}$ | $10^{78}$ | $10^{127}$ | $10^{147}$ | $10^{147}$ |
| expansion factor | 6 | 6 | 21 | 21 | 1365 |

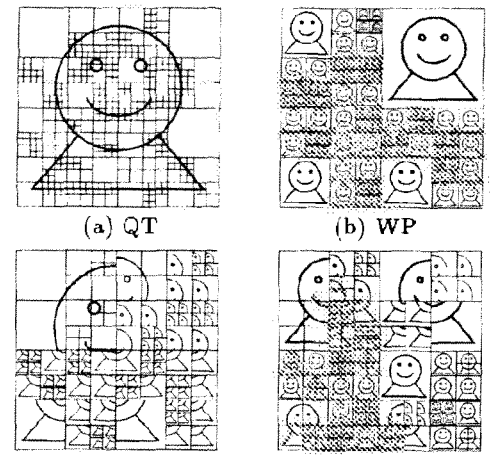
Table 1: Comparison of image decompositions of depth = 6 using QT, WP, DT, JASF and RSFT.

### 3.1. Single-trees

The WP and spatial QT image decompositions utilize single-trees. Each generates a library of $N_s$ basis elements from which may be chosen $B_s$ bases to represent the image. For a single-tree of depth=$D$ with splitting factor $\beta$ (for both quad-tree segmentation and four-band subband decomposition of images, $\beta = 4$), $N_s$ is given recursively by $N_s(D) = 1 + \beta N_s(D-1)$ and $B_s$ is given by $B_s(D) = 1 + B_s(D-1)^\beta$, where $N_s(0) = B_s(0) = 0$. For $D = 6$ the single-trees generate $B_s(6) \approx 10^{78}$ bases.

### 3.2. Double-tree (DT)

The DT generates a separate WP-tree for each spatial node in the spatial QT. The DT increases the number of basis elements and number of bases. The DT generates $N_d(D) = N_s(D) + \beta N_d(D-1)$ basis elements and $B_d(D) = 1 + B_s(D-1)^\beta + B_d(D-1)^\beta$ bases, where $N_d(0) = B_d(0) = 0$. For $D = 6$ the DT generates $B_d(6) \approx 10^{127}$ bases.



(a) QT (b) WP (c) DT (d) JASF graph

Figure 3: Example QT, WP, DT and JASF graph image bases. Each rectangle (node) corresponds to a selected basis element. (a) The QT nodes are image segments. (b) The WP nodes are image subbands. (c) The DT nodes are image-segment subbands. (d) The JASF graph nodes are, equivalently, segment-subbands and subband-segments.

### 3.3. JASF graph

The JASF graph integrates the spatial and partitionable frequency expansions, symmetrically. The JASF graph generates the same number of basis elements as the DT but significantly more bases, $B_g(D) = 1 + 2B_g(D-1)^\beta + B_g(D-2)^{\beta^2}$ bases, where $B_g(0) = 0$ and $B_g(1) = 1$. For $D = 6$ the JASF graph generates $B_d(6) \approx 10^{147}$ bases.

### 3.4. RSFT

By symmetrically combining segmentation with *non-partitionable* frequency expansion, a redundant space and frequency tree (RSFT) is generated. The RSFT increases the number of basis elements to $N_r(D) = 1 + 2\beta N_r(D-1)$ and the number of bases to $B_r(D) = 1 + \beta B_r(D-1)^\beta$, where $N_r(0) = 0$, $B_r(0) = 0$ and $B_r(1) = 1$.

When the frequency expansion is inherently *partitionable* (i.e., Haar filter bank has $\mathbf{H}_i$'s which are already block-diagonal, that is $\mathbf{H}_i = \mathbf{H}_i^{(M)}$), the RSFT and JASF graph generate the identical basis elements. However, the RSFT generates multiple copies of each basis element. For example, in Table 1, of the 37,449 basis elements generated by the RSFT, only 7,737 are unique.

Otherwise, when using a non-partitionable frequency expansion in the RSFT, many of the basis elements



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are nearly redundant. The difference between many of the basis elements stems only from the border extension used in the filtering operations. We have observed that these additional nearly redundant RSFT basis elements provide for little gain in compression performance, while they greatly increase the complexity.

## 4. JASF BASIS SELECTION

The selection of a basis from the JASF graph involves a three-way decision at each node: (1) choose $F$ (frequency-expansion), (2) choose $S$ (segmentation), or (3) choose neither. An example of a selected basis from the JASF graph is depicted in Figure 4. The basis selection procedure is carried out as follows:

1. Assign a coding cost ($J_i = R_i + \lambda D_i$) to each basis element (node) $i$ in the JASF graph, where $R_i, D_i$ gives the rate-distortion at trade-off $\lambda$ for basis element $i$ (see [3]).
2. Starting from the root node, and recursively at each $F$ and $S$ child node, choose the least cost path:
$$\min(\sum J_{i,f_k}, \sum J_{i,s_k}, J_i),$$
where $\sum J_{i,f_k}$ is the total cost of the $F$ child path, $\sum J_{i,s_k}$ is the total cost of the $S$ child path, and $J_i$ cost of choosing neither.
3. The final embedded tree gives the basis with the least total cost.

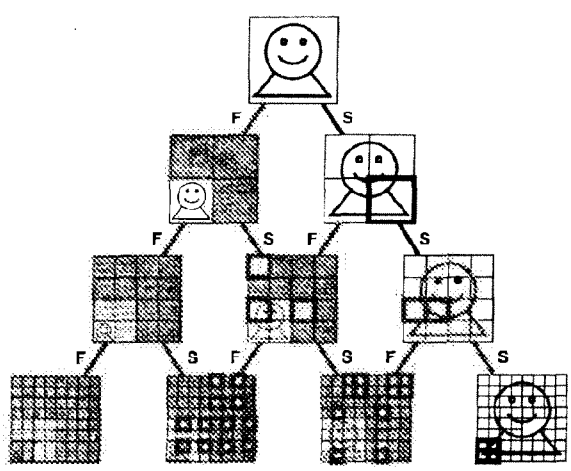


Figure 4: Example basis selected from JASF graph.

## 5. COMPRESSION EVALUATION

We now examine the compression performance of the basis selection procedure carried out on the spatial QT, WP-tree, DT, JASF graph and RSFT. We used a twelve-tap QMF filter for the frequency expansions. For the JASF graph, the frequency-expansions were carried out in the partitionable-form as discussed in Section 2. The results, given in Table 2, show that the JASF graph improves image compression performance over the spatial QT, WP-tree and DT. Furthermore, the bases selected by the JASF graph are not available in the spatial QT, WP-tree or DT. We see also that the RSFT tree provides no compression improvement over the JASF graph. The addition in the RSFT of the nearly-redundant basis elements does not improve the compression performance.

| | spatial QT | WP tree | DT | JASF graph | RSFT |
|---|---|---|---|---|---|
| 0.25 bpp | N/A | 27.9 db | 27.9 db | **28.4** db | **28.4** db |
| 0.5 bpp | 19.0 db | 32.3 db | 32.3 db | **32.7** db | **32.7** db |
| 1.0 bpp | 25.1 db | 36.8 db | 36.8 db | **37.5** db | **37.5** db |
| 2.0 bpp | 33.1 db | 42.9 db | 42.9 db | **43.8** db | **43.8** db |

Table 2: Compression results on the *Barbara* image.

## 6. SUMMARY

We developed a method for the jointly adaptive, space and frequency selection of an image basis. The JASF generates a symmetric decomposition of the image by combining partitionable frequency expansion and spatial segmentation. The JASF graph generates a greater number of bases than recent wavelet packet (WP), spatial quad-tree (QT) and double-tree (DT) methods. The bases are selected from the JASF graph by choosing at each node from a frequency expansion, spatial segmentation or neither. We demonstrated that image compression performance using the JASF graph improves over the QT, WP-tree and DT.

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# Overview of the H.264/AVC Video Coding Standard

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***Abstract*—H.264/AVC is newest video coding standard of the ITU-T Video Coding Experts Group and the ISO/IEC Moving Picture Experts Group. The main goals of the H.264/AVC standardization effort have been enhanced compression performance and provision of a "network-friendly" video representation addressing "conversational" (video telephony) and "nonconversational" (storage, broadcast, or streaming) applications. H.264/AVC has achieved a significant improvement in rate-distortion efficiency relative to existing standards. This article provides an overview of the technical features of H.264/AVC, describes profiles and applications for the standard, and outlines the history of the standardization process.**

***Index Terms*—AVC, H.263, H.264, JVT, MPEG-2, MPEG-4, standards, video.**

## I. Introduction

H.264/AVC is the newest international video coding standard [1]. By the time of this publication, it is expected to have been approved by ITU-T as Recommendation H.264 and by ISO/IEC as International Standard 14496-10 (MPEG-4 part 10) Advanced Video Coding (AVC).

The MPEG-2 video coding standard (also known as ITU-T H.262) [2], which was developed about ten years ago primarily as an extension of prior MPEG-1 video capability with support of interlaced video coding, was an enabling technology for digital television systems worldwide. It is widely used for the transmission of standard definition (SD) and high definition (HD) TV signals over satellite, cable, and terrestrial emission and the storage of high-quality SD video signals onto DVDs.

However, an increasing number of services and growing popularity of high definition TV are creating greater needs for higher coding efficiency. Moreover, other transmission media such as Cable Modem, xDSL, or UMTS offer much lower data rates than broadcast channels, and enhanced coding efficiency can enable the transmission of more video channels or higher quality video representations within existing digital transmission capacities.

Video coding for telecommunication applications has evolved through the development of the ITU-T H.261, H.262 (MPEG-2), and H.263 video coding standards (and later enhancements of H.263 known as H.263+ and H.263 + +), and has diversified from ISDN and T1/E1 service to embrace PSTN, mobile wireless networks, and LAN/Internet network delivery. Throughout this evolution, continued efforts have been made to maximize coding efficiency while dealing with the diversification of network types and their characteristic formatting and loss/error robustness requirements.

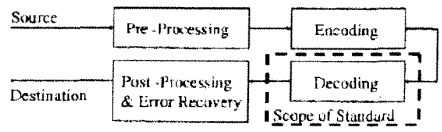


Fig. 1. Scope of video coding standardization.

Recently the MPEG-4 Visual (MPEG-4 part 2) standard [5] has also begun to emerge in use in some application domains of the prior coding standards. It has provided video shape coding capability, and has similarly worked toward broadening the range of environments for digital video use.

In early 1998, the *Video Coding Experts Group* (VCEG) ITU-T SG16 Q.6 issued a call for proposals on a project called H.26L, with the target to double the coding efficiency (which means halving the bit rate necessary for a given level of fidelity) in comparison to any other existing video coding standards for a broad variety of applications. The first draft design for that new standard was adopted in October of 1999. In December of 2001, VCEG and the *Moving Picture Experts Group* (MPEG) ISO/IEC JTC 1/SC 29/WG 11 formed a *Joint Video Team* (JVT), with the charter to finalize the draft new video coding standard for formal approval submission as H.264/AVC [1] in March 2003.

The scope of the standardization is illustrated in Fig. 1, which shows the typical video coding/decoding chain (excluding the transport or storage of the video signal). As has been the case for all ITU-T and ISO/IEC video coding standards, only the central decoder is standardized, by imposing restrictions on the bitstream and syntax, and defining the decoding process of the syntax elements such that every decoder conforming to the standard will produce similar output when given an encoded bitstream that conforms to the constraints of the standard. This limitation of the scope of the standard permits maximal freedom to optimize implementations in a manner appropriate to specific applications (balancing compression quality, implementation cost, time to market, etc.). However, it provides no guarantees of end-to-end reproduction quality, as it allows even crude encoding techniques to be considered conforming.

This paper is organized as follows. Section II provides a high-level overview of H.264/AVC applications and highlights some key technical features of the design that enable improved operation for this broad variety of applications. Section III explains the network abstraction layer (NAL) and the overall structure

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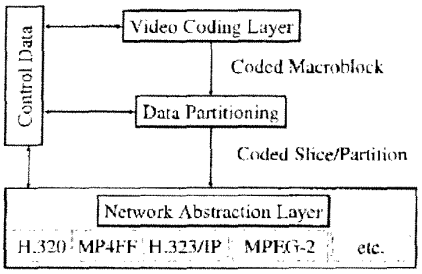


Fig. 2. Structure of H.264/AVC video encoder.

of H.264/AVC coded video data. The video coding layer (VCL) is described in Section IV. Section V explains the profiles supported by H.264/AVC and some potential application areas of the standard.

## II. Applications and Design Feature Highlights

The new standard is designed for technical solutions including at least the following application areas

- Broadcast over cable, satellite, cable modem, DSL, terrestrial, etc.
- Interactive or serial storage on optical and magnetic devices, DVD, etc.
- Conversational services over ISDN, Ethernet, LAN, DSL, wireless and mobile networks, modems, etc. or mixtures of these.
- Video-on-demand or multimedia streaming services over ISDN, cable modem, DSL, LAN, wireless networks, etc.
- Multimedia messaging services (MMS) over ISDN, DSL, ethernet, LAN, wireless and mobile networks, etc.

Moreover, new applications may be deployed over existing and future networks. This raises the question about how to handle this variety of applications and networks.

To address this need for flexibility and customizability, the H.264/AVC design covers a VCL, which is designed to efficiently represent the video content, and a NAL, which formats the VCL representation of the video and provides header information in a manner appropriate for conveyance by a variety of transport layers or storage media (see Fig. 2).

Relative to prior video coding methods, as exemplified by MPEG-2 video, some highlighted features of the design that enable enhanced coding efficiency include the following enhancements of the ability to predict the values of the content of a picture to be encoded.

- **Variable block-size motion compensation with small block sizes:** This standard supports more flexibility in the selection of motion compensation block sizes and shapes than any previous standard, with a minimum luma motion compensation block size as small as $4\times4$.
- **Quarter-sample-accurate motion compensation:** Most prior standards enable half-sample motion vector accuracy at most. The new design improves up on this by adding quarter-sample motion vector accuracy, as first found in an advanced profile of the MPEG-4 Visual (part 2) standard, but further reduces the complexity of the interpolation processing compared to the prior design.
- **Motion vectors over picture boundaries:** While motion vectors in MPEG-2 and its predecessors were required to point only to areas within the previously-decoded reference picture, the picture boundary extrapolation technique first found as an optional feature in H.263 is included in H.264/AVC.
- **Multiple reference picture motion compensation:** Predictively coded pictures (called "P" pictures) in MPEG-2 and its predecessors used only one previous picture to predict the values in an incoming picture. The new design extends upon the enhanced reference picture selection technique found in H.263++ to enable efficient coding by allowing an encoder to select, for motion compensation purposes, among a larger number of pictures that have been decoded and stored in the decoder. The same extension of referencing capability is also applied to motion-compensated bi-prediction, which is restricted in MPEG-2 to using two specific pictures only (one of these being the previous intra (I) or P picture in display order and the other being the next I or P picture in display order).
- **Decoupling of referencing order from display order:** In prior standards, there was a strict dependency between the ordering of pictures for motion compensation referencing purposes and the ordering of pictures for display purposes. In H.264/AVC, these restrictions are largely removed, allowing the encoder to choose the ordering of pictures for referencing and display purposes with a high degree of flexibility constrained only by a total memory capacity bound imposed to ensure decoding ability. Removal of the restriction also enables removing the extra delay previously associated with bi-predictive coding.
- **Decoupling of picture representation methods from picture referencing capability:** In prior standards, pictures encoded using some encoding methods (namely bi-predictively-encoded pictures) could not be used as references for prediction of other pictures in the video sequence. By removing this restriction, the new standard provides the encoder more flexibility and, in many cases, an ability to use a picture for referencing that is a closer approximation to the picture being encoded.
- **Weighted prediction:** A new innovation in H.264/AVC allows the motion-compensated prediction signal to be weighted and offset by amounts specified by the encoder. This can dramatically improve coding efficiency for scenes containing fades, and can be used flexibly for other purposes as well.
- **Improved "skipped" and "direct" motion inference:** In prior standards, a "skipped" area of a predictively-coded picture could not motion in the scene content. This had a detrimental effect when coding video containing global motion, so the new H.264/AVC design instead infers motion in "skipped" areas. For bi-predictively coded areas (called B slices), H.264/AVC also includes an enhanced motion inference method known as "direct" motion compensation, which improves further on prior "direct" prediction designs found in H.263+ and MPEG-4 Visual.



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- **Directional spatial prediction for intra coding:** A new technique of extrapolating the edges of the previously-decoded parts of the current picture is applied in regions of pictures that are coded as intra (i.e., coded without reference to the content of some other picture). This improves the quality of the prediction signal, and also allows prediction from neighboring areas that were not coded using intra coding (something not enabled when using the transform-domain prediction method found in H.263+ and MPEG-4 Visual).
- **In-the-loop deblocking filtering:** Block-based video coding produces artifacts known as blocking artifacts. These can originate from both the prediction and residual difference coding stages of the decoding process. Application of an adaptive deblocking filter is a well-known method of improving the resulting video quality, and when designed well, this can improve both objective and subjective video quality. Building further on a concept from an optional feature of H.263+, the deblocking filter in the H.264/AVC design is brought within the motion-compensated prediction loop, so that this improvement in quality can be used in inter-picture prediction to improve the ability to predict other pictures as well.

In addition to improved prediction methods, other parts of the design were also enhanced for improved coding efficiency, including the following.

- **Small block-size transform:** All major prior video coding standards used a transform block size of $8\times8$, while the new H.264/AVC design is based primarily on a $4\times4$ transform. This allows the encoder to represent signals in a more locally-adaptive fashion, which reduces artifacts known colloquially as "ringing". (The smaller block size is also justified partly by the advances in the ability to better predict the content of the video using the techniques noted above, and by the need to provide transform regions with boundaries that correspond to those of the smallest prediction regions.)
- **Hierarchical block transform:** While in most cases, using the small $4\times4$ transform block size is perceptually beneficial, there are some signals that contain sufficient correlation to call for some method of using a representation with longer basis functions. The H.264/AVC standard enables this in two ways: 1) by using a hierarchical transform to extend the effective block size use for low-frequency chroma information to an $8\times8$ array and 2) by allowing the encoder to select a special coding type for intra coding, enabling extension of the length of the luma transform for low-frequency information to a $16\times16$ block size in a manner very similar to that applied to the chroma.
- **Short word-length transform:** All prior standard designs have effectively required encoders and decoders to use more complex processing for transform computation. While previous designs have generally required 32-bit processing, the H.264/AVC design requires only 16-bit arithmetic.
- **Exact-match inverse transform:** In previous video coding standards, the transform used for representing the video was generally specified only within an error tolerance bound, due to the impracticality of obtaining an exact match to the ideal specified inverse transform. As a result, each decoder design would produce slightly different decoded video, causing a "drift" between encoder and decoder representation of the video and reducing effective video quality. Building on a path laid out as an optional feature in the H.263 + + effort, H.264/AVC is the first standard to achieve exact equality of decoded video content from all decoders.
- **Arithmetic entropy coding:** An advanced entropy coding method known as arithmetic coding is included in H.264/AVC. While arithmetic coding was previously found as an optional feature of H.263, a more effective use of this technique is found in H.264/AVC to create a very powerful entropy coding method known as CABAC (context-adaptive binary arithmetic coding).
- **Context-adaptive entropy coding:** The two entropy coding methods applied in H.264/AVC, termed CAVLC (context-adaptive variable-length coding) and CABAC, both use context-based adaptivity to improve performance relative to prior standard designs.

Robustness to data errors/losses and flexibility for operation over a variety of network environments is enabled by a number of design aspects new to the H.264/AVC standard, including the following highlighted features.

- **Parameter set structure:** The parameter set design provides for robust and efficient conveyance header information. As the loss of a few key bits of information (such as sequence header or picture header information) could have a severe negative impact on the decoding process when using prior standards, this key information was separated for handling in a more flexible and specialized manner in the H.264/AVC design.
- **NAL unit syntax structure:** Each syntax structure in H.264/AVC is placed into a logical data packet called a NAL unit. Rather than forcing a specific bitstream interface to the system as in prior video coding standards, the NAL unit syntax structure allows greater customization of the method of carrying the video content in a manner appropriate for each specific network.
- **Flexible slice size:** Unlike the rigid slice structure found in MPEG-2 (which reduces coding efficiency by increasing the quantity of header data and decreasing the effectiveness of prediction), slice sizes in H.264/AVC are highly flexible, as was the case earlier in MPEG-1.
- **Flexible macroblock ordering (FMO):** A new ability to partition the picture into regions called slice groups has been developed, with each slice becoming an independently-decodable subset of a slice group. When used effectively, flexible macroblock ordering can significantly enhance robustness to data losses by managing the spatial relationship between the regions that are coded in each slice. (FMO can also be used for a variety of other purposes as well.)
- **Arbitrary slice ordering (ASO):** Since each slice of a coded picture can be (approximately) decoded independently of the other slices of the picture, the H.264/AVC

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design enables sending and receiving the slices of the picture in any order relative to each other. This capability, first found in an optional part of H.263+, can improve end-to-end delay in real-time applications, particularly when used on networks having out-of-order delivery behavior (e.g., internet protocol networks).

- **Redundant pictures:** In order to enhance robustness to data loss, the H.264/AVC design contains a new ability to allow an encoder to send redundant representations of regions of pictures, enabling a (typically somewhat degraded) representation of regions of pictures for which the primary representation has been lost during data transmission.
- **Data Partitioning:** Since some coded information for representation of each region (e.g., motion vectors and other prediction information) is more important or more valuable than other information for purposes of representing the video content, H.264/AVC allows the syntax of each slice to be separated into up to three different partitions for transmission, depending on a categorization of syntax elements. This part of the design builds further on a path taken in MPEG-4 Visual and in an optional part of H.263++. Here, the design is simplified by having a single syntax with partitioning of that same syntax controlled by a specified categorization of syntax elements.
- **SP/SI synchronization/switching pictures:** The H.264/AVC design includes a new feature consisting of picture types that allow exact synchronization of the decoding process of some decoders with an ongoing video stream produced by other decoders without penalizing all decoders with the loss of efficiency resulting from sending an I picture. This can enable switching a decoder between representations of the video content that used different data rates, recovery from data losses or errors, as well as enabling trick modes such as fast-forward, fast-reverse, etc.

In Sections III and IV, a more detailed description of the key features is given.

## III. NAL

The NAL is designed in order to provide "network friendliness" to enable simple and effective customization of the use of the VCL for a broad variety of systems.

The NAL facilitates the ability to map H.264/AVC VCL data to transport layers such as:

- RTP/IP for any kind of real-time wire-line and wireless Internet services (conversational and streaming);
- File formats, e.g., ISO MP4 for storage and MMS;
- H.32X for wireline and wireless conversational services;
- MPEG-2 systems for broadcasting services, etc.

The full degree of customization of the video content to fit the needs of each particular application is outside the scope of the H.264/AVC standardization effort, but the design of the NAL anticipates a variety of such mappings. Some key concepts of the NAL are NAL units, byte stream, and packet format uses of NAL units, parameter sets, and access units. A short description of these concepts is given below whereas a more detailed description including error resilience aspects is provided in [6] and [7].

### A. NAL Units

The coded video data is organized into NAL units, each of which is effectively a packet that contains an integer number of bytes. The first byte of each NAL unit is a header byte that contains an indication of the type of data in the NAL unit, and the remaining bytes contain payload data of the type indicated by the header.

The payload data in the NAL unit is interleaved as necessary with *emulation prevention bytes*, which are bytes inserted with a specific value to prevent a particular pattern of data called a *start code prefix* from being accidentally generated inside the payload.

The NAL unit structure definition specifies a generic format for use in both packet-oriented and bitstream-oriented transport systems, and a series of NAL units generated by an encoder is referred to as a NAL unit stream.

### B. NAL Units in Byte-Stream Format Use

Some systems (e.g., H.320 and MPEG-2/H.222.0 systems) require delivery of the entire or partial NAL unit stream as an ordered stream of bytes or bits within which the locations of NAL unit boundaries need to be identifiable from patterns within the coded data itself.

For use in such systems, the H.264/AVC specification defines a byte stream format. In the byte stream format, each NAL unit is prefixed by a specific pattern of three bytes called a start code prefix. The boundaries of the NAL unit can then be identified by searching the coded data for the unique start code prefix pattern. The use of emulation prevention bytes guarantees that start code prefixes are unique identifiers of the start of a new NAL unit.

A small amount of additional data (one byte per video picture) is also added to allow decoders that operate in systems that provide streams of bits without alignment to byte boundaries to recover the necessary alignment from the data in the stream.

Additional data can also be inserted in the byte stream format that allows expansion of the amount of data to be sent and can aid in achieving more rapid byte alignment recovery, if desired.

### C. NAL Units in Packet-Transport System Use

In other systems (e.g., internet protocol/RTP systems), the coded data is carried in packets that are framed by the system transport protocol, and identification of the boundaries of NAL units within the packets can be established without use of start code prefix patterns. In such systems, the inclusion of start code prefixes in the data would be a waste of data carrying capacity, so instead the NAL units can be carried in data packets without start code prefixes.

### D. VCL and Non-VCL NAL Units

NAL units are classified into VCL and non-VCL NAL units. The VCL NAL units contain the data that represents the values of the samples in the video pictures, and the non-VCL NAL units contain any associated additional information such as parameter sets (important header data that can apply to a large

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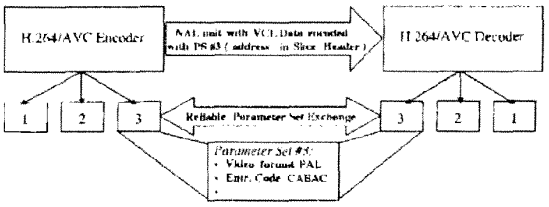


Fig. 3. Parameter set use with reliable "out-of-band" parameter set exchange.

number of VCL NAL units) and supplemental enhancement information (timing information and other supplemental data that may enhance usability of the decoded video signal but are not necessary for decoding the values of the samples in the video pictures).

### E. Parameter Sets

A parameter set is supposed to contain information that is expected to rarely change and offers the decoding of a large number of VCL NAL units. There are two types of parameter sets:

- sequence parameter sets, which apply to a series of consecutive coded video pictures called a coded video sequence;
- picture parameter sets, which apply to the decoding of one or more individual pictures within a coded video sequence.

The sequence and picture parameter-set mechanism decouples the transmission of infrequently changing information from the transmission of coded representations of the values of the samples in the video pictures. Each VCL NAL unit contains an identifier that refers to the content of the relevant picture parameter set and each picture parameter set contains an identifier that refers to the content of the relevant sequence parameter set. In this manner, a small amount of data (the identifier) can be used to refer to a larger amount of information (the parameter set) without repeating that information within each VCL NAL unit.

Sequence and picture parameter sets can be sent well ahead of the VCL NAL units that they apply to, and can be repeated to provide robustness against data loss. In some applications, parameter sets may be sent within the channel that carries the VCL NAL units (termed "in-band" transmission). In other applications (see Fig. 3), it can be advantageous to convey the parameter sets "out-of-band" using a more reliable transport mechanism than the video channel itself.

### F. Access Units

A set of NAL units in a specified form is referred to as an access unit. The decoding of each access unit results in one decoded picture. The format of an access unit is shown in Fig. 4.

Each access unit contains a set of VCL NAL units that together compose a *primary coded picture*. It may also be prefixed with an *access unit delimiter* to aid in locating the start of the access unit. Some *supplemental enhancement information* containing data such as picture timing information may also precede the primary coded picture.

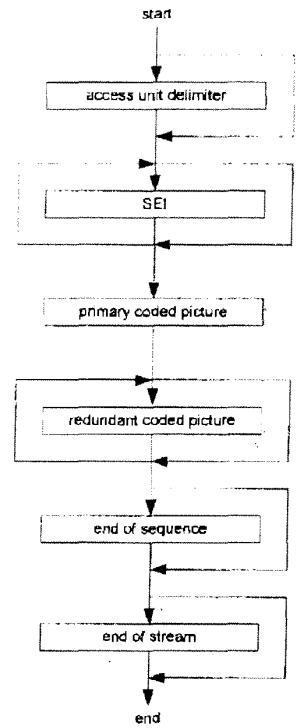


Fig. 4. Structure of an access unit.

The primary coded picture consists of a set of VCL NAL units consisting of *slices* or *slice data partitions* that represent the samples of the video picture.

Following the primary coded picture may be some additional VCL NAL units that contain redundant representations of areas of the same video picture. These are referred to as *redundant coded pictures*, and are available for use by a decoder in recovering from loss or corruption of the data in the primary coded pictures. Decoders are not required to decode redundant coded pictures if they are present.

Finally, if the coded picture is the last picture of a coded video sequence (a sequence of pictures that is independently decodable and uses only one sequence parameter set), an *end of sequence* NAL unit may be present to indicate the end of the sequence; and if the coded picture is the last coded picture in the entire NAL unit stream, an *end of stream* NAL unit may be present to indicate that the stream is ending.

### G. Coded Video Sequences

A coded video sequence consists of a series of access units that are sequential in the NAL unit stream and use only one sequence parameter set. Each coded video sequence can be decoded independently of any other coded video sequence, given the necessary parameter set information, which may be conveyed "in-band" or "out-of-band". At the beginning of a coded video sequence is an *instantaneous decoding refresh* (IDR) access unit. An IDR access unit contains an *intra* picture—a coded

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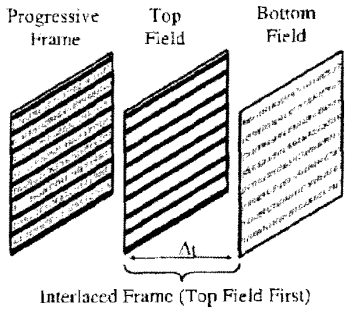


Fig. 5. Progressive and interlaced frames and fields.

picture that can be decoded without decoding any previous pictures in the NAL unit stream, and the presence of an IDR access unit indicates that no subsequent picture in the stream will require reference to pictures prior to the intra picture it contains in order to be decoded.

A NAL unit stream may contain one or more coded video sequences.

## IV. VCL

As in all prior ITU-T and ISO/IEC JTC1 video standards since H.261 [3], the VCL design follows the so-called block-based hybrid video coding approach (as depicted in Fig. 8), in which each coded picture is represented in block-shaped units of associated luma and chroma samples called *macroblocks*. The basic source-coding algorithm is a hybrid of inter-picture prediction to exploit temporal statistical dependencies and transform coding of the prediction residual to exploit spatial statistical dependencies. There is no single coding element in the VCL that provides the majority of the significant improvement in compression efficiency in relation to prior video coding standards. It is rather a plurality of smaller improvements that add up to the significant gain.

### A. Pictures, Frames, and Fields

A coded video sequence in H.264/AVC consists of a sequence of *coded pictures*. A coded picture in [1] can represent either an entire *frame* or a single *field*, as was also the case for MPEG-2 video.

Generally, a frame of video can be considered to contain two interleaved fields, a top and a bottom field. The top field contains even-numbered rows 0, 2, ..., H/2−1 with H being the number of rows of the frame. The bottom field contains the odd-numbered rows (starting with the second line of the frame). If the two fields of a frame were captured at different time instants, the frame is referred to as an interlaced frame, and otherwise it is referred to as a progressive frame (see Fig. 5). The coding representation in H.264/AVC is primarily agnostic with respect to this video characteristic, i.e., the underlying interlaced or progressive timing of the original captured pictures. Instead, its coding specifies a representation based primarily on geometric concepts rather than being based on timing.

### B. YCbCr Color Space and 4:2:0 Sampling

The human visual system seems to perceive scene content in terms of brightness and color information separately, and with greater sensitivity to the details of brightness than color. Video transmission systems can be designed to take advantage of this. (This is true of conventional analog TV systems as well as digital ones.) In H.264/AVC as in prior standards, this is done by using a YCbCr color space together with reducing the sampling resolution of the Cb and Cr chroma information.

The video color space used by H.264/AVC separates a color representation into three components called Y, Cb, and Cr. Component Y is called *luma*, and represents brightness. The two *chroma* components Cb and Cr represent the extent to which the color deviates from gray toward blue and red, respectively. (The terms luma and chroma are used in this paper and in the standard rather than the terms luminance and chrominance, in order to avoid the implication of the use of linear light transfer characteristics that is often associated with the terms luminance and chrominance.)

Because the human visual system is more sensitive to luma than chroma, H.264/AVC uses a sampling structure in which the chroma component has one fourth of the number of samples than the luma component (half the number of samples in both the horizontal and vertical dimensions). This is called 4:2:0 sampling with 8 bits of precision per sample. The sampling structure used is the same as in MPEG-2 Main-profile video. (Proposals for extension of the standard to also support higher-resolution chroma and a larger number of bits per sample are currently being considered.)

### C. Division of the Picture Into Macroblocks

A picture is partitioned into fixed-size macroblocks that each cover a rectangular picture area of $16 \times 16$ samples of the luma component and $8 \times 8$ samples of each of the two chroma components. This partitioning into macroblocks has been adopted into all previous ITU-T and ISO/IEC JTC1 video coding standards since H.261 [3]. Macroblocks are the basic building blocks of the standard for which the decoding process is specified. The basic coding algorithm for a macroblock is described after we explain how macroblocks are grouped into slices.

### D. Slices and Slice Groups

Slices are a sequence of macroblocks which are processed in the order of a raster scan when not using FMO which is described in the next paragraph. A picture maybe split into one or several slices as shown in Fig. 6. A picture is therefore a collection of one or more slices in H.264/AVC. Slices are self-contained in the sense that given the active sequence and picture parameter sets, their syntax elements can be parsed from the bitstream and the values of the samples in the area of the picture that the slice represents can be correctly decoded without use of data from other slices provided that utilized reference pictures are identical at encoder and decoder. Some information from other slices maybe needed to apply the deblocking filter across slice boundaries.



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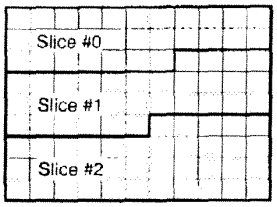


Fig. 6. Subdivision of a picture into slices when not using FMO.

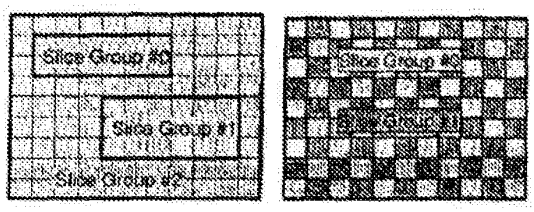


Fig. 7. Subdivision of a QCIF frame into slices when utilizing FMO.

FMO modifies the way how pictures are partitioned into slices and macroblocks by utilizing the concept of *slice groups*. Each slice group is a set of macroblocks defined by a *macroblock to slice group map*, which is specified by the content of the picture parameter set and some information from slice headers. The macroblock to slice group map consists of a slice group identification number for each macroblock in the picture, specifying which slice group the associated macroblock belongs to. Each slice group can be partitioned into one or more slices, such that a slice is a sequence of macroblocks within the same slice group that is processed in the order of a raster scan within the set of macroblocks of a particular slice group. (The case when FMO is not in use can be viewed as the simple special case of FMO in which the whole picture consists of a single slice group.)

Using FMO, a picture can be split into many macroblock scanning patterns such as interleaved slices, a dispersed macroblock allocation, one or more "foreground" slice groups and a "leftover" slice group, or a checker-board type of mapping. The latter two are illustrated in Fig. 7. The left-hand side macroblock to slice group mapping has been demonstrated for use in region-of-interest type of coding applications. The right-hand side macroblock to slice group mapping has been demonstrated useful for concealment in video conferencing applications where slice group #0 and slice group #1 are transmitted in separate packets and one of them is lost. For more details on the use of FMO, see [14].

Regardless of whether FMO is in use or not, each slice can be coded using different coding types as follows.

- **I slice:** A slice in which all macroblocks of the slice are coded using intra prediction.
- **P slice:** In addition to the coding types of the I slice, some macroblocks of the P slice can also be coded using inter prediction with at most *one* motion-compensated prediction signal per prediction block.
- **B slice:** In addition to the coding types available in a P slice, some macroblocks of the B slice can also be coded using inter prediction with *two* motion-compensated prediction signals per prediction block.

The above three coding types are very similar to those in previous standards with the exception of the use of reference pictures as described below. The following two coding types for slices are new.

- **SP slice:** A so-called switching P slice that is coded such that efficient switching between different pre-coded pictures becomes possible.
- **SI slice:** A so-called switching I slice that allows an exact match of a macroblock in an SP slice for random access and error recovery purposes.

For details on the novel concept of SP and SI slices, the reader is referred to [5], while the other slice types are further described below.

### *E. Encoding and Decoding Process for Macroblocks*

All luma and chroma samples of a macroblock are either spatially or temporally predicted, and the resulting prediction residual is encoded using transform coding. For transform coding purposes, each color component of the prediction residual signal is subdivided into smaller 4×4 blocks. Each block is transformed using an integer transform, and the transform coefficients are quantized and encoded using entropy coding methods.

Fig. 8 shows a block diagram of the VCL for a macroblock. The input video signal is split into macroblocks, the association of macroblocks to slice groups and slices is selected, and then each macroblock of each slice is processed as shown. An efficient parallel processing of macroblocks is possible when there are various slices in the picture.

### *F. Adaptive Frame/Field Coding Operation*

In interlaced frames with regions of moving objects or camera motion, two adjacent rows tend to show a reduced degree of statistical dependency when compared to progressive frames in. In this case, it may be more efficient to compress each field separately. To provide high coding efficiency, the H.264/AVC design allows encoders to make any of the following decisions when coding a frame.

1) To combine the two fields together and to code them as one single coded frame (frame mode).
2) To not combine the two fields and to code them as separate coded fields (field mode).
3) To combine the two fields together and compress them as a single frame, but when coding the frame to split the pairs of two vertically adjacent macroblocks into either pairs of two field or frame macroblocks before coding them.

The choice between the three options can be made adaptively for each frame in a sequence. The choice between the first two options is referred to as picture-adaptive frame/field (PAFF) coding. When a frame is coded as two fields, each field is partitioned into macroblocks and is coded in a manner very similar to a frame, with the following main exceptions:

- motion compensation utilizes reference fields rather than reference frames;
- the zig-zag scan of transform coefficients is different;



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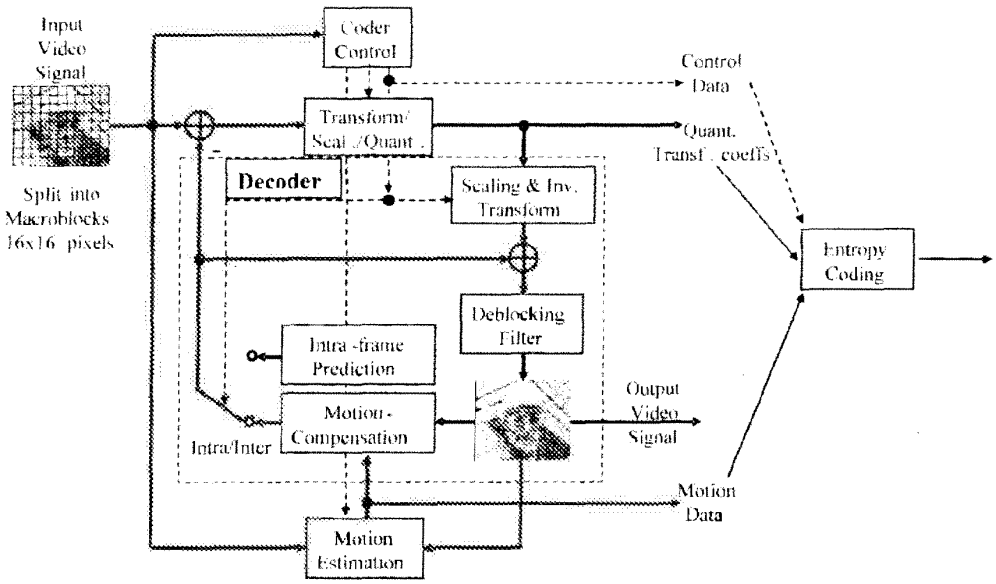


Fig. 8. Basic coding structure for H.264/AVC for a macroblock.

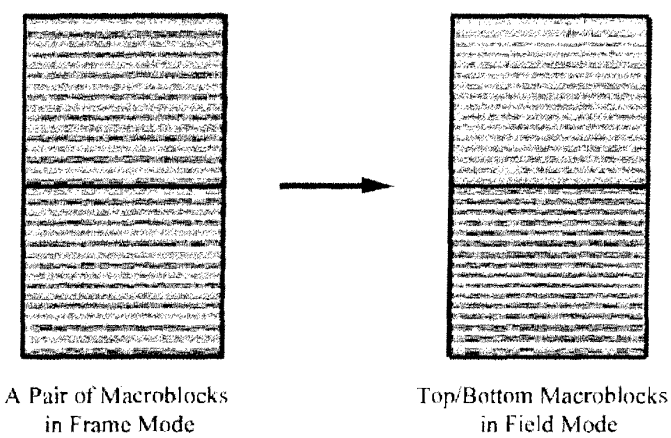


Fig. 9. Conversion of a frame macroblock pair into a field macroblock pair.

- the strong deblocking strength is not used for filtering horizontal edges of macroblocks in fields, because the field rows are spatially twice as far apart as frame rows and the length of the filter thus covers a larger spatial area.

During the development of the H.264/AVC standard, PAFF coding was reported to reduce bit rates in the range of 16% to 20% over frame-only coding mode for ITU-R 601 resolution sequences like "Canoa", "Rugby", etc.

If a frame consists of mixed regions where some regions are moving and others are not, it is typically more efficient to code the nonmoving regions in frame mode and the moving regions in the field mode. Therefore, the frame/field encoding decision can also be made independently for each vertical pair of macroblocks (a 16×32 luma region) in a frame. This coding option is referred to as macroblock-adaptive frame/field (MBAFF) coding. For a macroblock pair that is coded in frame mode, each macroblock contains frame lines. For a macroblock pair that is coded in field mode, the top macroblock contains top field lines and the bottom macroblock contains bottom field lines. Fig. 9 illustrates the MBAFF macroblock pair concept.

Note that, unlike in MPEG-2, the frame/field decision is made at the macroblock pair level rather than within the macroblock level. The reasons for this choice are to keep the basic macroblock processing structure intact, and to permit motion compensation areas as large as the size of a macroblock.

Each macroblock of a field macroblock pair is processed very similarly to a macroblock within a field in PAFF coding. However, since a mixture of field and frame macroblock pairs may occur within an MBAFF frame, the methods that are used for zig-zag scanning, prediction of motion vectors, prediction

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of intra prediction modes, intra-frame sample prediction, deblocking filtering, and context modeling in entropy coding are modified to account for this mixture. The main idea is to preserve as much spatial consistency as possible. It should be noted that the specification of spatial neighbors in MBAFF frames is rather complicated (please refer to [1]) and that in Sections IV-G-1, spatial neighbors are only described for non-MBAFF frames.

Another important distinction between MBAFF and PAFF is that in MBAFF, one field cannot use the macroblocks in the other field of the same frame as a reference for motion prediction (because some regions of each field are not yet available when a field macroblock of the other field is coded). Thus, sometimes PAFF coding can be more efficient than MBAFF coding (particularly in the case of rapid global motion, scene change, or intra picture refresh), although the reverse is usually true.

During the development of the standard, MBAFF was reported to reduce bit rates in the range of 14 to 16% over PAFF for ITU-R 601 resolution sequences like "Mobile and Calendar" and "MPEG-4 World News".

### G. Intra-Frame Prediction

Each macroblock can be transmitted in one of several coding types depending on the slice-coding type. In all slice-coding types, the following types of intra coding are supported, which are denoted as Intra_4×4 or Intra_16×16 together with chroma prediction and I_PCM prediction modes.

The Intra_4×4 mode is based on predicting each 4×4 luma block separately and is well suited for coding of parts of a picture with significant detail. The Intra_16×16 mode, on the other hand, performs prediction of the whole 16×16 luma block and is more suited for coding very smooth areas of a picture. In addition to these two types of luma prediction, a separate chroma prediction is conducted. As an alternative to Intra_4×4 and Intra_16×16, the I_PCM coding type allows the encoder to simply bypass the prediction and transform coding processes and instead directly send the values of the encoded samples. The I_PCM mode serves the following purposes.

1) It allows the encoder to precisely represent the values of the samples.
2) It provides a way to accurately represent the values of anomalous picture content without significant data expansion
3) It enables placing a hard limit on the number of bits a decoder must handle for a macroblock without harm to coding efficiency

In contrast to some previous video coding standards (namely H.263+ and MPEG-4 Visual), where intra prediction has been conducted in the transform domain intra prediction in H.264/AVC is always conducted in the spatial domain, by referring to neighboring samples of previously-coded blocks which are to the left and/or above the block to be predicted. This may incur error propagation in environments with transmission errors that propagate due to motion compensation into inter-coded macroblocks. Therefore, a constrained intra coding mode can be signaled that allows prediction only from intra-coded neighboring macroblocks.

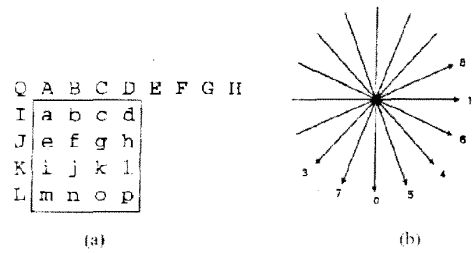


Fig. 10. (a) Intra_4×4 prediction is conducted for samples a-p of a block using samples A-Q. (b) Eight "prediction directions" for Intra_4×4 prediction.

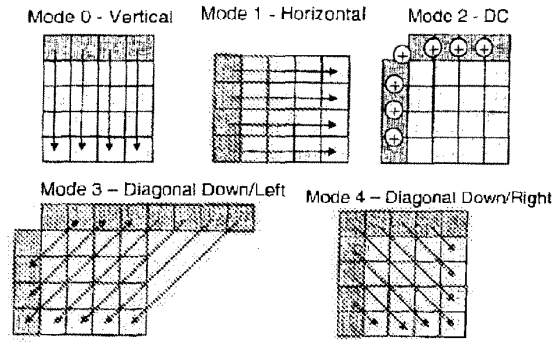


Fig. 11. Five of the nine Intra_4×4 prediction modes.

When using the Intra_4×4 mode, each 4×4 block is predicted from spatially neighboring samples as illustrated on the left-hand side of Fig. 10. The 16 samples of the 4×4 block which are labeled as a-p are predicted using prior decoded samples in adjacent blocks labeled as A-Q. For each 4×4 block, one of nine prediction modes can be utilized. In addition to "DC" prediction (where one value is used to predict the entire 4×4 block), eight directional prediction modes are specified as illustrated on the right-hand side of Fig. 10. Those modes are suitable to predict directional structures in a picture such as edges at various angles.

Fig. 11 shows five of the nine Intra_4×4 prediction modes. For mode 0 (vertical prediction), the samples above the 4×4 block are copied into the block as indicated by the arrows. Mode 1 (horizontal prediction) operates in a manner similar to vertical prediction except that the samples to the left of the 4×4 block are copied. For mode 2 (DC prediction), the adjacent samples are averaged as indicated in Fig. 11. The remaining six modes are diagonal prediction modes which are called diagonal-down-left, diagonal-down-right, vertical-right, horizontal-down, vertical-left, and horizontal-up prediction. As their names indicate, they are suited to predict textures with structures in the specified direction. The first two diagonal prediction modes are also illustrated in Fig. 11. When samples E-H (Fig. 10) that are used for the diagonal-down-left prediction mode are not available (because they have not yet been decoded or they are outside of the slice or not in an intra-coded macroblock in the constrained intra-mode), these samples are replaced by sample D. Note that in earlier draft versions of the Intra_4×4 prediction mode the four samples below sample L were also used for some prediction modes. However, due to the need to reduce memory access,

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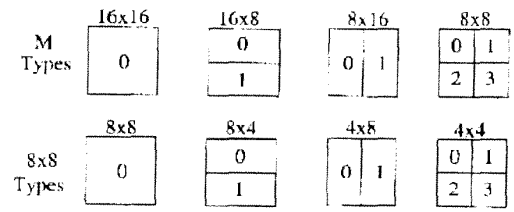


Fig. 12. Segmentations of the macroblock for motion compensation. Top: segmentation of macroblocks, bottom: segmentation of 8×8 partitions.

these have been dropped, as the relative gain for their use is very small.

When utilizing the Intra_16×16 mode, the whole luma component of a macroblock is predicted. Four prediction modes are supported. Prediction mode 0 (vertical prediction), mode 1 (horizontal prediction), and mode 2 (DC prediction) are specified similar to the modes in Intra_4×4 prediction except that instead of 4 neighbors on each side to predict a 4×4 block, 16 neighbors on each side to predict a 16×16 block are used. For the specification of prediction mode 4 (plane prediction), please refer to [1].

The chroma samples of a macroblock are predicted using a similar prediction technique as for the luma component in Intra_16×16 macroblocks, since chroma is usually smooth over large areas.

Intra prediction (and all other forms of prediction) across slice boundaries is not used, in order to keep all slices independent of each other.

### *H. Inter-Frame Prediction*

*1) Inter-Frame Prediction in P Slices:* In addition to the intra macroblock coding types, various *predictive* or motion-compensated coding types are specified as P macroblock types. Each P macroblock type corresponds to a specific partition of the macroblock into the block shapes used for motion-compensated prediction. Partitions with luma block sizes of 16×16, 16×8, 8×16, and 8×8 samples are supported by the syntax. In case partitions with 8×8 samples are chosen, one additional syntax element for each 8×8 partition is transmitted. This syntax element specifies whether the corresponding 8×8 partition is further partitioned into partitions of 8×4, 4×8, or 4×4 luma samples and corresponding chroma samples. Fig. 12 illustrates the partitioning.

The prediction signal for each predictive-coded M×N luma block is obtained by displacing an area of the corresponding reference picture, which is specified by a translational motion vector and a picture reference index. Thus, if the macroblock is coded using four 8×8 partitions and each 8×8 partition is further split into four 4×4 partitions, a maximum of 16 motion vectors may be transmitted for a single P macroblock.

The accuracy of motion compensation is in units of one quarter of the distance between luma samples. In case the motion vector points to an integer-sample position, the prediction signal consists of the corresponding samples of the reference picture; otherwise the corresponding sample is obtained using interpolation to generate noninteger positions. The prediction values at half-sample positions are obtained by applying a

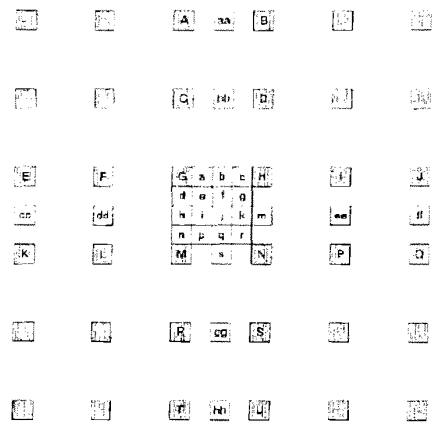

Fig. 13. Filtering for fractional-sample accurate motion compensation. Upper-case letters indicate samples on the full-sample grid, while lower case samples indicate samples in between at fractional-sample positions.

one-dimensional 6-tap FIR filter horizontally and vertically. Prediction values at quarter-sample positions are generated by averaging samples at integer- and half-sample positions.

Fig. 13 illustrates the fractional sample interpolation for samples a–k and n–r. The samples at half sample positions labeled $b$ and $h$ are derived by first calculating intermediate values $b_1$ and $h_1$, respectively by applying the 6-tap filter as follows:

$$b_1 = (E - 5F + 20G + 20H - 5I + J)$$
$$h_1 = (A - 5C + 20G + 20M - 5R + T).$$

The final prediction values for locations $b$ and $h$ are obtained as follows and clipped to the range of 0–255:

$$b = (b_1 + 16) \gg 5$$
$$h = (h_1 + 16) \gg 5.$$

The samples at half sample positions labeled as $j$ are obtained by

$$j_1 = cc - 5dd + 20h_1 + 20m_1 - 5ee + ff$$

where intermediate values denoted as $cc$, $dd$, $ee$, $m_1$, and $ff$ are obtained in a manner similar to $h_1$. The final prediction value $j$ is then computed as $j = (j_1 + 512) \gg 10$ and is clipped to the range of 0 to 255. The two alternative methods of obtaining the value of $j$ illustrate that the filtering operation is truly separable for the generation of the half-sample positions.

The samples at quarter sample positions labeled as a, c, d, n, f, i, k, and q are derived by averaging with upward rounding of the two nearest samples at integer and half sample positions as, for example, by

$$a = (G + b + 1) \gg 1.$$

The samples at quarter sample positions labeled as e, g, p, and r are derived by averaging with upward rounding of the two nearest samples at half sample positions in the diagonal direction as, for example, by

$$e = (b + h + 1) \gg 1.$$

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The prediction values for the chroma component are always obtained by bilinear interpolation. Since the sampling grid of chroma has lower resolution than the sampling grid of the luma, the displacements used for chroma have one-eighth sample position accuracy.

The more accurate motion prediction using full sample, half sample and one-quarter sample prediction represent one of the major improvements of the present method compared to earlier standards for the following two reasons.

1) The most obvious reason is more accurate motion representation.
2) The other reason is more flexibility in prediction filtering. Full sample, half sample and one-quarter sample prediction represent different degrees of low pass filtering which is chosen automatically in the motion estimation process. In this respect, the 6-tap filter turns out to be a much better tradeoff between necessary prediction loop filtering and has the ability to preserve high-frequency content in the prediction loop.

A more detailed investigation of fractional sample accuracy is presented in [8].

The syntax allows so-called motion vectors over picture boundaries, i.e., motion vectors that point outside the image area. In this case, the reference frame is extrapolated beyond the image boundaries by repeating the edge samples before interpolation.

The motion vector components are differentially coded using either median or directional prediction from neighboring blocks. No motion vector component prediction (or any other form of prediction) takes place across slice boundaries.

The syntax supports multipicture motion-compensated prediction [9], [10]. That is, more than one prior coded picture can be used as reference for motion-compensated prediction. Fig. 14 illustrates the concept.

Multiframe motion-compensated prediction requires both encoder and decoder to store the reference pictures used for inter prediction in a multipicture buffer. The decoder replicates the multipicture buffer of the encoder according to memory management control operations specified in the bitstream. Unless the size of the multipicture buffer is set to one picture, the index at which the reference picture is located inside the multipicture buffer has to be signalled. The reference index parameter is transmitted for each motion-compensated $16\times16$, $16\times8$, $8\times16$, or $8\times8$ luma block. Motion compensation for smaller regions than $8\times8$ use the same reference index for prediction of all blocks within the $8\times8$ region.

In addition to the motion-compensated macroblock modes described above, a P macroblock can also be coded in the so-called P_Skip type. For this coding type, neither a quantized prediction error signal, nor a motion vector or reference index parameter is transmitted. The reconstructed signal is obtained similar to the prediction signal of a P_$16\times16$ macroblock type that references the picture which is located at index 0 in the multipicture buffer. The motion vector used for reconstructing the P_Skip macroblock is similar to the motion vector predictor for the $16\times16$ block. The useful effect of this definition of the P_Skip coding type is that large areas with no change or constant motion like slow panning can be represented with very few bits.

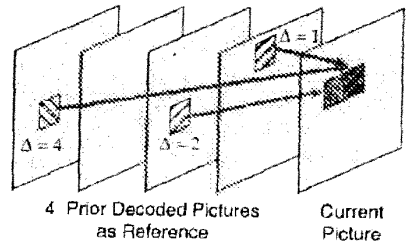


Fig. 14. Multiframe motion compensation. In addition to the motion vector, also picture reference parameters ($\Delta$) are transmitted. The concept is also extended to B slices.

*2) Inter-Frame Prediction in B Slices:* In comparison to prior video coding standards, the concept of B slices is generalized in H.264/AVC. This extension refers back to [11] and is further investigated in [12]. For example, other pictures can reference pictures containing B slices for motion-compensated prediction, depending on the memory management control operation of the multipicture buffering. Thus, the substantial difference between B and P slices is that B slices are coded in a manner in which some macroblocks or blocks may use a weighted average of two distinct motion-compensated prediction values for building the prediction signal. B slices utilize two distinct lists of reference pictures, which are referred to as the first (list 0) and second (list 1) reference picture lists, respectively. Which pictures are actually located in each reference picture list is an issue of the multipicture buffer control and an operation very similar to the conventional MPEG-2 B pictures can be enabled if desired by the encoder.

In B slices, four different types of inter-picture prediction are supported: list 0, list 1, bi-predictive, and direct prediction. For the bi-predictive mode, the prediction signal is formed by a weighted average of motion-compensated list 0 and list 1 prediction signals. The direct prediction mode is inferred from previously transmitted syntax elements and can be either list 0 or list 1 prediction or bi-predictive.

B slices utilize a similar macroblock partitioning as P slices. Beside the P_$16\times16$, P_$16\times8$, P_$8\times16$, P_$8\times8$, and the intra coding types, bi-predictive prediction and another type of prediction called direct prediction, are provided. For each $16\times16$, $16\times8$, $8\times16$, and $8\times8$ partition, the prediction method (list 0, list 1, bi-predictive) can be chosen separately. An $8\times8$ partition of a B macroblock can also be coded in direct mode. If no prediction error signal is transmitted for a direct macroblock mode, it is also referred to as B_Skip mode and can be coded very efficiently similar to the P_Skip mode in P slices. The motion vector coding is similar to that of P slices with the appropriate modifications because neighboring blocks may be coded using different prediction modes.

### *I. Transform, Scaling, and Quantization*

Similar to previous video coding standards, H.264/AVC utilizes transform coding of the prediction residual. However, in H.264/AVC, the transformation is applied to $4\times4$ blocks, and



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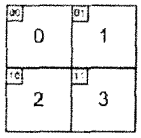


Fig. 15. Repeated transform for chroma blocks. The four blocks numbered 0–3 indicate the four chroma blocks of a chroma component of a macroblock.

instead of a $4\times4$ discrete cosine transform (DCT), a separable integer transform with similar properties as a $4\times4$ DCT is used. The transform matrix is given as

$$H = \begin{bmatrix} 1 & 1 & 1 & 1 \\ 2 & 1 & -1 & -2 \\ 1 & -1 & -1 & 1 \\ 1 & -2 & 2 & -1 \end{bmatrix}.$$

Since the inverse transform is defined by exact integer operations, inverse-transform mismatches are avoided. The basic transform coding process is very similar to that of previous standards. At the encoder, the process includes a forward transform, zig-zag scanning, scaling, and rounding as the quantization process followed by entropy coding. At the decoder, the inverse of the encoding process is performed except for the rounding. More details on the specific aspects of the transform in H.264/AVC can be found in [17].

It has already been mentioned that Intra_$16\times16$ prediction modes and chroma intra modes are intended for coding of smooth areas. For that reason, the DC coefficients undergo a second transform with the result that we have transform coefficients covering the whole macroblock. An additional $2\times2$ transform is also applied to the DC coefficients of the four $4\times4$ blocks of each chroma component. The procedure for a chroma block is illustrated in Fig. 15. The small blocks inside the larger blocks represent DC coefficients of each of the four $4\times4$ chroma blocks of a chroma component of a macroblock numbered as 0, 1, 2, and 3. The two indices correspond to the indices of the $2\times2$ inverse Hadamard transform.

To explain the idea behind these repeated transforms, let us point to a general property of a two-dimensional transform of very smooth content (where sample correlation approaches 1). In that situation, the reconstruction accuracy is proportional to the inverse of the one-dimensional size of the transform. Hence, for a very smooth area, the reconstruction error with a transform covering the complete $8\times8$ block is halved compared to using only $4\times4$ transform. A similar rationale can be used for the second transform connected to the INTRA-$16\times16$ mode.

There are several reasons for using a smaller size transform.

- One of the main improvements of the present standard is the improved prediction process both for inter and intra. Consequently, the residual signal has less spatial correlation. This generally means that the transform has less to offer concerning decorrelation. This also means that a $4\times4$ transform is essentially as efficient in removing statistical correlation as a larger transform
- With similar objective compression capability, the smaller $4\times4$ transform has visual benefits resulting in less noise around edges (referred to as "mosquito noise" or "ringing" artifacts).
- The smaller transform requires less computations and a smaller processing wordlength. Since the transformation process for H.264/AVC involves only adds and shifts, it is also specified such that mismatch between encoder and decoder is avoided (this has been a problem with earlier $8\times8$ DCT standards)

A quantization parameter is used for determining the quantization of transform coefficients in H.264/AVC. The parameter can take 52 values. Theses values are arranged so that an increase of 1 in quantization parameter means an increase of quantization step size by approximately 12% (an increase of 6 means an increase of quantization step size by exactly a factor of 2). It can be noticed that a change of step size by approximately 12% also means roughly a reduction of bit rate by approximately 12%.

The quantized transform coefficients of a block generally are scanned in a zig-zag fashion and transmitted using entropy coding methods. The $2\times2$ DC coefficients of the chroma component are scanned in raster-scan order. All inverse transform operations in H.264/AVC can be implemented using only additions and bit-shifting operations of 16-bit integer values. Similarly, only 16-bit memory accesses are needed for a good implementation of the forward transform and quantization process in the encoder.

### *J. Entropy Coding*

In H.264/AVC, two methods of entropy coding are supported. The simpler entropy coding method uses a single infinite-extent codeword table for all syntax elements except the quantized transform coefficients. Thus, instead of designing a different VLC table for each syntax element, only the mapping to the single codeword table is customized according to the data statistics. The single codeword table chosen is an exp-Golomb code with very simple and regular decoding properties.

For transmitting the quantized transform coefficients, a more efficient method called Context-Adaptive Variable Length Coding (CAVLC) is employed. In this scheme, VLC tables for various syntax elements are switched depending on already transmitted syntax elements. Since the VLC tables are designed to match the corresponding conditioned statistics, the entropy coding performance is improved in comparison to schemes using a single VLC table.

In the CAVLC entropy coding method, the number of nonzero quantized coefficients (N) and the actual size and position of the coefficients are coded separately. After zig-zag scanning of transform coefficients, their statistical distribution typically shows large values for the low frequency part decreasing to small values later in the scan for the high-frequency part. An example for a typical zig-zag scan of quantized transform coefficients could be given as follows:

$$7,\ 6,\ \ 2,\ 0,\ \ 1,\ 0,\ 0,\ 1,\ 0,\ 0,\ 0,\ 0,\ 0,\ 0,\ 0,\ 0.$$

Based on this statistical behavior, the following data elements are used to convey information of quantized transform coefficients for a luma $4\times4$ block.

*1) Number of Nonzero Coefficients (N) and "Trailing 1s":* "Trailing 1s" (T1s) indicate the number of coefficients with absolute value equal to 1 at the end of the scan. In the



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example $T1s = 2$ and the number of coefficients is $N = 5$. These two values are coded as a combined event. One out of 4 VLC tables is used based on the number of coefficients in neighboring blocks.

*2) Encoding the Value of Coefficients:* The values of the coefficients are coded. The T1s need only sign specification since they all are equal to +1 or −1. Please note that the statistics of coefficient values has less spread for the last nonzero coefficients than for the first ones. For this reason, coefficient values are coded in reverse scan order. In the examples above, -2 is the first coefficient value to be coded. A starting VLC is used for that. When coding the next coefficient (having value of 6 in the example) a new VLC may be used based on the just coded coefficient. In this way adaptation is obtained in the use of VLC tables. Six exp-Golomb code tables are available for this adaptation.

*3) Sign Information:* One bit is used to signal coefficient sign. For T1s, this is sent as single bits. For the other coefficients, the sign bit is included in the exp-Golomb codes.

Positions of each nonzero coefficient are coded by specifying the positions of 0s before the last nonzero coefficient. It is split into two parts:

*4) TotalZeroes:* This codeword specifies the number of zeros between the last nonzero coefficient of the scan and its start. In the example the value of TotalZeros is 3. Since it is already known that $N = 5$, the number must be in the range 0–11. 15 tables are available for $N$ in the range 1–15. (If $N = 16$ there is no zero coefficient.)

*5) RunBefore:* In the example it must be specified how the 3 zeros are distributed. First the number of 0s before the last coefficient is coded. In the example the number is 2. Since it must be in the range 0–3 a suitable VLC is used. Now there is only one 0 left. The number of 0s before the second last coefficient must therefore be 0 or 1. In the example the number is 1. At this point there are no 0s left and no more information is coded

The efficiency of entropy coding can be improved further if the Context-Adaptive Binary Arithmetic Coding (CABAC) is used [16]. On the one hand, the usage of arithmetic coding allows the assignment of a noninteger number of bits to each symbol of an alphabet, which is extremely beneficial for symbol probabilities that are greater than 0.5. On the other hand, the usage of adaptive codes permits adaptation to nonstationary symbol statistics. Another important property of CABAC is its context modeling. The statistics of already coded syntax elements are used to estimate conditional probabilities. These conditional probabilities are used for switching several estimated probability models. In H.264/AVC, the arithmetic coding core engine and its associated probability estimation are specified as multiplication-free low-complexity methods using only shifts and table look-ups. Compared to CAVLC, CABAC typically provides a reduction in bit rate between 5%–15% The highest gains are typically obtained when coding interlaced TV signals. More details on CABAC can be found in [16].

### K. In-Loop Deblocking Filter

One particular characteristic of block-based coding is the accidental production of visible block structures. Block edges are typically reconstructed with less accuracy than interior pixels and "blocking" is generally considered to be one of the most visible artifacts with the present compression methods. For this reason, H.264/AVC defines an adaptive in-loop deblocking filter, where the strength of filtering is controlled by the values of several syntax elements. A detailed description of the adaptive deblocking filter can be found in [18].

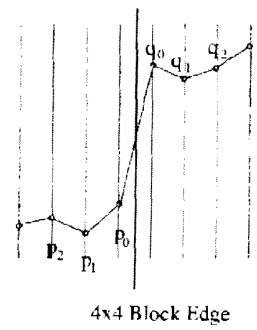


Fig. 16. Principle of deblocking filter.

Fig. 16 illustrates the principle of the deblocking filter using a visualization of a one-dimensional edge. Whether the samples $p_0$ and $q_0$ as well as $p_1$ and $q_1$ are filtered is determined using quantization parameter (QP) dependent thresholds $\alpha(\mathrm{QP})$ and $\beta(\mathrm{QP})$. Thus, filtering of $p_0$ *and* $q_0$ only takes place if each of the following conditions is satisfied:

$$1.\ |p_0 - q_0| < \alpha(\mathrm{QP})$$
$$2.\ |p_1 - p_0| < \beta(\mathrm{QP})$$
$$3.\ |q_1 - q_0| < \beta(\mathrm{QP})$$

where the $\beta(\mathrm{QP})$ is considerably smaller than $\alpha(\mathrm{QP})$. Accordingly, filtering of $p_1$ or $q_1$ takes place if the corresponding following condition is satisfied:

$$|p_2 - p_0| < \beta(\mathrm{QP}) \text{ or } |q_2 q_0| < \beta(\mathrm{QP}).$$

The basic idea is that if a relatively large absolute difference between samples near a block edge is measured, it is quite likely a blocking artifact and should therefore be reduced. However, if the magnitude of that difference is so large that it cannot be explained by the coarseness of the quantization used in the encoding, the edge is more likely to reflect the actual behavior of the source picture and should not be smoothed over.

The blockiness is reduced, while the sharpness of the content is basically unchanged. Consequently, the subjective quality is significantly improved. The filter reduces the bit rate typically by 5%–10% while producing the same objective quality as the nonfiltered video. Fig. 17 illustrates the performance of the deblocking filter.

### L. Hypothetical Reference Decoder

One of the key benefits provided by a standard is the assurance that all the decoders compliant with the standard will be able to decode a compliant compressed video. To achieve that, it is not sufficient to just provide a description of the coding algorithm. It is also important in a real-time system to specify how bits are fed to a decoder and how the decoded pictures



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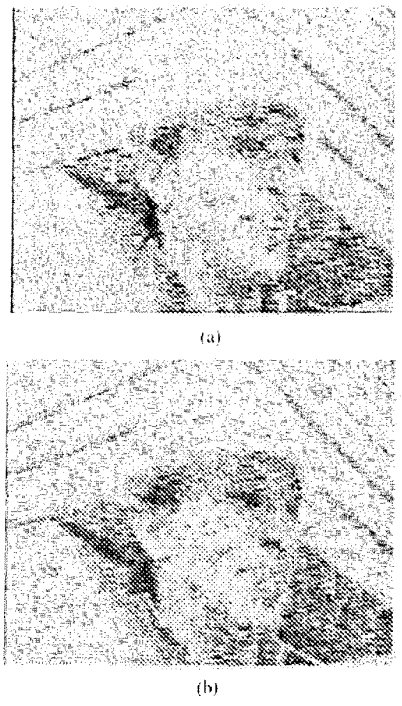

(a)

(b)

Fig. 17. Performance of the deblocking filter for highly compressed pictures (a) without deblocking filter and (b) with deblocking filter.

are removed from a decoder. Specifying input and output buffer models and developing an implementation independent model of a receiver achieves this. That receiver model is also called hypothetical reference decoder (HRD) and is described in detail in [19]. An encoder is not allowed to create a bitstream that cannot be decoded by the HRD. Hence, if in any receiver implementation the designer mimics the behavior of HRD, it is guaranteed to be able to decode all the compliant bitstreams.

In H.264/AVC HRD specifies operation of two buffers: 1) the coded picture buffer (CPB) and 2) the decoded picture buffer (DPB). CPB models the arrival and removal time of the coded bits. The HRD design is similar in spirit to what MPEG-2 had, but is more flexible in support of sending the video at a variety of bit rates without excessive delay.

Unlike MPEG-2, in H.264/AVC, multiple frames can be used for reference, the reference frames can be located either in past or future arbitrarily in display order, the HRD also specifies a model of the decoded picture buffer management to ensure that excessive memory capacity is not needed in a decoder to store the pictures used as references.

## V. Profiles and Potential Applications

### A. Profiles and Levels

Profiles and levels specify conformance points. These conformance points are designed to facilitate interoperability between various applications of the standard that have similar functional requirements. A *profile* defines a set of coding tools or algorithms that can be used in generating a conforming bitstream, whereas a *level* places constraints on certain key parameters of the bitstream.

All decoders conforming to a specific profile must support all features in that profile. Encoders are not required to make use of any particular set of features supported in a profile but have to provide conforming bitstreams, i.e., bitstreams that can be decoded by conforming decoders. In H.264/AVC, three profiles are defined, which are the Baseline, Main, and Extended Profile.

The Baseline profile supports all features in H.264/AVC except the following two feature sets:

- **Set 1:** B slices, weighted prediction, CABAC, field coding, and picture or macroblock adaptive switching between frame and field coding.
- **Set 2:** SP/SI slices, and slice data partitioning.

The first set of additional features is supported by the Main profile. However, the Main profile does not support the FMO, ASO, and redundant pictures features which are supported by the Baseline profile. Thus, only a subset of the coded video sequences that are decodable by a Baseline profile decoder can be decoded by a Main profile decoder. (Flags are used in the sequence parameter set to indicate which profiles of decoder can decode the coded video sequence).

The Extended Profile supports all features of the Baseline profile, and both sets of features on top of Baseline profile, except for CABAC.

In H.264/AVC, the same set of level definitions is used with all profiles, but individual implementations may support a different level for each supported profile. There are 15 levels defined, specifying upper limits for the picture size (in macroblocks) ranging from QCIF to all the way to above 4k×2k, decoder-processing rate (in macroblocks per second) ranging from 250k pixels/s to 250M pixels/s, size of the multipicture buffers, video bit rate ranging from 64 kbps to 240 Mbps, and video buffer size.

### B. Areas for the Profiles of the New Standard to be Used

The increased compression efficiency of H.264/AVC offers to enhance existing applications or enables new applications. A list of possible application areas is provided below.

- Conversational services which operate typically below 1 Mbps with low latency requirements. The ITU-T SG16 is currently modifying its systems recommendations to support H.264/AVC use in such applications, and the IETF is working on the design of an RTP payload packetization. In the near term, these services would probably utilize the Baseline profile (possibly progressing over time to also use other profiles such as the Extended profile). Some specific applications in this category are given below.
  - —H.320 conversational video services that utilize circuit-switched ISDN-based video conferencing.
  - —3GPP conversational H.324/M services.
  - —H.323 conversational services over the Internet with best effort IP/RTP protocols.
  - —3GPP conversational services using IP/RTP for transport and SIP for session setup.
- Entertainment video applications which operate between 1–8+ Mbps with moderate latency such as 0.5 to 2 s.



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The H.222.0/MPEG-2 Systems specification is being modified to support these application. These applications would probably utilize the Main profile and include the following.

—Broadcast via satellite, cable, terrestrial, or DSL.
—DVD for standard and high-definition video.
—Video-on-demand via various channels.

- Streaming services which typically operate at 50–1500 kbps and have 2 s or more of latency. These services would probably utilize the Baseline or Extended profile and may be distinguished by whether they are used in wired or wireless environments as follows:
  —3GPP streaming using IP/RTP for transport and RTSP for session setup. This extension of the 3GPP specification would likely use Baseline profile only.
  —Streaming over the wired Internet using IP/RTP protocol and RTSP for session setup. This domain which is currently dominated by powerful proprietary solutions might use the Extended profile and may require integration with some future system designs.
- Other services that operate at lower bit rates and are distributed via file transfer and therefore do not impose delay constraints at all, which can potentially be served by any of the three profiles depending on various other systems requirements are:
  —3GPP multimedia messaging services;
  —video mail.

## VI. History and Standardization Process

In this section, we illustrate the history of the standard. The development of H.264/AVC is characterized by improvements in small steps over the last 3–4 years as can be seen from Fig. 18. In Fig. 18, the coding performance is shown for two example progressive-scan video sequences, when enabling the typical coding options for the various versions of the standard since August 1999 until completion in April 2003. The dates and creation of the various versions are shown in Table I. The document and the software versions have been called test model long-term (TML) when being developed in VCEG and joint model (JM) when the development was continued in the joint video team (JVT) as a partnership between MPEG and VCEG. The development took place in small steps between each version of the design as can be seen from Fig. 18.

The work started in VCEG as a parallel activity to the completion of the last version of H.263. The first Test Model Long-Term (TML-1, curve with circles in Fig. 18) was produced in August 1999. TML-1 was similar to H.263 by using a combination of block prediction and block transform/quantization/coding of the residual signal. The PSNR performance of TML-1 was similar to that of H.263 (curve with diamond-shaped markers in Fig. 18) and below MPEG-4 ASP (curve with star-shaped markers in Fig. 18). However, the starting point was considered sufficient due to some perceptual benefits being shown and a judgment that the design could be incrementally improved. The results shown for H.263 and MPEG-4 ASP have been optimized using Lagrangian methods

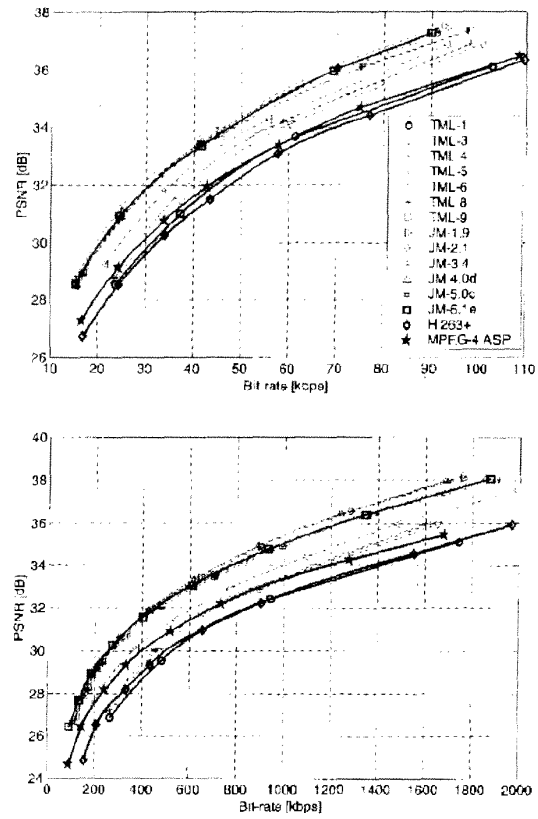


Fig. 18. Evolution of H.264/AVC since August 1999 until March 2003. Top: QCIF sequence Foreman coded at 10 Hz. Bottom: CIF sequence tempete coded at 30 Hz. The legend in the top figure indicates the various versions that have been run with typical settings.

as described in [13]. The main coding features of TML-1 are summarized as follows:

- Seven block partitions for inter prediction of a macroblock. The luminance component of a macroblock could be partitioned into 16×16, 16×8, 8×16, 8×8, 8×4, 4×8 or 4×4 blocks in a similar way as depicted in Fig. 12. The 16×16, 16×8, 8×16, and 8×8 blocks have remained in the design. Partitioning into smaller blocks was modified later (in JM-2.1) into a tree-structured macroblock partition as described above.
- 1/3-sample accurate motion-compensated prediction using 4-tap filter in horizontal and vertical direction. The filter taps were (−1, 12, 6, −1)/16 and (−1, 6, 12, −1)/16. One of the sample positions used a stronger low pass filter for more flexible prediction loop filtering. This was modified later (in TML-4) to 1/4-sample accurate prediction using a 6-tap as described above. For TML-2, a method called adaptive motion accuracy (AMA) was adopted which has never been implemented into the software. AMA was dropped due to lack of coding efficiency improvement in TML-4. In TML-7/8, 1/8-sample accurate motion compensation was introduced which was then dropped for complexity reasons in JM-5.

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TABLE I
HISTORY OF H.264/AVC STANDARDIZATION PROCESS. FOR TML VERSIONS WITH A *, NO SOFTWARE HAS BEEN CREATED

| No | TML/JM | Date | Location |
|---|---|---|---|
| 1 | TML-1 | Aug. 1999 | Berlin, Germany |
| 2 | TML-2* | Oct. 1999 | Red Bank, NJ, USA |
| 3 | TML-3 | Feb. 2000 | Geneva, Switzerland |
| 4 | TML-4 | May, 2000 | Osaka, Japan |
| 5 | TML-5 | Aug. 2000 | Portland, OR, USA |
| 6 | TML-6 | Jan. 2001 | Eibsee, Germany |
| 7 | TML-7* | Apr. 2001 | Austin, TX, USA |
| 8 | TML-8 | May 2001 | Porto Seguro, Brazil |
| 9 | TML-9 | Sep. 2001 | Santa Barbara, CA, USA |
| 10 | JM-1 | Dec. 2001 | Pattaya, Thailand |
| 11 | JM-2 | Feb. 2002 | Geneva, Switzerland |
| 12 | JM-3 | May 2002 | Fairfax, VA, USA |
| 13 | JM-4 | July 2002 | Klagenfurt, Austria |
| 14 | JM-5 | Oct. 2002 | Geneva, Switzerland |
| 15 | JM-6 | Dec. 2002 | Awaji, Japan |
| 16 | Final | Mar. 2003 | Pattaya, Thailand |

- Multiple reference frames, the decoupling of temporal order and display order, and the decoupling of picture type from the ability to use pictures as references were envisioned from the beginning, but were integrated in the software and draft text rather gradually.
- Intra prediction was done on $4\times4$ blocks and based on the neighboring samples. There were five prediction modes which were the ones shown in Fig. 9 except with a simpler version of Mode 3. The number of prediction modes was increased to 7 in TML-4 and further increased to 9 in JM-2. In TML-3, the Intra $16\times16$ prediction mode was introduced and in JM-3, the various prediction modes for chroma have been introduced.
- The transform for the residual signal had size $4\times4$. This was in contrast to all previous standards which used transform size $8\times8$. The transform was also no longer exact DCT but an integer transform very close to DCT. The integer definition resulted in an exact definition of the inverse transform. The transform had basis vectors

$$H = \begin{bmatrix} 13 & 13 & 13 & 13 \\ 17 & 7 & -7 & 17 \\ 13 & -13 & 13 & 13 \\ 7 & -17 & 17 & -7 \end{bmatrix}.$$

  The transform was later changed to the version described above in JM-2.
- An in-loop deblocking filter similar to the one used in H.263 was in TML-1, but only on intra frames. This filter has been considerably refined during the entire development of the standard.
- Entropy coding used one single exp-Golomb type VLC table for all syntax elements (including transform coefficients). This was extended later by CABAC in TML-7 and CAVLC for transform coefficients in JM-3.

TML-1 did not contain many of the features of the final design of JM-6 (squares in Fig. 18) including interlace support, B pictures and the NAL. The method of handling of interlaced video was among the last things integrated into the design (note that Fig. 18 does not show performance for interlaced video). The improvement of JM-6 relative to TML-1 is typically between 2–3 dB PSNR or between 40%–60% in bit-rate reduction.

## VII. CONCLUSIONS

The emerging H.264/AVC video coding standard has been developed and standardized collaboratively by both the ITU-T VCEG and ISO/IEC MPEG organizations. H.264/AVC represents a number of advances in standard video coding technology, in terms of both coding efficiency enhancement and flexibility for effective use over a broad variety of network types and application domains. Its VCL design is based on conventional block-based motion-compensated hybrid video coding concepts, but with some important differences relative to prior standards. We thus summarize some of the important differences:

- enhanced motion-prediction capability;
- use of a small block-size exact-match transform;
- adaptive in-loop deblocking filter;
- enhanced entropy coding methods.

When used well together, the features of the new design provide approximately a 50% bit rate savings for equivalent perceptual quality relative to the performance of prior standards (especially for higher-latency applications which allow some use of reverse temporal prediction).[1]

## ACKNOWLEDGMENT

The authors thank the experts of ITU-T VCEG, ISO/IEC MPEG, and the ITU-T/ISO/IEC Joint Video Team for their contributions. Thanks to K. Sühring and H. Schwarz for providing the data for the comparison of the various TML and JM versions.

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[4] "Video Coding for Low Bit Rate Communication," ITU-T, ITU-T Recommendation H.263 version 1, 1995.

[5] "Coding of audio-visual objects—Part 2: Visual," in *ISO/IEC 14496-2 (MPEG-4 Visual Version 1)*, Apr. 1999.

[6] S. Wenger, "H.264/AVC over IP," *IEEE Trans. Circuits Syst. Video Technol.*, vol. 13, pp. 645–656, July 2003.

[7] T. Stockhammer, M. M. Hannuksela, and T. Wiegand, "H.264/AVC in wireless environments," *IEEE Trans. Circuits Syst. Video Technol.*, vol. 13, pp. 657–673, July 2003.

[1]Further information and documents of the project is available by ftp at ftp://ftp.imte-files.org/jvt-experts.

SDOCID: <XP 11099249A I >

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[8] T. Wedi, "Motion compensation in H.264/AVC," *IEEE Trans. Circuits Syst. Video Technol.*, vol. 13, pp. 577–586, July 2003.

[9] T. Wiegand, X. Zhang, and B. Girod, "Long-term memory motion-compensated prediction," *IEEE Trans. Circuits Syst. Video Technol.*, vol. 9, pp. 70–84, Feb. 1999.

[10] T. Wiegand and B. Girod, *Multi-Frame Motion-Compensated Prediction for Video Transmission*. Norwell, MA: Kluwer, 2001.

[11] M. Flierl, T. Wiegand, and B. Girod, "A locally optimal design algorithm for block-based multi-hypothesis motion-compensated prediction," in *Proc. Data Compression Conf.*, Snowbird, UT, Mar. 1998, pp. 239–248.

[12] M. Flierl and B. Girod, "Generalized B pictures and the draft JVT/H.264 video compression standard," *IEEE Trans. Circuits Syst. Video Technol.*, vol. 13, pp. 587–597, July 2003.

[13] T. Wiegand, H. Schwarz, A. Joch, F. Kossentini, and G. J. Sullivan, "Rate-constrained coder control and comparison of video coding standards," *IEEE Trans. Circuits Syst. Video Technol.*, vol. 13, pp. 688–703, July 2003.

[14] S. Wenger, "H.264/AVC over IP," *IEEE Trans. Circuits Syst. Video Technol.*, vol. 13, pp. 645–656, July 2003.

[15] M. Karczewicz and R. Kurçeren, "The SP and SI frames design for H.264/AVC," *IEEE Trans. Circuits Syst. Video Technol.*, vol. 13, pp. 637–644, July 2003.

[16] D. Marpe, H. Schwarz, and T. Wiegand, "Context-adaptive binary arithmetic coding in the H.264/AVC video compression standard," *IEEE Trans. Circuits Syst. Video Technol.*, vol. 13, pp. 620–636, July 2003.

[17] H. Malvar, A. Hallapuro, M. Karczewicz, and L. Kerofsky, "Low-Complexity transform and quantization in H.264/AVC," *IEEE Trans. Circuits Syst. Video Technol.*, vol. 13, pp. 598–603, July 2003.

[18] P. List, A. Joch, J. Lainema, G. Bjøntegaard, and M. Karczewicz, "Adaptive deblocking filter," *IEEE Trans. Circuits Syst. Video Technol.*, vol. 13, pp. 614–619, July 2003.

[19] J. Ribas-Corbera, P. A. Chou, and S. Regunathan, "A generalized hypothetical reference decoder for H.264/AVC," *IEEE Trans. Circuits Syst. Video Technol.*, vol. 13, pp. 674–687, July 2003.

**Thomas Wiegand** received the Dr.-Ing. degree from the University of Erlangen-Nuremberg, Germany, in 2000 and the Dipl.-Ing. degree in electrical engineering from the Technical University of Hamburg-Harburg, Germany, in 1995.

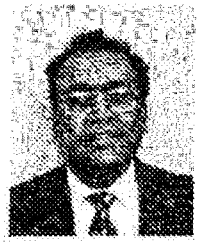
He is the Head of the Image Communication Group in the Image Processing Department, Fraunhofer-Institute for Telecommunications – Heinrich Hertz Institute (HHI), Berlin, Germany. During 1997 to 1998, he was a Visiting Researcher at Stanford University, Stanford, CA, and served as a Consultant to 8x8, Inc., Santa Clara, CA. From 1993 to 1994, he was a Visiting Researcher at Kobe University, Kobe, Japan. In 1995, he was a Visiting Scholar at the University of California at Santa Barbara, where he began his research on video compression and transmission. Since then, he has published several conference and journal papers on the subject and has contributed successfully to the ITU-T Video Coding Experts Group (ITU-T SG16 Q.6—VCEG)/ISO/IEC Moving Pictures Experts Group (ISO/IEC JTC1/SC29/WG11 – MPEG)/Joint Video Team (JVT) standardization efforts and holds various international patents in this field. He has been appointed as the Associated Rapporteur of the ITU-T VCEG (October 2000), the Associated Rapporteur/Co-Chair of the JVT that has been created by ITU-T VCEG and ISO/IEC MPEG for finalization of the H.264/AVC video coding standard (December 2001), and the Editor of the H.264/AVC video coding standard (February 2002).

**Gary J. Sullivan** (S'83–M'91–SM'01) received the B.S. and M.Eng. degrees in electrical engineering from the University of Louisville, Louisville, KY, in 1982 and 1983, respectively, and the Ph.D. and Eng. degrees in electrical engineering from the University of California, Los Angeles, in 1991.

He is the Chairman of the Joint Video Team (JVT) for the development of the next-generation H.264/MPEG4-AVC video coding standard, which was recently completed as a result of a joint project between the ITU-T video coding experts group (VCEG) and the ISO/IEC moving picture experts group (MPEG). He is also the Rapporteur of Advanced Video Coding in the ITU-T, where he has led VCEG (ITU-T Q.6/SG16) for about six years, and the ITU-T Video Liaison Representative to MPEG (ISO/IEC JTC1/SC29/WG11) and served as MPEG's Video Chairman during 2001–2002. He is currently a Program Manager of video standards and technologies in the eHome A/V Platforms Group of Microsoft Corporation, Redmond, WA, where he designed and remains lead engineer for the DirectX® Video Acceleration API/DDI feature of the Microsoft Windows® operating system platform. Prior to joining Microsoft in 1999, he was the Manager of Communications Core Research at PictureTel Corporation, the quondam world leader in videoconferencing communication. He was previously a Howard Hughes Fellow and Member of the Technical Staff in the Advanced Systems Division of Hughes Aircraft Corporation and was a terrain-following radar system software engineer for Texas Instruments. His research interests and areas of publication include image and video compression, rate-distortion optimization, motion representation, scalar and vector quantization, and error- and packet-loss-resilient video coding.

**Gisle Bjøntegaard** received the Dr. Phil. degree in physics from the University of Oslo, Oslo, Norway, in 1974.

From 1974 to 1996, he was a Senior Scientist with Telenor Research and Development, Oslo, Norway. His areas of research included radio link network design, reflector antenna design and construction, digital signal processing, and development of video compression methods. From 1996 to 2002, he was a Group Manager at Telenor Broadband Services, Oslo, Norway, where his areas of work included the design of point-to-point satellite communication and development of satellite digital TV platform. Since 2002, he has been a Principal Scientist at Tandberg Telecom, Lysaker, Norway, working with video-coding development and implementation. He has contributed actively to the development of the ITU video standards H.261, H.262, H.263, and H.264, as well as to ISO/IEC MPEG2 and MPEG4.



**Ajay Luthra** (S'79–M'81–SM'89) received the B.E. (Hons.) degree from BITS, Pilani, India, in 1975, the M.Tech. degree in communications engineering from IIT Delhi, Delhi, India, in 1977, and the Ph.D. degree from Moore School of Electrical Engineering, University of Pennsylvania, Philadelphia, in 1981.

From 1981 to 1984, he was a Senior Engineer at Interspec Inc., Philadelphia, PA, where he was involved in applications of digital signal and image processing for Bio-medical applications. From 1984 to 1995, he was with Tektronix, Beaverton, OR, where he was Manager of the Digital Signal and Picture Processing Group during 1985–1990 and then Director of the Communications/Video Systems Research Lab from 1990–1995. He is currently a Senior Director in Advanced Technology Group at Motorola, Broadband Communications Sector (formerly General Instrument), San Diego, CA, where he is involved in advanced development work in the areas of digital video compression and processing, streaming video, interactive TV, cable head-end system design, and advanced set-top box architectures. He has been an active member of the MPEG committee for the last ten years where he has chaired several technical subgroups. He is an Associate Rapporteur/Co-Chair of the Joint Video Team consisting of ISO/MPEG and ITU-T/H.26L experts working on developing next generation of video coding standards.

Dr. Luthra was an Associate Editor of the IEEE TRANSACTIONS ON CIRCUITS AND SYSTEMS FOR VIDEO TECHNOLOGY (2000–2002) and also a Guest Editor for its Special Issue on Streaming Video (March 2001).

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JR No = 2/12/09

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# PATENT COOPERATION TREATY

From the INTERNATIONAL SEARCHING AUTHORITY

**PCT**

NOTIFICATION OF TRANSMITTAL OF THE INTERNATIONAL SEARCH REPORT AND THE WRITTEN OPINION OF THE INTERNATIONAL SEARCHING AUTHORITY, OR THE DECLARATION

To:
FOLEY & LARDNER, LLP
Attn. Albert, G. Peter
11250 El Camino Real, Suite 200
San Diego, CA 92130
ETATS-UNIS D'AMERIQUE

(PCT Rule 44.1)

| | |
|---|---|
| | Date of mailing (day/month/year) 07/10/2008 |
| Applicant's or agent's file reference 037145-7827 | **FOR FURTHER ACTION** See paragraphs 1 and 4 below |
| International application No. PCT/IB2008/051351 | International filing date (day/month/year) 09/04/2008 |
| Applicant NOKIA CORPORATION | |

1. [x] The applicant is hereby notified that the international search report and the written opinion of the International Searching Authority have been established and are transmitted herewith.

   **Filing of amendments and statement under Article 19:**
   The applicant is entitled, if he so wishes, to amend the claims of the International Application (see Rule 46):

   **When?** The time limit for filing such amendments is normally two months from the date of transmittal of the International Search Report.

   **Where?** Directly to the International Bureau of WIPO, 34 chemin des Colombettes 1211 Geneva 20, Switzerland, Fascimile No.: (41-22) 338.82.70

   **For more detailed instructions,** see the notes on the accompanying sheet.

2. [ ] The applicant is hereby notified that no international search report will be established and that the declaration under Article 17(2)(a) to that effect and the written opinion of the International Searching Authority are transmitted herewith.

3. [ ] **With regard to the protest** against payment of (an) additional fee(s) under Rule 40.2, the applicant is notified that:

   [ ] the protest together with the decision thereon has been transmitted to the International Bureau together with the applicant's request to forward the texts of both the protest and the decision thereon to the designated Offices.

   [ ] no decision has been made yet on the protest; the applicant will be notified as soon as a decision is made.

4. **Reminders**

   Shortly after the expiration of **18 months** from the priority date, the international application will be published by the International Bureau. If the applicant wishes to avoid or postpone publication, a notice of withdrawal of the international application, or of the priority claim, must reach the International Bureau as provided in Rules 90*bis*.1 and 90*bis*.3, respectively, before the completion of the technical preparations for international publication.

   The applicant may submit comments on an informal basis on the written opinion of the International Searching Authority to the International Bureau. The International Bureau will send a copy of such comments to all designated Offices unless an international preliminary examination report has been or is to be established. These comments would also be made available to the public but not before the expiration of 30 months from the priority date.

   Within **19 months** from the priority date, but only in respect of some designated Offices, a demand for international preliminary examination must be filed if the applicant wishes to postpone the entry into the national phase **until 30 months** from the priority date (in some Offices even later); otherwise, the applicant must, **within 20 months** from the priority date, perform the prescribed acts for entry into the national phase before those designated Offices.

   In respect of other designated Offices, the time limit of **30 months** (or later) will apply even if no demand is filed within 19 months.

   See the Annex to Form PCT/IB/301 and, for details about the applicable time limits, Office by Office, see the *PCT Applicant's Guide*, Volume II, National Chapters and the WIPO Internet site.

| | |
|---|---|
| Name and mailing address of the International Searching Authority<br>European Patent Office, P.B. 5818 Patentlaan 2<br>NL-2280 HV Rijswijk<br>Tel. (+31-70) 340-2040, Tx. 31 651 epo nl,<br>Fax: (+31-70) 340-3016 | Authorized officer<br>Jolanda Offerman-Hazeleger |

## NOTES TO FORM PCT/ISA/220

These Notes are intended to give the basic instructions concerning the filing of amendments under article 19. The Notes are based on the requirements of the Patent Cooperation Treaty, the Regulations and the Administrative Instructions under that Treaty. In case of discrepancy between these Notes and those requirements, the latter are applicable. For more detailed information, see also the *PCT Applicant's Guide*, a publication of WIPO.

In these Notes, "Article", "Rule", and "Section" refer to the provisions of the PCT, the PCT Regulations and the PCT Administrative Instructions, respectively.

## INSTRUCTIONS CONCERNING AMENDMENTS UNDER ARTICLE 19

The applicant has, after having received the international search report and the written opinion of the International Searching Authority, one opportunity to amend the claims of the international application. It should however be emphasized that, since all parts of the international application (claims,description and drawings) may be amended during the international preliminary examination procedure, there is usually no need to file amendments of the claims under Article 19 except where, e.g. the applicant wants the latter to be published for the purposes of provisional protection or has another reason for amending the claims before international publication. Furthermore, it should be emphasized that provisional protection is available in some States only (see *PCT Applicant's Guide*, Volume I/A, Annexes B1 and B2).

The attention of the applicant is drawn to the fact that amendments to the claims under Article 19 are not allowed where the International Searching Authority has declared, under Article 17(2), that no international search report would be established (see *PCT Applicant's Guide*, Volume I/A, paragraph 296).

**What parts of the international application may be amended?**

Under Article 19, only the claims may be amended.

During the international phase, the claims may also be amended (or further amended) under Article 34 before the International Preliminary Examining Authority. The description and drawings may only be amended under Article 34 before the International Examining Authority.

Upon entry into the national phase, all parts of the international application may be amended under Article 28 or, where applicable, Article 41.

**When?** Within 2 months from the date of transmittal of the international search report or 16 months from the priority date, whichever time limit expires later. It should be noted, however, that the amendments will be considered as having been received on time if they are received by the International Bureau after the expiration of the applicable time limit but before the completion of the technical preparations for international publication (Rule 46.1).

**Where not to file the amendments?**

The amendments may only be filed with the International Bureau and not with the receiving Office or the International Searching Authority (Rule 46.2).

Where a demand for international preliminary examination has been/is filed, see below.

**How?** Either by cancelling one or more entire claims, by adding one or more new claims or by amending the text of one or more of the claims as filed.

A replacement sheet must be submitted for each sheet of the claims which, on account of an amendment or amendments, differs from the sheet originally filed.

All the claims appearing on a replacement sheet must be numbered in Arabic numerals. Where a claim is cancelled, no renumbering of the other claims is required. In all cases where claims are renumbered, they must be renumbered consecutively (Section 205(b)).

**The amendments must be made in the language in which the international application is to be published.**

**What documents must/may accompany the amendments?**

**Letter (Section 205(b)):**

The amendments must be submitted with a letter.

The letter will not be published with the international application and the amended claims. It should not be confused with the "Statement under Article 19(1)" (see below, under "Statement under Article 19(1)").

**The letter must be in English or French, at the choice of the applicant. However, if the language of the international application is English, the letter must be in English; if the language of the international application is French, the letter must be in French.**



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# PATENT COOPERATION TREATY

# PCT

## INTERNATIONAL SEARCH REPORT

(PCT Article 18 and Rules 43 and 44)

| Applicant's or agent's file reference<br>037145-7827 | **FOR FURTHER ACTION** see Form PCT/ISA/220 as well as, where applicable, item 5 below. | |
|---|---|---|
| International application No.<br>PCT/IB2008/051351 | International filing date *(day/month/year)*<br>09/04/2008 | (Earliest) Priority Date *(day/month/year)*<br>12/04/2007 |
| Applicant<br>NOKIA CORPORATION | | |

This international search report has been prepared by this International Searching Authority and is transmitted to the applicant according to Article 18. A copy is being transmitted to the International Bureau.

This international search report consists of a total of 3 sheets.

[X] It is also accompanied by a copy of each prior art document cited in this report.

1. **Basis of the report**
   a. With regard to the **language,** the international search was carried out on the basis of:
      [X] the international application in the language in which it was filed
      [ ] a translation of the international application into _____, which is the language of a translation furnished for the purposes of international search (Rules 12.3(a) and 23.1(b))
   b. [ ] This international search report has been established taking into account the **rectification of an obvious mistake** authorized by or notified to this Authority under Rule 91 (Rule 43.6*bis*(a)).
   c. [ ] With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, see Box No. I.
2. [ ] **Certain claims were found unsearchable** (See Box No. II)
3. [ ] **Unity of invention is lacking** (see Box No III)
4. With regard to the **title,**
   [X] the text is approved as submitted by the applicant
   [ ] the text has been established by this Authority to read as follows:
5. With regard to the **abstract,**
   [X] the text is approved as submitted by the applicant
   [ ] the text has been established, according to Rule 38.2(b), by this Authority as it appears in Box No. IV. The applicant may, within one month from the date of mailing of this international search report, submit comments to this Authority
6. With regard to the **drawings,**
   a. the figure of the **drawings** to be published with the abstract is Figure No. 1
      [X] as suggested by the applicant
      [ ] as selected by this Authority, because the applicant failed to suggest a figure
      [ ] as selected by this Authority, because this figure better characterizes the invention
   b. [ ] none of the figures is to be published with the abstract

Form PCT/ISA/210 (first sheet) (April 2007)

# INTERNATIONAL SEARCH REPORT

International application No
PCT/IB2008/051351

**A. CLASSIFICATION OF SUBJECT MATTER**
INV. H04N7/50

According to International Patent Classification (IPC) or to both national classification and IPC

**B. FIELDS SEARCHED**

Minimum documentation searched (classification system followed by classification symbols)
H04N G06F

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal, INSPEC

**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

| Category* | Citation of document, with indication, where appropriate, of the relevant passages | Relevant to claim No. |
|---|---|---|
| X | SANTAGO P ET AL: "USING CONVEX SET TECHNIQUES FOR COMBINED PIXEL AND FREQUENCY DOMAINCODING OF TIME-VARYING IMAGES" IEEE JOURNAL ON SELECTED AREAS IN COMMUNICATIONS, IEEE SERVICE CENTER, PISCATAWAY, US, vol. SAC-05, no. 7, 1 August 1987 (1987-08-01), pages 1127-1139, XP001053635 ISSN: 0733-8716 paragraph [VII. DESCRIPTION OF THE IMPLEMENTED CODER] ----- -/-- | 1-39 |

[X] Further documents are listed in the continuation of Box C. [ ] See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier document but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.
"&" document member of the same patent family

| Date of the actual completion of the international search | Date of mailing of the international search report |
|---|---|
| 29 September 2008 | 07/10/2008 |

| Name and mailing address of the ISA/ | Authorized officer |
|---|---|
| European Patent Office, P.B. 5818 Patentlaan 2<br>NL – 2280 HV Rijswijk<br>Tel. (+31-70) 340-2040, Tx. 31 651 epo nl,<br>Fax: (+31-70) 340-3016 | Wahrenberg, Annika |

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Form PCT/ISA/210 (second sheet) (April 2005)



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## INTERNATIONAL SEARCH REPORT

International application No
PCT/IB2008/051351

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

| Category* | Citation of document, with indication, where appropriate, of the relevant passages | Relevant to claim No. |
|---|---|---|
| A | SMITH J R ET AL: "Joint adaptive space and frequency basis selection" IMAGE PROCESSING, 1997. PROCEEDINGS., INTERNATIONAL CONFERENCE ON SANTA BARBARA, CA, USA 26-29 OCT. 1997, LOS ALAMITOS, CA, USA,IEEE COMPUT. SOC, US, vol. 3, 26 October 1997 (1997-10-26), pages 702-705, XP010253684 ISBN: 978-0-8186-8183-7 the whole document | 1-39 |
| A | CLARKE R J: "ON TRANSFORM CODING OF MOTION-COMPENSATED DIFFERENCE IMAGES" IEE PROCEEDINGS I. SOLID- STATE & ELECTRON DEVICES, INSTITUTION OF ELECTRICAL ENGINEERS. STEVENAGE, GB, vol. 139, no. 3 PART 01, 1 June 1992 (1992-06-01), pages 372-376, XP000305103 ISSN: 0956-3776 the whole document | 1-39 |
| A | WIEGAND T ET AL: "Overview of the H.264/AVC video coding standard" IEEE TRANSACTIONS ON CIRCUITS AND SYSTEMS FOR VIDEO TECHNOLOGY, IEEE SERVICE CENTER, PISCATAWAY, NJ, US, vol. 13, no. 7, 1 July 2003 (2003-07-01), pages 560-576, XP011099249 ISSN: 1051-8215 the whole document | 1-39 |
| A | SEGALL C A ET AL: "Pre- and post-processing algorithms for compressed video enhancement" SIGNALS, SYSTEMS AND COMPUTERS, 2000. CONFERENCE RECORD OF THE THIRTY- FOURTH ASILOMAR CONFERENCE ON OCT. 29 - NOV. 1, 2000, PISCATAWAY, NJ, USA,IEEE, vol. 2, 29 October 2000 (2000-10-29), pages 1369-1373, XP010535224 ISBN: 978-0-7803-6514-8 the whole document | 1-39 |

1

Form PCT/ISA/210 (continuation of second sheet) (April 2005)



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# PATENT COOPERATION TREATY

From the
INTERNATIONAL SEARCHING AUTHORITY

To:

see form PCT/ISA/220

# PCT

WRITTEN OPINION OF THE INTERNATIONAL SEARCHING AUTHORITY

(PCT Rule 43*bis*.1)

Date of mailing
*(day/month/year)* see form PCT/ISA/210 (second sheet)

Applicant's or agent's file reference
see form PCT/ISA/220

**FOR FURTHER ACTION**
See paragraph 2 below

| International application No. | International filing date *(day/month/year)* | Priority date *(day/month/year)* |
|---|---|---|
| PCT/IB2008/051351 | 09.04.2008 | 12.04.2007 |

International Patent Classification (IPC) or both national classification and IPC
INV. H04N7/50

Applicant
NOKIA CORPORATION

1. This opinion contains indications relating to the following items:

- ☒ Box No. I Basis of the opinion
- ☐ Box No. II Priority
- ☐ Box No. III Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
- ☐ Box No. IV Lack of unity of invention
- ☒ Box No. V Reasoned statement under Rule 43*bis*.1(a)(i) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement
- ☐ Box No. VI Certain documents cited
- ☐ Box No. VII Certain defects in the international application
- ☐ Box No. VIII Certain observations on the international application

2. **FURTHER ACTION**

If a demand for international preliminary examination is made, this opinion will usually be considered to be a written opinion of the International Preliminary Examining Authority ("IPEA") except that this does not apply where the applicant chooses an Authority other than this one to be the IPEA and the chosen IPEA has notifed the International Bureau under Rule 66.1*bis*(b) that written opinions of this International Searching Authority will not be so considered.

If this opinion is, as provided above, considered to be a written opinion of the IPEA, the applicant is invited to submit to the IPEA a written reply together, where appropriate, with amendments, before the expiration of 3 months from the date of mailing of Form PCT/ISA/220 or before the expiration of 22 months from the priority date, whichever expires later.

For further options, see Form PCT/ISA/220.

3. For further details, see notes to Form PCT/ISA/220.

| Name and mailing address of the ISA: | Date of completion of this opinion | Authorized Officer |
|---|---|---|
| European Patent Office - P.B. 5818 Patentlaan 2<br>NL-2280 HV Rijswijk - Pays Bas<br>Tel. +31 70 340 - 2040 Tx: 31 651 epo nl<br>Fax: +31 70 340 - 3016 | see form PCT/ISA/210 | Wahrenberg, Annika<br>Telephone No. +31 70 340-4890 |

Form (PCT/ISA/237) (Cover Sheet) (April 2005)

**Box No. I Basis of the opinion**

1. With regard to the **language**, this opinion has been established on the basis of:

   ☒ the international application in the language in which it was filed

   ☐ a translation of the international application into , which is the language of a translation furnished for the purposes of international search (Rules 12.3(a) and 23.1 (b)).

2. ☐ This opinion has been established taking into account the **rectification of an obvious mistake** authorized by or notified to this Authority under Rule 91 (Rule 43bis.1(a))

3. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application and necessary to the claimed invention, this opinion has been established on the basis of:

   a. type of material:

   ☐ a sequence listing

   ☐ table(s) related to the sequence listing

   b. format of material:

   ☐ on paper

   ☐ in electronic form

   c. time of filing/furnishing:

   ☐ contained in the international application as filed.

   ☐ filed together with the international application in electronic form.

   ☐ furnished subsequently to this Authority for the purposes of search.

4. ☐ In addition, in the case that more than one version or copy of a sequence listing and/or table relating thereto has been filed or furnished, the required statements that the information in the subsequent or additional copies is identical to that in the application as filed or does not go beyond the application as filed, as appropriate, were furnished.

5. Additional comments:



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**Box No. V Reasoned statement under Rule 43*bis*.1(a)(i) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement**

1. Statement

| | | | |
|---|---|---|---|
| Novelty (N) | Yes: | Claims | 2-11, 14-21, 23-29, 32-39 |
| | No: | Claims | 1, 12, 13, 22, 30, 31 |
| Inventive step (IS) | Yes: | Claims | NONE |
| | No: | Claims | 1-39 |
| Industrial applicability (IA) | Yes: | Claims | 1-39 |
| | No: | Claims | NONE |

2. Citations and explanations

**see separate sheet**



Amazon.com, Inc., Amazon.com Services LLC - Ex. 1002, Page 000117

**Re Item V.**

1. Reference is made to the following documents:
   D1: SANTAGO P ET AL: "USING CONVEX SET TECHNIQUES FOR COMBINED PIXEL AND FREQUENCY DOMAINCODING OF TIME-VARYING IMAGES" IEEE JOURNAL ON SELECTED AREAS IN COMMUNICATIONS, IEEE SERVICE CENTER, PISCATAWAY, US, vol. SAC-05, no. 7, 1 August 1987 (1987-08-01), pages 1127-1139, XP001053635 ISSN: 0733-8716
   D2: SEGALL C A ET AL: "Pre- and post-processing algorithms for compressed video enhancement" SIGNALS, SYSTEMS AND COMPUTERS, 2000. CONFERENCE RECORD OF THE THIRTY- FOURTH ASILOMAR CONFERENCE ON OCT. 29 - NOV. 1, 2000, PISCATAWAY, NJ, USA,IEEE, vol. 2, 29 October 2000 (2000-10-29), pages 1369-1373, XP010535224 ISBN: 978-0-7803-6514-8

2. The term *'spatial coding'* used in claims 1, 13 and 39 is vague and unclear and leaves the reader in doubt as to the meaning of the technical features to which it refers, thereby rendering the definition of the subject-matter of said claims unclear, Article 6 PCT.

   For the purpose of establishing this opinion, the aforementioned term has been interpreted as coding/representation of image samples in the spatial domain (see the description, para. [0011]).

3. The present application does not meet the criteria of Article 33(1) PCT, because the subject-matter of claims 1, 13, 22 and 31 is not new in the sense of Article 33(2) PCT.

   3.1 The document D1 discloses (the references in parentheses applying to this document):

   a method of encoding a prediction error signal for a block of data (page 1129, right-hand column, para. VII, lines 2-3), comprising:

calculating a difference signal representing differences between sample values of a predicted block of data and values for an original input block (*ibid*; para. IX, lines 2-3);

performing transform coding to the difference signal, thereby creating a first representation of a first component of the difference signal (fig. 5 - transform (F));

performing spatial coding to the difference signal, thereby creating a second representation of a first component of the difference signal (fig. 5 - mask coder); and joining the first and second representations (fig. 5 - POCS; para. VII).
The subject-matter of claim 1 is therefore not new.

3.2 The same reasoning applies *mutatis mutandis* to claims 13, 22 and 31, which, therefore, lack novelty.

4. Pre-filtering the prediction error signal to remove outlier samples is well known in the art (see e.g. D2, para. 4.1). The additional feature of claim 39, therefore, does not add anything of inventive significance.

5. The dependent claims (2-12, 14-21, 23, 30 and 31-38) are numerous, disparate and vague and it is not at all apparent that they relate to a single general inventive concept. Furthermore, they do not appear to contain subject-matter which makes an inventive contribution over the prior art D1 and D2.

***

## Possible steps after receipt of the international search report (ISR) and written opinion of the International Searching Authority (WO-ISA)

| | |
|---|---|
| General information | For all international applications filed on or after 01/01/2004 the competent ISA will establish an ISR. It is accompanied by the WO-ISA. Unlike the former written opinion of the IPEA (Rule 66.2 PCT), the WO-ISA is not meant to be responded to, but to be taken into consideration for further procedural steps. This document explains about the possibilities. |
| Amending claims under Art. 19 PCT | Within 2 months after the date of mailing of the ISR and the WO-ISA the applicant may file amended claims under Art. 19 PCT directly with the International Bureau of WIPO. The PCT reform of 2004 did not change this procedure. For further information please see Rule 46 PCT as well as form PCT/ISA/220 and the corresponding Notes to form PCT/ISA/220. |
| Filing a demand for international preliminary examination | In principle, the WO-ISA will be considered as the written opinion of the IPEA. This should, in many cases, make it unnecessary to file a demand for international preliminary examination. If the applicant nevertheless wishes to file a demand this must be done before expiry of 3 months after the date of mailing of the ISR/WO-ISA or 22 months after priority date, whichever expires later (Rule 54bis PCT). Amendments under Art. 34 PCT can be filed with the IPEA as before, normally at the same time as filing the demand (Rule 66.1 (b) PCT).<br><br>If a demand for international preliminary examination is filed and no comments/amendments have been received the WO-ISA will be transformed by the IPEA into an IPRP (International Preliminary Report on Patentability) which would merely reflect the content of the WO-ISA. The demand can still be withdrawn (Art. 37 PCT). |
| Filing informal comments | After receipt of the ISR/WO-ISA the applicant may file informal comments on the WO-ISA directly with the International Bureau of WIPO. These will be communicated to the designated Offices together with the IPRP (International Preliminary Report on Patentability) at 30 months from the priority date. Please also refer to the next box. |
| End of the international phase | At the end of the international phase the International Bureau of WIPO will transform the WO-ISA or, if a demand was filed, the written opinion of the IPEA into the IPRP, which will then be transmitted together with possible informal comments to the designated Offices. The IPRP replaces the former IPER (international preliminary examination report). |
| Relevant PCT Rules and more information | Rule 43 PCT, Rule 43bis PCT, Rule 44 PCT, Rule 44bis PCT, PCT Newsletter 12/2003, OJ 11/2003, OJ 12/2003 |



ISDOCID: <XS 20070401 0CK 1 >

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# Electronic Acknowledgement Receipt

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|---|---|
| **EFS ID:** | 4129790 |
| **Application Number:** | 12101019 |
| **International Application Number:** | |
| **Confirmation Number:** | 7368 |
| **Title of Invention:** | SPATIALLY ENHANCED TRANSFORM CODING |
| **First Named Inventor/Applicant Name:** | Jani Lainema |
| **Customer Number:** | 30542 |
| **Filer:** | Glenn Peter Albert Jr. |
| **Filer Authorized By:** | |
| **Attorney Docket Number:** | 037145-7826 |
| **Receipt Date:** | 17-OCT-2008 |
| **Filing Date:** | 10-APR-2008 |
| **Time Stamp:** | 19:55:02 |
| **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.) |
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| | Information Disclosure Statement Letter | 1 | 2 |
| | Information Disclosure Statement (IDS) Filed (SB/08) | 3 | 3 |

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| **Information:** | | | | | |
| 2 | NPL Documents | Clarke.pdf | 518127<br>bd8626f3eeaa0b0b7ca9fc3f4fed89007d6c1d5d | no | 5 |
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| **Information:** | | | | | |
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| **Warnings:** | | | | | |
| **Information:** | | | | | |
| 6 | NPL Documents | Wiegand.pdf | 2396772<br>03c590ab605c5e30a89c2562d2c28d0d910e8929 | no | 17 |
| **Warnings:** | | | | | |
| **Information:** | | | | | |
| 7 | NPL Documents | ISR.pdf | 727477<br>2eb46b4d0d2a1db54afdae02e6dc84570ec908f0 | no | 12 |
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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.**

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**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 NUMBER | FILING OR 371(C) DATE | FIRST NAMED APPLICANT | ATTY. DOCKET NO./TITLE |
|---|---|---|---|
| 12/101,019 | 04/10/2008 | Jani Lainema | 037145-7826 |

**CONFIRMATION NO. 7368**

30542
FOLEY & LARDNER LLP
P.O. BOX 80278
SAN DIEGO, CA 92138-0278

**PUBLICATION NOTICE**

*OC000000032747845*

**Title:**SPATIALLY ENHANCED TRANSFORM CODING

**Publication No.**US-2008-0260270-A1
**Publication Date:**10/23/2008

## 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/.

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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.

Further assistance in electronically accessing the publication, or about PAIR, is available by calling the Patent Electronic Business Center at 1-866-217-9197.

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PTO/SB/08 (09-05)
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**INFORMATION DISCLOSURE STATEMENT BY APPLICANT**

*(use as many sheets as necessary)*

Sheet 1 of 1

| *Complete if Known* | |
|---|---|
| **Application Number** | 12/101019 |
| **Filing Date** | 4/10/2008 |
| **First Named Inventor** | Jani Lainema |
| Art Unit | 2624 |
| Examiner Name | Bali, Vikkram |
| Attorney Docket Number | 037145-7828 |

**U.S. PATENT DOCUMENTS**

| Examiner Initials* | Cite No.[1] | Document Number / Number-Kind Code[2] (if known) | Publication Date MM-DD-YYYY | Name of Patentee or Applicant of Cited Document | Pages, Columns, Lines, Where Relevant Passages or Relevant Figures Appear |
|---|---|---|---|---|---|
| | A1 | 2007/0064797 | 03-22-2007 | MIAO ET AL. | |
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**UNPUBLISHED U.S. PATENT APPLICATION DOCUMENTS**

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**FOREIGN PATENT DOCUMENTS**

| Examiner Initials* | Cite No.[1] | Foreign Patent Document / Country Code[3] Number[4] Kind Code[5] (if known) | Publication Date MM-DD-YYYY | Name of Patentee or Applicant of Cited Documents | Pages, Columns, Lines, Where Relevant Passages or Relevant Figures Appear | T[6] |
|---|---|---|---|---|---|---|
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**NON PATENT LITERATURE DOCUMENTS**

| Examiner Initials* | Cite No.[1] | 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, page(s), volume-issue number(s), publisher, city and/or country where published. | T[6] |
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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 2 hours 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, 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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| **EFS ID:** | 8112143 |
| **Application Number:** | 12101019 |
| **International Application Number:** | |
| **Confirmation Number:** | 7368 |
| **Title of Invention:** | SPATIALLY ENHANCED TRANSFORM CODING |
| **First Named Inventor/Applicant Name:** | Jani Lainema |
| **Customer Number:** | 30542 |
| **Filer:** | Sanjeev K. Dhand |
| **Filer Authorized By:** | |
| **Attorney Docket Number:** | 037145-7826 |
| **Receipt Date:** | 29-JUL-2010 |
| **Filing Date:** | 10-APR-2008 |
| **Time Stamp:** | 15:43:54 |
| **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.) |
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| 1 | | IDS.pdf | 562208<br>363a58f99fce7f687202e09e7a639aed2be926f5 | yes | 3 |

| | Multipart Description/PDF files in .zip description | | |
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| | **Document Description** | **Start** | **End** |
| | Transmittal Letter | 1 | 2 |
| | Information Disclosure Statement (IDS) Filed (SB/08) | 3 | 3 |
| **Warnings:** | | | |
| **Information:** | | | |
| | **Total Files Size (in bytes):** | 562208 | |

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*IN THE UNITED STATES PATENT AND TRADEMARK OFFICE*

Applicant: Jani Lainema

Title: SPATIALLY ENHANCED TRANSFORM CODING

Appl. No.: 12/101019

Filing Date: 4/10/2008

Examiner: Bail, Vikkram

Art Unit: 2624

Confirmation Number: 7368

**INFORMATION DISCLOSURE STATEMENT UNDER 37 CFR §1.56**

Mail Stop Amendment
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Sir:

Submitted herewith on Form PTO/SB/08 is a listing of a document known to Applicant in order to comply with Applicant's duty of disclosure pursuant to 37 CFR §1.56.

The submission of any document herewith, which is not a statutory bar, is not intended as an admission that such document constitutes prior art against the claims of the present application or that such document is considered material to patentability as defined in 37 CFR §1.56(b). Applicant does not waive any rights to take any action which would be appropriate to antedate or otherwise remove as a competent reference any document which is determined to be a *prima facie* art reference against the claims of the present application.

## TIMING OF THE DISCLOSURE

The listed document is being submitted in compliance with 37 CFR §1.97(b), before the mailing date of the first Office Action on the merits.

## RELEVANCE OF EACH DOCUMENT

All of the documents are in English.

Applicant respectfully requests that each listed document be considered by the Examiner and be made of record in the present application and that an initialed copy of Form PTO/SB/08 be returned in accordance with MPEP §609.

Although Applicant believes that no fee is required, the Commissioner is hereby authorized to charge any additional fees which may be due to Deposit Account No. 19-0741.

Respectfully submitted,

Date July 28, 2010

By

FOLEY & LARDNER LLP
Customer Number: 30542
Telephone: (858) 847-6735
Facsimile: (858) 792-6773

G. Peter Albert, Jr., Reg. 37,268
By Sanjeev K. Dhand, Reg. No. 51,182
Attorney for Applicant

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PTO/SB/80 (11-08)
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I hereby revoke all previous powers of attorney given in the application identified in the attached statement under 37 CFR 3.73(b).

I hereby appoint:

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*OR*

☐ Practitioner(s) named below (if more than ten patent practitioners are to be named, then a customer number must be used):

| Name | Registration Number | Name | Registration Number |
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Please change the correspondence address for the application identified in the attached statement under 37 CFR 3.73(b) to:

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|---|---|---|---|
| ☐ Firm or Individual Name | | | |
| Address | | | |
| City | | State | Zip |
| Country | | | |
| Telephone | | Email | |

Assignee Name and Address:

Nokia Corporation
Keilalahdentie 4
Espoo, Finland 02150

**A copy of this form, together with a statement under 37 CFR 3.73(b) (Form PTO/SB/96 or equivalent) is required to be filed in each application in which this form is used. The statement under 37 CFR 3.73(b) may be completed by one of the practitioners appointed in this form if the appointed practitioner is authorized to act on behalf of the assignee, and must identify the application in which this Power of Attorney is to be filed.**

**SIGNATURE of Assignee of Record**

The individual whose signature and title is supplied below is authorized to act on behalf of the assignee

| | | | |
|---|---|---|---|
| Signature | | Date | 6 August 2010 |
| Name | Harri Honkasalo | Telephone | +358-71-8008000 |
| Title | Director, Patenting, Legal & IP | | |

This collection of information is required by 37 CFR 1.31, 1.32 and 1.33. 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 3 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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| | |
|---|---|
| **EFS ID:** | 9256964 |
| **Application Number:** | 12101019 |
| **International Application Number:** | |
| **Confirmation Number:** | 7368 |
| **Title of Invention:** | SPATIALLY ENHANCED TRANSFORM CODING |
| **First Named Inventor/Applicant Name:** | Jani Lainema |
| **Customer Number:** | 30542 |
| **Filer:** | Sanjeev K. Dhand/Marisol Moretto |
| **Filer Authorized By:** | Sanjeev K. Dhand |
| **Attorney Docket Number:** | 037145-7826 |
| **Receipt Date:** | 19-JAN-2011 |
| **Filing Date:** | 10-APR-2008 |
| **Time Stamp:** | 14:34:48 |
| **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 | Assignee showing of ownership per 37 CFR 3.73(b). | sb0096_37CFR3-73b_Statement_00002-5481.pdf | 33145<br>3c5973ce42b0f2cd9d6d320efb37b2738ba3fba1 | no | 2 |

**Warnings:**

**Information:**

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|---|---|---|---|---|---|
| 2 | Power of Attorney | Nokia_Executed_General_POA.pdf | 35715<br>f0313fef37df0c26d3f3681d73e832fdcace7199 | no | 1 |
| **Warnings:** | | | | | |
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| | | **Total Files Size (in bytes):** | 68860 | | |

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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.**

PTO/SB/96 (07-09)
Approved for use through 07/31/2012. OMB 0651-0031
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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.

## STATEMENT UNDER 37 CFR 3.73(b)

Applicant/Patent Owner: NOKIA CORPORATION

Application No./Patent No.: 12/101,019 Filed/Issue Date: April 10, 2008

Titled: SPATIALLY ENHANCED TRANSFORM CODING

NOKIA CORPORATION, a Corporation
(Name of Assignee) (Type of Assignee, e.g., corporation, partnership, university, government agency, etc.

states that it is:

1. [X] the assignee of the entire right, title, and interest in;

2. [ ] an assignee of less than the entire right, title, and interest in
(The extent (by percentage) of its ownership interest is _____ %); or

3. [ ] the assignee of an undivided interest in the entirety of (a complete assignment from one of the joint inventors was made)

the patent application/patent identified above, by virtue of either:

A. [X] An assignment from the inventor(s) of the patent application/patent identified above. The assignment was recorded in the United States Patent and Trademark Office at Reel 021174, Frame 0553, or for which a copy therefore is attached.

**OR**

B. [ ] A chain of title from the inventor(s), of the patent application/patent identified above, to the current assignee as follows:

1. From: _____ To: _____
The document was recorded in the United States Patent and Trademark Office at
Reel _____, Frame _____, or for which a copy thereof is attached.

2. From: _____ To: _____
The document was recorded in the United States Patent and Trademark Office at
Reel _____, Frame _____, or for which a copy thereof is attached.

3. From: _____ To: _____
The document was recorded in the United States Patent and Trademark Office at
Reel _____, Frame _____, or for which a copy thereof is attached.

[ ] Additional documents in the chain of title are listed on a supplemental sheet(s).

[ ] As required by 37 CFR 3.73(b)(1)(i), the documentary evidence of the chain of title from the original owner to the assignee was, or concurrently is being, submitted for recordation pursuant to 37 CFR 3.11.

[NOTE: A separate copy (*i.e.*, a true copy of the original assignment document(s)) must be submitted to Assignment Division in accordance with 37 CFR Part 3, to record the assignment in the records of the USPTO. See MPEP 302.08]

The undersigned (whose title is supplied below) is authorized to act on behalf of the assignee.

/Sanjeev K. Dhand/ — Signature
January 18, 2011 — Date

Sanjeev K. Dhand — Printed or Typed Name
Attorney — Title

This collection of information is required by 37 CFR 3.73(b). 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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# 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.

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 | FIRST NAMED APPLICANT | ATTY. DOCKET NO./TITLE |
|---|---|---|---|
| 12/101,019 | 04/10/2008 | Jani Lainema | 037145-7826 |

**CONFIRMATION NO. 7368**

**POWER OF ATTORNEY NOTICE**

30542
FOLEY & LARDNER LLP
P.O. BOX 80278
SAN DIEGO, CA 92138-0278

*OC000000045652867*

Date Mailed: 01/27/2011

## NOTICE REGARDING CHANGE OF POWER OF ATTORNEY

This is in response to the Power of Attorney filed 01/19/2011.

- The Power of Attorney to you in this application has been revoked by the assignee who has intervened as provided by 37 CFR 3.71. Future correspondence will be mailed to the new address of record(37 CFR 1.33).

/atesfai/

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Office of Data Management, Application Assistance Unit (571) 272-4000, or (571) 272-4200, or 1-888-786-0101

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
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| APPLICATION NUMBER | FILING OR 371(C) DATE | FIRST NAMED APPLICANT | ATTY. DOCKET NO./TITLE |
|---|---|---|---|
| 12/101,019 | 04/10/2008 | Jani Lainema | 037145-7826 |

**CONFIRMATION NO. 7368**

**POA ACCEPTANCE LETTER**

98359
AlbertDhand LLP
11622 El Camino Real, Suite 100
San Diego, CA 92130

*OC000000045652909*

Date Mailed: 01/27/2011

## NOTICE OF ACCEPTANCE OF POWER OF ATTORNEY

This is in response to the Power of Attorney filed 01/19/2011.

The Power of Attorney in this application is accepted. Correspondence in this application will be mailed to the above address as provided by 37 CFR 1.33.

/atesfai/

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Office of Data Management, Application Assistance Unit (571) 272-4000, or (571) 272-4200, or 1-888-786-0101

PTO/SB/08b (07-09)
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Substitute for form 1449/PTO

# INFORMATION DISCLOSURE STATEMENT BY APPLICANT

*(Use as many sheets as necessary)*

Sheet 1 of 1

| | Complete if Known |
|---|---|
| Application Number | 12/101,019 |
| Filing Date | 04/10/2008 |
| First Named Inventor | Jani Lainema |
| Art Unit | 2624 |
| Examiner Name | DO, ANH HONG |
| Attorney Docket Number | 00002-5481 |

**NON PATENT LITERATURE DOCUMENTS**

| Examiner Initials* | Cite No.[1] | 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, page(s), volume-issue number(s), publisher, city and/or country where published. | T[2] |
|---|---|---|---|
| | A1 | English translation of Office action for corresponding Korean Application No. 2009-7023527 dated January 6, 2011 | |
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| Examiner Signature | | Date Considered | |
|---|---|---|---|

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

1 Applicant's unique citation designation number (optional). 2 Applicant is to place a check mark here if English language Translation is attached.

This collection of information is required by 37 CFR 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 2 hours 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, 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 (1-800-786-9199) and select option 2.*

[translation]

## Korean Intellectual Property Office

## NON-FINAL REJECTION

Applicant
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Address: Keilalahdentie 4, FIN-02150 Espoo, Finland

Attorney
Name: Y.P. Lee, Mock & Partners
Address: Koryo Building, 1575-1 Seocho-dong, Seocho-gu, Seoul Republic of Korea 137-875
Designated Attorney: Youngpil LEE, et al.

Inventor: LAINEMA, Jani

Application No.: 10-2009-7023527

Title: Spatially Enhanced Transform Coding

1. Applicant is hereby notified pursuant to Article 63 of the Korean Patent Law that this application is rejected on the following grounds. Any comments/arguments along with any amendments that the applicant may wish to submit in response to this rejection must be filed by **6 March 2011**.

2. The due date for filing a response may be extended for a period of one or more months by filing a request for an extension of the time period for reply. Such a request must include an appropriate fee and should be filed by the due date for filing a response. More than one such request may be filed, but the due date for filing a response can only be extended for a maximum period of four months from the initial due date. If it is necessary to extend the time period for reply by more than four months, a reasonable explanation of such a need must be submitted along with the request.

## [EXAMINATION RESULTS]

- Examined claims: Claims 1-39
- Rejected parts of the present application and related articles of the Korean Patent Law

| Number | Rejected Parts | Related Articles |
|---|---|---|
| 1 | Claims 12-21 and 30-38 | Article 42, Paragraph 4(2) of the Korean Patent Law |
| 2 | Entire claims | Article 29, Paragraph 2 of the Korean Patent Law |

## [GROUNDS OF REJECTION]

1. The present application is not in condition for allowance because claims 12-21 and 30-38 are rejected under Article 42, Paragraph 4(2) of the Korean Patent Law as being indefinite for failing to particularly point out and distinctly claim the subject matter thereof on the grounds as particularly stated below.

**BELOW**

(1) Claims 12 and 30 are directed to "a product." However, a "product" indicates an object that includes a supplemental element added for commercialization, and thus, cannot be regarded as a proper invention category.

(2) Claims 13-21 are directed to "an apparatus." However, the purpose for using the apparatus is not clearly recited. Claims 31-38 are also rejected on the same rejection grounds.

(3) Claim 19 recites "the outlier values... (omitted)..... the non-outlier values....." However, the antecedent bases for "the outlier values" and "the non-outlier values" are not clear.

(4) Claim 20 recites, "the memory unit .... in the block of data if appropriate." However, the expression "if appropriate" is not technological clear, and the antecedent basis for "the block" is not clear either.

(5) Claim 21 recites, "the memory unit .... in the block of data if appropriate." However, the expression "if appropriate" is not clear technological clear, and the antecedent basis for "the block" is not clear.

(6) Claim 30 recites "..... to perform the process of claim 19." However, claim 19 is directed to an apparatus and does not recite "process (method)." Thus, the meaning of the recitation of claim 30 is not clear.

(7) Claim 31 recites "... a decoded representation of the data block." However, the antecedent basis for "the data block" is not clear.

2. The present application is not in condition for allowance because all claims are rejected under Article 29, Paragraph 2 of the Korean Patent Law as being obvious to one of ordinary skill in the art in view of the prior art of record before the filing of the present application on the grounds as particularly stated below.

**BELOW**

(1) Claim 1 is directed to a method of encoding a prediction error signal for a block of data, the method being characterized in the combination of transform coding and spatial coding. However, "Using Convex Set Techniques for Combined Pixel and Frequency

domain coding of time-varying images" (Santago P. et al., IEEE Journal on selected areas in communications, vol. SAC-05, no. 7, 1 August 1987, pages 1127-1139, hereinafter referred to as the cited reference), which is published before the filing of the present application, describes an encoding method in which encoding methods of a pixel area and a frequency area combined. Comparing the invention recited in claim 1 of the present application and the cited reference, transform coding performed to create a first representation, spatial coding performed to create a second representation, and joining the first and second representations, which are the main features of the present application, correspond to the cited reference describing combination of a pixel domain coding technique and a frequency domain coding technique. In detail, the transform coding recited in the present application corresponds to the frequency coding technique of the cited reference, and the spatial coding recited in the present application corresponds to the pixel encoding technique of the cited reference. The present application is different from the cited reference in that first a difference signal is calculated and coding is performed to the difference signal. However, the fact that encoding is performed to a difference signal is obvious in regard to a prediction coding process and it would have been obvious to one of ordinary skill in the art to simply add this operation. Thus, it would have been obvious to one of ordinary skill in the art to invent the invention recited in claim 1 in view of the cited reference.

(2) Details about outlier values recited in claim 2 and details about spatial coding and transform coding and a discrete transform (DCT) basis vector recited in claims 3-11 would have been obvious to one of ordinary skill in the art in view of the conventional art.

(3) Claim 12 is directed to a different object from claim 1 but recites the same technical features. Thus, claim 12 also would have been obvious to one of ordinary skill in the art on the same grounds as claim 1.

(4) Claims 13-21 are directed to a different category from claim 1 but recite the same technical features. Thus, claims 13-21 also would have been obvious to one of ordinary skill in the art on the same grounds as claim 1.

(5) Claims 22-29 are directed to a decoding method which is in accordance with the method of encoding recited in claims 1-11 and recite operations that are based on the method of encoding. Thus, the invention recited in claims 22-29 also would have been obvious to one of ordinary skill in the art on the same grounds as claims 1-11.

(6) Claim 30 is directed to a different object from claim 19 but recites the same technical features. Thus, claim 30 also would have been obvious to one of ordinary skill in the art on the same grounds as claim 19.

(7) Claims 31-38 are directed to a different category from the method of decoding recited in claims 22-29 but recite the same technical features. Thus, claims 31-38 also would have been obvious to one of ordinary skill in the art on the same grounds as claims 22-29.

(8) Claim 39 is a modified version of claim 1. However, it would have been obvious to one of ordinary skill in the art to change claim 1 into claim 39 in a way recited herein. Thus, the invention recited in claim 39 also would have been obvious to one of ordinary skill in the art to invent on the same grounds as claim 1.

Enclosure:
Santago P. et al., "Using Convex Set Techniques for Combined Pixel and Frequency domain coding of time-varying images." IEEE Journal on selected areas in communications, 1 August 1987, pages 1127-1139.

6 January 2011

**KOREAN INTELLECTUAL PROPERTY OFFICE**

Information and Communications Examination Bureau
Digital Broadcasting Examination Division

Examiner: Youngtae KIM

**발송번호:** 9-5-2011-000953960
**발송일자:** 2011.01.06
**제출기일:** 2011.03.06

**수신** 서울 서초구 서초동 1575-1 고려빌딩(리앤목특허법인)
**리앤목특허법인[이영필]**
**137-875**

YOUR INVENTION PARTNER

특 허 청

# 의견제출통지서

**출 원 인 명 칭** 노키아 코포레이션 (출원인코드: 520000368439)
**주 소** 핀랜드핀-02150 에스푸 카일알라덴티에 4
**대 리 인 명 칭** 리앤목특허법인
**주 소** 서울 서초구 서초동 1575-1 고려빌딩(리앤목특허법인)
**지정된변리사** 이영필 외 1명
**발 명 자 성 명** 라이네마 야니
**주 소** 핀란드 핀-33230 탐페레 키사켄타카투 12 베 6

**출 원 번 호** 10-2009-7023527
**발 명 의 명 칭** 공간적으로 향상된 변환 부호화

**1. 이 출원에 대한 심사결과 다음과 같은 거절이유가 있어 특허법 제63조에 따라 이를 통지하오니 의견이 있거나 보정이 필요할 경우에는 상기 제출기일까지 의견(답변, 소명)서[특허법시행규칙 별지 제24호서식] 또는/및 보정서[특허법시행규칙 별지 제9호서식]를 제출하여 주시기 바랍니다.**

**2. 상기 제출기일에 대하여 1월 단위로 4개월까지 지정기간연장신청을 할 수 있으며, 필요한 경우 4개월 범위 내에서 2개월 이상을 일괄하여 연장신청할 수 있습니다. 불가피한 사유의 발생(하단의 안내참조)으로 4개월을 초과하여 지정기간을 연장받고자 하는 때에는 그 사유를 기재한 소명서를 추가로 첨부하여 지정기간연장신청서를 제출하여야 합니다.**

**[심사결과]**

□ 심사 대상 청구항 : 제1-39항

□ 이 출원의 거절이유가 있는 부분과 관련 법조항

| 순번 | 거절이유가 있는 부분 | 관련 법조항 |
|---|---|---|
| 1 | 청구항 제12항 내지 제21항, 제30항 내지 제38항 | 특허법 제42조제4항제2호 |
| 2 | 청구항 전항 | 특허법 제29조제2항 |

**[구체적인 거절이유]**

1. 이 출원은 특허청구범위의 청구항 제12항 내지 제21항, 제30항 내지 제38항의 기재가 아래에 지적한 바와 같이 불비하여 특허법 제42조제4항제2호에 따른 요건을 충족하지 못하므로 특허를 받을 수 없습니다.

Amazon.com, Inc., Amazon.com Services LLC - Ex. 1002, Page 000144

- 아 래 -

(1) 청구항 제12항, 제30항은 "~제품'을 특허범위로 청구하고 있으나 '제품'은 상품화를 위해 부가적인 요소를 가미하고 있는 것을 시사한 것으로 적합한 발명의 카테고리로 볼 수 없습니다.

(2) 청구항 제13항 내지 제21항은 "장치"를 특허범위로 청구하고 있으나, 무엇을 위한 또는 무엇을 하는 '장치'인지 그것의 목적 또는 용도 등에 관한 기술적 특징이 명확하게 한정되지 않았습니다. 청구항 제31항 내지 청구항 제38항에 대해서도 동일한 취지의 거절이유를 갖고 있습니다.

(3) 청구항 제19항에 "상기 아웃라이어 값들을.....(중략).....상기 비-아웃라이어 값들은.....,"로 기재하고 있으나, 각각 '상기'가 지시하는 것이 명확하지 않습니다.

(4) 청구항 제20항에 "메모리 유닛은, 적절하다면, 데이터의 상기 블록 내에.....,"로 기재하고 있으나, '적절하다면'은 그 기술적 특징이 명확하지 않은 기재이며, '상기'가 지시하는 것이 명확하지 않습니다.

(5) 청구항 제21항에 "메모리 유닛은, 적절하다면, 데이터의 상기 블록 내에.....,"로 기재하고 있으나, '적절하다면'은 그 기술적 특징이 명확하지 않은 기재이며, '상기'가 지시하는 것이 명확하지 않습니다.

(6) 청구항 제30항에 "제19항의 프로세스들을 수행하는.....," 로 기재하고 있으나, 제19항은 장치 발명으로 프로세스(방법)에 대한 기재가 없으므로 인용하는 항과 내용이 명확하지 않습니다.

(7) 청구항 제31항의 "상기 데이터 블록의 복호화된 표현을.....,"로 기재하고 있으나 '상기'가 지시하는 것이 명확하지 않습니다.

2. 이 출원의 특허청구범위의 청구항 전항에 기재된 발명은 아래와 같이 그 출원 전에 이 발명이 속하는 기술분야에서 통상의 지식을 가진 자(이하 '당업자' )가 용이하게 발명할 수 있는 것이므로 특허법 제29조제2항에 따라 특허를 받을 수 없습니다.

- 아 래 -

(1) 본 출원의 특허청구범위 제1항에 기재된 발명은 변환 부호화와 공간 부호화를 결합하는 것을 특징으로 하는 부호화 방법으로 인정되며, 본 출원이 출원되기 전에 반포된 간행물인 "Using Convex Set Techniques for Combined Pixel and Frequency domain coding of time-varying images."(Santago P. et al., IEEE Journal on selected areas in communications, vol. SAC-05,no.7, 1 August 1987, pages 1127-1139. 이하 '인용발명'이라 한다.)에는 픽셀 영역과 주파수 영역의 부호화 방법을 결합하는 부호화 방법에 대해 기재하

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고 있습니다. 본 출원의 특허청구범위 제1항과 인용발명을 대비하면, 본원발명의 주요한 기술적 특징인 변환 부호화를 실행하여 첫 번째 표현을 생성하고, 공간 부호화를 실행하여 두 번째 표현을 생성하여 결합하는 것은 인용발명의 픽셀 도메인 코딩 기술과 주파수 도메인 코딩 기술을 결합하는 것에 대응하는 것으로 본원발명의 변환 부호화는 인용발명의 주파수 코딩 기술에 대응하고 본원발명의 공간 부호화는 인용발명의 픽셀 부호화 기술에 대응하는 것입니다. 다만 차이점으로는, 본 출원의 제1항은 차이 신호를 먼저 계산하여 차이 신호를 대상으로 한다는 점이나 차이 신호를 대상으로 부호화하는 것은 예측 부호화 과정에서 통상적으로 사용되는 발명임을 고려할 때 당업자가 단순 추가할 수 있는 단계입니다. 따라서 본 출원의 특허청구범위 제1항은 당업자가 인용발명으로부터 쉽게 발명할 수 있는 것입니다.

(2) 청구항 제2항의 아웃라이어 값과 관련된 사항 및 청구항 제3항 내지 제11항의 공간 부호화 및 변환 부호화 관련 사항, DCT 기본 벡터 관련사항은 당업자가 통상의 기술로부터 단순 접목할 수 있는 것입니다.

(3) 청구항 제12항은 제1항과 청구된 대상이 상이하지만 그 기술적 특징은 동일한 것이므로 상기항과 동일한 이유로 당업자가 쉽게 발명할 수 있는 것입니다.

(4) 청구항 제13항 내지 제21항은 청구항 제1항과 발명의 카테고리가 상이하지만 그 대응하는 기술적 특징은 동일한 것이므로 상기항과 동일한 이유로 당업자가 쉽게 발명할 수 있는 것입니다.

(5) 청구항 제22항 내지 제29항은 제1항 내지 제1항의 부호화 방법에 대응하는 복호화 방법으로 그 기술적 특징은 부호화 방법에 기인한 것으로 상기항과 동일한 이유로 당업자가 쉽게 발명할 수 있는 것입니다.

(6) 청구항 제30항은 제19항과 청구된 대상이 상이하지만 그 기술적 특징은 동일한 것이므로 상기항과 동일한 이유로 당업자가 쉽게 발명할 수 있는 것입니다.

(7) 청구항 제31항 내지 제38항은 제22항 내지 제29항의 복호화 방법과 발명의 카테고리가 상이하지만 그 기술적 특징은 동일한 것이므로 상기항과 동일한 이유로 당업자가 쉽게 발명할 수 있는 것입니다.

(8) 청구항 제39항은 제1항을 설계 변경한 것으로 당업자가 통상의 창작능력으로 변경할 수 있는 정도이므로 제1항과 마찬가지로 업자가 쉽게 발명할 수 있는 것입니다.

**[첨 부]**

첨부1 Santago P. et al., "Using Convex Set Techniques for Combined Pixel and Frequency domain coding of time-varying images." IEEE Journal on selected areas in communications, 1 August 1987, pages 1127-1139. 끝.

2011.01.06

특허청 정보통신심사국

디지털방송심사팀 심사관 김영태

<< 안내 >>

1. 특허법 제47조제2항에 따라 특허출원서에 최초로 첨부된 명세서 또는 도면에 기재된 사항의 범위 안에서 명세서 또는 도면을 보정할 수 있음을 알려드립니다.
(참고 : 최후거절이유통지 후 및 특허거절결정에 대한 심판 청구 후 30일내의 보정에 대해서는 특허법 제47조 제2항 및 제3항의 규정이 추가로 적용됩니다.)

2. 보정료 납부안내
o 명세서 또는 도면을 보정하기 위하여 명세서등 보정서를 전자문서로 제출할 경우 매건 4,000원, 서면으로 제출할 경우 매건 14,000원의 보정료를 납부하여야 합니다.
o 보정료는 접수번호를 부여받아 이를 납부자번호로 "특허료등의 징수규칙" 별지 제1호서식에 기재하여, 접수번호를 부여받은 날의 다음 날까지 납부하여야 합니다. 다만, 납부일이 공휴일(토요휴무일을 포함한다)에 해당하는 경우에는 그날 이후의 첫 번째 근무일까지 납부하여야 합니다.
o 보정료는 국고수납은행(대부분의 시중은행)에 납부하거나, 인터넷지로(www.giro.or.kr)로 납부할 수 있습니다. 다만, 보정서를 우편으로 제출하는 경우에는 보정료에 상응하는 통상환을 동봉하여 제출하시면 특허청에서 납부해드립니다.

3. 지정기간연장 안내 : 연장가능기간(4개월)을 초과하여 지정기간을 연장하고자 소명서를 첨부하여 지정기간연장신청서를 제출한 경우 심사관은 아래의 사유에 해당되는지를 판단하여 지정기간연장의 승인 여부 및 연장할 수 있는 기간을 정하여 통지합니다.
【4개월을 초과하여 지정기간연장을 할 수 있는 사유】
① 기간만료 전 1개월 이내에 최초로 대리인을 선임하거나 선임된 대리인 모두를 해임·변경한 경우
② 기간만료 전 1개월 이내에 출원인변경신고서를 제출한 경우
③ 기간만료 전 2개월 이내에 외국특허청의 심사결과를 받은 경우로서 동 심사결과를 보정서에 반영하고자 하는 경우(이 경우 신청서 제출 시 해당 심사결과 사본 및 그 기초가 된 청구범위 사본도 같이 제출해야 함)
④ 의견제출통지서의 송달이 1개월 이상 지연된 경우(1개월 추가 연장 가능)
⑤ 원출원 또는 분할출원이 심판이나 소송에 계류 중인 경우
⑥ 거절이유와 관련된 시험 및 결과측정에 기간이 더 필요한 경우
⑦ 기타 불가피하게 기간연장이 필요하다고 인정되는 경우
단, 제3자가 심사청구한 때에는 ①~⑤의 경우라도 불승인

※ 이 통지서의 내용에 대해 문의사항이 있으시면 특허청 ☎ 042-481-8367(담당심사관 김영태)로, 서식 또는 절차에 대하여는 특허고객 상담센터 ☎1544-8080로 문의하시기 바랍니다.
☞ 특허청 주소 : (302-701) 대전광역시 서구 선사로 139 정부대전청사 특허청

# Electronic Acknowledgement Receipt

| | |
|---|---|
| **EFS ID:** | 9592406 |
| **Application Number:** | 12101019 |
| **International Application Number:** | |
| **Confirmation Number:** | 7368 |
| **Title of Invention:** | SPATIALLY ENHANCED TRANSFORM CODING |
| **First Named Inventor/Applicant Name:** | Jani Lainema |
| **Customer Number:** | 98359 |
| **Filer:** | Sanjeev K. Dhand |
| **Filer Authorized By:** | |
| **Attorney Docket Number:** | 0002-5481 |
| **Receipt Date:** | 10-MAR-2011 |
| **Filing Date:** | 10-APR-2008 |
| **Time Stamp:** | 18:37:06 |
| **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 | | IDS.pdf | 459068<br>7c0c0946c05e3cbeefcafce4726216bbe43afade | yes | 3 |

| | Multipart Description/PDF files in .zip description | | |
|---|---|---|---|
| | **Document Description** | **Start** | **End** |
| | Transmittal Letter | 1 | 2 |
| | Information Disclosure Statement (IDS) Filed (SB/08) | 3 | 3 |

**Warnings:**

**Information:**

| | | | | | |
|---|---|---|---|---|---|
| 2 | NPL Documents | KR_OA.pdf | 812537<br>e7462c51b2874598c7a4cb0898e0211cd9e6596d | no | 8 |

**Warnings:**

**Information:**

| | |
|---|---|
| **Total Files Size (in bytes):** | 1271605 |

**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.**

*IN THE UNITED STATES PATENT AND TRADEMARK OFFICE*

| | |
|---|---|
| Applicant: | Jani Lainema |
| Title: | SPATIALLY ENHANCED TRANSFORM CODING |
| Appl. No.: | 12/101,019 |
| Filing Date: | 04/10/2008 |
| Examiner: | DO, ANH HONG |
| Art Unit: | 2624 |
| Confirmation Number: | 7368 |

**INFORMATION DISCLOSURE STATEMENT UNDER 37 CFR §1.56**

Mail Stop Amendment
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Sir:

Submitted herewith on Form PTO/SB/08 is a listing of documents known to Applicants in order to comply with Applicants' duty of disclosure pursuant to 37 CFR §1.56.

A copy of each non-U.S. patent document and each non-patent document is being submitted to comply with the provisions of 37 CFR §1.97 and §1.98.

The submission of any document herewith, which is not a statutory bar, is not intended as an admission that such document constitutes prior art against the claims of the present application or that such document is considered material to patentability as defined in 37 CFR §1.56(b). Applicants do not waive any rights to take any action which would be appropriate to antedate or otherwise remove as a competent reference any document which is determined to be a *prima facie* art reference against the claims of the present application.



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## TIMING OF THE DISCLOSURE

The listed documents are being submitted in compliance with 37 CFR §1.97(b), before the mailing date of the first Office Action on the merits.

## RELEVANCE OF EACH DOCUMENT

All the documents are in English and from an office action for corresponding Korean Application No. 2009-7023527.

Applicants respectfully request that each listed document be considered by the Examiner and be made of record in the present application and that an initialed copy of Form PTO/SB/08 be returned in accordance with MPEP §609.

Although Applicant believes that no fee is required, the Commissioner is hereby authorized to charge any additional fees which may be due to Deposit Account No. 50-5302.

Respectfully submitted,

Date March 4, 2011

By /Sanjeev K. Dhand/

AlbertDhand LLP
Customer Number: 98359
Telephone: (858) 764-2453
Facsimile: (858) 430-4886

Sanjeev K. Dhand
Attorney for Applicant
Registration No. 51,182



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| APPLICATION NUMBER | PATENT NUMBER | GROUP ART UNIT | FILE WRAPPER LOCATION |
|---|---|---|---|
| 12/101,019 | | 2624 | |

OC000000047228914

## Correspondence Address/Fee Address Change

**The following fields have been set to Customer Number 12268 on 04/18/2011**

- **Correspondence Address**
- **Maintenance Fee Address**

**The address of record for Customer Number 12268 is:**

**12268**
**AlbertDhand LLP**
**11622 El Camino Real**
**Suite 100**
**San Diego, CA 92130**



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# UNITED STATES PATENT AND TRADEMARK OFFICE

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| APPLICATION NO. | FILING DATE | FIRST NAMED INVENTOR | ATTORNEY DOCKET NO. | CONFIRMATION NO. |
|---|---|---|---|---|
| 12/101,019 | 04/10/2008 | Jani Lainema | 00002-5481 | 7368 |

12268 7590 05/12/2011
AlbertDhand LLP
11622 El Camino Real
Suite 100
San Diego, CA 92130

| EXAMINER |
|---|
| DO, ANH HONG |

| ART UNIT | PAPER NUMBER |
|---|---|
| 2624 | |

| MAIL DATE | DELIVERY MODE |
|---|---|
| 05/12/2011 | 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.



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| Office Action Summary | Application No. | Applicant(s) | |
|---|---|---|---|
| | 12/101,019 | LAINEMA, JANI | |
| | Examiner | Art Unit | |
| | ANH DO | 2624 | |

*-- 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) 1-39 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) 1-39 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 10 April 2008 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 10/17/08, 7/29/10, 3/10/11.

4) ☐ Interview Summary (PTO-413) Paper No(s)/Mail Date. _____ .

5) ☐ Notice of Informal Patent Application

6) ☐ Other: _____.



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## DETAILED ACTION

### *Claim Rejections - 35 USC § 101*

1. 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.

2. Claims 1-12, 22-29, and 39 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, the steps of "calculating", "performing transform", "performing spatial", and "joining" in claim 1 are not tied to any particular machine/apparatus, therefore do not qualify as a statutory process. Similarly, claims 22 and 39 do not qualify as statutory processes.

3. Claims 13-21 and 30-38 are rejected under 35 U.S.C. 101 because the claimed invention is directed to non-statutory subject matter as follows. Claims 13-21 and 30-38 define a computer based structural organization embodying

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[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).

functional descriptive material. However, the claims do not define a computer readable medium or memory and is thus non-statutory for that reason (i.e., “when functional descriptive material is recorded on some computer-readable medium it becomes structurally and functionally interrelated to the medium and will be statutory in most cases since use of technology permits the function of the descriptive material to be realized” – Guidelines Annex IV). That is, the scope of the presently claimed a computer based structural organization can range from paper on which the program is written, to a program simply contemplated and memorized by a person. The Examiner suggests amending the claims to embody the program on “computer-readable medium” or equivalent in order to make the claim statutory. Any amendment to the claim should be commensurate with its corresponding disclosure.

### *Claim Rejections - 35 USC § 112*

2. The following is a quotation of the second paragraph of 35 U.S.C. 112:

> The specification shall conclude with one or more claims particularly pointing out and distinctly claiming the subject matter which the applicant regards as his invention.

3. Claim 30 is rejected under 35 U.S.C. 112, second paragraph, as being indefinite for failing to particularly point out and distinctly claim the subject matter which applicant regards as the invention.

4. Claim 30 recites the limitation "processes" in 2. There is insufficient antecedent basis for this limitation in the claim. Claim 19 recites an apparatus, not a process.

---

## *Contact Information*

Any inquiry concerning this communication or earlier communications from the examiner should be directed to ANH H. DO whose telephone number is 571-272-7433. The examiner can normally be reached on 5/4-9.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, JASON M. REPKO can be reached on 571-272-8624. The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300.

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).

May 09, 2011

/ANH H DO/
Primary Examiner, Art Unit 2624

| Notice of References Cited | Application/Control No. 12/101,019 | Applicant(s)/Patent Under Reexamination LAINEMA, JANI | |
|---|---|---|---|
| | Examiner ANH DO | Art Unit 2624 | Page 1 of 1 |

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| * | | Document Number Country Code-Number-Kind Code | Date MM-YYYY | Name | Classification |
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| * | B | US-5,598,214 | 01-1997 | Kondo et al. | 375/240.14 |
| * | C | US-4,125,861 | 11-1978 | Mounts et al. | 375/240.12 |
| | D | US- | | | |
| | E | US- | | | |
| | F | US- | | | |
| | G | US- | | | |
| | H | US- | | | |
| | I | US- | | | |
| | J | US- | | | |
| | K | US- | | | |
| | L | US- | | | |
| | M | US- | | | |

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|---|---|---|---|---|---|---|
| | N | JP02002152049A | 05-2002 | JAPAN | PELLY | H03M 007/36 |
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| * | | Include as applicable: Author, Title Date, Publisher, Edition or Volume, Pertinent Pages) |
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**CONFIRMATION NO. 7368**

| SERIAL NUMBER | FILING or 371(c) DATE | CLASS | GROUP ART UNIT | ATTORNEY DOCKET NO. |
|---|---|---|---|---|
| 12/101,019 | 04/10/2008<br>**RULE** | 382 | 2624 | 00002-5481 |

**APPLICANTS**
Jani Lainema, Tampere, FINLAND;

**** CONTINUING DATA ****************************
This appln claims benefit of 60/911,480 04/12/2007

**** FOREIGN APPLICATIONS ****************************

**** IF REQUIRED, FOREIGN FILING LICENSE GRANTED ****
04/28/2008

| Foreign Priority claimed | ☐ Yes ☑ No | | STATE OR COUNTRY | SHEETS DRAWINGS | TOTAL CLAIMS | INDEPENDENT CLAIMS |
|---|---|---|---|---|---|---|
| 35 USC 119(a-d) conditions met | ☐ Yes ☑ No | ☐ Met after Allowance | | | | |
| Verified and Acknowledged | /ANH HONG DO /<br>Examiner's Signature | Initials | FINLAND | 9 | 39 | 5 |

**ADDRESS**

AlbertDhand LLP
11622 El Camino Real
Suite 100
San Diego, CA 92130
UNITED STATES

**TITLE**

SPATIALLY ENHANCED TRANSFORM CODING

| FILING FEE RECEIVED | | |
|---|---|---|
| 2530 | 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 |

## EAST Search History

## EAST Search History (Prior Art)

| Ref # | Hits | Search Query | DBs | Default Operator | Plurals | Time Stamp |
|---|---|---|---|---|---|---|
| L1 | 3543 | difference and (prediction adj error) | USPAT | OR | OFF | 2011/05/09 09:18 |
| L2 | 0 | 1 and ((sample adj values) with (predicted adj block)) | USPAT | OR | OFF | 2011/05/09 09:19 |
| L3 | 21 | 1 and ((sample adj values) and (predicted adj block)) | USPAT | OR | OFF | 2011/05/09 09:19 |
| L4 | 0 | 3 and (spatial adj coding) | USPAT | OR | OFF | 2011/05/09 09:19 |
| L5 | 0 | 3 and (spatial near coding) | USPAT | OR | OFF | 2011/05/09 09:19 |
| L6 | 21 | 3 and spatial | USPAT | OR | OFF | 2011/05/09 09:20 |
| L7 | 0 | 6 and (second adj component) | USPAT | OR | OFF | 2011/05/09 09:20 |
| L8 | 0 | 6 and (second adj representation) | USPAT | OR | OFF | 2011/05/09 09:20 |
| L9 | 0 | 6 and (first adj representation) | USPAT | OR | OFF | 2011/05/09 09:20 |
| L10 | 0 | 6 and (first adj component) | USPAT | OR | OFF | 2011/05/09 09:20 |
| L11 | 629 | (first adj component) with difference | USPAT | OR | OFF | 2011/05/09 09:21 |
| L12 | 2 | 11 and 1 | USPAT | OR | OFF | 2011/05/09 09:21 |
| L13 | 325 | difference and (prediction adj error) | EPO; JPO | OR | OFF | 2011/05/09 09:23 |
| L14 | 1 | 13 and (first adj component) | EPO; JPO | OR | OFF | 2011/05/09 09:23 |
| L15 | 3469 | difference and (prediction adj error) | US-PGPUB | OR | OFF | 2011/05/09 09:25 |
| L16 | 3 | 15 and ((second adj component) with difference) | US-PGPUB | OR | OFF | 2011/05/09 09:26 |

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- Video
- encoding a prediction error signal for a block of data and calculating a differenc Search
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coding a predictio...:

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1. SPATIALLY ENHANCED **TRANSFORM CODING** - Patent application ...
... **encoding** a **prediction error signal** for a **block** of **data**, comprising:**calculating** a **difference signal representing differences between sample values** of a **predicted block** of **data** and **values** for an **original** ...
www.faqs.org/patents/app/20080260270 - Cached

2. Inter-frame predictive **encoding** system with **encoded** and ...
... **error representing** a **difference between** the **prediction signal** and a ... **difference between** the output **data** from ... of **calculating differences between** vectors in each **predicted** ...
www.freepatentsonline.com/4985768.html - Cached

3. FLAC - format
... **BLOCK_DATA** ... **data** (i.e. 44.1kHz, 2 channel, 16 bits per **sample**). The effect of the **encoding** ... **difference between** the **original signal** and the **predicted signal** (called the **error** ...
flac.sourceforge.net/format.html - Cached

4. METHOD AND APPARATUS FOR **CALCULATING** AN SSD AND **ENCODING** A ...
... **calculating** the Sum of Squared **Differences** (SSD) **between** a source **block** and a reconstructed **block** of image or video **data encoding** ... **prediction**: P [0111] Using the **original block S** and the **predicted block** P to compute the residual (**difference** ...
www.faqs.org/patents/app/20080243971 - Cached

5. Video **signal encoding** - Patent 4125861
... **signal** indicative of the **prediction error between** said **sample** and a **predicted** ... is a **block** diagram of a video **signal encoding** ... or **difference between** the **error signal** e ...
www.freepatentsonline.com/4125861.html - Cached

Amazon.com, Inc., Amazon.com Services LLC - Ex. 1002, Page 000161

US Patent # 5,598,214. Hierarchical **encoding** and decoding ...

... **difference between** the **predicted signal** and the **original** ... **values** g(c) **representing** an optimum **predicted** pixel **value** for each class. The **prediction calculating** ... **block data** ...

www.patents.com/us-5598214.html - Cached

US Patent # 5,966,179. Information **signal encoding** apparatus ...

... **difference signals representing differences between sample values** of the **input** digital information **signal**, (b) **block** ... **difference value between** the **data** d2 supplied from the average **value calculating** circuit 43 and the **predicted** ...

www.patents.com/us-5966179.html - Cached

3.

**Coding** Apparatus

... **block** of **sample values** of the **input signal** is **coded** by using **data** representative of a **difference between prediction** ... **difference** with a **data** quantity of **data representing** the **sample values** ...

www.docstoc.com/docs/49911949/Coding-Apparatus---Patent... - Cached

9.

Linear predictive **coding** - Factbites

... **calculating** the mean of the **error signals** in each **block** ... **difference between** the **predicted signal** and the **original**. ... **data** set, changing, smoothing and replacing **values** ...

www.factbites.com/topics/Linear-predictive-coding - Cached

0.

**Signal**-predictive audio transmission system - US Patent ...

... **prediction error signal** has ... the **difference between** an **original signal sample** ... **representing differences between** each **input sample** and a corresponding **predicted sample** ...

www.patentstorm.us/patents/7225135/-description.html - Cached

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www.yahoo.com

encoding a prediction error signal for a block of data and Search

1 2 3 4 5 Next >

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Amazon.com, Inc., Amazon.com Services LLC - Ex. 1002, Page 000168

Amazon.com, Inc., Amazon.com Services LLC - Ex. 1002, Page 000170

PTO/SB/08 (09-06)
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|---|---|---|---|---|---|
| **INFORMATION DISCLOSURE STATEMENT BY APPLICANT** | | | | **Application Number** | 12/101019 |
| | | | | **Filing Date** | 4/10/2008 |
| Date Submitted: October 10, 2008 | | | | **First Named Inventor** | Jani Lainema |
| | | | | Art Unit | ~~2624~~ 2624 |
| *(use as many sheets as necessary)* | | | | Examiner Name | ~~Unassigned~~ ANH HONG DO |
| Sheet | 1 | of | 1 | Attorney Docket Number | 037145-7826 |

**U.S. PATENT DOCUMENTS**

| Examiner Initials* | Cite No.[1] | Document Number / Number-Kind Code[2] (*if known*) | Publication Date MM-DD-YYYY | Name of Patentee or Applicant of Cited Document | Pages, Columns, Lines, Where Relevant Passages or Relevant Figures Appear |
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|---|---|---|---|
| | A1 | Santago P., et al. "Using Convex Set Techniques for Combined Pixel and Frequency Domaincoding of Time-Varying Images." IEEE Journal on Selected Areas in Communications, IEEE Service Center, vol. SAC-05, no. 7, 1 August 1987, pages 1127-1139. | |
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| | A4 | Wiegand T. et al. "Overview of the H.264/AVC video coding standard." IEEE Transactions on Circuits and Systems for Video Technology, IEEE Service Center, vol. 13, no. 7, July 1, 2003, pages 560-576. | |
| | A5 | Segall C. A. et al. "Pre- and post-processing algorithms for compressed video enhancements." Signals, Systems and Computers, 2000. Conference Record of the Thirty-Fourth Asilomar Conference on October 29- November 1, 2000, vol. 2, October 29, 2000, pages 1369-1373. | |
| | A6 | Copy of the International Search Report PCT Application No. PCT/IB2008/051351 | |

| Examiner Signature | /Anh Do/ | Date Considered | 05/09/2011 |
|---|---|---|---|

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DLMR_550129.1 ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /A.D./

| Search Notes | Application/Control No. | Applicant(s)/Patent under Reexamination | |
|---|---|---|---|
| | 12/101,019 | | |
| | Examiner | Art Unit | |
| | ANH DO | 2624 | |

| SEARCHED | | | |
|---|---|---|---|
| Class | Subclass | Date | Examiner |
| 382 | 238, 232, 166, 103, 173, 275, | 5/9/2011 | AD |
| 348 | 169, 581 | | |
| 704 | 500, 219, | | |
| | É9.0 | | |
| 375 | 240.12, | | |
| | 240.14, | | |
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| SEARCH NOTES (INCLUDING SEARCH STRATEGY) | | |
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| Index of Claims | Application/Control No. | Applicant(s)/Patent Under Reexamination |
|---|---|---|
| | 12101019 | LAINEMA, JANI |
| | **Examiner** | **Art Unit** |
| | ANH DO | 2624 |

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| ✓ | Rejected | - | Cancelled | N | Non-Elected | A | Appeal |
| = | Allowed | ÷ | Restricted | I | Interference | O | Objected |

☐ Claims renumbered in the same order as presented by applicant ☐ CPA ☐ T.D. ☐ R.1.47

| CLAIM | | DATE | | | | | | | | |
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| Final | Original | 05/09/2011 | | | | | | | | |
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| | 35 | ✓ | | | | | | | | |
| | 36 | ✓ | | | | | | | | |

| Index of Claims | Application/Control No. | Applicant(s)/Patent Under Reexamination |
|---|---|---|
| | 12101019 | LAINEMA, JANI |
| | **Examiner** | **Art Unit** |
| | ANH DO | 2624 |

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| ✓ | Rejected | - | Cancelled | N | Non-Elected | A | Appeal |
| = | Allowed | ÷ | Restricted | I | Interference | O | Objected |

☐ Claims renumbered in the same order as presented by applicant ☐ CPA ☐ T.D. ☐ R.1.47

| CLAIM | | DATE | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Final | Original | 05/09/2011 | | | | | | | | |
| | 37 | ✓ | | | | | | | | |
| | 38 | ✓ | | | | | | | | |
| | 39 | ✓ | | | | | | | | |



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Sheet 1 of 1

| *Complete if Known* | |
|---|---|
| Application Number | 12/101019 |
| Filing Date | 4/10/2008 |
| First Named Inventor | Jani Lainema |
| Art Unit | 2624 |
| Examiner Name | ~~[illegible]~~ ANH HONG DO |
| Attorney Docket Number | 037145-7828 |

**U.S. PATENT DOCUMENTS**

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|---|---|---|---|---|---|
| | A1 | 2007/0064797 | 03-22-2007 | MIAO ET AL. | |

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| Application Number | 12/101,019 |
| Filing Date | 04/10/2008 |
| First Named Inventor | Jani Lainema |
| Art Unit | 2624 |
| Examiner Name | DO, ANH HONG |
| Attorney Docket Number | 00002-5481 |

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From: 1962

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**Author**

- ☐ de With, P. (1)
- ☐ Farin, D. (1)
- ☐ Jungong Han (1)

**Affiliation**

- ☐ Eindhoven Univ. of Technol., Eindhoven (1)

**Publication Title**

- ☐ Circuits and Systems, 1999. ISCAS '99. Proceedings of the 1999 IEEE International Symposium on (5)
- ☐ Circuits and Systems for Video Technology, IEEE Transactions on (1)
- ☐ Proceedings of the IRE (1)
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PAT-NO: JP02002152049A

DOCUMENT-IDENTIFIER: JP 2002152049 A

TITLE: DATA PROCESSING APPARATUS AND DATA PROCESSING METHOD

PUBN-DATE: May 24, 2002


INVENTOR-INFORMATION:

| NAME | COUNTRY |
| --- | --- |
| PELLY, JASON CHARLES | N/A |

ASSIGNEE-INFORMATION:

| NAME | COUNTRY |
| --- | --- |
| SONY UNITED KINGDOM LTD | N/A |



APPL-NO: JP2001269264

APPL-DATE: September 5, 2001

PRIORITY-DATA: 2000200021769 ( September 5, 2000)

INT-CL (IPC): H03M007/36, H03M007/40



ABSTRACT:

PROBLEM TO BE SOLVED: To achieve modeling processing to enhance prediction accuracy by utilizing features of a data source.

SOLUTION: The data processing apparatus of this invention is provided with a first prediction processing circuit where a data symbol of a data source having first component data and second component data relating to the first component data is expressed as a modeled data symbol, a data symbol of the first component is predicted from preceding first and second component data symbols

to generate the modeled data symbol to express the first component data symbol.
A difference between the preceding first component data symbol and the
preceding second component data symbol corresponding to the preceding first
component data symbol is calculated and the difference is subtracted from the
second component symbol corresponding to the first component symbol to decide
the predicted first component symbol, the predicted value corresponding to the
first component symbol is subtracted from the first component symbol to
calculate a prediction error of the first component symbol and the modeled data
symbol is generated from the predicted error.

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## Inventor Name Search Result

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Last Name = LAINEMA
First Name = JANI

| Application# | Patent# | PG Pub# | Status | Date Filed | Title | Examiner Name | Inventor Name |
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| Application# | Patent# | PG Pub# | Status | Date Filed | Title | Examiner Name | Inventor Name |
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| 61434586 | Not Issued | | 20 | 01/20/2011 | Method for Coding and Apparatus | , | LAINEMA, JANI |
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**( Not for submission under 37 CFR 1.99)**

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| Application Number | 12101019 |
| Filing Date | 2008-04-10 |
| First Named Inventor | Lainema, Jani |
| Art Unit | 2624 |
| Examiner Name | Do, Anh Hong |
| Attorney Docket Number | 00002-5481 |

**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 | | | | | |

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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 |
|---|---|---|---|---|---|---|
| | 1 | | | | | |

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] i | 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 | | | | | | | ☐ |

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**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 | 12101019 |
|---|---|---|
| | Filing Date | 2008-04-10 |
| | First Named Inventor | Lainema, Jani |
| | Art Unit | 2624 |
| | Examiner Name | Do, Anh Hong |
| | Attorney Docket Number | 00002-5481 |

| | | | |
|---|---|---|---|
| | 1 | Office Action for Mexican Patent Application No. MX/a/2009/010921, dated March 23, 2011. | ☐ |
| | 2 | English translation of Office Action for Mexican Patent Application No. MX/a/2009/010921, dated March 23, 2011. | ☐ |

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 | 12101019 |
| | Filing Date | 2008-04-10 |
| | First Named Inventor | Lainema, Jani |
| | Art Unit | 2624 |
| | Examiner Name | Do, Anh Hong |
| | Attorney Docket Number | 00002-5481 |

**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.

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

☐ A certification statement is not submitted herewith.

**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 | /Sanjeev K. Dhand/ | Date (YYYY-MM-DD) | 2011-06-23 |
|---|---|---|---|
| Name/Print | Sanjeev K. Dhand | Registration Number | 51,182 |

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.**

Instituto Mexicano de Propiedad Industrial

*"2011, Año del Turismo en México"*

DIRECCION DIVISIONAL DE PATENTES
SUBDIRECCION DIVISIONAL DE EXAMEN DE FONDO DE PATENTES AREAS MECANICA, ELECTRICA Y DE REGISTROS DE DISEÑOS INDUSTRIALES Y MODELOS DE UTILIDAD
COORDINACION DEPARTAMENTAL DE EXAMEN DE FONDO AREA ELECTRICA
Expediente **MX/a/2009/010921** de Patente PCT.

P10/332

**Requisito 1** **Asunto:** Se comunica el resultado del examen de fondo.

México, D.F., a 23 de marzo de 2011

CATALINA LOZADA BROWN
Apoderado de
NOKIA CORPORATION
Insurgentes Sur 1722, Despacho 701
Col. Florida
01030, , Distrito Federal

No. de Folio: **21897**

RECIBI ORIGINAL
Nombre:
Fecha:
Firma:

HERRERO & ASOCIADOS
05 ABR 2011
RECIBIDO
ACOSTA SALDAÑA CA
FOLIO IFE 2605121

REF: Su solicitud No. MX/a/2009/010921 de Patente PCT presentada el 09 de Abril de 2008

Como resultado del examen de fondo, realizado con fundamento en los artículos 53 de la Ley de la Propiedad Industrial (LPI) y 42 del Reglamento de la Ley de la Propiedad Industrial (RLPI), se le comunica lo siguiente:

El examen fue realizado en base a los siguientes documentos de la solicitud:

Descripción: páginas 1 a la 25, como originalmente fueron presentadas.

Reivindicaciones: No.1 a la 39 como originalmente fueron presentadas.

Figuras: No. 1 a la 9 como originalmente fueron presentadas.

1. Durante el proceso de búsqueda practicado a la solicitud de patente se encontró el reporte preliminar de patentabilidad internacional **PCT/IB2008/051351**, correspondiente a la prioridad reclamada, No. de publicación **WO 2008/126019 A2** de fecha 23 **de octubre de 2008** practicado por la **Oficina Europea de Patentes (EPO)**, donde se citan documentos de categoría **X y Y**:

   - **SANTIAGO P ET AL: "USING CONVEX SET TECHNIQUES COMBINED PIXEL AND FRECUENCY DOMAINCODING OF THE TIME-VARYING IMAGES" IEEE JOURNAL ON SELECTED AREAS IN COMMUNICATIONS, IEEE SERVICE CENTER, PISCATAWAY, US, vol. SAC-05, no. 7, 1 August 1987 (1987-08-01), pages 1127-1139, XP001053635 ISSN: 0733-8716.**
   - **SEGALL C A ET AL: "Pre- and post-processing algorithms for compressed video enhancement" SIGNALS, SYSTEMS AND COMPUTERS, 2000, CONFERENCE ON OCT, 29 – NOV 1, 2000, PISCATAWAY, NJ, USA, IEEE, vol. 2, 29 October 2000 (2000-10-29), pages 1369-1373, XP010535224 ISBN: 978-0-7803-6514-8.**

   En cumplimiento a lo dispuesto por los artículos 54, 55 y 179 de la LPI y 43 y 44 del RLPI, se deberá presentar la traducción de los documentos citados que a su vez están señalados en dicho reporte, debido a que afecta **la novedad y actividad inventiva** de la presente solicitud de patente.

   Se anexa copia del reporte.

MX/2011/21897

Las aclaraciones o modificaciones realizadas ya sea en la descripción, en los dibujos y/o en las reivindicaciones, no deberán contener materia adicional con mayor alcance que la materia presentada originalmente en la solicitud y/o elementos que den soporte a reivindicaciones adicionales, de tal manera que se cumpla con lo establecido en el artículo 55 BIS LPI.

Asimismo deberá efectuar el pago que establece la tarifa vigente y exhibir el comprobante correspondiente.

Para que satisfaga estos requisitos, se le concede un plazo de dos meses contados a partir del día siguiente a la fecha en que se le notifique el presente oficio, apercibido que de no cumplir este requerimiento en el plazo señalado se considerará abandonada su solicitud de patente de conformidad con lo dispuesto por los arts. 55 y 58 de la Ley de la Propiedad Industrial.

El presente oficio corresponde al primer requerimiento de examen de fondo, el cual se emite, además de lo fundamentado anteriormente, conforme al artículo 13 del Acuerdo por el que se establecen Reglas y Criterios para la resolución de diversos trámites ante el Instituto Mexicano de la Propiedad industrial, publicado en el Diario Oficial de la Federación el día 9 de agosto de 2004.

El suscrito firma el presente oficio con fundamento en los artículos 6° fracciones III y XI y 7° bis 2 de la Ley de la Propiedad Industrial (Diario Oficial de la Federación (D.O.F.) 27/06/1991, reformada el 02/08/1994, 26/12/1997, 17/05/1999, 26/01/2004, 16/06/2005 y 25/01/2006); artículos 1°, 3° fracción V inciso a) sub inciso iii), 4° y 12° fracciones I, II, III, IV y VI del Reglamento del Instituto Mexicano de la Propiedad Industrial (D.O.F. 14/12/1999, reformado el 01/07/2002, 15/07/2004, 28/07/2004 y 7/09/2007); artículos 1°, 3°, 5° fracción V inciso a) sub inciso iii), 16 fracciones I, II, III, IV y VI y 30 del Estatuto Orgánico del Instituto Mexicano de la Propiedad Industrial (D.O.F. 27/12/1999, reformado el 10/10//2002, 29/07/2004, 04/08/2004 y 13/09/2007); 1°, 3° y 5° incisos e) e i) y penúltimo párrafo del Acuerdo que delega facultades en los Directores Generales Adjuntos, Coordinador, Directores Divisionales, Titulares de las Oficinas Regionales, Subdirectores Divisionales, Coordinadores Departamentales y otros subalternos del Instituto Mexicano de la Propiedad Industrial. (D.O.F. 15/12/1999, reformado el 04/02/2000, 29/07/2004, 04/08/2004 y 13/09/2007).

A T E N T A M E N T E
**EL COORDINADOR DEPARTAMENTAL**

**ING. HECTOR JAVIER SANCHEZ VARGAS**

ABQ/DDP.6.2011.2



Amazon.com, Inc., Amazon.com Services LLC - Ex. 1002, Page 000199

*1.- During the prior art search conducted for the present application, it has been found the International Preliminary Report on Patentability* [copy enclosed] *for the PCT application* ***PCT/IB2008/051351,*** *that corresponds to the claimed priority, publication Number* ***WO 2008/126019 A2*** *dated* ***October 23, 2008*** *and carried out by the* ***European Patent Office (EPO)****, in the IPRP, there are cited documents classified as "X" and "Y", namely:*

***D1 [X] SANTAGO P ET AL: "USING CONVEX SET TECHNIQUES FOR COMBINED PIXEL AND FREQUENCY DOMAIN CODING OF TIME-VARYING IMAGES" IEEE JOURNAL ON SELECTED AREAS IN COMMUNICATIONS, IEEE SERVICE CENTER, PISCATAWAY, US, vol. SAC-05, no. 7, 1 August 1987 (1987-08-01), pages 1127-1139, XP001053635 ISSN: 0733-8716.***

***D2 [A] SEGALL C A ET AL: "Pre- and post-processing algorithms for compressed video enhancement" SIGNALS, SYSTEMS AND COMPUTERS, 2000. CONFERENCE RECORD OF THE THIRTY- FOURTH ASILOMAR CONFERENCE ON OCT. 29 - NOV. 1, 2000, PISCATAWAY, NJ, USA,IEEE, vol. 2, 29 October 2000 (2000-10-29), pages 1369-1373, XP010535224 ISBN: 978-0-7803-6514-8.***

*Therefore, according to articles 54, 55 and 179 of the Mexican Patent Law and Articles 43 and 44 of its Regulations, applicant should file a Spanish translation of said documents cited in IPRP, since they affect the novelty and the inventive step of the present patent application.*

# Electronic Acknowledgement Receipt

| | |
|---|---|
| **EFS ID:** | 10368019 |
| **Application Number:** | 12101019 |
| **International Application Number:** | |
| **Confirmation Number:** | 7368 |
| **Title of Invention:** | SPATIALLY ENHANCED TRANSFORM CODING |
| **First Named Inventor/Applicant Name:** | Jani Lainema |
| **Customer Number:** | 12268 |
| **Filer:** | Sanjeev K. Dhand |
| **Filer Authorized By:** | |
| **Attorney Docket Number:** | 00002-5481 |
| **Receipt Date:** | 23-JUN-2011 |
| **Filing Date:** | 10-APR-2008 |
| **Time Stamp:** | 14:39:48 |
| **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 | Information Disclosure Statement (IDS) Form (SB08) | IDS_23JUN2011.pdf | 28363<br>37d2d1b2df311df5e35b4fa5b7ff817ea21f150c | no | 3 |

**Warnings:**

**Information:**

| This is not an USPTO supplied IDS fillable form | | | | | |
|---|---|---|---|---|---|
| 2 | Non Patent Literature | MX_Office_Action_23MAR2011.pdf | 148304<br>f27f26ae327843c95b98308ca4d566205df14242 | no | 2 |
| **Warnings:** | | | | | |
| **Information:** | | | | | |
| 3 | Non Patent Literature | English_Translation_of_MX_OA.pdf | 45511<br>3c1078b7d4c9e6d87f4833c590277244f0756c5d | no | 1 |
| **Warnings:** | | | | | |
| **Information:** | | | | | |
| | | | **Total Files Size (in bytes):** | 222178 | |

**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.**

***IN THE UNITED STATES PATENT AND TRADEMARK OFFICE***

Applicant: Lainema

Title: SPATIALLY ENHANCED TRANSFORM CODING

Appl. No.: 12/101,019

Filing Date: 04/10/2008

Examiner: Do, Anh Hong

Art Unit: 2624

Confirmation Number: 7368

AMENDMENT AND REPLY UNDER 37 C.F.R. § 1.111

Mail Stop AMENDMENT
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Sir:

This communication is responsive to the non-final Office Action dated May 12, 2011, concerning the above-referenced patent application.

**Amendments to the Claims** are reflected in the listing of claims which begins on page 2 of this document.

**Remarks/Arguments** begin on page 9 of this document.

Please amend the application as follows:



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**Amendments to the Claims:**

This listing of claims will replace all prior versions, and listings, of claims in the application:

**Listing of Claims:**

1. (Currently Amended) A method ~~of encoding a prediction error signal for a block of data~~, comprising:

calculating, by a processor, a difference signal representing differences between sample values of a predicted block of data and values for an original input block;

performing, by a processor, transform coding to the difference signal, thereby creating a first representation of a first component of the difference signal;

performing, by a processor, spatial coding to the difference signal, thereby creating a second representation of a first component of the difference signal; [[and]]

joining, by a processor, the first and second representations to form a coded prediction error signal; and

at least one of transmitting or storing the coded prediction error signal.

2. (Original) The method of claim 1, further comprising, before performing transform coding and spatial coding, substituting outlier values in the difference signal with non-outlier values to create a modified prediction error signal.

3. (Original) The method of claim 2, wherein transform coding is applied to the modified prediction error signal and spatial coding is applied to a residual thereof.

4. (Original) The method of claim 2, wherein spatial coding is applied to the modified prediction error signal and transform coding is applied to a residual thereof.

5. (Original) The method of claim 1, wherein, for transform coding, at least one transform coefficient is set to zero.



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6. (Original) The method of claim 1, wherein, for spatial coding, at least one spatial sample is set to zero.

7. (Original) The method of claim 2, wherein the non-outlier values used to replace the outlier values comprise an average of neighboring prediction error values.

8. (Original) The method of claim 1, further comprising providing an indication that no transform coefficients exist in the block of data if appropriate.

9. (Original) The method of claim 1, further comprising providing an indication that no spatial samples exist in the block of data if appropriate.

10. (Original) The method of claim 1, wherein for the transform coding, a transform coefficient is formed, the transform coefficient comprising a weighting coefficient of a discrete transform basis vector.

11. (Original) The method of claim 10, wherein the discrete transform comprises a discrete orthogonal transform.

12. (Currently Amended) A computer program product, embodied in a <u>non-transitory</u> computer-readable medium, comprising computer code configured to perform the ~~implemented the processes~~ <u>method</u> of claim 1.

13. (Original) An apparatus, comprising:

a processor; and

a memory unit communicatively connected to a controller and comprising:

computer code for performing transform coding to the difference signal, thereby creating a first representation of a first component of the difference signal;



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computer code for performing spatial coding to the difference signal, thereby creating a second representation of a first component of the difference signal; and

computer code for joining the first and second representations.

14. (Original) The apparatus of claim 13, wherein the memory unit further comprises computer code for, before performing transform coding and spatial coding, substituting outlier values in the difference signal with non-outlier values to create a modified prediction error signal.

15. (Original) The apparatus of claim 14, wherein transform coding is applied to the modified prediction error signal and spatial coding is applied to a residual thereof.

16. (Original) The apparatus of claim 14, wherein spatial coding is applied to the modified prediction error signal and transform coding is applied to a residual thereof.

17. (Original) The apparatus of claim 13, wherein, for transform coding, at least one transform coefficient is set to zero.

18. (Original) The apparatus of claim 13, wherein, for spatial coding, at least one spatial sample is set to zero.

19. (Original) The apparatus of claim 13, wherein the non-outlier values used to replace the outlier values comprise an average of neighboring prediction error values.

20. (Original) The apparatus of claim 13, further comprising providing an indication that no transform coefficients exist in the block of data if appropriate.

21. (Original) The apparatus of claim 13, further comprising providing an indication that no spatial samples exist in the block of data if appropriate.



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22. (Currently Amended) A method ~~of decoding a prediction error signal for a block of data~~, comprising:

receiving a coded prediction error signal, the coded prediction error signal including a plurality of transform coefficients and a plurality of spatial samples;

decoding, by a processor, the plurality of transformed coefficients into decoded transform information;

decoding, by a processor, the plurality of spatial samples into decoded spatial information; and

adding, by a processor, the decoded transform information, the decoded spatial information, and a reconstructed prediction of the block of data, thereby forming a decoded representation of the block of data.

23. (Original) The method of claim 22, wherein an indication is provided that no transform coefficients exist in the block of data if appropriate.

24. (Original) The method of claim 22, wherein an indication is provided that that no spatial samples exist in the block of data if appropriate.

25. (Original) The method of claim 22, wherein the decoding of the plurality of transformed coefficients and spatial samples includes dequantization of each, and wherein the dequantization of transformed coefficients and spatial samples are related to each other.

26. (Original) The method of claim 22, wherein the decoding of the plurality of transformed coefficients and spatial samples includes dequantization of each, and wherein the dequantization of transformed coefficients and spatial samples are different from each other.

27. (Original) The method of claim 22, wherein the decoding of the spatial samples is dependent upon the decoding of the transformed coefficients.



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28. (Original) The method of claim 22, wherein the decoding of the transformed coefficients is dependent upon the decoding of the spatial samples.

29. (Original) The method of claim 22, wherein at least some of the plurality of spatial samples are decoded as a single unit.

30. (Currently Amended) A computer program product, embodied in a non-transitory computer-readable medium, comprising computer code configured to perform the ~~processes~~ method of ~~claim 19~~ claim 22.

31. (Original) An apparatus, comprising:

a processor; and

a memory unit communicatively connected to the processor and including:

computer code for processing a received coded prediction error signal, the coded prediction error signal including a plurality of transformed coefficients and a plurality of spatial samples;

computer code for decoding the plurality of transformed coefficients into decoded transform information;

computer code for decoding the plurality of spatial samples into decoded spatial information; and

computer code for adding the decoded transform information, the decoded spatial information, and a reconstructed prediction of the block of data, thereby forming a decoded representation of the block of data.

32. (Original) The apparatus of claim 31, wherein an indication is provided that no transform coefficients exist in the block of data if appropriate.

33. (Original) The apparatus of claim 31, wherein an indication is provided that that no spatial samples exist in the block of data if appropriate.



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34. (Original) The apparatus of claim 31, wherein the decoding of the plurality of transformed coefficients and spatial samples includes dequantization of each, and wherein the dequantization of transformed coefficients and spatial samples are related to each other.

35. (Original) The apparatus of claim 31, wherein the decoding of the plurality of transformed coefficients and spatial samples includes dequantization of each, and wherein the dequantization of transformed coefficients and spatial samples are different from each other.

36. (Original) The apparatus of claim 31, wherein the decoding of the spatial samples is dependent upon the decoding of the transformed coefficients.

37. (Original) The apparatus of claim 31, wherein the decoding of the transformed coefficients is dependent upon the decoding of the spatial samples.

38. (Original) The apparatus of claim 31, wherein at least some of the plurality of spatial samples are decoded as a single unit.

39. (Currently Amended) A method ~~of encoding a prediction error signal for a block of data~~, comprising:

calculating<u>, by a processor,</u> a difference signal representing differences between sample values of a predicted block of data and values for an original input block;

substituting<u>, by a processor,</u> outlier values in the difference signal with non-outlier values to create a modified prediction error signal;

performing<u>, by a processor,</u> one of transform coding and spatial coding to the modified prediction error signal, creating one of a transform coded data and spatial coded data

performing<u>, by a processor,</u> an inverse of the one of transform coding and spatial coding;



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applying, by a processor, the other of transform coding and spatial coding to a residual from the inverse transform or spatial decoding, creating the other of transform coded data and spatial coded data; [[and]]

joining, by a processor, the transform coded data and the spatial coded data to form a coded prediction error signal; and

at least one of transmitting or storing the coded prediction error signal.



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REMARKS

Applicant respectfully requests reconsideration of the present application in view of the foregoing amendments and in view of the reasons that follow.

Claims 1, 12, 22, 30 and 39 are currently being amended.

This amendment adds, changes and/or deletes claims in this application. A detailed listing of all claims that are, or were, in the application, irrespective of whether the claim(s) remain under examination in the application, is presented, with an appropriate defined status identifier.

After amending the claims as set forth above, claims 1-39 remain pending in this application.

Claim Rejections under 35 U.S.C. § 101

Claims 1-12, 22-29 and 39 were rejected under 35 U.S.C. § 101 as allegedly being directed to statutory subject matter.

As to claim 1, Applicant has amended claim 1 to recite "at least one of transmitting or storing the coded prediction error signal." Support for this feature may be found in the originally filed specification and drawings at, for example, paragraph [0003]. Further, Applicant has amended claim 1 to clarify that the various steps are performed by a processor. Therefore, claim 1, as well as dependent claims 2-12, are now directed to statutory subject matter.

As to claim 22, Applicant respectfully notes that claim 22 already recites "receiving a coded prediction error signal …." Further, Applicant has amended claim 22 to clarify that the various steps are performed by a processor. Therefore, claim 22, as well as dependent claims 23-29, are directed to statutory subject matter.

As to claim 39, Applicant has amended claim 39 to recite "at least one of transmitting or storing the coded prediction error signal." Support for this feature may be found in the



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originally filed specification and drawings at, for example, paragraph [0003]. Further, Applicant has amended claim 39 to clarify that the various steps are performed by a processor. Therefore, claim 39 is now directed to statutory subject matter.

Claims 13-21 and 30-38 were rejected under 35 U.S.C. § 101 as allegedly being directed to statutory subject matter. Applicant respectfully traverses this rejection for at least the following reasons.

The Examiner argues that the claims to no define a computer readable medium or memory and suggests "amending the claims to embody the program on 'computer-readable medium.' " Office Action dated May 12, 2011, page 3.

As to claims 13 and 31, Applicant respectfully notes that claims 13 and 31 each recite "a memory unit … including" computer code. Thus, these claims already recite a computer readable medium ("memory unit"). Accordingly, claims 13 and 31, as well as dependent claims 14-21 and 32-38, are directed to statutory subject matter.

As to claim 30, Applicant has amended the claim to recite that the computer program product is "embodied on a non-transitory computer-readable medium."

Accordingly, the rejections under 35 U.S.C. § 101 should be withdrawn.

Claim Rejection under 35 U.S.C. § 112

Claim 30 was rejected under 35 U.S.C. § 112, second paragraph, as allegedly being indefinite. Applicant has amended claim 30 to correct the language objected to by the Examiner. The claim is now in definite form, and the rejection under 35 U.S.C. § 112 should be withdrawn.

Conclusion

Applicant believes that the present application is now in condition for allowance. Favorable reconsideration of the application as amended is respectfully requested.



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The Examiner is invited to contact the undersigned by telephone if it is felt that a telephone interview would advance the prosecution of the present application.

The Commissioner is hereby authorized to charge any additional fees which may be required regarding this application under 37 C.F.R. §§ 1.16-1.17, or credit any overpayment, to Deposit Account No. 50-5302. Should no proper payment be enclosed herewith, as by the credit card payment instructions in EFS-Web being incorrect or absent, resulting in a rejected or incorrect credit card transaction, the Commissioner is authorized to charge the unpaid amount to Deposit Account No. 50-5302. If any extensions of time are needed for timely acceptance of papers submitted herewith, Applicant hereby petitions for such extension under 37 C.F.R. §1.136 and authorizes payment of any such extensions fees to Deposit Account No. 50-5302.

Respectfully submitted,

Date August 11, 2011 By /Sanjeev K. Dhand/

ALBERTDHAND LLP
Customer Number: 12268
Telephone: (858) 764-2453
Facsimile: (858) 430-4886

Sanjeev K. Dhand
Attorney for Applicant
Registration No. 51,182



Amazon.com, Inc., Amazon.com Services LLC - Ex. 1002, Page 000213

# Electronic Acknowledgement Receipt

| | |
|---|---|
| **EFS ID:** | 10721070 |
| **Application Number:** | 12101019 |
| **International Application Number:** | |
| **Confirmation Number:** | 7368 |
| **Title of Invention:** | SPATIALLY ENHANCED TRANSFORM CODING |
| **First Named Inventor/Applicant Name:** | Jani Lainema |
| **Customer Number:** | 12268 |
| **Filer:** | Sanjeev K. Dhand/Karen LePari |
| **Filer Authorized By:** | Sanjeev K. Dhand |
| **Attorney Docket Number:** | 00002-5481 |
| **Receipt Date:** | 11-AUG-2011 |
| **Filing Date:** | 10-APR-2008 |
| **Time Stamp:** | 19:48:30 |
| **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_11AUG2011.pdf | 116673<br>06cbcfd68d15abbd49cf487c3d322298a4bd6d68 | yes | 11 |

| | Multipart Description/PDF files in .zip description | | |
|---|---|---|---|
| | **Document Description** | **Start** | **End** |
| | Amendment/Req. Reconsideration-After Non-Final Reject | 1 | 1 |
| | Claims | 2 | 8 |
| | Applicant Arguments/Remarks Made in an Amendment | 9 | 11 |

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| **Warnings:** | |
| **Information:** | |
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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/08a (01-10)
Approved for use through 07/31/2012. OMB 0651-0031
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# INFORMATION DISCLOSURE STATEMENT BY APPLICANT

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

| | |
|---|---|
| Application Number | 12101019 |
| Filing Date | 2008-04-10 |
| First Named Inventor | Lainema, Jani |
| Art Unit | 2624 |
| Examiner Name | Do, Anh Hong |
| Attorney Docket Number | 00002-5481 |

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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 |
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| | 1 | | | | | |

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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 | 12101019 |
| | Filing Date | 2008-04-10 |
| | First Named Inventor | Lainema, Jani |
| | Art Unit | 2624 |
| | Examiner Name | Do, Anh Hong |
| | Attorney Docket Number | 00002-5481 |

| | | | |
|---|---|---|---|
| | 1 | Office Action for Chinese Patent Application No. 200880017526.3., dated May 18, 2011. | ☐ |
| | 2 | English translation of Office Action for Chinese Patent Application No. 200880017526.3., dated May 18, 2011. | ☐ |

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

**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 | 12101019 |
|---|---|---|
| | Filing Date | 2008-04-10 |
| | First Named Inventor | Lainema, Jani |
| | Art Unit | 2624 |
| | Examiner Name | Do, Anh Hong |
| | Attorney Docket Number | 00002-5481 |

**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.

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

☐ A certification statement is not submitted herewith.

**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 | /Sanjeev K. Dhand/ | Date (YYYY-MM-DD) | 2011-08-12 |
|---|---|---|---|
| Name/Print | Sanjeev K. Dhand | Registration Number | 51,182 |

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.**

## 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 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.

中华人民共和国国家知识产权局 EF090968P

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北京市朝阳区东三环中路1号环球金融中心办公楼东楼20层 北京市金杜律师事务所

鄢迅

发文日：

2011年05月18日

2KJ

申请号或专利号：200880017526.3　　发文序号：2011051400038440

申请人或专利权人：诺基亚公司

发明创造名称：空间增强的变换编码

# 第一次审查意见通知书

（进入国家阶段的PCT申请）

1. ☒应申请人提出的实质审查请求，根据专利法第35条第1款的规定，国家知识产权局对上述发明专利申请进行实质审查。
   ☐根据专利法第35条第2款的规定，国家知识产权局决定自行对上述发明专利申请进行实质审查。
2. ☒申请人要求以其在：
   US专利局的申请日2007年04月12日为优先权日。
3. ☐经审查，申请人于____提交的修改文件，不符合专利法实施细则第51条第1款的规定，不予接受。
4. ☐审查是针对原始提交的国际申请的中文文本或中文译文进行的。
   ☒审查是针对下列申请文件进行的：
   依据专利合作条约第28条或者第41条提交的修改，权利要求第1-58项；
   2009年11月25日提交的说明书第1-46段、说明书附图、说明书摘要、摘要附图。
5. ☒本通知书引用下列对比文献（其编号在今后的审查过程中继续沿用）

| 编号 | 文件号或名称 | 公开日期（或抵触申请的申请日） |
|---|---|---|
| 1 | USING CONVEX SET TECHNIQUES FOR COMBINED PIXEL AND FREQUENCY DOMAINCODING OF TIME-VARYING IMAGES; 1987-08-01, 《IEEE JOURNAL ON SELECTED AREAS IN COMMUNICATIONS, IEEE SERVICE CENTER, PISCATAWAY, US》, 第5卷，第7期，第1129页到第1132页 | 19870801 |

6. 审查的结论性意见：
   关于说明书：
   ☐申请的内容属于专利法第5条规定的不授予专利权的范围。
   ☐说明书不符合专利法第26条第3款的规定。
   ☐说明书不符合专利法第33条的规定。
   ☐说明书的撰写不符合专利法实施细则第17条的规定。
   ☐____
   关于权利要求书：
   ☐权利要求____不符合专利法第2条第2款的规定。

中华人民共和国国家知识产权局 专利审查业务章

210402
2010.2

纸件申请，回函请寄：100088 北京市海淀区蓟门桥西土城路6号 国家知识产权局专利局受理处收
电子申请，应当通过电子专利申请系统以电子文件形式提交相关文件。除另有规定外，以纸件等其他形式提交的文件视为未提交。



Amazon.com, Inc., Amazon.com Services LLC - Ex. 1002, Page 000220

☐ 权利要求____不符合专利法第 9 条第 1 款的规定。
☒ 权利要求 1, 22, 40, 51 不具备专利法第 22 条第 2 款规定的新颖性。
☒ 权利要求 2-11, 23-26, 41-50, 52-55 不具备专利法第 22 条第 3 款规定的创造性。
☐ 权利要求____不具备专利法第 22 条第 4 款规定的实用性。
☒ 权利要求 12, 30 属于专利法第 25 条规定的不授予专利权的范围。
☒ 权利要求 13-14, 27-29, 31, 36-39, 56-58 不符合专利法第 26 条第 4 款的规定。
☐ 权利要求____不符合专利法第 31 条第 1 款的规定。
☐ 权利要求____不符合专利法第 33 条的规定。
☐ 权利要求____不符合专利法实施细则第 19 条的规定。
☐ 权利要求____不符合专利法实施细则第 20 条的规定。
☐ 权利要求____不符合专利法实施细则第 21 条的规定。
☐ 权利要求____不符合专利法实施细则第 22 条的规定。
☐ ____

☐ 申请不符合专利法第 26 条第 5 款或者实施细则第 26 条的规定。
☐ 申请不符合专利法第 20 条第 1 款的规定。
☐ 分案申请不符合专利法实施细则第 43 条第 1 款的规定。

上述结论性意见的具体分析见本通知书的正文部分。

7. 基于上述结论性意见，审查员认为：

☐ 申请人应当按照通知书正文部分提出的要求，对申请文件进行修改。

☒ 申请人应当在意见陈述书中论述其专利申请可以被授予专利权的理由，并对通知书正文部分中指出的不符合规定之处进行修改，否则将不能授予专利权。

☐ 专利申请中没有可以被授予专利权的实质性内容，如果申请人没有陈述理由或者陈述理由不充分，其申请将被驳回。

☐ ____

8. 申请人应注意下列事项：

（1）根据专利法第 37 条的规定，申请人应当在收到本通知书之日起的 4 个月内陈述意见，如果申请人无正当理由逾期不答复，其申请将被视为撤回。

（2）申请人对其申请的修改应当符合专利法第 33 条的规定，不得超出原说明书和权利要求书记载的范围，同时申请人对专利申请文件进行的修改应当符合专利法实施细则第 51 条第 3 款的规定，按照本通知书的要求进行修改。

（3）申请人的意见陈述书和／或修改文本应当邮寄或递交国家知识产权局专利局受理处，凡未邮寄或递交给受理处的文件不具备法律效力。

（4）未经预约，申请人和／或代理人不得前来国家知识产权局与审查员举行会晤。

9. 本通知书正文部分共有 4 页，并附有下列附件：

☐ 引用的对比文件的复印件共____份____页。

☐ ____

审查员：陈德锋　　联系电话：62411501　　审查部门：通信发明审查部

专利审查业务章

# 中华人民共和国国家知识产权局

## 第一次审查意见通知书

（进入国家阶段的PCT申请）

申请号:2008800175263

OMJ

本申请涉及一种空间增强的变换编码，经审查，现提出如下审查意见。

1、权利要求1不具备专利法第二十二条第二款所规定的新颖性。

权利要求1要求保护一种用于编码针对数据块的预测误差信号的方法，对比文件1也公开了一种编码预测误差信号的方法，并具体公开了以下的技术特征（参见第1129页右栏第53行到第1131页左栏第25行，第1132页右栏第50行到第57行、图5）：该方法包括以下步骤：计算帧差（相当于表示预测的数据块的样本值和原始输入块的值之间的差值的差值信号）；通过图5中的变换模块对差值信号进行变换编码，得到变换编码后的值（相当于差值信号的第一分量的第一表示）；指示像素值在前后两帧中是否改变的值称为掩码，通过图5中的掩码编码器对掩码进行编码（相当于对差值信号执行空间编码），得到对掩码进行编码后的值（相当于差值信号的第一分量的第二表示）；通过图5的POCS模块将变换编码和掩码编码后的值合并（相当于合并所述第一表示和第二表示）。该权利要求所要求保护的技术方案与该对比文件所公开的内容相比，所不同的仅仅是文字表达方式上略有差别，其技术方案实质上是相同的，且两者属于相同的技术领域，解决相同的技术问题，并能产生相同的技术效果，因此该权利要求所要求保护的技术方案不具备新颖性。

2、权利要求2-4，7不具备专利法第二十二条第三款规定的创造性。

在对预测误差信号进行编码时，为了保证编码的准确性，而将异常值替换为非异常值，该非异常值可以为相邻预测误差值的平均值，以及根据实际需要，对修改后的预测误差信号或者其残差分别应用变换编码或空间编码属于本领域技术人员的常用技术手段，由此可知，在对比文件1的基础上结合本领域的公知常识，得到上述权利要求所要求保护的技术方案，对本领域技术人员来说是显而易见的。因此上述权利要求所要求保护的技术方案不具有突出的实质性特点和显著的进步，因而不具备创造性。

3、权利要求5-6，8-9不具备专利法第二十二条第三款规定的创造性。

在进行变换编码和空间编码时，为了改进编码的性能，而将至少一个变换系数或者至少一个空间样本设置为0对本领域技术人员来说是常见的，属于本领域的公知常识。在对图像块进行编码时，指示特定的图像区域不存在变换系数或者空间样本也属于本领域技术人员的常用技术手段，由此可知，在对比文件1的基础上结合本领域的公知常识，得到上述权利要求所要求保护的技术方案，对本领域技术人员来说是显而易见的。因此上述权利要求所要求保护的技术方案



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不具有突出的实质性特点和显著的进步，因而不具备创造性。

4、权利要求 10-11 不具备专利法第二十二条第三款规定的创造性。

对比文件1已经公开了对于变换编码，形成变换系数（参见说明书第1130页右栏第37行到1131页左栏第4行）。对于本领域技术人员来说，该变换系数包括离散变换基础向量的加权系数，以及该离散变换包括离散正交变换都属于本领域的公知常识，由此可知，在对比文件1的基础上结合本领域的公知常识，得到上述权利要求所要求保护的技术方案，对本领域技术人员来说是显而易见的。因此上述权利要求所要求保护的技术方案不具有突出的实质性特点和显著的进步，因而不具备创造性。

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5、权利要求 12，30 请求保护一种计算机程序产品，而计算机程序属于智力活动的规则和方法，属于专利法第二十五条第一款第二项所述的智力活动的规则和方法的范围，不属于专利法的保护的客体,因此不能被授予专利权。

6、权利要求 13-14 不符合专利法第二十六条第四款的规定。

权利要求13-14请求保护一种用于编码数据的设备,其包括由计算机代码限定的存储器单元,由于有关计算机代码限定的内容既不是结构特征,也不是方法特征,因此上述权利要求的保护范围不清楚,未清楚的表述出所请求保护的是一种具有怎样结构的用于编码数据的设备, 因而不符合专利法第二十六条第四款的规定。

基于同样的理由，权利要求 31 也不符合专利法第二十六条第四款的规定。

需要提醒申请人的是，申请人如果要以产品的形式保护其计算机程序流程，则应按照审查指南第二部分第九章 5.2 规定的方式撰写。

7、权利要求22不具备专利法第二十二条第二款所规定的新颖性。

权利要求22要求保护一种解码针对数据块的预测误差信号的方法，对比文件1公开了一种编码预测误差信号的方法，并具体公开了以下的技术特征（参见第1129页右栏第53行到第1131页左栏第25行，第1132页右栏第50行到第57行、图5）：该方法包括以下步骤：计算帧差（相当于表示预测的数据块的样本值和原始输入块的值之间的差值的差值信号）；通过图5中的变换模块对差值信号进行变换编码，得到变换编码后的值（相当于差值信号的第一分量的第一表示）；指示像素值在前后两帧中是否改变的值称为掩码，通过图5中的掩码编码器对掩码进行编码（相当于对差值信号执行空间编码），得到对掩码进行编码后的值（相当于差值信号的第一分量的第二表示）；通过图5的POCS模块将变换编码和掩码编码后的值合并（相当于给出第一表示和第二表示）。要对对比文件1所公开的编码方法进行相应的编码，必然会首先接收编码后的包括多个变换系数和多个空间样本的预测误差信号，并分别对多个变换系数和空间样本进行解码，



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并利用所述解码后的变换信息、空间信息以及数据块的重构预测相加，以形成数据块的解码表示。因此，该权利要求的技术特征已经被对比文件1隐含公开，该权利要求所要求保护的技术方案与该对比文件所公开的内容相比，所不同的仅仅是文字表达方式上略有差别，其技术方案实质上是相同的，且两者属于相同的技术领域，解决相同的技术问题，并能产生相同的技术效果，因此该权利要求所要求保护的技术方案不具备新颖性。

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8、权利要求23-26不具备专利法第二十二条第三款规定的创造性。

在对图像块进行解码时，指示特定的图像区域不存在变换系数或者空间样本属于本领域技术人员的常用技术手段；另外，对本领域技术人员来说，在解码的过程中，对多个变换系数和空间样本进行去量化处理也是常见的处理，变换的系数和空间样本的去量化既可以彼此相关也可以彼此不同，这也属于本领域的公知常识；由此可知，在对比文件 1 的基础上结合本领域的公知常识，得到上述权利要求所要求保护的技术方案，对本领域技术人员来说是显而易见的。因此上述权利要求所要求保护的技术方案不具有突出的实质性特点和显著的进步，因而不具备创造性。

9、权利要求 27-29 没有以说明书为依据，不符合专利法第二十六条第四款的规定。

权利要求27-29的附加技术特征在说明书中没有记载，说明书中并没有记载空间样本的解码和变换的系数的解码之间的相互依赖关系，也没有记载多个空间样本中的至少一些被解码为单个单元，并且所属技术领域的技术人员也无法从说明书充分公开的内容中得到或概括得出该技术方案。因此该权利要求没有以说明书为依据，不符合专利法第二十六条第四款的规定。

基于同样的理由，权利要求 36-38，56-58 也没有以说明书为依据，不符合专利法第二十六条第四款的规定。

10、权利要求 39 不符合专利法第二十六条第四款的规定。

该权利要求中出现了“对修改的预测误差信号执行变换编码和空间编码之一，创建变换编码的数据和空间编码的数据之一；执行反向的变换编码和空间编码之一”，其包含了只执行变换编码后，又只执行反向的空间编码，在没有进行空间编码之前，显然不能执行反向的空间编码，因此上述表述的逻辑不清楚；另外，该权利要求中还出现了“对来自反向变换解码或反向空间解码的残差应用所述变换编码和空间编码中的另一个，创建变换编码的数据和空间编码的数据中的另一个”，本领域技术人员不清楚“变换编码和空间编码中的另一个”，“变换编码的数据和空间编码的数据中的另一个”具体指代的是什么，该不清楚之处导致该权利要求保护的范围不清楚，申请人应该对此进行修改，同时注意修改不得超出原中请文件记载的范围。

11、权利要求40不具备专利法第二十二条第二款所规定的新颖性。

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权利要求40是对应于方法权利要求1的装置权利要求，其技术特征是一一对应的，基于评述权利要求1的理由，权利要求40也不具备专利法第二十二条第二款所规定的新颖性。

12、权利要求41-50不符合专利法第二十二条第三款有关创造性的规定。

从属权利要求 41-50 对于“一种用于编码针对数据块的预测误差信号的设备”进行进一步限定的附加技术特征与从属权利要求 2-11 的对于“一种用于编码针对数据块的预测误差信号的方法”进行进一步限定的附加技术特征是一一对应的，基于评述权利要求 2-11 的理由，权利要求41-50也不具备创造性。

13、权利要求51不具备专利法第二十二条第二款所规定的新颖性。

权利要求51是对应于方法权利要求22的装置权利要求，其技术特征是一一对应的，基于评述权利要求22的理由，权利要求51也不具备专利法第二十二条第二款所规定的新颖性。

14、权利要求52-55不符合专利法第二十二条第三款有关创造性的规定。

从属权利要求 52-55 对于“一种用于解码针对数据块的预测误差信号的设备”进行进一步限定的附加技术特征与从属权利要求23-26的对于“一种用于解码针对数据块的预测误差信号的方法”进行进一步限定的附加技术特征是一一对应的，基于评述权利要求23-26的理由，权利要求52-55也不具备创造性。

申请人应当在本通知书指定的答复期限内对本通知书提出的问题逐一进行答复，必要时应修改专利申请文件,否则本申请将难以获得批准。申请人对申请文件的修改应当符合专利法第三十三条的规定，不得超出原说明书和权利要求书记载的范围。

申请人提交的修改文件应当包括：修改涉及部分的原文复印件，在该复印件上标注出所作的增加、删除或替换；重新打印的替换页（一式两份），用于替换相应的原文。申请人应当确保上述两部分在内容上的一致性。

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审查员姓名：[redacted]
审查员代码：[redacted]



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# The Patent Office of the People's Republic of China

Address: No. 6 XITUCHENG ROAD, JIMEN BRIDGE, HAIDIAN DISTRICT, BEIJING Post Code: 100088

| Applicant: **NOKIA CORPORATION** | ISSUING DATE: |
|---|---|
| Agent: **Xun FENG** | Date:18 Month:05 Year:2011 |
| Application No.: 200880017526.3 | |
| Title: SPATIALLY ENHANCED TRANSFORM CODING | |

## THE FIRST OFFICE ACTION

(PCT Application Entering the Chinese National Phase)

1. ☒ According to Article 35 Paragraph 1 of the Patent Law, the examiner conducted a substantive examination to the above-mentioned patent application upon the applicant's request.

   ☐ According to Article 35 paragraph 2 of the Patent Law, Chinese Patent Office decided on its own initiative to conduct a substantive examination to the above-mentioned patent application.

2. ☒ The applicant requested to take

   April 12, 2007 on which an application is filed with the US patent office as the priority date.

   _____ on which an application is filed with the _____ patent office as the priority date.

   _____ on which an application is filed with the _____ patent office as the priority date.

3. ☐ The amended document(s) submitted on Year____Month____Day____ is/are not in conformity with Rule 51 of the Implementing Regulations.

4. ☐ The examination has been conducted based on the Chinese translation of the international application text as originally filed.

   ☒ The examination has been conducted based on the following text(s):

   Claims 1-58 filed under Rule 28/41 of PCT;

   Paragraphs 1-46, accompanying drawings, abstract, and abridged figure filed on November 25, 2009.

5. ☒ The following reference document(s) is/are cited (the reference numeral(s) thereof will be used in the examination procedure thereafter)

| No. | Reference No. or Title | Publishing Date (or filing date of conflicting application) |
|---|---|---|
| 1 | USING CONVEX SET TECHNIQUES FOR COMBINED PIXEL AND FREQUENCY DOMAINCODING OF TIME-VARYING IMAGES; August 1, 1987, <<IEEE JOURNAL ON SELECTED AREAS IN COMMUNICATIONS, IEEE SERVICE CENTER, PISCATAWAY, US>>, VOL. 5, NO. 7, PAGES 1129-1132 | August 1, 1987 |
| 2 | | |
| 3 | | |

6. Concluding comments

   ☐ on the specification:

   ☐ The inventions belong to unpatentable subject matter as prescribed by Article 5 of the Patent Law.

   ☐ The specification is not in conformity with the provision of Article 26, paragraph 3 of the Patent Law.

   ☐ The writing of the specification is not in conformity with the provision of Article 33 of the Patent Law.

   ☐ The writing of the specification is not in conformity with the provision of Rule 17 of the Implementing Regulations.



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☒ on the claims:

☐ Claim(s)_____do(es) not comply with the provision of Article 2 paragraph 2 of the Patent Law.

☐ Claim(s)_____do(es) not comply with the provision of Article 9 paragraph 1 of the Patent Law.

☒ Claim(s) 1, 22, 40, 51 do(es) not possess novelty as requested by Article 22 paragraph 2 of the Patent Law.

☒ Claim(s) 2-11, 23-26, 41-50, 52-55 do(es) not possess inventiveness as requested by Article 22 paragraph 3 of the Patent Law.

☐ Claim(s)_____do(es) not possess practical applicability as requested by Article 22 paragraph 4 of the Patent Law.

☒ Claim(s) 12, 30 belong(s) to non-patentable subject matter as prescribed by Article 25 of the Patent law.

☒ Claim(s) 13-14, 27-29, 31, 36-39, 56-58 do(es) not comply with the provision of Article 26 paragraph 4 of the Patent Law.

☐ Claim(s)_____do(es) not comply with the provision of Article 31 paragraph 1 of the Patent Law.

☐ Claim(s)_____do(es) not comply with the provision of Article 33 of the Patent Law.

☐ Claim(s)_____do(es) not comply with provision of Rule 19 of the Implementing Regulations.

☐ Claim(s)_____do(es) not comply with the provision of Rule 20 of the Implementing Regulations.

☐ Claim(s)_____do(es) not comply with the provision of Rule 21 of the Implementing Regulations.

☐ Claim(s)_____do(es) not comply with the provision of Rule 22 of the Implementing Regulations.

☐ Application do(es) not comply with the provision of Article 26 paragraph 5 of the Patent Law or Rule 26 of the Implementing Regulations.

☐ Application do(es) not comply with the provision of Article 20 paragraph 1 of the Patent Law..

☐ Divisional application do(es) not comply with the provision of Rule 43 paragraph 1 of the Implementing Regulations.

The detailed analysis for the above concluding comments is presented on the text of this Office Action.

7. Based on the above concluding comments, the examiner is of the opinion that

☐ The applicant should amend the application document(s) in accordance with the requirement as specified in the Office Action.

☒ The applicant should, in his observation, expound the patentability of the application, and amend the defects pointed out in the Office Action; or the application can hardly be approved.

☐ The examiner deems that the application lacks substantive features to make it patentable. Therefore, the application will be rejected if no convincing reasons are provided to prove its patentability.

☐

8. The applicant should pay attention to the following matters:

(1) According to Article 37 of the Patent Law, the applicant is required to submit his observations within 4 months upon receipt of this Office Action. If the time limit for making response is not met without any justified reason, the application will be deemed to have been withdrawn.

(2) The amendment(s) made by the applicant must meet the requirements of Article 33 of the Patent Law. The amended text should be in duplicate, its format should conform to the related confinement in the Guidelines for Patent Examination.

(3) The observation and/of the amended document(s) must be mailed or delivered to the Receiving Section of the Chinese Patent Office. No legal effect shall apply for any document(s) that are not mailed to or reached the Receiving Section.

(4) The applicant and/or the agent should not go to the Chinese Patent Office to interview the examiner without being invited.

9. The text of this Office Action contains 4 page(s), and has the following attachment(s):

☐_____copies of the cited references, all together_____pages.



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# Text of the First Office Action

(PCT application in Chinese national phase)

The present application relates to spatially enhanced transform coding. Upon examination, comments are hereby presented as follows:

1. Claim 1 lacks novelty under Article 22.2 of the Chinese Patent Law.

Claim 1 recites a method of encoding a prediction error signal for a block of data. D1 also discloses a method of encoding a prediction error signal and specifically reveals the following technical features (see page 1129, right column, line 53-page 1131, left column, line 25; page 1132, right column, lines 50-57 of the description and Fig.5): the method comprises the following steps: calculating a frame difference (corresponding to "calculating a difference signal representing differences between sample values of a predicted block of data and values for an original input block"); performing transform coding to the difference signal by means of a transform module in Fig.5 to obtain a transform coded value (corresponding to "a first representation of a first component of the difference signal"); performing, through a mask coder in Fig.5, coding to the mask which is a value indicating whether a pixel value changes in two adjacent frames (corresponding to "performing spatial coding to the difference signal") to obtain a mask coded value (corresponding to "a second representation of a first component of the difference signal"); joining the transform coded value and the mask coded value through a POCS module shown in Fig.5 (corresponding to "joining the first and second representations"). The only difference between the technical solution as claimed in Claim 1 and the contents disclosed in D1 resides in the slight difference in literal expression, and the two technical solutions are substantively the same, fall into the same technical field, solve the same technical problem and produce the same technical effect. Therefore, the technical solution recited in Claim 1 lacks novelty.

2. Claims 2-4 and 7 lack an inventive step under Article 22.3 of the Chinese Patent Law.

It is commonly-used technical means for those skilled in the art to substitute outlier values with non-outlier values to ensure the coding accuracy upon coding the prediction error signal, the non-outlier values being an average of



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neighboring prediction error values, and to respectively apply transform coding or spatial coding to the modified prediction error signal or a residual thereof. Therefore, it is obvious for those skilled in the art to obtain the claimed technical solutions of Claims 2-4 and 7 on the basis of D1 in conjunction with the common knowledge in the art. Accordingly, the technical solutions recited in said claims neither have any prominent substantive features nor represent any notable progress and hence lack an inventive step.

3. Claims 5-6 and 8-9 lack an inventive step under Article 22.3 of the Chinese Patent Law.

Upon performing transform coding and spatial coding, it is common for those skilled in the art and common general knowledge in the art to set at least one transform coefficient or at least one spatial sample to be zero in order to improve the coding performance; upon performing coding to image blocks, it is common technical means for those skilled in the art to provide an indication that no transform coefficients or no spatial samples exist in the specific image areas. Therefore, it is obvious for those skilled in the art to obtain the claimed technical solutions of Claims 5-6 and 8-9 on the basis of D1 in conjunction with the common knowledge in the art. Accordingly, the technical solutions recited in said claims neither have any prominent substantive features nor represent any notable progress and hence lack an inventive step.

4. Claims 10-11 lack an inventive step under Article 22.3 of the Chinese Patent Law.

D1 already discloses for the transform coding, a transform coefficient is formed (see page 1130, right column, line 37-page 1131, left column, line 4 of the description of D1). It is common knowledge for those skilled in the art that the transform coefficient comprises a weighting coefficient of a discrete transform basis vector, and the discrete transform comprises a discrete orthogonal transform. Therefore, it is obvious for those skilled in the art to obtain the claimed technical solutions of Claims 10-11 on the basis of D1 in conjunction with the common knowledge in the art. Accordingly, the technical solutions recited in said claims neither have any prominent substantive features nor represent any notable progress and hence lack an inventive step.

5. Claims 12 and 30 recite a computer program product. However, a computer program belongs to rules and methods for metal activities and falls



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within the scope of rules and methods for mental activities as set forth in Article 25.1(2) of the Chinese Patent Law and does not belong to subject matter as protected in the Chinese Patent Law. Hence, said claims cannot be granted a patent right.

6. Claims 13-14 fail to meet the requirement of Article 26.4 of the Chinese Patent Law.

Claims 13-14 recite an apparatus for encoding data, comprising a memory unit defined by a computer code. The contents limited by the computer code are neither structural features nor method features. Hence, the protection scope of said claims is unclear, and said claims do not clearly indicate what structure the recited apparatus for encoding data has. Hence, said claims fail to meet the requirement of Article 26.4 of the Chinese Patent Law.

For the same reasons, Claim 31 also fails to meet the requirement of Article 26.4 of the Chinese Patent Law.

Applicant is reminded herein that if Applicant wants to protect the computer program flow in the form of a product, he shall draft it in a manner as set out in Patent Examination Guidelines, Part II, Chapter 9, Section 5.2.

7. Claim 22 lacks novelty under Article 22.2 of the Chinese Patent Law.

Claim 22 recites a method of decoding a prediction error signal for a block of data. D1 also discloses a method of encoding a prediction error signal and specifically reveals the following technical features (see page 1129, right column, line 53-page 1131, left column, line 25; page 1132, right column, lines 50-57 of the description and Fig.5): the method comprises the following steps: calculating a frame difference (corresponding to "calculating a difference signal representing differences between sample values of a predicted block of data and values for an original input block"); performing transform coding to the difference signal by means of a transform module in Fig.5 to obtain a transform coded value (corresponding to "a first representation of a first component of the difference signal"); performing, through a mask coder in Fig.5, coding to the mask which is a value indicating whether a pixel value changes in two adjacent frames (corresponding to "performing spatial coding to the difference signal") to obtain a mask coded value (corresponding to "a second representation of a first component of the difference signal"); joining the transform coded value and the mask coded value through a POCS module shown in Fig.5 (corresponding to



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"joining the first and second representations"). In order to perform decoding with respect to the coding method disclosed in D1, it is necessary to first receive a coded prediction error signal, the coded prediction error signal including a plurality of transform coefficients and a plurality of spatial samples, decode the plurality of transformed coefficients and the plurality of spatial samples, and add the decoded transform information, the decoded spatial information, and a reconstructed prediction of the block of data, thereby forming a decoded representation of the block of data. Therefore, the technical features of Claim 22 have already been implicitly disclosed in D1. The only difference between the technical solution as claimed in Claim 22 and the contents disclosed in D1 resides in the slight difference in literal expression, and the two technical solutions are substantively the same, fall into the same technical field, solve the same technical problem and produce the same technical effect. Therefore, the technical solution recited in Claim 22 lacks novelty.

8. Claims 23-26 lack an inventive step under Article 22.3 of the Chinese Patent Law.

Upon performing decoding to image blocks, it is common technical means for those skilled in the art to provide an indication that no transform coefficients or no spatial samples exist in the specific image areas. Besides, dequantizing a plurality of transformed coefficients and spatial samples is common processing during decoding for those skilled in the art. It is common knowledge in the art that the dequantization of transformed coefficients and spatial samples are either related to each other or different from each other. Therefore, it is obvious for those skilled in the art to obtain the claimed technical solutions of Claims 23-26 on the basis of D1 in conjunction with the common knowledge in the art. Accordingly, the technical solutions recited in said claims neither have any prominent substantive features nor represent any notable progress and hence lack an inventive step.

9. Claims 27-29 are not supported by the description and fail to comply with Article 26.4 of the Chinese Patent Law.

The additional technical features of Claims 27-29 are not disclosed in the description. The description does not disclose the mutual dependence between the decoding of the spatial samples and the decoding of the transformed coefficients, nor discloses at least some of the plurality of spatial



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samples are decoded as a single unit. Furthermore, those skilled in the art cannot obtain or summarize to get the technical solution from the contents sufficiently disclosed in the description. Hence, Claims 27-29 are not supported by the description and fail to comply with Article 26.4 of the Chinese Patent Law.

For the same reason, Claims 36-38 and 56-58 are not supported by the description and fail to comply with Article 26.4 of the Chinese Patent Law.

10. Claim 39 fails to meet the requirement of Article 26.4 of the Chinese Patent Law.

Claim 39 recites *inter alia* "performing one of transform coding and spatial coding to the modified prediction error signal, creating one of a transform coded data and spatial coded data; performing an inverse of the one of transform coding and spatial coding". The foregoing recitation includes only performing transform coding, then only performing an inverse of spatial coding. It is obviously impossible to perform an inverse of spatial coding without performing spatial coding. Therefore, the foregoing recitation is unclear in logic. Besides, Claim 39 recites *inter alia* "applying the other of transform coding and spatial coding to a residual from the inverse transform or spatial decoding, creating the other of transform coded data and spatial coded data". Those skilled in the art are not clear about what is specifically referred to by "the other of transform coding and spatial coding" and "the other of transform coded data and spatial coded data". The unclarity renders the protection scope of said claim unclear. Applicant shall make amendments thereto and meanwhile note that any amendment may not go beyond the scope of the original application documents.

11. Claim 40 lacks novelty under Article 22.2 of the Chinese Patent Law.

Claim 40 is an apparatus claim corresponding to the method Claim 1, and the technical features of Claim 40 correspond to those of Claim 1. For the reasons as stated in Claim 1, Claim 40 lacks novelty under Article 22.2 of the Chinese Patent Law.

12. Claims 41-50 lack an inventive step under Article 22.3 of the Chinese Patent Law.

The additional technical features of dependent Claims 41-50 further limiting "an apparatus for encoding a prediction error signal for a block of data" correspond to the additional technical features of dependent Claims 2-11 further defining "a method of encoding a prediction error signal for a block of data". For



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the reasons as in the comments on Claims 2-11, Claims 41-50 lack an inventive step.

13. Claim 51 lacks novelty under Article 22.2 of the Chinese Patent Law.

Claim 51 is an apparatus claim corresponding to the method Claim 22, and the technical features of Claim 51 correspond to those of Claim 22. For the reasons as stated in Claim 22, Claim 51 lacks novelty under Article 22.2 of the Chinese Patent Law.

14. Claims 52-55 lack an inventive step under Article 22.3 of the Chinese Patent Law.

The additional technical features of dependent Claims 52-55 further limiting "an apparatus for decoding a prediction error signal for a block of data" correspond to the additional technical features of dependent Claims 23-26 further defining "a method of decoding a prediction error signal for a block of data". For the reasons as in the comments on Claims 23-26, Claims 52-55 lack an inventive step.

Applicant should make a response to all the problems specified in the Office Action herein within the prescribed time period for response and amend the application documents if necessary; otherwise, the present application is unlikely to be approved. Any amendments to the application documents should comply with Article 33 of the Chinese Patent Law and may not exceed the scope of disclosure contained in the original description and claims.

The amended documents to be submitted by Applicant should include: a copy of the parts of the original to which amendments are made and on which pertinent addition, deletion and substitution are marked with red pen; a copy of printed replacement sheets for substituting the corresponding parts of the original. Applicant should ensure the foregoing two parts in conformity with each other in content.



Amazon.com, Inc., Amazon.com Services LLC - Ex. 1002, Page 000233

# Electronic Acknowledgement Receipt

| | |
|---|---|
| **EFS ID:** | 10725908 |
| **Application Number:** | 12101019 |
| **International Application Number:** | |
| **Confirmation Number:** | 7368 |
| **Title of Invention:** | SPATIALLY ENHANCED TRANSFORM CODING |
| **First Named Inventor/Applicant Name:** | Jani Lainema |
| **Customer Number:** | 12268 |
| **Filer:** | Sanjeev K. Dhand/Karen LePari |
| **Filer Authorized By:** | Sanjeev K. Dhand |
| **Attorney Docket Number:** | 00002-5481 |
| **Receipt Date:** | 12-AUG-2011 |
| **Filing Date:** | 10-APR-2008 |
| **Time Stamp:** | 15:30:47 |
| **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 | Information Disclosure Statement (IDS) Form (SB08) | IDS_12AUG2011.pdf | 612319<br>8562ba32ab0c69119d6d9d592b1f7f9d17a0250d | 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.

| | | | | | |
|---|---|---|---|---|---|
| 2 | Non Patent Literature | CH_Office_Action_18MAY2011.pdf | 2048261<br>e668d5a8385a2c4d0144db2d4166abfba1ca7c02 | no | 6 |
| **Warnings:** | | | | | |
| **Information:** | | | | | |
| 3 | Non Patent Literature | English_Translation_CH_Office_Action_18MAY2011.pdf | 5777555<br>7e72786f38900a2c02f7a2b0b6696dae0d06053c | no | 8 |
| **Warnings:** | | | | | |
| **Information:** | | | | | |
| | | | **Total Files Size (in bytes):** | 8438135 | |

**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.**

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 |
|---|---|---|
| 12/101,019 | 04/10/2008 | |

## 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 08/11/2011 | (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)) | * 39 | Minus | ** 20 | = 19 | X $ = | | OR | X $52= | 988 |
| Independent (37 CFR 1.16(h)) | * 5 | Minus | ***3 | = 2 | X $ = | | OR | X $220= | 440 |
| ☐ 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 | 1428 |

| 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:
/MARCUS PRIDGEN/

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

# NOTICE OF ALLOWANCE AND FEE(S) DUE

12268 7590 09/16/2011
AlbertDhand LLP
11622 El Camino Real
Suite 100
San Diego, CA 92130

| EXAMINER |
|---|
| DO, ANH HONG |

| ART UNIT | PAPER NUMBER |
|---|---|
| 2624 | |

DATE MAILED: 09/16/2011

| APPLICATION NO. | FILING DATE | FIRST NAMED INVENTOR | ATTORNEY DOCKET NO. | CONFIRMATION NO. |
|---|---|---|---|---|
| 12/101,019 | 04/10/2008 | Jani Lainema | 00002-5481 | 7368 |

TITLE OF INVENTION: SPATIALLY ENHANCED TRANSFORM CODING

| 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 | 12/16/2011 |

**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.**



PTOL-85 (Rev. 02/11)

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# 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)

12268 7590 09/16/2011
AlbertDhand LLP
11622 El Camino Real
Suite 100
San Diego, CA 92130

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. |
|---|---|---|---|---|
| 12/101,019 | 04/10/2008 | Jani Lainema | 00002-5481 | 7368 |

TITLE OF INVENTION: SPATIALLY ENHANCED TRANSFORM CODING

| 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 | 12/16/2011 |

| EXAMINER | ART UNIT | CLASS-SUBCLASS |
|---|---|---|
| DO, ANH HONG | 2624 | 382-238000 |

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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UNITED STATES PATENT AND TRADEMARK OFFICE

**UNITED STATES DEPARTMENT OF COMMERCE**
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Alexandria, Virginia 22313-1450
www.uspto.gov

| APPLICATION NO. | FILING DATE | FIRST NAMED INVENTOR | ATTORNEY DOCKET NO. | CONFIRMATION NO. |
|---|---|---|---|---|
| 12/101,019 | 04/10/2008 | Jani Lainema | 00002-5481 | 7368 |

12268 7590 09/16/2011
AlbertDhand LLP
11622 El Camino Real
Suite 100
San Diego, CA 92130

| EXAMINER |
|---|
| DO, ANH HONG |

| ART UNIT | PAPER NUMBER |
|---|---|
| 2624 | |

DATE MAILED: 09/16/2011

**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 700 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 700 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.





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## 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) | |
|---|---|---|---|
| | 12/101,019 | LAINEMA, JANI | |
| | Examiner | Art Unit | |
| | ANH DO | 2624 | |

***-- 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 *Amendment 8/11/2011*.

2. ☐ An election was made by the applicant in response to a restriction requirement set forth during the interview on _____; the restriction requirement and election have been incorporated into this action.

3. ☒ The allowed claim(s) is/are *1-39*.

4. ☐ 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**.

5. ☐ 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.

6. ☐ 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).**

7. ☐ 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 See Continuation Sheet
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 _____.

/ANH H DO/
Primary Examiner, Art Unit 2624



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Continuation of Attachment(s) 3. Information Disclosure Statements (PTO/SB/08), Paper No./Mail Date: 6/23/20011 + 8/12/2011.

## DETAILED ACTION

### *Response to Arguments*

1. Applicant's arguments, see Remarks (pages 9 and 10), filed 8/11/2011, with respect to claims 1-39 have been fully considered and are persuasive. The rejection of claims 1-39 has been withdrawn.

### *Allowable Subject Matter*

2. Claims 1-39 are allowed.

3. The following is an examiner's statement of reasons for allowance:

* The rejected claims have been amended to overcome the rejection under 35 U.S.C. 101 and 112, second paragraph;

* The present invention provides a new method and system for coding and decoding digital video material, so as to allow for the utilization of selected transform basis functions that give good overall representation of the image block with minimum amount of transform coefficients (specification, page 4, paragraph [0011]).

Particularly, the new method and system comprise the following features, which the prior art taken either singly or in combination does not teach:

- joining, by a processor, the first and second representations to form a coded prediction error signal (see independent claims 1 and 13);

- adding, by a processor, the decoded transform information, … of the block of data (see independent claims 22 and 31);

- joining, by a processor, the transform coded data and the spatial coded data to form a coded prediction error signal (see independent claim 39).

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."

***Contact Information***

Any inquiry concerning this communication or earlier communications from the examiner should be directed to ANH H. DO whose telephone number is 571-272-7433. The examiner can normally be reached on 5/4-9.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, JASON M. REPKO can be reached on 571-272-8624. The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300.

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).

September 12, 2011

/ANH H DO/
Primary Examiner, Art Unit 2624

PTO/SB/08a (01-10)
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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| **INFORMATION DISCLOSURE STATEMENT BY APPLICANT** ( **Not for submission under 37 CFR 1.99)** | | |
|---|---|---|
| | Application Number | 12101019 |
| | Filing Date | 2008-04-10 |
| | First Named Inventor | Lainema, Jani |
| | Art Unit | 2624 |
| | Examiner Name | Do, Anh Hong |
| | Attorney Docket Number | 00002-5481 |

| **U.S.PATENTS** | | | | | | Remove |
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ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /A.D./

| INFORMATION DISCLOSURE STATEMENT BY APPLICANT ( Not for submission under 37 CFR 1.99) | Application Number | 12101019 |
|---|---|---|
| | Filing Date | 2008-04-10 |
| | First Named Inventor | Lainema, Jani |
| | Art Unit | 2624 |
| | Examiner Name | Do, Anh Hong |
| | Attorney Docket Number | 00002-5481 |

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|---|---|---|---|
| | 1 | Office Action for Chinese Patent Application No. 200880017526.3., dated May 18, 2011. | ☐ |
| | 2 | English translation of Office Action for Chinese Patent Application No. 200880017526.3., dated May 18, 2011. | ☐ |

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**EXAMINER SIGNATURE**

| Examiner Signature | /Anh Do/ | Date Considered | 09/12/2011 |
|---|---|---|---|

*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.

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EFS Web 2.1.17

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /A.D./

| Search Notes | Application/Control No. | Applicant(s)/Patent under Reexamination | |
|---|---|---|---|
| | 12/101,019 | LAINEMA, JANI | |
| | Examiner | Art Unit | |
| | ANH DO | 2624 | |

| SEARCHED | | | |
|---|---|---|---|
| Class | Subclass | Date | Examiner |
| 382 | 238, 232, 166, 103, 173, 275, | 5/9/2011 | AD |
| 348 | 169, 581 | | |
| 704 | 500, 219, | | |
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| SEARCH NOTES (INCLUDING SEARCH STRATEGY) | | |
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| Index of Claims | Application/Control No. | Applicant(s)/Patent Under Reexamination |
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| | 12101019 | LAINEMA, JANI |
| | **Examiner** | **Art Unit** |
| | ANH DO | 2624 |

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☐ Claims renumbered in the same order as presented by applicant ☐ CPA ☐ T.D. ☐ R.1.47

| CLAIM | | DATE | | | | | | | | |
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| Index of Claims | Application/Control No. | Applicant(s)/Patent Under Reexamination |
|---|---|---|
| | 12101019 | LAINEMA, JANI |
| | **Examiner** | **Art Unit** |
| | ANH DO | 2624 |

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|---|---|---|---|---|---|---|---|
| ✓ | Rejected | - | Cancelled | N | Non-Elected | A | Appeal |
| = | Allowed | ÷ | Restricted | I | Interference | O | Objected |

☐ Claims renumbered in the same order as presented by applicant ☐ CPA ☐ T.D. ☐ R.1.47

| CLAIM | | DATE | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Final | Original | 09/12/2011 | | | | | | | | |
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# INFORMATION DISCLOSURE STATEMENT BY APPLICANT

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

| | |
|---|---|
| Application Number | 12101019 |
| Filing Date | 2008-04-10 |
| First Named Inventor | Lainema, Jani |
| Art Unit | 2624 |
| Examiner Name | Do, Anh Hong |
| Attorney Docket Number | 00002-5481 |

**U.S.PATENTS**

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| INFORMATION DISCLOSURE STATEMENT BY APPLICANT ( Not for submission under 37 CFR 1.99) | Application Number | 12101019 |
|---|---|---|
| | Filing Date | 2008-04-10 |
| | First Named Inventor | Lainema, Jani |
| | Art Unit | 2624 |
| | Examiner Name | Do, Anh Hong |
| | Attorney Docket Number | 00002-5481 |

| | | | |
|---|---|---|---|
| | 1 | Office Action for Mexican Patent Application No. MX/a/2009/010921, dated March 23, 2011. | ☐ |
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**EXAMINER SIGNATURE**

| Examiner Signature | /Anh Do/ | Date Considered | 09/12/2011 |
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ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /A.D./

| Issue Classification | Application/Control No. 12/101,019 | Applicant(s)/Patent under Reexamination LAINEMA, JANI |
|---|---|---|
| | Examiner ANH DO | Art Unit 2624 |

# ISSUE CLASSIFICATION

| ORIGINAL | | INTERNATIONAL CLASSIFICATION | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| CLASS | SUBCLASS | CLAIMED | | | | | NON-CLAIMED | | | |
| 382 | 236 | G | 6 | K | 9 | /46 | | | | / |
| CROSS REFERENCES | | | | | | | | | | |
| CLASS | SUBCLASS (ONE SUBCLASS PER BLOCK) | | | | | / | | | | / |
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|---|---|---|
| NONE (Assistant Examiner) (Date) | /ANH HONG DO/ 9/12/2011 (Primary Examiner) (Date) | Total Claims Allowed: 39 |
| (Legal Instruments Examiner) (Date) | | O.G. Print Claim(s) 1 / O.G. Print Fig. 4 |

☒ 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 | Final | Original |
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| | 29 | | 59 | | 89 | | 119 | | 149 | | 179 | | 209 |
| | 30 | | 60 | | 90 | | 120 | | 150 | | 180 | | 210 |

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12268 7590 09/16/2011
AlbertDhand LLP
11622 El Camino Real
Suite 100
San Diego, CA 92130

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|---|---|
| Marisol Moretto | (Depositor's name) |
| /Marisol Moretto/ | (Signature) |
| November 4, 2011 | (Date) |

| APPLICATION NO. | FILING DATE | FIRST NAMED INVENTOR | ATTORNEY DOCKET NO. | CONFIRMATION NO. |
|---|---|---|---|---|
| 12/101,019 | 04/10/2008 | Jani Lainema | 00002-5481 | 7368 |

TITLE OF INVENTION: SPATIALLY ENHANCED TRANSFORM CODING

| APPLN. TYPE | SMALL ENTITY | ISSUE FEE DUE | PUBLICATION FEE DUE | PREV. PAID ISSUE FEE | TOTAL FEE(S) DUE | DATE DUE |
|---|---|---|---|---|---|---|
| nonprovisional | NO | $1740 ~~XXXXX~~ | $300 | $0 | ~~XXXX~~ $2040.00 | 12/16/2011 |

| EXAMINER | ART UNIT | CLASS-SUBCLASS |
|---|---|---|
| DO, ANH HONG | 2624 | 382-238000 |

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- ☐ 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.**

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1 AlbertDhand LLP
2
3

3. ASSIGNEE NAME AND RESIDENCE DATA TO BE PRINTED ON THE PATENT (print or type)

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(B) RESIDENCE: (CITY and STATE OR COUNTRY): 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

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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 /G. Peter Albert, Jr./ Date November 4, 2011

Typed or printed name G. Peter Albert, Jr Registration No. 37268

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# Electronic Patent Application Fee Transmittal

| | |
|---|---|
| **Application Number:** | 12101019 |
| **Filing Date:** | 10-Apr-2008 |
| **Title of Invention:** | SPATIALLY ENHANCED TRANSFORM CODING |
| **First Named Inventor/Applicant Name:** | Jani Lainema |
| **Filer:** | Glenn Peter Albert Jr./Marisol Moretto |
| **Attorney Docket Number:** | 00002-5481 |

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 | 1740 | 1740 |
| Publ. Fee- early, voluntary, or normal | 1504 | 1 | 300 | 300 |

| Description | Fee Code | Quantity | Amount | Sub-Total in USD($) |
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| **Extension-of-Time:** | | | | |
| **Miscellaneous:** | | | | |
| | | | **Total in USD ($)** | **2040** |

# Electronic Acknowledgement Receipt

| | |
|---|---|
| **EFS ID:** | 11340179 |
| **Application Number:** | 12101019 |
| **International Application Number:** | |
| **Confirmation Number:** | 7368 |
| **Title of Invention:** | SPATIALLY ENHANCED TRANSFORM CODING |
| **First Named Inventor/Applicant Name:** | Jani Lainema |
| **Customer Number:** | 12268 |
| **Filer:** | Glenn Peter Albert Jr./Marisol Moretto |
| **Filer Authorized By:** | Glenn Peter Albert Jr. |
| **Attorney Docket Number:** | 00002-5481 |
| **Receipt Date:** | 04-NOV-2011 |
| **Filing Date:** | 10-APR-2008 |
| **Time Stamp:** | 19:04:58 |
| **Application Type:** | Utility under 35 USC 111(a) |

## Payment information:

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| Submitted with Payment | yes |
| Payment Type | Credit Card |
| Payment was successfully received in RAM | $2040 |
| RAM confirmation Number | 16030 |
| Deposit Account | 505302 |
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Charge any Additional Fees required under 37 C.F.R. Section 1.16 (National application filing, search, and examination fees)

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Charge any Additional Fees required under 37 C.F.R. Section 1.19 (Document supply fees)

Charge any Additional Fees required under 37 C.F.R. Section 1.20 (Post Issuance fees)

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 | Issue Fee Payment (PTO-85B) | 00002-5481-IssueFeeTransmittalPTOL-85-04-NOV2011.pdf | 1339193<br>4f7c708a73ef844fa4c5fcd0d216e9e9bc1da759 | no | 1 |
| **Warnings:** | | | | | |
| **Information:** | | | | | |
| 2 | Fee Worksheet (SB06) | fee-info.pdf | 31783<br>96df9e924e264d7c187427a7c1bb9667dc407fd7 | no | 2 |
| **Warnings:** | | | | | |
| **Information:** | | | | | |
| | | | **Total Files Size (in bytes):** | 1370976 | |

**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.**

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 NO. | ISSUE DATE | PATENT NO. | ATTORNEY DOCKET NO. | CONFIRMATION NO. |
|---|---|---|---|---|
| 12/101,019 | 12/13/2011 | 8077991 | 00002-5481 | 7368 |

12268 7590 11/22/2011

AlbertDhand LLP
11622 El Camino Real
Suite 100
San Diego, CA 92130

# 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 915 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):

Jani Lainema, Tampere, FINLAND;

**IN THE UNITED STATES PATENT AND TRADEMARK OFFICE**

| | | | |
|---|---|---|---|
| In re: | Jani Lainema | Group Art Unit: | 2624 |
| Appl. No.: | 12/101,019 | Confirmation No. | 7368 |
| Filed: | April 10, 2008 | Examiner: | Anh Hong Do |
| For: | SPATIALLY ENHANCED TRANSFORM CODING | | |

Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

**REVOCATION OF POWER OF ATTORNEY**
**AND NEW POWER OF ATTORNEY BY ASSIGNEE**
**AND CHANGE OF CORRESPONDENCE ADDRESS**

**NOKIA CORPORATION**, the Assignee of record hereby revokes all powers of attorney previously granted with respect to the above-identified patent application, and appoints the practitioners associated with the Customer Number provided below to prosecute this application and to transact all business in the Patent and Trademark Office connected therewith, and directs that all correspondence be addressed to that Customer Number:

**Customer Number 10949**

with full power of substitution and revocation to transact all business in the Patent and Trademark Office in connection therewith.

Please direct telephone calls to the attention of:

Guy R. Gosnell
Registration No. 34,610
Tel Charlotte Office (704) 444-1000
Fax Charlotte Office (704) 444-1111

**NOKIA CORPORATION**, the assignee of record, hereby elects under 37 C.F.R. § 3.71 to prosecute this patent application and certifies that it is the assignee of the entire right, title, and interest in the patent application identified above by virtue of the **§ 3.73(b) information cited below**:

Assignment from the inventor(s) of the patent application identified above.
The assignment was recorded in the United States Patent and Trademark Office at Reel 021174, Frame 0553.

☒ As required by 37 CFR 3.73(b)(1)(i), the documentary evidence of the chain of title from the original owner to the assignee was, or concurrently is being, submitted for recordation pursuant to 37 CFR 3.11.

The undersigned (whose title is supplied below) is empowered to sign this certificate on behalf of the Assignee.

Assignee of Record:

**NOKIA CORPORATION**

By: Kari P

Print Name: Kari Puranen

Title: Director, Software Patenting

Date: 23. Nov 2011

**CUSTOMER NO. 10949**
**ALSTON & BIRD LLP**
Bank of America Plaza
101 South Tryon Street, Suite 4000
Charlotte, NC 28280-4000
Tel Charlotte Office (704) 444-1000
Fax Charlotte Office (704) 444-1111

LEGAL02/32986224v1

# Electronic Acknowledgement Receipt

| | |
|---|---|
| **EFS ID:** | 11525355 |
| **Application Number:** | 12101019 |
| **International Application Number:** | |
| **Confirmation Number:** | 7368 |
| **Title of Invention:** | SPATIALLY ENHANCED TRANSFORM CODING |
| **First Named Inventor/Applicant Name:** | Jani Lainema |
| **Customer Number:** | 12268 |
| **Filer:** | Robert Flynt Strean/LARIEKO WELCH |
| **Filer Authorized By:** | Robert Flynt Strean |
| **Attorney Docket Number:** | 00002-5481 |
| **Receipt Date:** | 01-DEC-2011 |
| **Filing Date:** | 10-APR-2008 |
| **Time Stamp:** | 17:18:08 |
| **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 | Power of Attorney | 412757_POA.pdf | 90358<br>e75f5a5423a630f31484bd465601c2810d2f34c3 | no | 2 |

**Warnings:**

**Information:**

| Total Files Size (in bytes): | 90358 |
|---|---|

**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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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 | ATTY. DOCKET NO./TITLE |
|---|---|---|---|
| 12/101,019 | 04/10/2008 | Jani Lainema | 042933/412757 |

**CONFIRMATION NO. 7368**

**POA ACCEPTANCE LETTER**

*OC000000051357433*

10949
Nokia Corporation and Alston & Bird LLP
c/o Alston & Bird LLP
Bank of America Plaza, 101 South Tryon Street
Suite 4000
Charlotte, NC 28280-4000

Date Mailed: 12/13/2011

## NOTICE OF ACCEPTANCE OF POWER OF ATTORNEY

This is in response to the Power of Attorney filed 12/01/2011.

The Power of Attorney in this application is accepted. Correspondence in this application will be mailed to the above address as provided by 37 CFR 1.33.

/sibrahim/

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Office of Data Management, Application Assistance Unit (571) 272-4000, or (571) 272-4200, or 1-888-786-0101

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
**United States Patent and Trademark Office**
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| APPLICATION NUMBER | FILING OR 371(C) DATE | FIRST NAMED APPLICANT | ATTY. DOCKET NO./TITLE |
|---|---|---|---|
| 12/101,019 | 04/10/2008 | Jani Lainema | 00002-5481 |

**CONFIRMATION NO. 7368**

**POWER OF ATTORNEY NOTICE**

*OC000000051357426*

12268
AlbertDhand LLP
11622 El Camino Real
Suite 100
San Diego, CA 92130

Date Mailed: 12/13/2011

## NOTICE REGARDING CHANGE OF POWER OF ATTORNEY

This is in response to the Power of Attorney filed 12/01/2011.

- The Power of Attorney to you in this application has been revoked by the assignee who has intervened as provided by 37 CFR 3.71. Future correspondence will be mailed to the new address of record(37 CFR 1.33).

/sibrahim/

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Office of Data Management, Application Assistance Unit (571) 272-4000, or (571) 272-4200, or 1-888-786-0101