IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Re: Application of: Jani Lainema

Attorney Docket: 944-001.107-2

Serial No.: to be assigned

Group Art Unit: to be assigned

Filed: herewitgh

For: **METHOD AND DEVICE FOR INDICATING QUANTIZER PARAMETERS IN A VIDEO CODING SYSTEM**

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

PRELIMINARY AMENDMENT IN CONJUNCTION WITH FILING A DIVISIONAL APPLICATION

Sir:

In conjunction with filing a divisional application, please amend the patent application as follows:

I hereby certify that this correspondence is being deposited with the United States Postal Service "Express Mail Post Office to Addressee" service under 37 C.F.R. 1.10, Express Mail Label No. EV914764379US, on the date indicated below and is addressed to Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.

7-25-07

Cathy Sturmer — Date

AMAZON-1002
8,175,148

In the Specification

Please amend the paragraph beginning on page 1, line 4 as follows:

This application is a divisional application of and claims priority to a co-pending U.S. patent application Serial No. 10/421,629, filed April 23, 2003, which is based on and claims priority to U.S. provisional application No. 60/374,667, filed April 23, 2002.

Please amend the paragraph beginning on page 6, line 7 as follows:

The quantized DCT coefficients for each block are passed from the quantizer 106 to the video multiplex coder 170, as indicated by line 125 in Figure 1. The video multiplex coder 170 orders the quantized transform coefficients for each block using a zigzag scanning procedure, thereby converting the two-dimensional array of quantized transform coefficient values into a one-dimensional array. [[.]] Typically, the video multiplex coder 170 next represents each non-zero quantized coefficient in the one-dimensional array by a pair of values, referred to as *level* and *run*, *level* being the value of the quantized coefficient and *run* being the number of consecutive zero-valued coefficients preceding the coefficient in question. The *run* and *level* values are further compressed using entropy coding. For example, a method such as variable length coding (VLC) may be used to produce a set of variable length codewords representative of each (*run*, *level*) pair.

Please amend the paragraph beginning on page 15, line 29 as follows:

Preferably, an indication of the default level of quantization to be used throughout encoding of the digital video sequence is provided. Even more preferably, an indication of the default level of quantization is provided in the encoded bit-stream representative of the digital video sequence, ~~Advantaegously~~ advantageously, the encoded bit-stream, including the indication of the default level of quantization to be used throughout encoding of the digital video sequence, is transmitted to a video decoding device.

In the Drawings

Please replace Figures 5 and 6 with the attached replacement sheets showing the corrected Figures 5 and 6.

In the Claims

1. (canceled)

2. (canceled)

3. (canceled)

4. (currently amended) ~~An encoding method according to claim 1, further comprising the step of~~ A method of encoding a digital video sequence for use in a video coding application to produce an encoded video bit-stream representative of the digital video sequence, the digital video sequence comprising a number of frames, each frame of said sequence comprising an array of pixels divided into a plurality of blocks, each block comprising a certain number of said pixels, said method comprising:

encoding a frame of the digital video sequence by applying motion compensated prediction to blocks of pixels for producing corresponding blocks of prediction error values;

applying a transform coding technique to said blocks of prediction error values to produce sets of transform coefficient values representative of said blocks of prediction error values;

defining a default level of quantization for use in encoding of the digital video sequence to quantize the sets of transform coefficient values; and

providing an indication of the default level of quantization to a decoding process.

5. (original) An encoding method according to claim 4, wherein said indication of the default level of quantization is provided in the encoded bit-stream representative of the digital video sequence.

6. (original) An encoding method according to claim 5, wherein the encoded bit-stream is transmitted from a video encoding device to a corresponding video decoding device.

7. (currently amended) An encoding method according to claim [[1]] 4, wherein the default level of quantization is updated during the encoding of the digital video sequence, said method further

comprising ~~the step of~~ providing an indication of the updated default level of quantization to a decoding process.

8. (currently amended) An encoding method according to claim [[1]] 4, wherein said sets of transform coefficient values are quantized to yield sets of quantized transform coefficient values representative of said blocks of prediction error values based on a level of quantization different from the default level of quantization.

9. (currently amended) An encoding method according to claim 8, further comprising ~~the step of~~ providing to a decoding process an indication of a difference between said level of quantization and the default level of quantization.

10. (original) An encoding method according to claim 8, wherein said level of quantization is adjusted from one frame of the digital video sequence to another such that an actual level of quantization applied to the sets of transform coefficients for a particular frame of the digital video sequence is different from the default level of quantization.

11.(original) An encoding method according to claim 10, wherein said actual level of quantization is representable as a difference with respect to the default level of quantization.

12. (currently amended) An encoding method according to claim 10, further comprising ~~the step of~~ providing to a decoding process an indication of a difference between said actual level of quantization and the default level of quantization.

13. (original) An encoding method according to claim 8, wherein the plurality of blocks of pixels, into which a frame of said digital video sequence is divided, are grouped into one or more segments and wherein the level of quantization applied to said sets of transform coefficient values is adjusted from one segment of a frame to another such that an actual level of quantization applied to the sets of transform coefficients for a particular segment of a frame is different from the default level of quantization.

14. (currently amended) An encoding method according to claim 13, further comprising ~~the step of~~ providing to a decoding process an indication of a difference between said level of quantization and the default level of quantization.

15. (canceled)

16. (canceled)

17. (currently amended) A video encoder for encoding a digital video sequence to produce an encoded video bit-stream representative of the digital video sequence, the digital video sequence comprising a number of frames, each frame of said sequence comprising an array of pixels divided into a plurality of blocks, each block comprising a certain number of said pixels, said video encoder comprising:

means for encoding a frame of the digital video sequence by applying motion compensated prediction to blocks of pixels to provide corresponding blocks of prediction error values;

means for transforming said blocks of prediction error values for providing sets of transform coefficient values representative of said blocks of prediction error values;

means for selecting a default level of quantization for quantizing said sets of transform coefficient values; and ~~according to claim 15, arranged to provide~~

means for providing an indication of said default level of quantization in the encoded bit-stream representative of the digital video sequence.

18. (currently amended) A video encoder according to claim [[15]] 17, wherein said sets of transform coefficient values are quantized to yield sets of quantized transform coefficient values representative of said blocks of prediction error values based on a level of quantization different from the default level of quantization.

19. (original) A video encoder according to claim 18, arranged to provide an indication of a difference between said level of quantization and the default level of quantization in the encoded bit-stream.

20. (currently amended) A video encoder according to claim [[15]] 17, wherein the default level of quantization can be updated and the video encoder is arranged to provide an indication of the updated default level of quantization in the encoded bit-stream.

21. (original) A video encoder according to claim 20, wherein said sets of transform coefficient values are quantized to yield sets of quantized transform coefficient values representative of said blocks of prediction error values based on a level of quantization different from the updated default level of quantization.

22. (original) A video encoder according to claim 18, wherein said level of quantization applied to said sets of transform coefficient values can be adjusted from one frame of the digital video sequence to another so as to apply an actual level of quantization to the sets of transform coefficients for a particular frame of the digital video sequence and wherein said actual level of quantization is different from the default level of quantization.

23. (original) A video encoder according to claim 22, arranged to provide an indication of said difference with respect to the default level of quantization in the encoded bit-stream representative of the digital video sequence.

24. (original) A video encoder according to claim 18, arranged to group the plurality of blocks into which a frame of said digital video sequence is divided into one or more segments and to adjust the level of quantization applied to said sets of transform coefficient values from one segment of a frame to another so as to apply an actual level of quantization to the sets of transform coefficients for a particular segment of a frame, wherein said actual level of quantization is different from the default level of quantization, said video encoder further arranged to represent the actual level of quantization for use in the particular segment as a difference with respect to the default level of quantization.

25. (original) A video encoder according to claim 24, further arranged to provide an indication of said difference with respect to the default level of quantization in the encoded bit-stream representative of the digital video sequence.

26. (currently amended) A video encoder according to claim [[15]] 17, provided in a multimedia terminal.

27. (currently amended) A video encoder according to claim [[15]] 17, provided in a radio telecommunications device.

Claims 28-36. (canceled)

37. (new) A video encoder for encoding a digital video sequence to produce an encoded video bit-stream representative of the digital video sequence, the digital video sequence comprising a number of frames, each frame of said sequence comprising an array of pixels divided into a plurality of blocks, each block comprising a certain number of said pixels, said video encoder comprising:

a module for encoding a frame of the digital video sequence by applying motion compensated prediction to blocks of pixels to provide corresponding blocks of prediction error values;

a module for transforming said blocks of prediction error values for providing sets of transform coefficient values representative of said blocks of prediction error values; and

a module for selecting a default level of quantization for quantizing said sets of transform coefficient values, wherein the default level is specific to the video coding applications.

REMARKS

In the patent application, claims 1-36 are pending.

Applicant has canceled claims 1-3, 15, 16 and 28-36, amended 4, 7, 8, 9, 12, 17, 18, 20, 26 and 27 and added new claim 37.

Applicant has also amended claims 4 and 17 to be in independent from incorporating the limitations of claims 1 and 15, respectively, and amended claims 7, 8, 18, 20, 26 and 27 to change the claim dependency. Applicant has amended claims 9, 14 and 28 to remove the expression "the step of", and added a new claim 37.

New claim 37 has substantially the same limitations as claim 4. Regarding claim 37, the encoding module is described as the combiner 116 on p.30, lines 21-23; the transforming module is shown as the transform block 104 in Figure 5, and the selecting module is described as the coding control block 660 on p.30, line 31 to p.31, line 10.

Applicant has amended the specification to correct two typographical errors.

Applicant has amended Figures 5 and 6. In Figure 5, the coding control block 160 should be labeled 660 as described on p.29, lines 1-4. In Figure 6, the coding control block 260 should be labeled 760 as described on p.32, lines 24-27.

No new matter has been introduced.

Respectfully submitted,

Kenneth Q. Lao
Registration No. 40,061

Date: July 25, 2007

WARE, FRESSOLA, VAN DER SLUYS
& ADOLPHSON LLP
Bradford Green, Building 5
755 Main Street, PO Box 224
Monroe, CT 06468
(203) 261-1234
USPTO Customer No. 004955

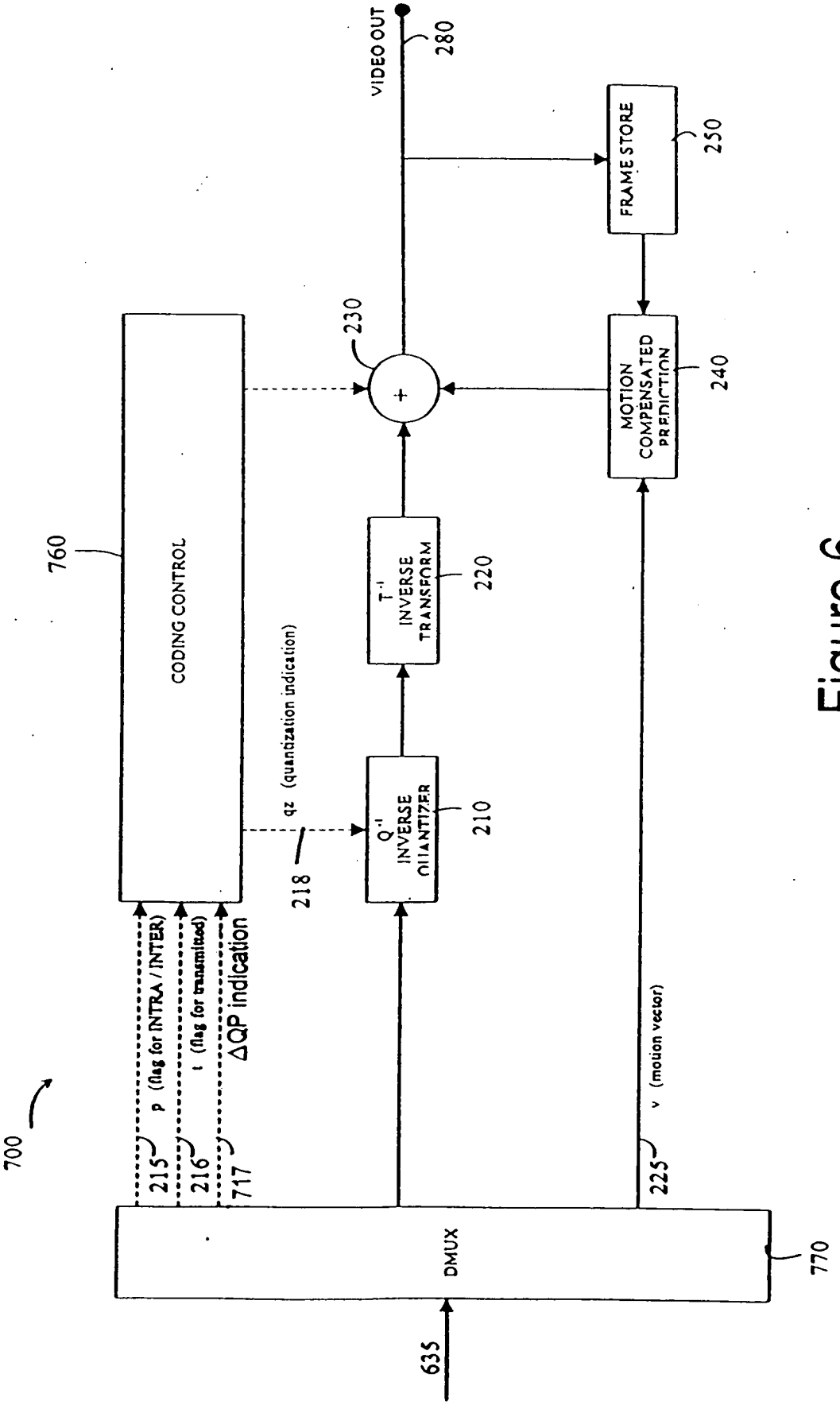

700
760
CODING CONTROL
215
216
717
p (flag for INTRA / INTER)
t (flag for transmitted)
ΔQP indication
qz (quantization indication)
218
Q⁻¹ INVERSE QUANTIZER
210
T⁻¹ INVERSE TRANSFORM
220
230
+
VIDEO OUT
280
FRAME STORE
250
MOTION COMPENSATED PREDICTION
240
v (motion vector)
225
DMUX
770
635

Figure 6

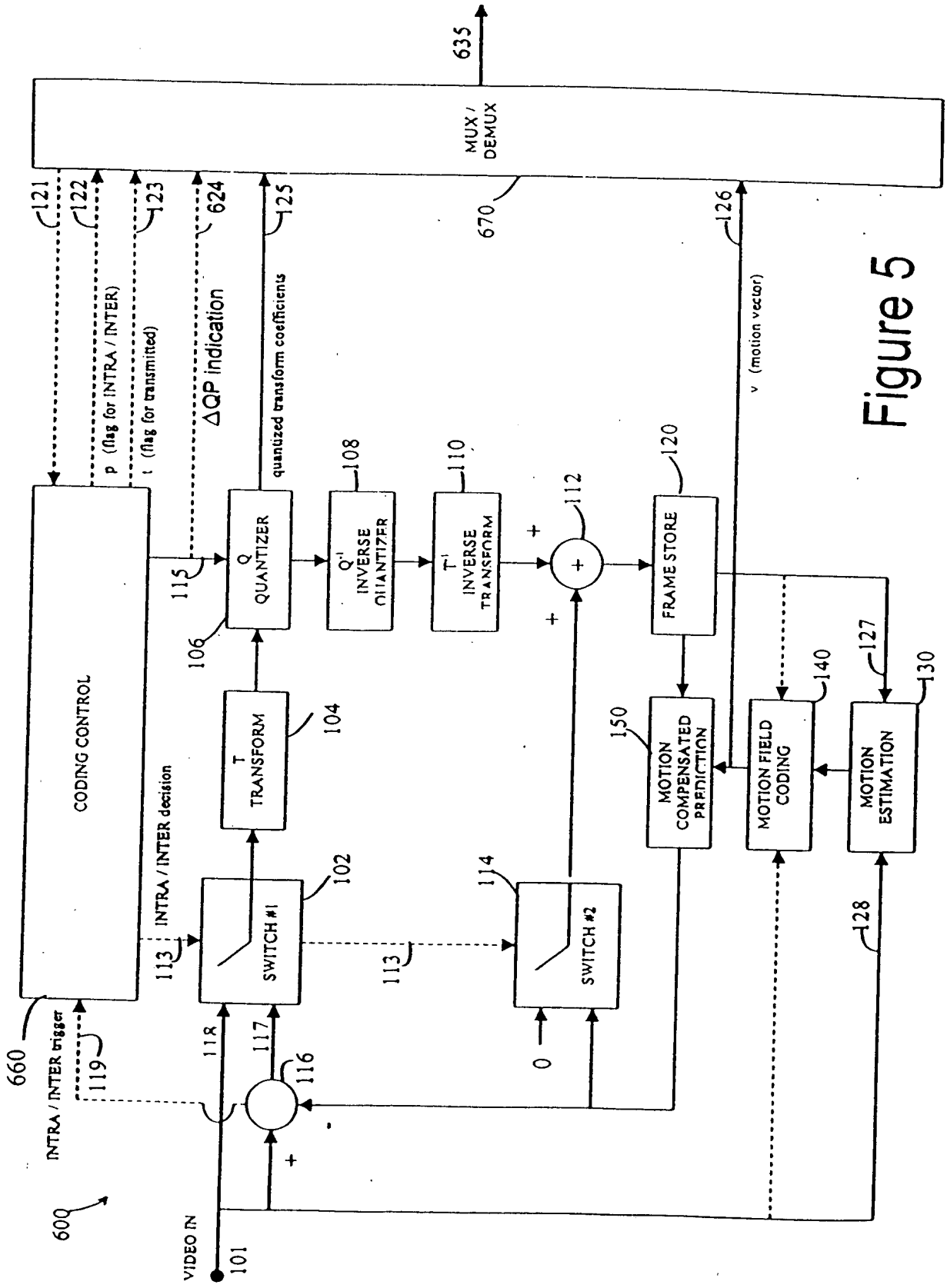

635
MUX / DEMUX
670
121
122
123
624
125
126
p (flag for INTRA / INTER)
t (flag for transmitted)
ΔQP indication
quantized transform coefficients
v (motion vector)
CODING CONTROL
Q QUANTIZER
108
Q⁻¹ INVERSE QUANTIZER
110
T⁻¹ INVERSE TRANSFORM
112
120
FRAME STORE
T TRANSFORM
104
106
115
INTRA / INTER decision
113
SWITCH #1
102
114
SWITCH #2
150
MOTION COMPENSATED PREDICTION
140
MOTION FIELD CODING
127
130
MOTION ESTIMATION
128
660
INTRA / INTER trigger
119
118
117
116
0
600
VIDEO IN
101

Figure 5

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Re: Application of: Jani Lainema

Attorney Docket: 944-001.107-2

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Examiner: to be assigned

For: **METHOD AND DEVICE FOR INDICATING QUANTIZER PARAMETERS IN A VIDEO CODING SYSTEM**

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

INFORMATION DISCLOSURE STATEMENT

Sir:

Applicant submits herewith references of which they are aware, which they believe may be material to the examination of this application and in respect of which they may have a duty to disclose in accordance with 37 CFR 1.56.

While this Information Disclosure Statement may be "material" pursuant to 37 CFR 1.56, it is not intended to constitute an admission that any document referred to herein is "prior art" for this invention unless specifically designated as such.

In accordance with 37 CFR 1.97(g), the filing of this Information Disclosure Statement shall not be construed to mean that a search has been made or that no other material information as defined under 37 CFR 1.56(a) exists.

I hereby certify that this correspondence is being deposited with the United States Postal Service "Express Mail Post Office to Addressee" service under 37 C.F.R. 1.10, Express Mail Label No. EV914764379US, on the date indicated below and is addressed to Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.

7.25.07

Cathy Sturmer — Date

A PTO-1449 with cited reference is also enclosed.

This IDS is being submitted prior to receipt of a first Official Action in this matter; therefore, the undersigned respectfully submits that no fee is due for filing this IDS. Should any fees be due of which the undersigned is unaware, the Commissioner is hereby authorized to charge deposit account 23-0442 any fee deficiency required to submit this IDS.

Respectfully submitted,

Kenneth Q. Lao
Registration No. 40,061

Date: July 25, 2007

WARE, FRESSOLA, VAN DER SLUYS
& ADOLPHSON LLP
Bradford Green, Building 5
755 Main Street, PO Box 224
Monroe, CT 06468
(203) 261-1234

FORM PTO-1449 INFORMATION DISCLOSURE STATEMENT	ATTY DOCKET NO. 944-001.107-2	SERIAL NO. To be assigned
	APPLICANTS: Jani Lainema	
	FILING DATE: herewith	ART UNIT: to be assigned

UNITED STATES PATENT DOCUMENTS

EXAM. INITIAL		DOCUMENT NUMBER	DATE	INVENTOR/ASSIGNEE	CLASS	SUBCLASS	FILING DATE IF APPROPRIATE
		U.S. 5,231,484	July 27, 2991	Gonzales et al.	358	133	
		U.S. 5,751,358	May 12, 1998	Suzuki et al.	348	405	
		U.S. 5,054,103	Oct. 1, 1991	Yasuda et al.	382	56	
		U.S. 5,144,426	Sept. 1, 1992	Tanaka et al.	358	133	
		U.S. 5,715,009	Feb. 3, 1998	Tahara et al.	348	423	
		U.S. 6,256,349	July 3, 2001	Suzuki et al.	375	240.18	
		U.S. 5,237,410	Aug. 17, 1993	Inoue	358	136	
		U.S. 2003/152146	Aug. 14, 2003	Lin et al.	375	240.16	
		U.S. 6,677,868	Jan. 13, 2004	Kerofsky et al.	341	107	

FOREIGN PATENT DOCUMENTS

		DOCUMENT NUMBER	DATE	COUNTRY	CLASS	SUBCLASS	TRANSLATION YES/NO

OTHER DOCUMENTS (INCLUDING AUTHOR, TITLE, DATE, PERTINENT PAGES, ETC.)

		"Joint Model Number 1 (JM-1)", Doc. JVT-A003, Appendix B; Joint Video Team (JVT) of ISO/IEC MPEG and ITU-T VCEG; January 2002; pp. 1-79.

Examiner (To be assigned)	Date:

PATENT APPLICATION SERIAL NO._____

U.S. DEPARTMENT OF COMMERCE
PATENT AND TRADEMARK OFFICE
FEE RECORD SHEET

07/30/2007 WABDELR1 00000036 11881367

01 FC:1011	300.00	OP
02 FC:1111	500.00	OP
03 FC:1311	200.00	OP
04 FC:1202	150.00	OP

Repln. Ref: 07/30/2007 WABDELR1 0013022400
DA#:230442 Name/Number:11881367
FC: 9204 $750.00 CR

PTO-1556
(5/87)

*U.S. Government Printing Office: 2002- 489-267/69033

CLAIMS ONLY	SERIAL NO	FILING DATE
	APPLICANT(S)	

CLAIMS

	AS FILED		AFTER 1ST AMENDMENT		AFTER 2ND AMENDMENT							
	IND	DEP	IND	DEP	IND	DEP		IND	DEP	IND	DEP	IND	DEP
1							51						
2							52						
3							53						
4	1						54						
5							55						
6							56						
7							57						
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10							60						
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12							62		1				
13							63						
14			10				64						
15							65						
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17	1						67						
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36							86						
37	1						87						
38							88						
39							89						
40							90						
41							91						
42							92						
43							93						
44							94						
45							95						
46							96						
47							97						
48							98						
49							99						
50							100						
TOTAL IND.	3						TOTAL IND.						
TOTAL DEP.	20						TOTAL DEP.						
TOTAL CLAIMS	23						TOTAL CLAIMS						

PTO-2202 (Replication only) (1/03)

PTO/SB/06 (02-07)
Approved for use through 02/28/2007. OMB 0651-0032
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
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PATENT APPLICATION FEE DETERMINATION RECORD

Substitute for Form PTO-875

Application or Docket Number: 11881367

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	$150		N/A	$300
SEARCH FEE (37 CFR 1.16(k), (l), or (m))	N/A	N/A	N/A	$250		N/A	$500
EXAMINATION FEE (37 CFR 1.16(o), (p), or (q))	N/A	N/A	N/A	$100		N/A	$200
TOTAL CLAIMS (37 CFR 1.16(i))	23 minus 20 =	* 3	x $25 =	150	OR	x $50 =	150
INDEPENDENT CLAIMS (37 CFR 1.16(h))	3 minus 3 =	* 0	x $100 =			x $200 =	
APPLICATION SIZE FEE (37 CFR 1.16(s))	If the specification and drawings exceed 100 sheets of paper, the application size fee due is $250 ($125 for small entity) for each additional 50 sheets or fraction thereof. See 35 U.S.C. 41(a)(1)(G) and 37 CFR 1.16(s).		$125			$250	
MULTIPLE DEPENDENT CLAIM PRESENT (37 CFR 1.16(j))			+180 =			+360 =	
			TOTAL			TOTAL	150

* If the difference in column 1 is less than zero, enter "0" in column 2.

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 ($)	SMALL ENTITY ADDITIONAL FEE ($)	OR	OTHER THAN SMALL ENTITY RATE ($)	OTHER THAN SMALL ENTITY ADDITIONAL FEE ($)
Total (37 CFR 1.16(i))	*	Minus	**	=	x $25 =		OR	x $50 =	
Independent (37 CFR 1.16(h))	*	Minus	***	=	x $100 =		OR	x $200 =	
Application Size Fee (37 CFR 1.16(s))					$125			$250	
FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))					+180 =		OR	+360 =	
					TOTAL ADD'L FEE		OR	TOTAL ADD'L FEE	

AMENDMENT B

	(Column 1) CLAIMS REMAINING AFTER AMENDMENT		(Column 2) HIGHEST NUMBER PREVIOUSLY PAID FOR	(Column 3) PRESENT EXTRA	RATE ($)	ADDITIONAL FEE ($)	OR	RATE ($)	ADDITIONAL FEE ($)
Total (37 CFR 1.16(i))	*	Minus	**	=	x $25 =		OR	x $50 =	
Independent (37 CFR 1.16(h))	*	Minus	***	=	x $100 =		OR	x $200 =	
Application Size Fee (37 CFR 1.16(s))					$125			$250	
FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))					+180 =		OR	+360 =	
					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.

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.

U.S. PTO
11/881367
07/26/2007

18334 U.S. PTO
072607

Practitioner's Docket No. 944-001.107-2 ***PATENT***

Preliminary Classification:

Proposed Class:

Subclass:

NOTE: "All applicants are requested to include a preliminary classification on newly filed patent applications. The preliminary classification, preferably class and subclass designations, should be identified in the upper right-hand corner of the letter of transmittal accompanying the application papers, for example 'Proposed Class 2, subclass 129.'" M.P.E.P. § 601, 7th ed.

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

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

NEW APPLICATION TRANSMITTAL

Transmitted herewith for filing is the patent application of

Inventor(s): Jani Lainema

WARNING: *37 C.F.R.§ 1.41(a)(1) points out:*

"(a) A patent is applied for in the name or names of the actual inventor or inventors.

"(1) The inventorship of a nonprovisional application is that inventorship set forth in the oath or declaration as prescribed by § 1.63, except as provided for in § 1.53(d)(4) and § 1.63(d). If an oath or declaration as prescribed by § 1.63 is not filed during the pendency of a nonprovisional application, the inventorship is that inventorship set forth in the application papers filed pursuant to § 1.53(b), unless a petition under this paragraph accompanied by the fee set forth in § 1.17(l) is filed supplying or changing the name or names of the inventor or inventors."

For (title): METHOD AND DEVICE FOR INDICATING QUANTIZER PARAMETERS IN A VIDEO CODING SYSTEM

CERTIFICATION UNDER 37 C.F.R. § 1.10*

*(Express Mail label number is **mandatory**)*
(Express Mail certification is optional.)

I hereby certify that this New Application Transmittal and the documents referred to as attached therein are being deposited with the United States Postal Service on this date July 25, 2007, in an envelope as "Express Mail Post Office to Addressee," mailing Label Number EV914764379US, addressed to the: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.

Cathy Sturmer
(type or print name of person mailing paper)

Signature of person mailing paper

WARNING: *Certificate of mailing (first class) or facsimile transmission procedures of 37 C.F.R. § 1.8 cannot be used to obtain a date of mailing or transmission for this correspondence.*

WARNING: *Each paper or fee filed by "Express Mail" **must** have the number of the "Express Mail" mailing label placed thereon prior to mailing. 37 C.F.R. § 1.10(b).*
*Since the filing of correspondence under § 1.10 without the Express Mail mailing label thereon is an oversight that can be avoided by the exercise of reasonable care, requests for waiver of this requirement will **not** be granted on petition." Notice of Oct. 24, 1996, 60 Fed. Reg. 56,439, at 56,442.*

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1. Type of Application

This new application is for a(n)

(check one applicable item below)

☒ Original (nonprovisional)

☐ Design

☐ Plant

WARNING: *"**Do not** use this transmittal for a completion in the U.S. of an International Application under 35 U.S.C. § 37(c)(4), unless the International Application is being filed as a divisional, continuation or continuation-in-part application.*

WARNING: ***Do not** use this transmittal for the filing of a provisional application.*

NOTE: If one of the following 3 items apply, then complete and attach ADDED PAGES FOR NEW APPLICATION TRANSMITTAL WHERE BENEFIT OF A PRIOR U.S. APPLICATION CLAIMED and a NOTIFICATION IN PARENT APPLICATION OF THE FILING OF THIS CONTINUATION APPLICATION.

☒ Divisional
☐ Continuation
☐ Continuation-in-part (C-I-P)

2. Benefit of Prior U.S. Application(s) (35 U.S.C. §§ 119(e), 120, or 121)

NOTE: A nonprovisional application may claim an invention disclosed in one or more prior filed copending nonprovisional applications or copending international applications designating the United States of America. In order for a nonprovisional application to claim the benefit of a prior filed copending nonprovisional application or copending international application designating the United States of America, each prior application must name as an inventor at least one inventor named in the later filed nonprovisional application and disclose the named inventor's invention claimed in at least one claim of the later filed nonprovisional application in the manner provided by the first paragraph of 35 U.S.C. § 112. Each prior application must also be:

(i) An international application entitled to a filing date in accordance with PCT Article 11 and designated the United States of America; or

(ii) Complete as set forth in § 1.51(b); or

(iii) Entitled to a filing date as set forth in § 1.53(b) or § 1.53(d) and include the basic filing fee set forth in § 1.16; or

(iv) Entitled to a filing date as set forth in § 1.53(b) and have paid therein the processing and retention fee set forth in § 1.21(l) within the time period set forth in § 1.53(f).

37 C.F.R. § 1.78(a)(1).

NOTE: If the new application being transmitted is a divisional, continuation or a continuation-in-part of a parent case, or where the parent case is an International Application which designated the U.S., or benefit of a prior provisional application is claimed, then check the following item and complete and attach ADDED PAGES FOR NEW APPLICATION TRANSMITTAL WHERE BENEFIT OF PRIOR U.S. APPLICATION(S) CLAIMED.

WARNING: *If an application claims the benefit of the filing date of an earlier filed application under 35 U.S.C. §§ 120, 121 or 365(c), the 20-year term of that application will be based upon the filing date of the earliest U.S. application that the application makes reference to under 35 U.S.C. §§ 120,121 or 365(c). (35 U.S.C. § 154(a)(2) does not take into account, for the determination of the patent term, any application on which priority is claimed under 35 U.S.C. §§ 199, 365(a) or 365(b).) For a c-i-p application, applicant should review whether any claim in the patent that will issue is supported by an earlier application and, if not, the applicant should consider canceling the reference to the earlier filed application. The term of a patent is not based on a claim-by-claim approach. See Notice of April 14, 1995, 60 Fed. Reg. 20,195, at 20,205.*

WARNING: *When the last day of pendency of a provisional application falls on a Saturday, Sunday, or Federal holiday within the District of Columbia, any nonprovisional application claiming benefit of the provisional application **must** be filed prior to the Saturday, Sunday, or Federal holiday within the District of Columbia. See 37 C.F.R. § 1.78(a)(3).*

☒ The new application being transmitted claims the benefit of prior U.S. application(s). Enclosed are ADDED PAGES FOR NEW APPLICATION TRANSMITTAL WHERE BENEFIT OF PRIOR U.S. APPLICATION(S) CLAIMED.

3. Papers Enclosed

A. Required for filing date under 37 C.F.R. § 1.53(b) (Regular) or 37 C.F.R. § 1.153 (Design) Application

33 Pages of specification
6 Pages of claims
8 Sheets of drawings

WARNING: ***DO NOT** submit original drawings. A high quality copy of the drawings should be supplied when filing a patent application. The drawings that are submitted to the Office must be on strong, white, smooth, and non-shiny paper and meet the standards according to § 1.84. If corrections to the drawings are necessary, they should be made to the original drawing and a high-quality copy of the corrected original drawing then submitted to the Office. Only one copy is required or desired. For comments on proposed then-new 37 C.F.R. § 1.84, see Notice of March 9, 1988 (1990 O.G. 57-62).*

NOTE: "Identifying indicia, if provided, should include the application number or the title of the invention, inventor's name, docket number (if any), and the name and telephone number of a person to call if the Office is unable to match the drawings to the proper application. This information should be placed on the back of each sheet of drawing a minimum distance of 1.5 cm (5/8 inch) down from the top of the page . . ." 37 C.F.R. § 1.84(c)).

(complete the following, if applicable)

☐ The enclosed drawing(s) are photograph(s). Three (3) sets of photographs and a "PETITION TO ACCEPT PHOTOGRAPH(S) AS DRAWING(S)" are attached. 37 C.F.R. § 1.84(b).
☐ The enclosed drawing(s) are in color. Three (3) sets of color drawings and a "PETITION TO ACCEPT COLOR DRAWING(S)" are attached. 37 C.F.R. §§ 1.84(a)(2) and 1.84(b).
☒ formal
☐ informal

B. Other Papers Enclosed

2 Pages of declaration and power of attorney
1 Pages of abstract
1 Other (Title Page)

4. Additional papers enclosed

☐ Amendment to claims

☐ Cancel in this application claims _____ before calculating the filing fee. (At least one original independent claim must be retained for filing purposes.)
☐ Add the claims shown on the attached amendment. (Claims added have been numbered consecutively following the highest numbered original claims.)

☒ Preliminary Amendment

☒ Information Disclosure Statement (37 C.F.R. § 1.98)

☒ Form PTO-1449

☐ Citations

- ☐ Declaration of Biological Deposit
- ☐ Submission of "Sequence Listing," computer readable copy and/or amendment pertaining thereto for biotechnology invention containing nucleotide and/or amino acid sequence.
- ☐ Authorization of Attorney(s) to Accept and Follow Instructions from Representative
- ☐ Special Comments
- ☐ Other

5. Declaration or oath (including power of attorney)

NOTE: A newly executed declaration is not required in a continuation or divisional application provided that the prior nonprovisional application contained a declaration as required, the application being filed is by all or fewer than all the inventors named in the prior application, there is no new matter in the application being filed, and a copy of the executed declaration filed in the prior application (showing the signature or an indication thereon that it was signed) is submitted. The copy must be accompanied by a statement requesting deletion of the names of person(s) who are not inventors of the application being filed. If the declaration in the prior application was filed under § 1.47, then a copy of that declaration must be filed accompanied by a copy of the decision granting § 1.47 status or, if a nonsigning person under § 1.47 has subsequently joined in a prior application, then a copy of the subsequently executed declaration must be filed. See 37 C.F.R. §§ 1.63(d)(1)-(3).

NOTE: A declaration filed to complete an application must be executed, identify the specification to which it is directed, identify each inventor by full name including family name and at least one given name, without abbreviation together with any other given name or initial, and the residence, post office address and country or citizenship of each inventor, and state whether the inventor is a sole or joint inventor. 37 C.F.R. § 1.63(a)(1)-(4).

NOTE: "The inventorship of a nonprovisional application is that inventorship set forth in the oath or declaration as prescribed by § 1.62, except as provided for in § 1.53(d)(4) and § 1.63(d). If an oath or declaration as prescribed by § 1.63 is not filed during the pendency of a nonprovisional application, the inventorship is that inventorship set forth in the application papers filed pursuant to § 1.53(b), unless a petition under this paragraph accompanied by the fee set forth in § 1.17(l) is filed supplying or changing the name or names of the inventor or inventors." 37 C.F.R. § 1.41(a)(1).

☒ Enclosed

Executed by

(check **all** applicable boxes)

- ☐ inventor(s).
- ☐ legal representative of inventor(s). 37 C.F.R. §§ 1.42 or 1.43.
- ☐ joint inventor or person showing a proprietary interest on behalf of inventor who refused to sign or cannot be reached.
  - ☐ This is the petition required by 37 C.F.R. § 1.47 and the statement required by 37 C.F. R. § 1.47 is also attached. *See* item 13 below for fee.
- ☐ Not Enclosed

NOTE: Where the filing is a completion in the U.S. of an International Application or where the completion of the U.S. application contains subject matter in addition to the International Application, the application may be treated as a continuation or continuation-in-part, as the case may be, utilizing ADDED PAGE FOR NEW APPLICATION TRANSMITTAL WHERE BENEFIT OF PRIOR U.S. APPLICATION CLAIMED.

- ☐ Application is made by a person authorized under 37 C.F.R. § 1.41(c) on behalf of *all* the above named inventor(s).

(The declaration or oath, along with the surcharge required by 37 C.F.R. § 1.16(e) can be filed subsequently).

☐ Showing that the filing is authorized.
(not required unless called into question. 37 C.F.R. § 1.41(d))

6. Inventorship Statement

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

The inventorship for all the claims in this application are:

☒ The same.

or

☐ Not the same. An explanation, including the ownership of the various claims at the time the last claimed invention was made,
☐ is submitted.
☐ will be submitted

7. Language

NOTE: An application including a signed oath or declaration may be filed in a language other than English. An English translation of the non-English language application and the processing fee of $130.00 required by 37 C.F.R. § 1.17(k) is required to be filed with the application, or within such time as may be set by the Office. 37 C.F.R. § 1.52(d).

☒ English

☐ Non English

☐ The attached translation includes a statement that the translation is accurate. 37 C.F.R. § 1.52(d).

8. Assignment

☐ An assignment of the invention to Nokia Corporation

☐ is attached. A separate ☐ "COVER SHEET FOR ASSIGNMENT (DOCUMENT) ACCOMPANYING NEW PATENT APPLICATION" or ☐ FORM PTO 1595 is also attached.
☐ will follow.

NOTE: "If an assignment is submitted with a new application, send two separate letters-one for the application and one for the assignment." Notice of May 4, 1990 (1114 O.G. 77-78).

WARNING: *A newly executed "CERTIFICATE UNDER 37 C.F.R. § 3.73(b)" must be filed when a continuation-in-part application is filed by an assignee. Notice of April 30, 193, 1150 O.G. 62-64.*

☒ This is a ☐ continuation ☒divisional application and the assignment document for the parent application 10/421,629 was filed on August 13, 2003.

Reel 014385
Frame 0356

9. Certified Copy

Certified copy(ies) of application(s)

Country	Appln. No.	Filed
Country	Appln. No.	Filed
Country	Appln. No.	Filed

from which priority is claimed

- ☐ is (are) attached.
- ☐ will follow.

NOTE: The foreign application forming the basis for the claim for priority must be referred to in the oath or declaration. 37 C.F.R. § 1.55(a) and 1.63.

NOTE: This item is for any foreign priority for which the application being filed directly relates. If any parent U.S. application or International Application from which this application claims benefit under 35 U.S.C. § 120 is itself entitled to priority from a prior foreign application, then complete item 18 on the ADDED PAGES FOR NEW APPLICATION TRANSMITTAL WHERE BENEFIT OF PRIOR U.S. APPLICATION(S) CLAIMED.

10. Fee Calculation (37 C.F.R. § 1.16)

A. ☒ Regular application

CLAIMS AS FILED

Number filed		Number Extra		Rate	Basic Fee 37 C.F.R. § 1.16(a) $1000.00
Total Claims (37 C.F.R. § 1.16(c))	36 -20 =	16	x	$50.00 =	$800.00
Independent Claims (37 C.F.R. § 1.16(b))	4 - 3 =	1	x	$100.00 =	$100.00
Multiple dependent claim(s), if any (37 C.F.R. § 1.16(d))			+	$200.00	

- ☐ Amendment canceling extra claims is enclosed.
- ☐ Amendment deleting multiple-dependencies is enclosed.
- ☒ Fee for extra claims is not being paid at this time.

NOTE: If the fees for extra claims are not paid on filing, they must be paid or the claims canceled by amendment, prior to the expiration of the time period set for response by the Patent and Trademark Office in any notice of fee deficiency. 37 C.F.R. § 1.16(d).

Filing Fee Calculation $ 1900.00

B. ☐ Design application ($330.00 – 37 C.F.R. § 1.16(f))

Filing Fee Calculation $_____

C. ☐ Plant application

($510.00 - 37 C.F.R. § 1.16(g))

Filing Fee Calculation $_____

11. Small Entity Statement(s)

☐ Statement(s) that this is a filing by a small entity under 37 C.F.R. §§ 1.9 and 1.27 is **no longer necessary**.

WARNING: *"Status as a small entity must be specifically established in each application or patent in which the status is available and desired. Status as a small entity in one application or patent does not affect any other application or patent, including applications or patents which are directly or indirectly dependent upon the application or patent in which the status has been established. The refiling of an application under § 1.53 as a continuation, division, or continuation-in-part (including a continued prosecution application under § 1.53(d)), or the filing of a reissue application requires a new determination as to continued entitlement to small entity status for the continuing or reissue application. A nonprovisional application claiming benefit under 35 U.S.C. § 119(e), 120, 121, or 365(c) of a prior application, or a reissue application may rely on a statement filed in the prior application or in the patent if the nonprovisional application or the reissue application includes a reference to the statement in the prior application or in the patent or includes a copy of the statement in the prior application or in the patent and status as a small entity is still proper and desired. The payment of the small entity basic statutory filing fee will be treated as such a reference for purposes of this section." 37 C.F.R. § 1.28(a)(2).*

WARNING: *"Small entity status must not be established when the person or persons signing the. . . statement can **unequivocally** make the required self-certification." M.P.E.P., § 509.03, 6th ed., rev. 2, July 1996 (emphasis added).*

(complete the following, if applicable)

☐ Status as a small entity was claimed in prior application

_____/_____, filed on _____, from which benefit is being claimed for this application under:

35 U.S.C. § ☐ 119(e),

☐ 120,

☐ 121,

☐ 365(c),

and which status as a small entity is still proper and desired.

☐ A copy of the statement in the prior application is included.

Filing Fee Calculation (50% of **A**, **B**, or **C** above)

$_____

NOTE: Any excess of the full fee paid will be refunded if a small entity statement and a refund request are filed within 2 months of the date of timely payment of a full fee. The two-month period is not extendable under § 1.136. 37 C.F.R. § 1.28(a).

12. Request for International-Type Search (37 C.F.R. § 1.104(d))

(complete, if applicable)

☐ Please prepare an international-type search report for this application at the time when national examination on the merits takes place.

13. Fee Payment Being Made at This Time

☐ Not Enclosed

☐ No filing fee is to be paid at this time.
(This and the surcharge required by 37 C.F.R. § 1.16(e) can be paid subsequently.)

☒ Enclosed

☒ Filing fee $ 1900.00

☐ Recording assignment
($40.00 – 37 C.F.R. § 1.21(h))
(See attached "COVER SHEET FOR ASSIGNMENT ACCOMPANYING NEW APPLICATION.") $_____

☐ Petition fee for filing by other than all the inventors or person on behalf of the inventor where inventor refused to sign or cannot be reached.
($130.00 – 37 C.F.R. §§ 1.47 and 1.17(i)) $_____

☐ For processing an application with a specification in a non-English language
($130.00; 37 C.F.R. §§ 1.52(d) and 1.17(k)) $_____

☐ Processing and retention fee
($130.00, 37 C.F.R. §§ 1.52(d) and 1.21(l)) $_____

☐ Fee for international-type search report
($40.00; 37 C.F.R. § 1.21(e)) $_____

NOTE: 37 C.F.R. § 1.21(l) establishes a fee for processing and retaining any application that is abandoned for failing to complete the application pursuant to 37 C.F.R. § 1.53(f) and this, as well as the changes to 37 C.F.R. §§ 1.53 and 1.78(a)(1), indicate that in order to obtain the benefit of a prior U.S. application, either the basic filing fee must be paid, or the processing and retention fee of § 1.21(l) must be paid, within 1 year from the notification under § 53(f).

Total fees enclosed **$ 1900.00**

14. Method of Payment of Fees

☒ Attached is a ☒check ☐ money order in the amount of $ 1900.00

☐ Authorization is hereby made to charge the amount of $_____

☐ to Deposit Account No. _____

☐ to Credit card as shown on the attached credit card information authorization form PTO-2038.

WARNING: *Credit card information should **not** be included on this form as it may become public.*

☒ **Charge any additional fees required by this paper or credit any overpayment to Deposit Account No. 23-0442.**

15. Authorization to Charge Additional Fees

WARNING: *If no fees are to be paid on filing, the following items should not be completed.*

WARNING: *Accurately count claims, especially multiple dependent claims, to avoid unexpected high charges, if extra claim charges are authorized.*

☐ The Office is hereby authorized to charge, in the manner shown above, the following additional fees that may be required by this paper and during the entire pendency of this application.

☐ 37 C.F.R. § 1.16(a), (f), or (g) (filing fees)
☐ 37 C.F.R. § 1.16(b), (c), and (d) (presentation of extra claims)

NOTE: Because additional fees for excess or multiple dependent claims not paid on filing or on later presentation must only be paid or these claims canceled by amendment prior to the expiration of the time period set for response by the P.T.O. in any notice of fee deficiency (37 C.F.R. § 1.16(d)), it might be best not to authorize the P.T.O. to charge additional claim fees, except possibly when dealing with amendments after final action.

☐ 37 C.F.R. § 1.16(e) (surcharge for filing the basic filing fee and/or declaration on a date later than the filing date of the application)

☐ 37 C.F.R. § 1.17(a)(1)-(5) (extension fees pursuant to § 1.136(a))

☐ 37 C.F.R. § 1.17 (application processing fees)

WARNING: *"...A written request may be submitted in an application that is an authorization to treat any concurrent or future reply, requiring a petition for an extension of time under this paragraph for its timely submission, as incorporating a petition for extension of time for the appropriate length of time. An authorization to charge all required fees, fees under § 1.17, or all required extension of time fees will be treated as a constructive petition for an extension of time in any concurrent or future reply requiring a petition for an extension of time under this paragraph for its timely submission. Submission of the fee set forth in § 1.17(a) will also be treated as a constructive petition for an extension of time in any concurrent reply requiring a petition for an extension of time under this paragraph for its timely submission." 37 C.F.R. § 1.136(a)(3).*

☐ 37 C.F.R. § 1.18 (issue fee at or before mailing of Notice of Allowance, pursuant to 37 C.F.R. § 1.311(b))

NOTE: Where an authorization to charge the issue fee to a deposit account has been filed before the mailing of a Notice of Allowance, the issue fee will be automatically charged to the deposit account at the time of mailing the Notice of Allowance. 37 C.F.R. § 1.311(b).

NOTE: 37 C.F.R. § 1.28(b) requires "Notification of any change in status resulting in loss of entitlement to small entity status must be filed in the application . . . prior to paying, or at the time of paying, . . . issue fee." From the wording of 37 C.F.R. § 1.28(b), (a) notification of change of status must be made even if the fee is paid as "other than a small entity" and (b) no notification is required if the change is to another small entity.

16. Instructions as to Overpayment

NOTE: "...Amounts of twenty-five dollars or less will not be returned unless specifically requested within a reasonable time, nor will the payer be notified of such amounts; amounts over twenty-five dollars may be returned by check or, if requested, by credit to a deposit account." 37 C.F.R. § 1.26(a).

☒ Credit Account No. 23-0442
☐ Refund

Date: July 25, 2007

Reg. No. 40,061

Tel. No. (203) 261-1234

Customer No. 004955

SIGNATURE OF PRACTITIONER

Kenneth Q. Lao
(type or print name of practitioner
Ware, Fressola, Van Der Sluys &
Adolphson LLP
755 Main Street
P.O. (Correspondence) Address
P.O. Box 224
Monroe, CT 06468

☒ **Incorporation by reference of added pages**

(check the following item if the application in this transmittal claims the benefit of prior U.S. application(s) (including an international application entering the U.S. stage as a continuation, divisional or C-I-P application) and complete and attach the ADDED PAGES FOR NEW APPLICATION TRANSMITTAL WHERE BENEFIT OF PRIOR U.S. APPLICATION(S) CLAIMED.)

☒ Plus Added Pages for New Application Transmittal Where Benefit of Prior U.S. Application(s) Claimed

Number of pages added 5

☐ Plus Added Pages for Papers Referred to in Item 4 Above

Number of pages added _____

☐ Plus added pages deleting names of inventor(s) named in prior application(s) who is/are no longer inventor(s) of the subject matter claimed in this application.

Number of pages added _____

☐ Plus "Assignment Cover Letter Accompanying New Application"

Number of pages added _____

☐ **Statement Where No Further Pages Added**

(if no further pages form a part of this Transmittal, then end this Transmittal with this page and check the following item.

☐ This transmittal ends with this page.

Practitioner's Docket No. 944-001.107-2 **PATENT**

ADDED PAGES FOR APPLICATION TRANSMITTAL WHERE BENEFIT OF PRIOR U.S APPLICATION(S) CLAIMED

NOTE: See 37 CFR 1.78.

17. Relate Back

WARNING: *If an application claims the benefit of the filing date of an earlier filed application under 35 U.S.C. 120, 121 or 365(c), the 20-year term of that application will be based upon the filing date of the earliest U.S. application that the application makes reference to under 35 U.S.C. 120, 121 or 365(c). 35 U.S.C. 154(a)(2) does not take into account, for the determination of the patent term, any application on which priority is claimed under 35 U.S.C. 119, 365(a) or 365(b). For a c-i-p application, applicant should review whether any claim in the patent that will issue is supported by an earlier application and, if not, the applicant should consider canceling the reference to the earlier filed application. The term of a patent is not based on a claim-by-claim approach. See Notice of April 14, 1995, 60 Fed. Reg. 20,195, at 20,205.*

(complete the following, if applicable)

☒ Amend the specification by inserting, before the first line, the following sentence:

A. 35 U.S.C. 119(e)

NOTE: "Any nonprovisional application claiming the benefit of one or more prior filed copending provisional applications must contain or be amended to contain in the first sentence of the specification following the title a reference to each such prior provisional application, identifying it as a provisional application, and including the provisional application number (consisting of series code and serial number). "37 C.F.R. § 1.78(a)(4).

☐ "This application claims the benefit of U.S. Provisional Application(s) No(s).:

APPLICATION NO(S).:	**FILING DATE**
_____ / _____	_____ "
_____ / _____	_____ "
_____ / _____	_____ "

B. 35 U.S.C. 120, 121 and 365(c)

NOTE: "Except for a continued prosecution application filed under § 1.53(d), any nonprovisional application claiming the benefit of one or more prior filed copending nonprovisional applications or international applications designating the United States of America must contain or be amended to contain in the first sentence of the specification following the title a reference to each such prior application, identifying it by application number (consisting of the series code and serial number) or international application number and international filing date and indicating the relationship of the applications . . . Cross-references to other related applications may be made when appropriate." (See § 1.14(a)). 37 C.F.R. § 1.78(a)(2).

☒ "This application is a

☐ continuation

☐ continuation-in-part

☒ divisional

of copending application(s)

☒ application number 10/421,629 filed on April 23, 2003

☐ International Application _____ filed on _____

_____ and which designated the U.S."

NOTE: The proper reference to a prior filed PCT application that entered the U.S. national phase is the U.S. serial number and the filing date of the PCT application that designated the U.S.

NOTE: (1) Where the application being transmitted adds subject matter to the International Application, then the filing can be as a continuation-in-part or (2) if it is desired to do so for other reasons then the filing can be as a continuation.

NOTE: The deadline for entering the national phase in the U.S. for an international application was clarified in the Notice of April 28, 1987 (1079 O.G. 32 to 46) as follows:

"The Patent and Trademark Office considers the International application to be pending until the 22nd month from the priority date if the United States has been designated and no Demand for International Preliminary Examination has been filed prior to the expiration of the 19th month from the priority date and until the 32nd month from the priority date if a Demand for International Preliminary Examination which elected the United States of America has been filed prior to the expiration of the 19th month from the priority date, provided that a copy of the international application has been communicated to the Patent and Trademark Office within the 20 or 30 month period respectively. If a copy of the international application has not been communicated to the Patent and Trademark Office within the 20 or 30 month period respectively, the international application becomes abandoned as to the United States 20 or 30 months from the priority date respectively. These periods have been placed in the rules as paragraph (h) of § 1.494 and paragraph (i) of § 1.495. A continuing application under 35 U.S.C. 365(c) and 120 may be filed any time during the pendency of the international application."

☐ "The nonprovisional application designated above, namely application _____ / _____, filed _____, claims the benefit of U.S. Provisional Application(s) No(s).:

APPLICATION NO(S).:	**FILING DATE**
_____ / _____	_____ "
_____ / _____	_____ "
_____ / _____	_____ "

☐ Where more than one reference is made above, please combine all references into one sentence.

18. Relate Back – 35 U.S.C. 119 Priority Claim for Prior Application

The prior U.S. application(s), including any prior International Application designating the U.S., identified above in item 17B, in turn itself claim(s) foreign priority(ies) as follows:

Country	Appln. No.	Filed on

The certified copy(ies) has (have)

☐ been filed on _____, in prior application 0 /_____, which was filed on _____.

☐ is (are) attached.

*WARNING: The certified copy of the priority application that may have been communicated to the PTO by the International Bureau may **not** be relied on without any need to file a certified copy of the priority application **in the continuation application.** This is so because the certified copy of the priority application communicated by the International Bureau is placed in a folder and is not assigned a U.S. serial number unless the national stage is entered. Such folders are disposed of if the national stage is not entered. Therefore, such certified copies may not be available if needed later in the prosecution of a continuing application. An alternative would be to physically remove the priority documents from the folders and transfer them to the continuing application. The resources required to request transfer, retrieve the folders, make suitable record notations, transfer the certified copies, enter and make a record of such copies in the Continuing Application are substantial. Accordingly, the priority documents in folders of international applications that have not entered the national stage may not be relied on. Notice of April 28, 1987 (1079 O.G. 32 to 46).*

19. Maintenance of Copendency of Prior Application

NOTE: The PTO finds it useful if a copy of the petition filed in the prior application extending the term for response is filed with the papers constituting the filing of the continuation application. Notice of November 5, 1985 (1060 O.G. 27).

A. ☐ Extension of time in prior application

*(This item **must** be completed and the papers filed in the prior application, if the period set **in the prior application** has run.)*

☐ A petition, fee and response extends the term in the pending **prior** application until _____.

☐ A **copy** of the petition filed in prior application is attached.

B. ☐ Conditional Petition for Extension of Time in Prior Application

(complete this item, if previous item not applicable)

☐ A conditional petition for extension of time is being filed in the pending **prior** application.

☐ A **copy** of the conditional petition filed in the prior application is attached.

20. Further Inventorship Statement Where Benefit of Prior Application(s) Claimed

(complete applicable item (a), (b) and/or (c) below)

(a) ☐ This application discloses and claims only subject matter disclosed in the prior application whose particulars are set out above and the inventor(s) in this application are

☐ the same.

☐ less than those named in the prior application. It is requested that the following inventor(s) identified for the prior application be deleted:

_____

(type name(s) of inventor(s) to be deleted)

(b) ☐ This application discloses and claims additional disclosure by amendment and a new declaration or oath is being filed. With respect to the prior application, the inventor(s) in this application are

☐ the same.

☐ the following additional inventor(s) have been added:

_____

(type name(s) of inventor(s) to be added)

(c) The inventorship for all the claims in this application are

☒ the same

☐ not the same. An explanation, including the ownership of the various claims at the time the last claimed invention was made

☐ is submitted.

☐ will be submitted.

21. Abandonment of Prior Application (if applicable)

☐ Please abandon the prior application at a time while the prior application is pending, or when the petition for extension of time or to revive in that application is granted, and when this application is granted a filing date, so as to make this application copending with said prior application.

NOTE: According to the Notice of May 13, 1983 (103, TMOG 6-7), the filing of a continuation or continuation-in-part application is a proper response with respect to a petition for extension of time or a petition to revive and should include the express abandonment of the prior application conditioned upon the granting of the petition and the granting of a filing date to the continuing application.

22. Petition for Suspension of Prosecution for the Time Necessary to File an Amendment

WARNING: *"The claims of a new application may be finally rejected in the first Office action in those situations where (1) the new application is a continuing application of, or a substitute for, an earlier application, and (2) all the claims of the new application (a) are drawn to the same invention claimed in the earlier application, and (b) would have been properly finally rejected on the grounds of art of record in the next Office action if they had been entered in the earlier application." MPEP, § 706.07(b).*

NOTE: Where it is possible that the claims on file will give rise to a first action final for this continuation application and for some reason an amendment cannot be filed promptly (e.g., experimental data is being gathered) it may be desirable to file a petition for suspension of prosecution for the time necessary.

(check the next item, if applicable)

☐ There is provided herewith a Petition To Suspend Prosecution for the Time Necessary to File An Amendment (New Application Filed Concurrently)

23. Small Entity (37 CFR § 1.28(a))

☐ Applicant has established small entity status by the filing of a statement in parent application 0 /_____ on _____.

☐ A copy of the statement previously filed is included.

WARNING: *See 37 CFR § 1.28(a).*

24. NOTIFICATION IN PARENT APPLICATION OF THIS FILING

☒ A notification of the filing of this
(check one of the following)

☐ continuation

☐ continuation-in-part

☒ divisional

is being filed in the parent application, from which this application claims priority under 35 U.S.C. § 120.

Practitioner's Docket No. 944-001.107 **PATENT**

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re application of: Lainema
Application No.: 10/421,629 Group No.: 2621
Filed: April 23, 2003 Examiner: Gims Philippe
For: METHOD AND DEVICE FOR INDICATING QUANTIZER PARAMETERS IN A VIDEO CODING SYSTEM

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

NOTIFICATION OF FILING OF CONTINUING, DIVISIONAL OR CONTINUED PROSECUTION APPLICATION

Notification is hereby being made of the filing of a:

- ☐ continuation
- ☐ continuation-in-part
- ☒ divisional
- ☐ continued prosecution

application for this case

- ☒ concurrently herewith.
- ☐ on _____.

Date

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Tel. No.: (203) 261-1234

Customer No.: 004955

SIGNATURE OF PRACTITIONER

Kenneth Q. Lao
(type or print name of practitioner)

WARE, FRESSOLA, VAN DER SLUYS & ADOLPHSON LLP
Bradford Green, Building Five
755 Main Street, P.O. Box 224
P.O. Address
Monroe, Connecticut 06468

PATENT
Attorney Docket No. 944-001.107-1

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

PATENT APPLICATION

of

Jani LAINEMA

for

METHOD AND DEVICE FOR INDICATING QUANTIZER PARAMETERS IN A VIDEO CODING SYSTEM

Express Mail No. EV914764379US

METHOD AND DEVICE FOR INDICATING QUANTIZER PARAMETERS IN A VIDEO CODING SYSTEM

This application is based on and claims priority to U.S. provisional application No. 60/374,667, filed April 23, 2002.

Field of the Invention

The invention relates to a method, an encoder, a decoder and a device for the coding of digital video. More specifically, the invention relates to the indication of quantization parameter (QP) values in a video coding system.

Background of the Invention

Digital video sequences, like ordinary motion pictures recorded on film, comprise a sequence of still images, the illusion of motion being created by displaying the images one after the other, typically at a rate between 15 and 30 frames per second.

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

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

The lower spatial resolution of the chrominance components is usually attained by sub-sampling. Typically, each frame of a video sequence is divided into so-called "macroblocks",

which comprise luminance (Y) information and associated chrominance (U, V) information, which is spatially sub-sampled. Figure 1 illustrates one way in which macroblocks can be formed. As shown in Figure 1, a frame of a video sequence represented using a YUV color model, each component having the same spatial resolution. Macroblocks are formed by representing a region of 16x16 image pixels in the original image as four blocks of luminance information, each luminance block comprising an 8x8 array of luminance (Y) values and two, spatially corresponding, chrominance components (U and V) which are sub-sampled by a factor of two in both the horizontal and vertical directions to yield corresponding arrays of 8x8 chrominance (U, V) values. According to certain video coding recommendations, such as International Telecommunications Union (ITU-T) recommendation H.26L, the block size used within the macroblocks can be other than 8x8, for example 4x8 or 4x4 (see T. Wiegand, "Joint Model Number 1", Doc. JVT-A003, Joint Video Team (JVT) of ISO/IEC MPEG and ITU-T VCEG, Jan. 2002, Sections 2.2 and 2.3). ITU-T recommendation H.26L also allows macroblocks to be organized together to form so-called "slices". More specifically, each slice is formed from a number of consecutive macroblocks in coding order and is encoded in such a way that it can be decoded independently without making reference to any other slice of the same frame. This arrangement is advantageous, as it tends to limit the propagation of artefacts in the decoded video that may arise due to transmission errors. While there is no specific limitation on the way in which slices may be constructed, one straightforward scheme is to group all the macroblocks in a single row of a frame together as a slice. This arrangement, together with the division of a QCIF format image into 16x16 macroblocks is illustrated in Figure 2.

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

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

Video compression methods are based on reducing the redundant and perceptually irrelevant parts of video sequences. The redundancy in video sequences can be categorised into spatial, temporal and spectral redundancy. "Spatial redundancy" is the term used to describe the correlation (similarity) between neighbouring pixels within a frame. The term "temporal redundancy" expresses the fact that objects appearing in one frame of a sequence are likely to appear in subsequent frames, while "spectral redundancy" refers to the correlation between different colour components of the same image.

There is often a significant amount of spatial redundancy between the pixels that make up each frame of a digital video sequence. In other words, the value of any pixel within a frame of the sequence is substantially the same as the value of other pixels in its immediate vicinity. Typically, video coding systems reduce spatial redundancy using a technique known as "block-based transform coding", in which a mathematical transformation, such as a two-dimensional Discrete Cosine Transform (DCT), is applied to blocks of image pixels. This transforms the image data from a representation comprising pixel values to a form comprising a set of coefficient values representative of spatial frequency components. This alternative representation of the image data reduces spatial redundancy significantly and thereby produces a more compact representation of the image data.

Frames of a video sequence which are compressed using block-based transform coding, without reference to any other frame within the sequence, are referred to as INTRA-coded or I-frames.

Generally, video coding systems not only reduce the spatial redundancy within individual frames of a video sequence, but also make use of a technique known as "motion-compensated prediction", to reduce the temporal redundancy in the sequence. Using motion-compensated prediction, the image content of some (often many) of the frames in a digital

video sequence is "predicted" from one or more other frames in the sequence, known as "reference" frames. Prediction of image content is achieved by tracking the motion of objects or regions of an image between a frame to be coded (compressed) and the reference frame(s) using "motion vectors". As in the case of INTRA-coding, motion compensated prediction of a video frame is typically performed macroblock-by-macroblock.

Frames of a video sequence, compressed using motion-compensated prediction, are generally referred to as INTER-coded or P-frames. Motion-compensated prediction alone rarely provides a sufficiently precise representation of the image content of a video frame and therefore it is typically necessary to provide a so-called "prediction error" (PE) frame with each INTER-coded frame. The prediction error frame represents the difference between a decoded version of the INTER-coded frame and the image content of the frame to be coded. More specifically, the prediction error frame comprises values that represent the difference between pixel values in the frame to be coded and corresponding reconstructed pixel values formed on the basis of a predicted version of the frame in question. Consequently, the prediction error frame has characteristics similar to a still image and block-based transform coding can be applied in order to reduce its spatial redundancy and hence the amount of data (number of bits) required to represent it.

In order to illustrate the operation of a video coding system in greater detail, reference will now be made to Figures 3 and 4. Figure 3 is a schematic diagram of a generic video encoder that employs a combination of INTRA- and INTER-coding to produce a compressed (encoded) video bit-stream. A corresponding decoder is illustrated in Figure 4 and will be described later in the text.

The video encoder 100 comprises an input 101 for receiving a digital video signal from a camera or other video source (not shown). It also comprises a transformation unit 104 which is arranged to perform a block-based discrete cosine transform (DCT), a quantizer 106, an inverse quantizer 108, an inverse transformation unit 110, arranged to perform an inverse block-based discrete cosine transform (IDCT), combiners 112 and 116, and a frame store 120. The encoder further comprises a motion estimator 130, a motion field coder 140 and a motion compensated predictor 150. Switches 102 and 114 are operated co-operatively by control manager 160 to switch the encoder between an INTRA-mode of video encoding and an INTER-mode of video encoding. The encoder 100 also comprises a video multiplex coder 170 which forms a single bit-stream from the various types of information produced by the encoder 100 for further transmission to a remote receiving terminal or, for example, for storage on a mass storage medium, such as a computer hard drive (not shown).

Encoder 100 operates as follows. Each frame of uncompressed video provided from the video source to input 101 is received and processed macroblock by macroblock, preferably in raster-scan order. When the encoding of a new video sequence starts, the first frame to be encoded is encoded as an INTRA-coded frame. Subsequently, the encoder is programmed to code each frame in INTER-coded format, unless one of the following conditions is met: 1) it is judged that the current macroblock of the frame being coded is so dissimilar from the pixel values in the reference frame used in its prediction that excessive prediction error information is produced, in which case the current macroblock is coded in INTRA-coded format; 2) a predefined INTRA frame repetition interval has expired; or 3) feedback is received from a receiving terminal indicating a request for a frame to be provided in INTRA-coded format.

Operation of the encoder 100 in INTRA-coding mode will now be described. In INTRA-coding mode, the control manager 160 operates the switch 102 to accept video input from input line 118. The video signal input is received macroblock by macroblock and the blocks of luminance and chrominance values which make up each macroblock are passed to the DCT transformation block 104. Here a 2-dimensional discrete cosine transform is performed and a 2-dimensional array of DCT coefficients is formed for each block.

The DCT coefficients for each block are passed to the quantizer 106, where they are quantized using a quantization parameter QP. Selection of the quantization parameter QP is controlled by the control manager 160 via control line 115.

In more detail, quantization of the DCT coefficients is performed by dividing each coefficient value by the quantization parameter QP and rounding the result to the nearest integer. In this way the quantization process yields a set of quantized DCT coefficient values that have a reduced numerical precision compared with the coefficient values originally generated by DCT transformation block 104. Thus, in general, each of the quantized DCT coefficients may be represented by a smaller number of data bits than required to represent the corresponding coefficient before quantization. Furthermore, certain DCT coefficients are reduced to zero by the quantization process, thus reducing the number of coefficients that must be coded. Both these effects result in a reduction in the amount of data (i.e. data bits) required to represent the DCT coefficients for an image block. Thus, quantization provides a further mechanism by which the amount of data required to represent each image of the video sequence can be reduced. It also introduces an irreversible loss of information, which leads to a corresponding reduction in image quality. While this reduction in image quality may not always be desirable, quantization of DCT coefficient values does provide the

possibility to adjust the number of bits required to encode a video sequence to take into account e.g. the bandwidth available for transmission of the encoded sequence or the desired quality of the coded video. More specifically, by increasing the value of QP used to quantize the DCT coefficients, a lower quality, but more compact representation of the video sequence can be created. Conversely, by reducing the value of QP, a higher quality but less compressed encoded bit-stream can be formed.

The quantized DCT coefficients for each block are passed from the quantizer 106 to the video multiplex coder 170, as indicated by line 125 in Figure 1. The video multiplex coder 170 orders the quantized transform coefficients for each block using a zigzag scanning procedure, thereby converting the two-dimensional array of quantized transform coefficient values into a one-dimensional array. . Typically, the video multiplex coder 170 next represents each non-zero quantized coefficient in the one-dimensional array by a pair of values, referred to as *level* and *run*, *level* being the value of the quantized coefficient and *run* being the number of consecutive zero-valued coefficients preceding the coefficient in question. The *run* and *level* values are further compressed using entropy coding. For example, a method such as variable length coding (VLC) may be used to produce a set of variable length codewords representative of each (*run*, *level*) pair.

Once the (*run*, *level*) pairs have been entropy (e.g. variable length) coded, the video multiplex coder 170 further combines them with control information, also entropy coded, for example, using a variable length coding method appropriate for the kind of information in question, to form a single compressed bit-stream of coded image information 135. It is this bit-stream, including the variable length codewords representative of the (*run, level*) pairs and control information relating, among other things, to the quantization parameter QP used for quantizing the DCT coefficients, which is transmitted from the encoder.

A locally decoded version of the macroblock is also formed in the encoder 100. This is done by passing the quantized transform coefficients for each block, output by quantizer 106, through inverse quantizer 108 and applying an inverse DCT transform in inverse transformation block 110. Inverse quantization is performed by reversing the quantization operation performed in quantizer 106. More specifically, inverse quantizer 108 attempts to recover the original DCT coefficient values for a given image block by multiplying each quantized DCT coefficient value by quantization parameter QP. Because of the rounding operation performed as part of the quantization process in quantizer 106, it is generally not possible to recover the original DCT coefficient values exactly. This results in a discrepancy

between the recovered DCT coefficient values and those originally produced by DCT transformation block 104 (hence the irreversible loss of information referred to above).

The operations performed by inverse quantizer 108 and inverse transformation block 110 yield a reconstructed array of pixel values for each block of the macroblock. The resulting decoded image data is input to combiner 112. In INTRA-coding mode, switch 114 is set so that the input to the combiner 112 via switch 114 is zero. In this way, the operation performed by combiner 112 is equivalent to passing the decoded image data unaltered.

As subsequent macroblocks of the current frame are received and undergo the previously described encoding and local decoding steps in blocks 104, 106, 108, 110 and 112, a decoded version of the INTRA-coded frame is built up in frame store 120. When the last macroblock of the current frame has been INTRA-coded and subsequently decoded, the frame store 120 contains a completely decoded frame, available for use as a prediction reference frame in coding a subsequently received video frame in INTER-coded format. The flag indicating INTRA or INTER-code format is provided in line 122.

Operation of the encoder 100 in INTER-coding mode will now be described. In INTER-coding mode, the control manager 160 operates switch 102 to receive its input from line 117, which comprises the output of combiner 116. The combiner 116 receives the video input signal macroblock by macroblock from input 101. As combiner 116 receives the blocks of luminance and chrominance values which make up the macroblock, it forms corresponding blocks of prediction error information. The prediction error information represents the difference between the block in question and its prediction, produced in motion compensated prediction block 150. More specifically, the prediction error information for each block of the macroblock comprises a two-dimensional array of values, each of which represents the difference between a pixel value in the block of luminance or chrominance information being coded and a decoded pixel value obtained by forming a motion-compensated prediction for the block, according to the procedure described below.

The prediction error information for each block of the macroblock is passed to DCT transformation block 104, which performs a two-dimensional discrete cosine transform on each block of prediction error values to produce a two-dimensional array of DCT transform coefficients for each block.

The transform coefficients for each prediction error block are passed to quantizer 106 where they are quantized using a quantization parameter QP, in a manner analogous to that described above in connection with operation of the encoder in INTRA-coding mode. Again, selection of the quantization parameter QP is controlled by the control manager 160 via

control line 115. The accuracy of prediction error coding can be adjusted depending on the available bandwidth and/or required quality of the coded video. In a typical Discrete Cosine Transform (DCT) based system this is done by varying the Quantizer Parameter (QP) used in quantizing the DCT coefficients the DCT coefficients to a specific accuracy.

The quantized DCT coefficients representing the prediction error information for each block of the macroblock are passed from quantizer 106 to video multiplex coder 170, as indicated by line 125 in Figure 1. As in INTRA-coding mode, the video multiplex coder 170 orders the transform coefficients for each prediction error block using a zigzag scanning procedure and then represents each non-zero quantized coefficient as a (*run, level*) pair. It further compresses the (*run, level*) pairs using entropy coding, in a manner analogous to that described above in connection with INTRA-coding mode. Video multiplex coder 170 also receives motion vector information (described in the following) from motion field coding block 140 via line 126 and control information (e.g. including an indication of the quantization parameter QP) from control manager 160. It entropy codes the motion vector information and control information and forms a single bit-stream of coded image information, 135 comprising the entropy coded motion vector, prediction error and control information. The indication, qz, of the quantization parameter QP is provided to multiplex xoswe 170 via line 124.

The quantized DCT coefficients representing the prediction error information for each block of the macroblock are also passed from quantizer 106 to inverse quantizer 108. Here they are inverse quantized, in a manner analogous to that previously described in connection with operation of the encoder in INTRA-coding mode. In INTER-coding mode, the quality of the encoded video bit-stream and the number of bits required to represent the video sequence can be adjusted by varying the degree of quantization applied to the DCT coefficients representing the prediction error information.

The resulting blocks of inverse quantized DCT coefficients are applied to inverse DCT transform block 110, where they undergo inverse DCT transformation to produce locally decoded blocks of prediction error values. The locally decoded blocks of prediction error values are then input to combiner 112. In INTER-coding mode, switch 114 is set so that the combiner 112 also receives predicted pixel values for each block of the macroblock, generated by motion-compensated prediction block 150. The combiner 112 combines each of the locally decoded blocks of prediction error values with a corresponding block of predicted pixel values to produce reconstructed image blocks and stores them in frame store 120.

As subsequent macroblocks of the video signal are received from the video source and undergo the previously described encoding and decoding steps in blocks 104, 106, 108, 110, 112, a decoded version of the frame is built up in frame store 120. When the last macroblock of the frame has been processed, the frame store 120 contains a completely decoded frame, available for use as a prediction reference frame in encoding a subsequently received video frame in INTER-coded format.

Formation of a prediction for a macroblock of the current frame will now be described. Any frame encoded in INTER-coded format requires a reference frame for motion-compensated prediction. This means, necessarily, that when encoding a video sequence, the first frame to be encoded, whether it is the first frame in the sequence, or some other frame, must be encoded in INTRA-coded format. This, in turn, means that when the video encoder 100 is switched into INTER-coding mode by control manager 160, a complete reference frame, formed by locally decoding a previously encoded frame, is already available in the frame store 120 of the encoder. In general, the reference frame is formed by locally decoding either an INTRA-coded frame or an INTER-coded frame.

The first step in forming a prediction for a macroblock of the current frame is performed by motion estimation block 130. The motion estimation block 130 receives the blocks of luminance and chrominance values which make up the current macroblock of the frame to be coded via line 128. It then performs a block matching operation in order to identify a region in the reference frame which corresponds substantially with the current macroblock. In order to perform the block matching operation, motion estimation block accesses reference frame data stored in frame store 120 via line 127. More specifically, motion estimation block 130 performs block-matching by calculating difference values (e.g. sums of absolute differences) representing the difference in pixel values between the macroblock under examination and candidate best-matching regions of pixels from a reference frame stored in the frame store 120. A difference value is produced for candidate regions at all possible positions within a predefined search region of the reference frame and motion estimation block 130 determines the smallest calculated difference value. The offset between the macroblock in the current frame and the candidate block of pixel values in the reference frame that yields the smallest difference value defines the motion vector for the macroblock in question.

Once the motion estimation block 130 has produced a motion vector for the macroblock, it outputs the motion vector to the motion field coding block 140. The motion field coding block 140 approximates the motion vector received from motion estimation

block 130 using a motion model comprising a set of basis functions and motion coefficients. More specifically, the motion field coding block 140 represents the motion vector as a set of motion coefficient values which, when multiplied by the basis functions, form an approximation of the motion vector. Typically, a translational motion model having only two motion coefficients and basis functions is used, but motion models of greater complexity may also be used.

The motion coefficients are passed from motion field coding block 140 to motion compensated prediction block 150. Motion compensated prediction block 150 also receives the best-matching candidate region of pixel values identified by motion estimation block 130 from frame store 120. Using the approximate representation of the motion vector generated by motion field coding block 140 and the pixel values of the best-matching candidate region from the reference frame, motion compensated prediction block 150 generates an array of predicted pixel values for each block of the macroblock. Each block of predicted pixel values is passed to combiner 116 where the predicted pixel values are subtracted from the actual (input) pixel values in the corresponding block of the current macroblock, thereby forming a set of prediction error blocks for the macroblock.

Operation of the video decoder 200, shown in Figure 2 will now be described. The decoder 200 comprises a video multiplex decoder 270, which receives an encoded video bit-stream 135 from the encoder 100 and demultiplexes it into its constituent parts, an inverse quantizer 210, an inverse DCT transformer 220, a motion compensated prediction block 240, a frame store 250, a combiner 230, a control manager 260, and an output 280.

The control manager 260 controls the operation of the decoder 200 in response to whether an INTRA- or an INTER-coded frame is being decoded. An INTRA / INTER trigger control signal, which causes the decoder to switch between decoding modes is derived, for example, from picture type information associated with each compressed video frame received from the encoder. The INTRA / INTER trigger control signal is extracted from the encoded video bit-stream by the video multiplex decoder 270 and is passed to control manager 260 via control line 215.

Decoding of an INTRA-coded frame is performed macroblock-by-macroblock. The video multiplex decoder 270 separates the encoded information for the blocks of the macroblock from possible control information relating to the macroblock in question. The encoded information for each block of an INTRA-coded macroblock comprises variable length codewords representing the VLC coded *level* and *run* values for the non-zero quantized DCT coefficients of the block. The video multiplex decoder 270 decodes the

variable length codewords using a variable length decoding method corresponding to the encoding method used in the encoder 100 and thereby recovers the (*run*, *level*) pairs. It then reconstructs the array of quantized transform coefficient values for each block of the macroblock and passes them to inverse quantizer 210. Any control information relating to the macroblock is also decoded in the video multiplex decoder using an appropriate decoding method and is passed to control manager 260. In particular, information relating to the level of quantization applied to the transform coefficients (i.e. quantization parameter QP) is extracted from the encoded bit-stream by video multiplex decoder 270 and provided to control manager 260 via control line 217. The control manager, in turn, conveys this information to inverse quantizer 210 via control line 218. Inverse quantizer 210 inverse quantizes the quantized DCT coefficients for each block of the macroblock according to the control information relating to quantization parameter QP and provides the now inverse quantized DCT coefficients to inverse DCT transformer 220. The inverse quantization operation performed by inverse quantizer 210 is identical to that performed by inverse quantizer 108 in the encoder.

Inverse DCT transformer 220 performs an inverse DCT transform on the inverse quantized DCT coefficients for each block of the macroblock to form a decoded block of image information comprising reconstructed pixel values. The reconstructed pixel values for each block of the macroblock are passed via combiner 230 to the video output 280 of the decoder where, for example, they can be provided to a display device (not shown). The reconstructed pixel values for each block of the macroblock are also stored in frame store 250. Because motion-compensated prediction is not used in the encoding/decoding of INTRA coded macroblocks control manager 260 controls combiner 230 to pass each block of pixel values as such to the video output 280 and frame store 250. As subsequent macroblocks of the INTRA-coded frame are decoded and stored, a decoded frame is progressively assembled in the frame store 250 and thus becomes available for use as a reference frame for motion compensated prediction in connection with the decoding of subsequently received INTER-coded frames.

INTER-coded frames are also decoded macroblock by macroblock. The video multiplex decoder 270 receives the encoded video bit-stream 135 and separates the encoded prediction error information for each block of an INTER-coded macroblock from encoded motion vector information and possible control information relating to the macroblock in question. As explained in the foregoing, the encoded prediction error information for each block of the macroblock typically comprises variable length codewords representing the *level*

and *run* values for the non-zero quantized transform coefficients of the prediction error block in question. The video multiplex decoder 270 decodes the variable length codewords using a variable length decoding method corresponding to the encoding method used in the encoder 100 and thereby recovers the (*run*, *level*) pairs. It then reconstructs an array of quantized transform coefficient values for each prediction error block and passes them to inverse quantizer 210. Control information relating to the INTER-coded macroblock is also decoded in the video multiplex decoder 270 using an appropriate decoding method and is passed to control manager 260. Information relating to the level of quantization (QP) applied to the transform coefficients of the prediction error blocks is extracted from the encoded bit-stream and provided to control manager 260 via control line 217. The control manager, in turn, conveys this information to inverse quantizer 210 via control line 218. Inverse quantizer 210 inverse quantizes the quantized DCT coefficients representing the prediction error information for each block of the macroblock according to the control information relating to quantization parameter QP and provides the now inverse quantized DCT coefficients to inverse DCT transformer 220. Again, the inverse quantization operation performed by inverse quantizer 210 is identical to that performed by inverse quantizer 108 in the encoder. The INTRA/INTER flag is provided in line 215.

The inverse quantized DCT coefficients representing the prediction error information for each block are then inverse transformed in the inverse DCT transformer 220 to yield an array of reconstructed prediction error values for each block of the macroblock.

The encoded motion vector information associated with the macroblock is extracted from the encoded video bit-stream 135 by video multiplex decoder 270 and is decoded. The decoded motion vector information thus obtained is passed via control line 225 to motion compensated prediction block 240, which reconstructs a motion vector for the macroblock using the same motion model as that used to encode the INTER-coded macroblock in encoder 100. The reconstructed motion vector approximates the motion vector originally determined by motion estimation block 130 of the encoder. The motion compensated prediction block 240 of the decoder uses the reconstructed motion vector to identify the location of a region of reconstructed pixels in a prediction reference frame stored in frame store 250. The region of pixels indicated by the reconstructed motion vector is used to form a prediction for the macroblock in question. More specifically, the motion compensated prediction block 240 forms an array of pixel values for each block of the macroblock by copying corresponding pixel values from the region of pixels identified in the reference frame. These blocks of pixel values, derived from the reference frame, are passed from

motion compensated prediction block 240 to combiner 230 where they are combined with the decoded prediction error information. In practice, the pixel values of each predicted block are added to corresponding reconstructed prediction error values output by inverse DCT transformer 220. In this way, an array of reconstructed pixel values for each block of the macroblock is obtained. The reconstructed pixel values are passed to the video output 280 of the decoder and are also stored in frame store 250.

As subsequent macroblocks of the INTER-coded frame are decoded and stored, a decoded frame is progressively assembled in the frame store 250 and thus becomes available for use as a reference frame for motion-compensated prediction of other INTER-coded frames.

As described above, typical video encoding and decoding systems (commonly referred to as video codecs) are based on motion compensated prediction and prediction error coding. Motion compensated prediction is obtained by analyzing and coding motion between video frames and reconstructing image segments using the motion information. Prediction error coding is used to code the difference between motion compensated image segments and corresponding segments of the original image. The accuracy of prediction error coding can be adjusted depending on the available bandwidth and required quality of the coded video. In a typical Discrete Cosine Transform (DCT) based system this is done by varying the quantization parameter (QP) used in quantizing the DCT coefficients to a specific accuracy.

It should be noted that, in order to stay in synchronization with the encoder, the decoder has to know the exact value of the QP used in the coded video sequence. Typically, the QP value is transmitted once per slice leading to increase in the number of bits needed to encode the image. (As previously explained, a slice contains part of the image and is coded independently from other slices in order to avoid propagation of possible transmission errors inside the picture). For example, if the coding of a single QP value takes 6 bits and 20 images, each divided into 10 slices, are transmitted every second, 1.2kbps is spent for the QP information alone.

Prior art solutions (for example, the H.26L video coding recommendation presented in the document by T. Wiegand, "Joint Model Number 1", Doc. JVT-A003, Joint Video Team (JVT) of ISO/IEC MPEG and ITU-T VCEG, Jan. 2002) code the picture/slice QP parameters independently with a fixed or variable length code. This leads to increased transmission bit-rate as described above. More specifically, according to H.26L Joint Model Number 1, the quantization parameter value QP used in quantizing the DCT coefficient values is typically indicated in the encoded bit-stream at the beginning of each picture (see T. Wiegand, "Joint

Model Number 1", Doc. JVT-A003, Joint Video Team (JVT) of ISO/IEC MPEG and ITU-T VCEG, Jan. 2002, Section 3.3.1). If the macroblocks within a frame are arranged into slices then the QP value is also indicated at the beginning of each slice of the frame (e.g. in an optional slice header portion of the encoded bit-stream). In both cases, the QP value is indicated as such or is coded using an appropriate variable length coding scheme. As stated above, it should be realized that this scheme is very costly in terms of the number of bits required to represent the quantization parameter information, particularly in situations where frames are divided into many slices and / or the available bandwidth available for transmission of the encoded video sequence is low. This is a particularly significant problem in mobile video applications in which the encoded video bit-stream is transmitted over a radio communications link. In this situation, the bandwidth available for transmission of the encoded video bit-stream may be as low as 20kbits/s and the QP information included in the bit-stream may represent a significant proportion of the overall available bandwidth.

Furthermore, according to H.26L, the value of QP may optionally be varied at the macroblock level by inserting a quantizer change parameter (Dquant) in the portion of the encoded bit-stream representative of the macroblock in question (see T. Wiegand, "Joint Model Number 1", Doc. JVT-A003, Joint Video Team (JVT) of ISO/IEC MPEG and ITU-T VCEG, Jan. 2002, Section 3.4.7). This leads to a further increase in the amount of information in the encoded bit-stream that is devoted to the indication of QP related information.

In view of the foregoing, it should be realised that there is a significant need for an improved mechanism for indicating information relating to quantization parameter values in video coding systems.

Summary of the Invention

The present invention improves prior art solutions for indicating QP related information by introducing a sequence level QP. This allows the encoder application to decide a video sequence dependent reference QP to be used in coding of the picture / slice QPs. Now, according to the invention, instead of coding the absolute values of picture / slice QPs, it is enough to code the difference between the reference sequence QP and the actually used picture / slice QP. In this way there is no need to transmit a full QP for every picture / slice, but a statistically smaller difference value is transmitted and used to reconstruct the picture / slice QP, thus leading to reduction in transmission bit-rate.

The bit-rate savings are most evident in the case of constant QP. In this case, it is sufficient to send just one bit per slice to indicate that the sequence QP is to be used when decoding the slice. For example, in the previously described example, the bit-rate for QP is reduced from 1.2kbps to 0.2kbps (now only one bit needs to be sent instead of six for each slice).

According to a first aspect of the invention, there is provided a method of encoding a digital video sequence, the method being applied in a video coding application to produce an encoded video bit-stream representative of the digital video sequence. The digital video sequence comprises a number of frames, each frame of the sequence comprising an array of pixels and is divided into a plurality of blocks, each block comprising a certain number of pixels. The method comprises encoding a frame of the digital video sequence by applying motion compensated prediction to blocks of pixels, thereby producing corresponding blocks of prediction error values. A transform coding technique is applied to the blocks of prediction error values to produce sets of transform coefficient values representative of the blocks of prediction error values and a level of quantization is applied to the sets of transform coefficient values to yield sets of quantized transform coefficient values. According to the invention, the method further comprises defining a default level of quantization to be used throughout encoding of the digital video sequence to quantize the sets of transform coefficient values.

Advantageously, the method according to the first aspect of the invention is also used to indicate quantization parameter (QP) values used to quantize sets of transform coefficient values representative of blocks of pixel values produced for frames coded in INTRA-coding mode in a manner analogous to that described above for indicating the quantization parameter values used to quantize sets of transform coefficient values representative of prediction error values produced for frames coded in INTER-coding mode.

Advantageously, the default level of quantization to be used throughout encoding of the digital video sequence is specific to the video sequence being encoded. Alternatively, the default level of quantization is specific to the video coding application.

Preferably, an indication of the default level of quantization to be used throughout encoding of the digital video sequence is provided. Even more preferably, an indication of the default level of quantization is provided in the encoded bit-stream representative of the digital video sequence, Advantaegously, the encoded bit-stream, including the indication of the default level of quantization to be used throughout encoding of the digital video sequence, is transmitted to a video decoding device.

Advantageously, the default level of quantization to be used throughout encoding of the digital video sequence to quantize the sets of transform coefficient values can be updated during encoding of the digital video sequence and a further indication indicative of the updated default level of quantization is provided.

The indication of the updated default level of quantization is preferably transmitted to a video decoding device, advantageously, in the encoded bit-stream representative of the digital video sequence.

Advantageously, the level of quantization applied to said sets of transform coefficient values can be adjusted such that the actual level of quantization applied to the sets of transform coefficient values is different from the default level of quantization to be used throughout encoding of the video sequence. Preferably, the actual level of quantization applied is represented as a difference with respect to the default level of quantization. Advantageously, an indication of the difference with respect to the default level of quantization is provided in the encoded bit-stream representative of the digital video sequence.

In an embodiment of the video encoding method according to the first aspect of the invention, the level of quantization applied to the sets of transform coefficient values can be adjusted from one frame of the digital video sequence to another such that an actual level of quantization applied to the sets of transform coefficients for a particular frame of the digital video sequence is different from the default level of quantization to be used throughout encoding of the digital video sequence. Advantageously, in this embodiment, the actual level of quantization to be used in the particular frame is represented as a difference with respect to the default level of quantization and an indication of the difference with respect to the default level of quantization is provided in the encoded bit-stream representative of the digital video sequence.

In an alternative embodiment of the video encoding method according to the first aspect of the invention, the plurality of blocks into which a frame of the digital video sequence is divided are grouped into one or more segments and the level of quantization applied to the sets of transform coefficient values can be adjusted from one segment of a frame to another such that an actual level of quantization applied to the sets of transform coefficients for a particular segment of a frame is different from the default level of quantization to be used throughout encoding of the digital video sequence. Advantageously, in this alternative embodiment, the actual level of quantization to be used in the particular segment is represented as a difference with respect to the default level of quantization and an

indication of the difference with respect to the default level of quantization is provided in the encoded bit-stream representative of the digital video sequence.

Advantageously, if the default level of quantization is to be used to quantize all sets of transform coefficient values throughout the digital video sequence, an indication of the default level of quantization is provided together with an indication that said default level is to be used to quantize all sets of transform coefficient values throughout the digital video sequence.

According to a second aspect of the invention, there is provided a method of decoding an encoded digital video sequence, the method being applied in a video decoding application to produce a decoded digital video sequence. The digital video sequence comprises a number of frames, each frame of the sequence comprising an array of pixels and being divided into a plurality of blocks, each block comprising a certain number of pixels, frames of the digital video sequence having been encoded by applying motion compensated prediction to blocks of pixels to produce corresponding blocks of prediction error values and applying a transform coding technique to the blocks of prediction error values to produce sets of transform coefficient values representative of the blocks of prediction error values and applying a level of quantization to the sets of transform coefficient values to yield sets of quantized transform coefficient values representative of the blocks of prediction error values. According to the invention, the decoding method comprises defining a default level of inverse quantization to be used throughout decoding of the encoded digital video sequence to inverse quantize the sets of quantized transform coefficient values.

Advantageously, the default level of inverse quantization is identical to a default level of quantization used to quantize the sets of transform coefficient values during encoding of the video sequence.

Advantageously, the default level of inverse quantization defined to be used throughout decoding of the encoded digital video sequence is specific to the encoded video sequence being decoded. Alternatively, the default level of inverse quantization is specific to the video decoding application.

Advantageously, the decoding method comprises retrieving an indication of the default level of inverse quantization, preferably from a bit-stream representative of the encoded digital video sequence.

Advantageously, the default level of inverse quantization can be updated during decoding of the digital video sequence. Preferably, updating of the default level of inverse quantization is performed responsive to an indication of an updated default level of

quantization used during encoding of the video sequence, retrieved from a bit-stream representative of the encoded digital video sequence. Alternatively, the default level of inverse quantization is updated responsive to an indication of an updated default level of quantization used during encoding of the video sequence, transmitted from a video encoding device.

Advantageously, the level of inverse quantization applied to the sets of quantized transform coefficient values can be adjusted such that an actual level of inverse quantization applied to the sets of quantized transform coefficient values is different from the default level of inverse quantization to be used throughout decoding of the encoded digital video sequence. In this case, the actual level of inverse quantization is determined by adding a difference value to the default level of inverse quantization, the difference value being representative of the difference between the default level of inverse quantization and the actual level of inverse quantization to be applied. Preferably, an indication of the difference value is retrieved from a bit-stream representative of the encoded digital video sequence.

In an embodiment of the video decoding method according to the second aspect of the invention, the level of inverse quantization applied to the sets of quantized transform coefficient values is adjusted from one frame of the digital video sequence to another such that an actual level of inverse quantization applied to the sets of quantized transform coefficients for a particular frame of the digital video sequence is different from the default level of inverse quantization to be used throughout decoding of the encoded digital video sequence. Advantageously, in this embodiment, the actual level of inverse quantization to be used in the particular frame is determined by adding a frame-specific difference value to the default level of inverse quantization, the frame-specific difference value being representative of the difference between the default level of inverse quantization and the actual level of inverse quantization to be used in the particular frame. Preferably, an indication of said frame-specific difference value is retrieved from a bit-stream representative of the encoded digital video sequence.

In an alternative embodiment of the video decoding method according to the second aspect of the invention, the plurality of blocks into which a frame of said digital video sequence is divided are grouped into one or more segments and the level of inverse quantization applied to the sets of quantized transform coefficient values is adjusted from one segment of a frame to another such that an actual level of inverse quantization applied to the sets of quantized transform coefficients for a particular segment of a frame is different from the default level of inverse quantization to be used throughout decoding of the encoded

digital video sequence. Advantageously, in this alternative embodiment, the actual level of inverse quantization to be used in the particular segment is determined by adding a segment-specific difference value to the default level of inverse quantization, the segment-specific difference value being representative of the difference between the default level of inverse quantization and the actual level of inverse quantization to be used in the particular segment. Preferably, an indication of the segment-specific difference value is retrieved from a bit-stream representative of the encoded digital video sequence.

According to a third aspect of the invention, there is provided an encoder for encoding a digital video sequence to produce an encoded video bit-stream representative of the digital video sequence, the digital video sequence comprising a number of frames, each frame of the sequence comprising an array of pixels and being divided into a plurality of blocks, each block comprising a certain number of pixels. The video encoder according to the third aspect of the invention is arranged to encode a frame of the digital video sequence by applying motion compensated prediction to blocks of pixels, thereby producing corresponding blocks of prediction error values. It is further arranged to apply a transform coding technique to blocks of prediction error values to produce sets of transform coefficient values representative of said blocks of prediction error values and to apply a level of quantization to said sets of transform coefficient values to yield sets of quantized transform coefficient values. According to the invention, the video encoder is further arranged to define a default level of quantization to be used throughout encoding of the digital video sequence to quantize the sets of transform coefficient values.

Advantageously, the encoder according to the third aspect of the invention is also arranged to indicate quantization parameter (QP) values used to quantize sets of transform coefficient values representative of blocks of pixel values produced for frames coded in INTRA-coding mode in a manner analogous to that described above for indicating the quantization parameter values used to quantize sets of transform coefficient values representative of prediction error values produced for frames coded in INTER-coding mode.

Advantageously, the default level of quantization defined by the video encoder is specific to the video sequence being encoded.

Advantageously, the video encoder is further arranged to provide an indication of the default level of quantization in the encoded bit-stream representative of the digital video sequence. Even more advantageously, it is arranged to transmit the encoded bit-stream to a corresponding video decoder.

Advantageously the video encoder is further arranged to update the default level of quantization during encoding of the digital video sequence and to provide an indication of the updated default level of quantization. Preferably, the encoder is also arranged to transmit the indication of the updated default level of quantization to a corresponding video decoder. Advantageously, the encoder includes the indication of the updated default level of quantization in the encoded bit-stream representative of the digital video sequence.

Preferably, the video encoder is further arranged to adjust the level of quantization applied to the sets of transform coefficient values and thereby to apply an actual level of quantization that is different from the default level of quantization. Preferably, the video encoder is still further arranged to represent the actual level of quantization as a difference with respect to the default level of quantization and to provide an indication of the difference with respect to the default level of quantization in the encoded bit-stream representative of the digital video sequence.

In one embodiment, a video encoder according to the third aspect of the invention is arranged to adjust the level of quantization applied to the sets of transform coefficient values from one frame of the digital video sequence to another. In this way it is arranged to apply an actual level of quantization to the sets of transform coefficients for a particular frame that is different from the default level of quantization to be used throughout encoding of the digital video sequence. Advantageously, the video encoder according to this embodiment is further arranged to represent the actual level of quantization to be used in the particular frame as a difference with respect to the default level of quantization and to provide an indication of the difference with respect to the default level of quantization in the encoded bit-stream representative of the digital video sequence.

In an alternative embodiment, a video encoder according to the third aspect of the invention is further arranged to group the plurality of blocks into which a frame of the digital video sequence is divided into one or more segments and to adjust the level of quantization applied to the sets of transform coefficient values from one segment of a frame to another. In this way the video encoder is arranged to apply an actual level of quantization to the sets of transform coefficients for a particular segment of a frame that is different from the default level of quantization to be used throughout encoding of the digital video sequence. Advantageously, the video encoder according to this alternative embodiment is further arranged to represent the actual level of quantization to be used in the particular segment as a difference with respect to the default level of quantization and to provide an indication of the

difference with respect to the default level of quantization in the encoded bit-stream representative of the digital video sequence.

In a particular embodiment, the video encoder is arranged to provide an indication of the default level of quantization and an indication that the default level is to be used to quantize all sets of transform coefficient values throughout the digital video sequence.

Advantageously, the video encoder according to the third aspect of the invention is provided in a multimedia terminal. Even more preferably, it is implemented in a radio telecommunications device.

According to a fourth aspect of the invention, there is provided a decoder for decoding an encoded digital video sequence to produce a decoded digital video sequence. The digital video sequence comprises a number of frames, each frame of the sequence comprising an array of pixels and being divided into a plurality of blocks, each block comprising a certain number of pixels, frames of the digital video sequence having been encoded by applying motion compensated prediction to blocks of pixels to produce corresponding blocks of prediction error values and applying a transform coding technique to the blocks of prediction error values to produce sets of transform coefficient values representative of said blocks of prediction error values and applying a level of quantization to the sets of transform coefficient values to yield sets of quantized transform coefficient values representative of the blocks of prediction error values. According to the invention, the video decoder is arranged to define a default level of inverse quantization to be used throughout decoding of the encoded digital video sequence to inverse quantize the sets of quantized transform coefficient values.

Preferably, the default level of inverse quantization is identical to a default level of quantization used to quantize the sets of transform coefficient values during encoding of the video sequence.

Advantageously, the default level of inverse quantization defined to be used throughout decoding of the encoded digital video sequence is specific to the encoded video sequence being decoded.

Advantageously, the video decoder is arranged to retrieve an indication of the default level of inverse quantization, preferably from a bit-stream representative of the encoded digital video sequence.

Advantageously, the video decoder is arranged to update the default level of inverse quantization during decoding of the digital video sequence, preferably by retrieving an indication of an updated default level of quantization from a bit-stream representative of the

encoded digital video sequence. Alternatively, the video decoder is arranged to receive an indication of an updated default level of quantization transmitted from a video encoding device.

Preferably, the video decoder is arranged to adjust the level of inverse quantization applied to the sets of quantized transform coefficient values and to apply an actual level of inverse quantization to the sets of quantized transform coefficient values that is different from the default level of inverse quantization. Advantageously, the decoder is arranged to determine the actual level of inverse quantization by adding a difference value to the default level of inverse quantization, the difference value being representative of the difference between the default level of inverse quantization and the actual level of inverse quantization to be applied. Preferably, the video decoder is arranged to retrieve an indication of the difference value from a bit-stream representative of the encoded digital video sequence.

In one embodiment, a video decoder according to the fourth aspect of the invention is arranged to adjust the level of inverse quantization applied to the sets of quantized transform coefficient values from one frame of the digital video sequence to another and to apply an actual level of inverse quantization to the sets of quantized transform coefficients for a particular frame of the digital video sequence that is different from the default level of inverse quantization to be used throughout decoding of the encoded digital video sequence. Advantageously, the decoder is arranged to determine the actual level of inverse quantization to be used in the particular frame by adding a frame-specific difference value to the default level of inverse quantization, the frame-specific difference value being representative of the difference between the default level of inverse quantization and the actual level of inverse quantization to be used in the particular frame. Preferably, the video decoder is arranged to retrieve an indication of the frame-specific difference value from a bit-stream representative of the encoded digital video sequence.

In an alternative embodiment, a video decoder according to the fourth aspect of the invention is arranged to decode an encoded video sequence in which the plurality of blocks into which a frame of said digital video sequence is divided are grouped into one or more segments and is further arranged to adjust the level of inverse quantization applied to the sets of quantized transform coefficient values from one segment of a frame to another and to apply an actual level of inverse quantization to the sets of quantized transform coefficients for a particular segment of a frame that is different from the default level of inverse quantization to be used throughout decoding of the encoded digital video sequence. Preferably, the decoder is arranged to determine the actual level of inverse quantization to be

used in the particular segment by adding a segment-specific difference value to the default level of inverse quantization, the segment-specific difference value being representative of the difference between the default level of inverse quantization and the actual level of inverse quantization to be used in the particular segment. Preferably, the video decoder is arranged to retrieve an indication of the segment-specific difference value from a bit-stream representative of the encoded digital video sequence.

According to a fifth aspect of the invention, there is provided a multimedia terminal comprising an encoder according the third aspect of the invention.

According to a sixth aspect of the invention, there is provided a multimedia terminal comprising a decoder according to the fourth aspect of the invention.

Preferably, the multimedia terminal according to the fifth and / or sixth aspects of the invention is a mobile multimedia terminal arranged to communicate with a mobile telecommunications network by means of a radio connection.

Brief Description of the Drawings

Figure 1 illustrates the formation of a 16x16 macroblock according to prior art.

Figure 2 illustrates subdivision of a QCIF picture into 16x16 macroblocks and grouping of consecutive macroblocks into slices.

Figure 3 is a schematic block diagram of a generic video encoder according to prior art.

Figure 4 is a schematic block diagram of a generic video decoder according to prior art and corresponding to the encoder shown in Figure 3.

Figure 5 is a schematic block diagram of a video encoder according to an embodiment of the invention.

Figure 6 is a schematic block diagram of a video decoder according to an embodiment of the invention and corresponding to the encoder shown in Figure 5.

Figure 7 illustrates a decoding process according to one possible embodiment of the invention. Quantization parameters (QP) for each slice are obtained by adding the Sequence QP (SQP) to slice specific difference QP values (ΔQP^n).

Figure 8 is a schematic block diagram of a multimedia communications terminal in which the method according to the invention may be implemented.

Detailed Description of the Invention

In a preferred embodiment of the invention a video sequence specific quantization parameter (QP) is transmitted and used as a reference when coding and decoding the actual

picture / slice quantization parameters. In this way there is no need to transmit a full QP for every picture / slice, but a statistically smaller difference value is transmitted and used to reconstruct the picture / slice QP, thus leading to reduction in transmission bit-rate.

Embodiments of the invention will now be described with reference to Figures 5 through 8.

Figure 5 is a schematic block diagram of a video encoder 600 implemented according to the preferred embodiment of the invention. The structure of the video encoder shown in Figure 5 is substantially identical to that of the prior art video encoder illustrated in Figure 3, with appropriate modifications to those parts of the encoder that perform operations relating to the quantization of DCT transform coefficients and the signalling of quantization parameter (QP) values used in the video encoding process. All parts of the video encoder that implement functions and operate in a manner identical to the previously described prior art video encoder are identified with identical reference numbers. As the invention is particularly relevant to the signalling of quantization parameter (QP) values at the slice or frame level, it will be assumed throughout the following description that video encoder 600 according to the preferred embodiment of the invention is specifically adapted to apply a video coding method in which the frames of a video sequence to be coded are divided into macroblocks and the macroblocks are further grouped into slices, an indication of the quantization parameter being provided at the beginning of each frame and at the beginning of each new slice within a frame. An example of such a video coding method is the previously cited ITU-T H.26L video coding recommendation, as described in T. Wiegand, "Joint Model Number 1", Doc. JVT-A003, Joint Video Team (JVT) of ISO/IEC MPEG and ITU-T VCEG, Jan. 2002. Alternatively, the method can be applied in a video coding system in which an indication of the quantization parameter is given only at the beginning of a frame. While the following detailed description is written specifically to illustrate application of the method according to the invention in the indication and signalling of slice level quantization parameters, it should be appreciated that the method can applied in an exactly analogous manner to the representation of frame (picture) level quantization parameters.

Operation of video encoder 600 will now be considered in detail. When encoding a digital video sequence, encoder 600 operates in a manner similar to that previously described in connection with Figure 3 to generate INTRA-coded and INTER-coded compressed video frames. As explained earlier in the text, in INTRA-coding mode, a Discrete Cosine Transform (DCT) is applied to each block of image data (pixel values) in order to produce a corresponding two-dimensional array of transform coefficient values. The DCT operation is

performed in transform block 104 and the coefficients thus produced are subsequently passed to quantizer 106, where they are quantized. In INTER-coding mode, the DCT transform performed in block 104 is applied to blocks of prediction error values. The transform coefficients produced as a result of this operation are also passed to quantizer 106 where they too are quantized.

According to the invention, when starting to encode a new video sequence, encoder 600 determines a default or reference level of quantization that is to be used throughout encoding of the video sequence to quantize the DCT coefficient values generated in quantizer 106. Throughout the following description, this default or reference level of quantization will be termed a "sequence level quantization parameter", or SQP for short. The choice of an SQP for a given video sequence is controlled by control manager 660 and, for example, may be based on consideration of the properties of the sequence to be encoded and the bandwidth available for transmission of the encoded bit-stream produced by the encoder.

In the preferred embodiment of the invention, encoder 600 determines SQP as the default or reference level of quantization to be used when operating in INTER-coding mode, i.e. in situations when the DCT coefficients generated in transform block 104 are representative of prediction error values. It should be appreciated that the method according to the invention can also be applied to the quantization of DCT coefficient values produced in traditional INTRA-coding mode utilizing no spatial prediction. However, given the different origins of the transform coefficients in INTRA- and INTER-coding modes (the DCT coefficients produced in INTRA-coding mode are derived from pixel values, while those generated in INTER-coding mode are produced by applying a DCT transform to prediction error values) it is unlikely that a single SQP value can be determined that is optimum for quantization of DCT coefficients in both INTRA- and INTER-coding modes. Therefore, in an embodiment in which the method according to the invention is used in both INTRA- and INTER-coding mode, two SQP values are preferably be used, one that provides the most efficient representation of QP value information in INTRA-coding mode and another that provides the most efficient representation of QP values used during INTER-coding. In all other respects, the method according to the invention may be applied in a directly analogous way in both INTRA-and INTER-coding modes. Of course, in an alternative embodiment, a single SQP value may be defined and used as the sequence level quantization parameter for both INTRA- and INTER-coded frames. This is a practical approach especially in modern video coding systems, such as the one described in T. Wiegand, "Joint Model Number 1", Doc. JVT-A003, Joint Video Team (JVT) of ISO/IEC

MPEG and ITU-T VCEG, Jan. 2002, where spatial prediction is applied to the INTRA coded macroblocks before coding the INTRA rediction error with DCT.

It should further be noted that as the majority of frames in a typical video sequence are encoded as INTER frames, the greatest saving in bit-rate is achieved by applying the method according to the invention to the representation of QP values in INTER-coding mode. Thus, in the preferred embodiment of the invention, a single SQP value is used, this value being indicative of a default or reference value of quantization to be used in quantizing DCT coefficients representative of prediction error values in INTER-coding mode.

Having determined the SQP value to be used for the sequence, control manager 660 provides an indication of the selected SQP value via control line 122 to video multiplex coder 670 which, in turn, inserts an indication of the SQP value into the bit-stream 635 of coded image information representative of the video sequence. Preferably, this indication is provided in a sequence header portion of the encoded video bit-stream 635.

Video encoder 600 then starts to encode the video sequence. As explained in connection with the description of prior art video encoder 100, illustrated in Figure 3, the first frame of the sequence to be encoded is encoded in INTRA-format. As the SQP value defined according to the preferred embodiment of the invention is specific to the quantization of DCT coefficient values produced in INTER-coding mode, operation of encoder 600 in INTRA-coding mode is entirely analogous to that of prior art video encoder 100 and will not be considered in further detail here.

Once encoding of the first frame is complete, control manager 660 switches video encoder 600 into INTER-coding mode. In INTER-coding mode, switch 102 is operated to receive its input from line 117, which comprises the output of combiner 116. Combiner 116 receives the video input signal macroblock by macroblock from input 101 and forms a block of prediction error information for each block of the macroblock. The prediction error information for each block is passed to DCT transformer 104, which performs a two-dimensional discrete cosine transform on each block of prediction error values to produce a two-dimensional array of DCT transform coefficients for the block in question. The transform coefficients for each prediction error block are then passed to quantizer 106 where they are quantized, as previously described, using a quantization parameter QP. The rest of the INTER-coding process continues as previously described in connection with prior art video encoder 100.

As each macroblock is received, control manager 660 determines whether the macroblock currently being processed is the first macroblock of a slice. If it is, the control

manager determines a quantization parameter value QP to be used in quantizing the DCT coefficient values generated in DCT transformer 104. It should be noted that it is possible to make an estimation about the QP based on the bit-budget allowed for the frame, bits already spent in the previous slices or the same frame and possibly the bits spent for slices in the previous frame. Having done this, control manager 660 determines a difference (ΔQP) between the previously defined sequence level quantization parameter value SQP and the actual QP value to be used for the slice in question. It then passes an indication of this difference via control line 624 to video multiplex coder 670, which further includes an indication of the difference value ΔQP in bit-stream 635. Preferably, this indication is provided in a slice header portion of the encoded video bit-stream 635 containing control information specific to the slice in question. This process is repeated until all slices of the current frame have been encoded in INTER-coded format, at which point the video encoder starts to encode the next frame of the video sequence.

A video decoder 700 implemented according to a preferred embodiment of the invention will now be described with reference to Figure 6. The structure of the video decoder illustrated in Figure 6 is substantially identical to that of the prior art video decoder shown in Figure 4, with appropriate modifications to those parts of the decoder that perform operations relating to the inverse quantization of DCT transform coefficients. All parts of the video decoder that implement functions and operate in a manner identical to the previously described prior art video decoder are identified with identical reference numbers.

Here it is assumed that the video decoder of Figure 6 corresponds to the encoder described in connection with Figure 5 and is therefore capable of receiving and decoding the bit-stream 635 transmitted by encoder 600. As previously described, in the preferred embodiment of the invention, encoder 600 determines a sequence level quantization parameter SQP to be used in INTER-coding mode. Correspondingly, decoder 700 is adapted to receive an indication of this SQP value and to use the sequence level quantization parameter SQP in the determination of inverse quantization parameters to be applied to blocks of quantized transform coefficient values (representative of prediction error values) received in the encoded bit-stream for INTER-coded frames. In an alternative embodiment of the invention, the same process may also be applied to quantized transform coefficient values extracted from the bit-stream for INTRA-coded frames. As explained above, in this alternative embodiment, an indication of two SQP values may be provided, one for INTRA-coded frames of the sequence and one for INTER-coded frames. In a further alternative

embodiment, a single sequence level quantization parameter may be indicated for frames coded in both INTRA- and INTER-coding modes.

Operation of a video decoder according to the preferred embodiment of the invention will now be described in detail. Decoder 700 receives bit-stream 635 and separates it into its constituent parts. This operation is performed by video multiplex decoder 770.

When starting to decode a new sequence, video multiplex decoder 770 first extracts information and parameters relating to the sequence as a whole from the sequence header portion of the received bit-stream 635. As explained above in connection with the description of encoder 600, according to the preferred embodiment of the invention, the sequence header portion of the bit-stream is modified to contain an indication of the sequence level quantization parameter SQP used in quantization of DCT coefficient values produced in INTER-coding mode. Video multiplex decoder extracts the indication of the SQP value from the bit-stream and, if it was encoded, for example using variable length coding, applies appropriate decoding to recover the SQP value. It then passes the SQP value to the decoder's control manager 760, which stores it in the decoder's memory.

Video decoder 700 then starts to decode the encoded frames of the video sequence, the decoding of each frame commencing as soon as the video decoder starts receiving information relating to the frame in video bit-stream 635. Video multiplex decoder 770 extracts an INTRA / INTER trigger control signal from picture type information associated with each compressed video frame received in the encoded bit-stream 635 and passes it to control manager 760 via control line 215. The control manager 760 controls the operation of the decoder responsive to the INTRA / INTER trigger control signal, so as to switch the decoder into the correct decoding mode.

In the preferred embodiment of the invention, the decoding of frames coded in INTRA-format is performed in a manner analogous to that previously described in connection with the operation of prior art video decoder 200. The decoding of frames encoded in INTER-format, on the other hand, proceeds as described in the following.

When it receives an indication that the next frame to be decoded is an INTER-coded frame, extracted from the received bit-stream by video multiplex decoder 770, control manager 760 switches decoder 700 into INTER-mode. As explained in connection with the description of encoder 600, according to the preferred embodiment of the invention, in which the macroblocks of each frame are grouped into slices, encoded bit-stream 635 comprises certain slice-specific control information, which includes an indication of a slice-specific QP value, represented as a difference value ΔQP with respect to the sequence level quantization

parameter SQP. Advantageously, the control information specifically related to each slice is provided in the bit-stream as a header portion specific to the slice in question. On receiving such a portion of the bit-stream, video multiplex decoder extracts the slice-specific control information from the slice header portion of the bit-stream and passes the indication of ΔQP for the slice, retrieved from the bit-stream, to control manager 760 via control line 717.

Next, control manager 760 determines a level of inverse quantization to be applied to the quantized DCT coefficients of the macroblocks in the slice. This is done by combining the ΔQP value for the slice with the sequence specific quantization parameter SQP, previously received and stored in the decoder's memory. As described earlier in the text, the inverse quantization operation performed in the decoder involves multiplying each quantized DCT coefficient by a value equal to the level of quantization originally applied, that is, by the QP value used in the corresponding encoder to quantize the DCT coefficients. Thus, according to the preferred embodiment of the invention, control manager 760 determines the level of inverse quantization for the macroblocks of the slice by adding the received ΔQP value for the slice to SQP. It then passes this value to inverse quantizer 210 via control line 218.

As encoded information for each macroblock of the slice is received in the bit-stream 635, video multiplex decoder 770 separates the encoded prediction error information for each block of the macroblock from encoded motion vector information. It reconstructs the quantized DCT transform coefficients representative of the prediction error values for each block and passes them to inverse quantizer 210. Inverse quantizer 210 then inverse quantizes the quantized DCT coefficients according to the slice QP constructed from the ΔQP and SQP values by control manager 760. It then provides the inverse quantized DCT coefficients to inverse DCT transformer 220. The rest of the decoding process continues as previously described in connection with prior art video decoder 200.

The steps of receiving a slice-specific ΔQP value, combining ΔQP with SQP and inverse quantizing the qauntized DCT coefficients for each block of the macroblocks within the slice is repeated for each slice of the frame until all slices of the current INTER-coded frame have been decoded. At this point video encoder 700 starts decoding the next frame of the encoded video sequence.

Figure 7 illustrates the way in which slice-specific QP values are reconstructed according to the preferred embodiment of the invention. As can be seen from the figure, the process comprises the steps of:

1. retrieving a sequence level quantization parameter (SQP);
2. retrieving a picture or slice level difference quantization parameter (ΔQP);
3. adding the difference quantization parameters to the sequence level quantization parameter to obtain the quantization parameters for a picture or a slice;
4. constructing the received prediction error-coding coefficients by means of said picture or slice quantization parameter.

Figure 8 presents a terminal device comprising video encoding and decoding equipment which may be adapted to operate in accordance with the present invention. More precisely, the figure illustrates a multimedia terminal 80 implemented according to ITU-T recommendation H.324. The terminal can be regarded as a multimedia transceiver device. It includes elements that capture, encode and multiplex multimedia data streams for transmission via a communications network, as well as elements that receive, de-multiplex, decode and display received multimedia content. ITU-T recommendation H.324 defines the overall operation of the terminal and refers to other recommendations that govern the operation of its various constituent parts. This kind of multimedia terminal can be used in real-time applications such as conversational videotelephony, or non real-time applications such as the retrieval and / or streaming of video clips, for example from a multimedia content server in the Internet.

In the context of the present invention, it should be appreciated that the H.324 terminal shown in Figure 8 is only one of a number of alternative multimedia terminal implementations suited to application of the inventive method. It should also be noted that a number of alternatives exist relating to the location and implementation of the terminal equipment. As illustrated in Figure 8, the multimedia terminal may be located in communications equipment connected to a fixed line telephone network such as an analogue PSTN (Public Switched Telephone Network). In this case the multimedia terminal is equipped with a modem 91, compliant with ITU-T recommendations V.8, V.34 and optionally V.8bis. Alternatively, the multimedia terminal may be connected to an external modem. The modem enables conversion of the multiplexed digital data and control signals produced by the multimedia terminal into an analogue form suitable for transmission over the PSTN. It further enables the multimedia terminal to receive data and control signals in analogue form from the PSTN and to convert them into a digital data stream that can be demultiplexed and processed in an appropriate manner by the terminal.

An H.324 multimedia terminal may also be implemented in such a way that it can be connected directly to a digital fixed line network, such as an ISDN (Integrated Services Digital Network). In this case the modem 91 is replaced with an ISDN user-network interface. In Figure 8, this ISDN user-network interface is represented by alternative block 92.

H.324 multimedia terminals may also be adapted for use in mobile communication applications. If used with a wireless communication link, the modem 91 can be replaced with any appropriate wireless interface, as represented by alternative block 93 in Figure 8. For example, an H.324/M multimedia terminal can include a radio transceiver enabling connection to the current 2nd generation GSM mobile telephone network, or the proposed 3rd generation UMTS (Universal Mobile Telephone System).

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

A typical H.324 multimedia terminal will now be described in further detail with reference to Figure 8.

The multimedia terminal 80 includes a variety of elements referred to as "terminal equipment". This includes video, audio and telematic devices, denoted generically by reference numbers 81, 82 and 83, respectively. The video equipment 81 may include, for example, a video camera for capturing video images, a monitor for displaying received video content and optional video processing equipment. The audio equipment 82 typically includes a microphone, for example for capturing spoken messages, and a loudspeaker for reproducing received audio content. The audio equipment may also include additional audio processing units. The telematic equipment 83, may include a data terminal, keyboard, electronic whiteboard or a still image transceiver, such as a fax unit.

The video equipment 81 is coupled to a video codec 85. The video codec 85 comprises a video encoder 600 and a corresponding video decoder 700 both implemented according to the invention (see Figures 5 and 6). The video codec 85 is responsible for encoding captured video data in an appropriate form for further transmission over a communications link and decoding compressed video content received from the communications network. In the example illustrated in Figure 8, the video codec is implemented according to ITU-T

recommendation H.26L, with appropriate modifications to implement the method according to the invention in both the encoder and the decoder of the video codec.

The terminal's audio equipment is coupled to an audio codec, denoted in Figure 8 by reference number 86. Like the video codec, the audio codec comprises an encoder/decoder pair. It converts audio data captured by the terminal's audio equipment into a form suitable for transmission over the communications link and transforms encoded audio data received from the network back into a form suitable for reproduction, for example on the terminal's loudspeaker. The output of the audio codec is passed to a delay block 87. This compensates for the delays introduced by the video coding process and thus ensures synchronisation of audio and video content.

The system control block 84 of the multimedia terminal controls end-to-network signalling using an appropriate control protocol (signalling block 88) to establish a common mode of operation between a transmitting and a receiving terminal. The signalling block 88 exchanges information about the encoding and decoding capabilities of the transmitting and receiving terminals and can be used to enable the various coding modes of the video encoder. The system control block 84 also controls the use of data encryption. Information regarding the type of encryption to be used in data transmission is passed from encryption block 89 to the multiplexer/de-multiplexer (MUX/DMUX unit) 90.

During data transmission from the multimedia terminal, the MUX/DMUX unit 90 combines encoded and synchronised video and audio streams with data input from the telematic equipment 83 and possible control data, to form a single bit-stream. Information concerning the type of data encryption (if any) to be applied to the bit-stream, provided by encryption block 89, is used to select an encryption mode. Correspondingly, when a multiplexed and possibly encrypted multimedia bit-stream is being received, MUX/DMUX unit 90 is responsible for decrypting the bit-stream, dividing it into its constituent multimedia components and passing those components to the appropriate codec(s) and/or terminal equipment for decoding and reproduction.

If the multimedia terminal 80 is a mobile terminal, that is, if it is equipped with a radio transceiver 93, it will be understood by those skilled in the art that it may also comprise additional elements. In one embodiment it comprises a user interface having a display and a keyboard, which enables operation of the multimedia terminal 80 by a user, a central processing unit, such as a microprocessor, which controls the blocks responsible for different functions of the multimedia terminal, a random access memory RAM, a read only memory ROM, and a digital camera. The microprocessor's operating instructions, that is program

code corresponding to the basic functions of the multimedia terminal 80, is stored in the read-only memory ROM and can be executed as required by the microprocessor, for example under control of the user. In accordance with the program code, the microprocessor uses the radio transceiver 93 to form a connection with a mobile communication network, enabling the multimedia terminal 80 to transmit information to and receive information from the mobile communication network over a radio path.

The microprocessor monitors the state of the user interface and controls the digital camera. In response to a user command, the microprocessor instructs the camera to record digital images into the RAM. Once an image is captured, or alternatively during the capturing process, the microprocessor segments the image into image segments (for example macroblocks) and uses the encoder to perform motion compensated encoding of the segments in order to generate a compressed image sequence, as explained in the foregoing description. A user may command the multimedia terminal 80 to display the captured images on its display or to send the compressed image sequence using the radio transceiver 93 to another multimedia terminal, a video telephone connected to a fixed line network (PSTN) or some other telecommunications device. In a preferred embodiment, transmission of image data is started as soon as the first segment is encoded so that the recipient can start a corresponding decoding process with a minimum delay.

Although described in the context of particular embodiments, it will apparent to those skilled in the art that a number of modifications and various changes to these teachings may be made. Thus, while the invention has been particularly shown and described with respect to one or more preferred embodiments thereof, it will be understood by those skilled in the art that certain modifications or changes may be made therein without departing from the scope and spirit of the invention as set forth above.

In particular, according to a second possible embodiment of the invention, a sequence QP is not transmitted but an application specific constant is used as sequence QP instead.

In a third possible embodiment of the invention the sequence QP can be updated depending on the changing characteristics of the video sequence if a reliable way of transmitting the new sequence QP is available. The updated SQP value can be either included in the encoded bit-stream representative of the video sequence or can be transmitted directly from encoder to decoder in an associated control channel.

In a fourth possible embodiment of the invention, if QP is constant for the whole video sequence only the value of the sequence QP is transmitted together with the information that it should be used as the QP for all the pictures / slices.

What is claimed is:

1. A method of encoding a digital video sequence for use in a video coding application to produce an encoded video bit-stream representative of the digital video sequence, the digital video sequence comprising a number of frames, each frame of said sequence comprising an array of pixels divided into a plurality of blocks, each block comprising a certain number of said pixels, said method comprising the steps of:

encoding a frame of the digital video sequence by applying motion compensated prediction to blocks of pixels for producing corresponding blocks of prediction error values;

applying a transform coding technique to said blocks of prediction error values to produce sets of transform coefficient values representative of said blocks of prediction error values; and

defining a default level of quantization for use in encoding of the digital video sequence to quantize the sets of transform coefficient values.

2. An encoding method according to claim 1, wherein said default level of quantization is specific to the video sequence being encoded.

3. An encoding method according to claim 1, wherein said default level of quantization is specific to the video coding application.

4. An encoding method according to claim 1, further comprising the step of providing an indication of the default level of quantization to a decoding process.

5. An encoding method according to claim 4, wherein said indication of the default level of quantization is provided in the encoded bit-stream representative of the digital video sequence.

6. An encoding method according to claim 5, wherein the encoded bit-stream is transmitted from a video encoding device to a corresponding video decoding device.

7. An encoding method according to claim 1, wherein the default level of quantization is updated during the encoding of the digital video sequence, said method further comprising

the step of providing an indication of the updated default level of quantization to a decoding process.

8. An encoding method according to claim 1, wherein said sets of transform coefficient values are quantized to yield sets of quantized transform coefficient values representative of said blocks of prediction error values based on a level of quantization different from the default level of quantization.

9. An encoding method according to claim 8, further comprising the step of providing to a decoding process an indication of a difference between said level of quantization and the default level of quantization.

10. An encoding method according to claim 8, wherein said level of quantization is adjusted from one frame of the digital video sequence to another such that an actual level of quantization applied to the sets of transform coefficients for a particular frame of the digital video sequence is different from the default level of quantization.

11. An encoding method according to claim 10, wherein said actual level of quantization is representable as a difference with respect to the default level of quantization.

12. An encoding method according to claim 10, further comprising the step of providing to a decoding process an indication of a difference between said actual level of quantization and the default level of quantization.

13. An encoding method according to claim 8, wherein the plurality of blocks of pixels, into which a frame of said digital video sequence is divided, are grouped into one or more segments and wherein the level of quantization applied to said sets of transform coefficient values is adjusted from one segment of a frame to another such that an actual level of quantization applied to the sets of transform coefficients for a particular segment of a frame is different from the default level of quantization.

14. An encoding method according to claim 13, further comprising the step of providing to a decoding process an indication of a difference between said level of quantization and the default level of quantization.

15. A video encoder for encoding a digital video sequence to produce an encoded video bit-stream representative of the digital video sequence, the digital video sequence comprising a number of frames, each frame of said sequence comprising an array of pixels divided into a plurality of blocks, each block comprising a certain number of said pixels, said video encoder comprising:

means for encoding a frame of the digital video sequence by applying motion compensated prediction to blocks of pixels to provide corresponding blocks of prediction error values;

means for transforming said blocks of prediction error values for providing sets of transform coefficient values representative of said blocks of prediction error values; and

means for selecting a default level of quantization for quantizing said sets of transform coefficient values.

16. A video encoder according to claim 15, wherein said default level of quantization is specific to the video sequence to be encoded.

17. A video encoder according to claim 15, arranged to provide an indication of said default level of quantization in the encoded bit-stream representative of the digital video sequence.

18. A video encoder according to claim 15, wherein said sets of transform coefficient values are quantized to yield sets of quantized transform coefficient values representative of said blocks of prediction error values based on a level of quantization different from the default level of quantization.

19. A video encoder according to claim 18, arranged to provide an indication of a difference between said level of quantization and the default level of quantization in the encoded bit-stream.

20. A video encoder according to claim 15, wherein the default level of quantization can be updated and the video encoder is arranged to provide an indication of the updated default level of quantization in the encoded bit-stream.

21. A video encoder according to claim 20, wherein said sets of transform coefficient values are quantized to yield sets of quantized transform coefficient values representative of said blocks of prediction error values based on a level of quantization different from the updated default level of quantization.

22. A video encoder according to claim 18, wherein said level of quantization applied to said sets of transform coefficient values can be adjusted from one frame of the digital video sequence to another so as to apply an actual level of quantization to the sets of transform coefficients for a particular frame of the digital video sequence and wherein said actual level of quantization is different from the default level of quantization.

23. A video encoder according to claim 22, arranged to provide an indication of said difference with respect to the default level of quantization in the encoded bit-stream representative of the digital video sequence.

24. A video encoder according to claim 18, arranged to group the plurality of blocks into which a frame of said digital video sequence is divided into one or more segments and to adjust the level of quantization applied to said sets of transform coefficient values from one segment of a frame to another so as to apply an actual level of quantization to the sets of transform coefficients for a particular segment of a frame, wherein said actual level of quantization is different from the default level of quantization, said video encoder further arranged to represent the actual level of quantization for use in the particular segment as a difference with respect to the default level of quantization.

25. A video encoder according to claim 24, further arranged to provide an indication of said difference with respect to the default level of quantization in the encoded bit-stream representative of the digital video sequence.

26. A video encoder according to claim 15, provided in a multimedia terminal.

27. A video encoder according to claim 15, provided in a radio telecommunications device.

28. A method of decoding an encoded digital video sequence for use in a video decoding application to produce a decoded digital video sequence, the digital video sequence

comprising a number of frames, each frame of said sequence comprising an array of pixels divided into a plurality of blocks, each block comprising a certain number of said pixels, frames of the digital video sequence encoded by:

applying motion compensated prediction to blocks of pixels for producing corresponding blocks of prediction error values;

applying a transform coding technique to said blocks of prediction error values to produce sets of transform coefficient values representative of said blocks of prediction error values; and

applying a level of quantization to said sets of transform coefficient values to yield sets of quantized transform coefficient values representative of said blocks of prediction error values, wherein an indication of said level of quantization is provided in the encoded bit-stream including the encoded digital video sequence, said decoding method comprising the step of:

selecting a default level of inverse quantization for use in decoding of the encoded digital video sequence to inverse quantize the sets of quantized transform coefficient values, said default level selected based on the indication of said level of quantization provided in the encoded bit-stream.

29. A decoding method according to claim 28, wherein said default level of inverse quantization is specific to the encoded video sequence being decoded.

30. A decoding method according to claim 28, wherein said default level of inverse quantization is specific to the video decoding application.

31. A decoding method according to claim 28, wherein said level of quantization is updated in said yielding of said sets of quantized transform coefficient values, said decoding method further comprising the step of updating the default level of inverse quantization in response to the updated level of quantization.

32. A video decoder for decoding an encoded digital video sequence to produce a decoded digital video sequence, the digital video sequence comprising a number of frames, each frame of said sequence comprising an array of pixels divided into a plurality of blocks, each block comprising a certain number of said pixels, frames of the digital video sequence encoded by:

applying motion compensated prediction to blocks of pixels for producing corresponding blocks of prediction error values;

applying a transform coding technique to said blocks of prediction error values to produce sets of transform coefficient values representative of said blocks of prediction error values; and

applying a level of quantization to said sets of transform coefficient values to yield sets of quantized transform coefficient values representative of said blocks of prediction error values, wherein an indication of said level of quantization is provided in the encoded bit-stream including the encoded digital video sequence, said video decoder comprising:

means for retrieving the encoded digital video sequence from the encoded bit-stream; and

means for selecting a default level of inverse quantization for use in decoding of the encoded digital video sequence to inverse quantize the sets of quantized transform coefficient values, said default level of inverse quantization selected based on said indication of said level of quantization provided in the encoded bit-stream.

33. A video decoder according to claim 32, wherein said default level of inverse quantization is specific to the encoded video sequence being decoded.

34. A video decoder to claim 32, wherein said level of quantization is updated in said yielding of said sets of quantized transform coefficient values, said video decoder arranged to update the default level of inverse quantization in response to the updated level of quantization.

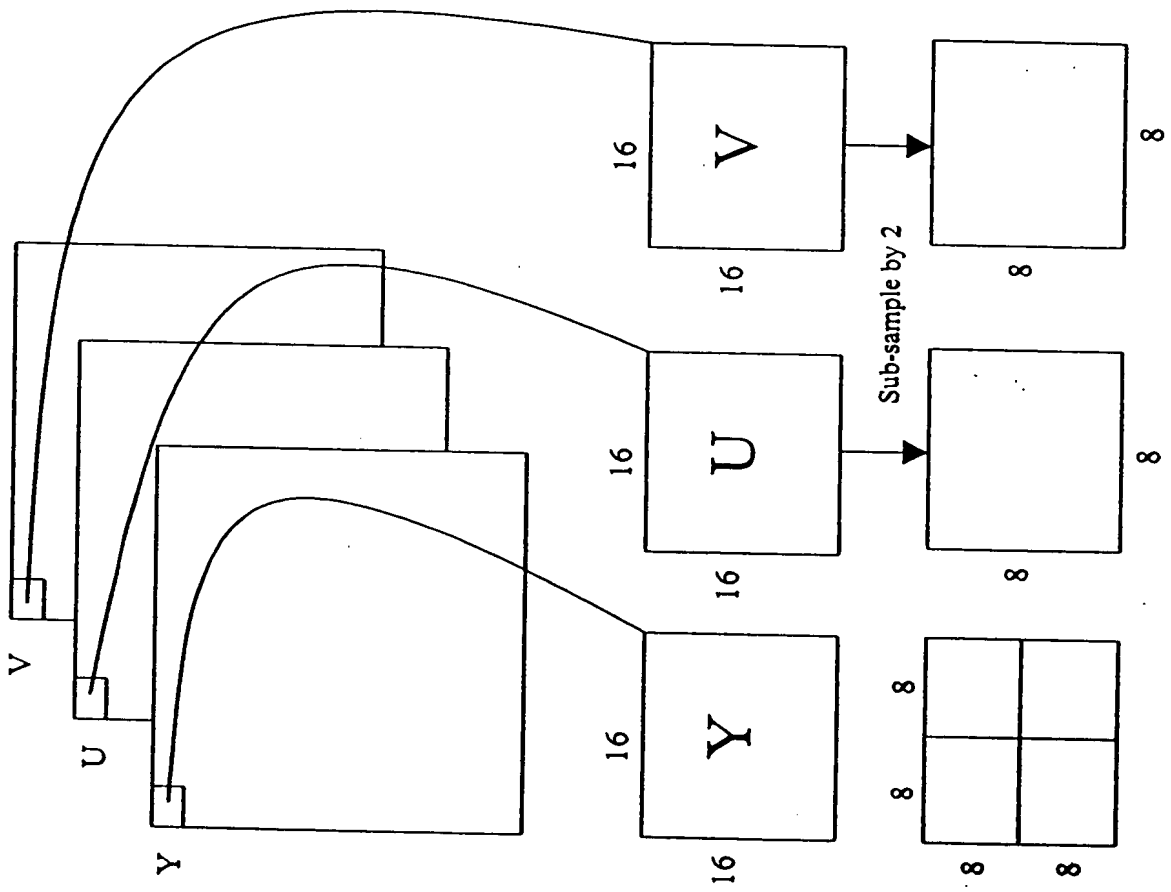
35. A video decoder according to claim 32, provided in a multimedia terminal.

36. A video decoder according to claim 32, provided in a radio telecommunications device.

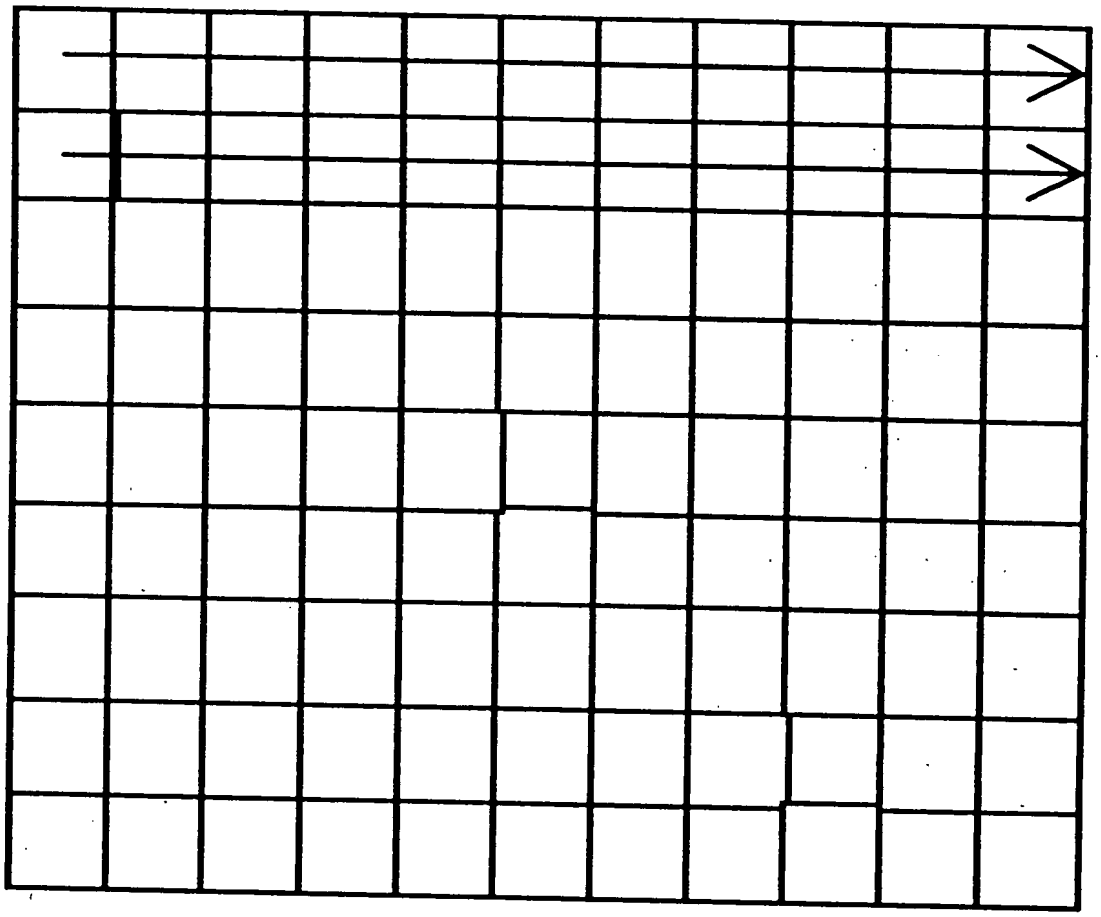
Abstract

A method and device for coding of digital video sequence, wherein an indication of quantization parameter (QP) is provided in the encoded bit-stream for decoding purposes. The QP related information is indicated by introducing a sequence level quantization parameter value SQP. More specifically, instead of coding the absolute values of picture/slice QPs, an indication of the difference ΔQP between the sequence level quantization parameter SQP and the picture/slice QP is provided. This eliminates the need to transmit a full QP for every picture/slice, and enables a statistically smaller difference value to be transmitted, thus providing a reduction in transmission bit-rate. The difference value is subsequently used in a corresponding decoder to reconstruct the picture/slice QP.

Figure 1



QCIF Image



9

11

Figure 2

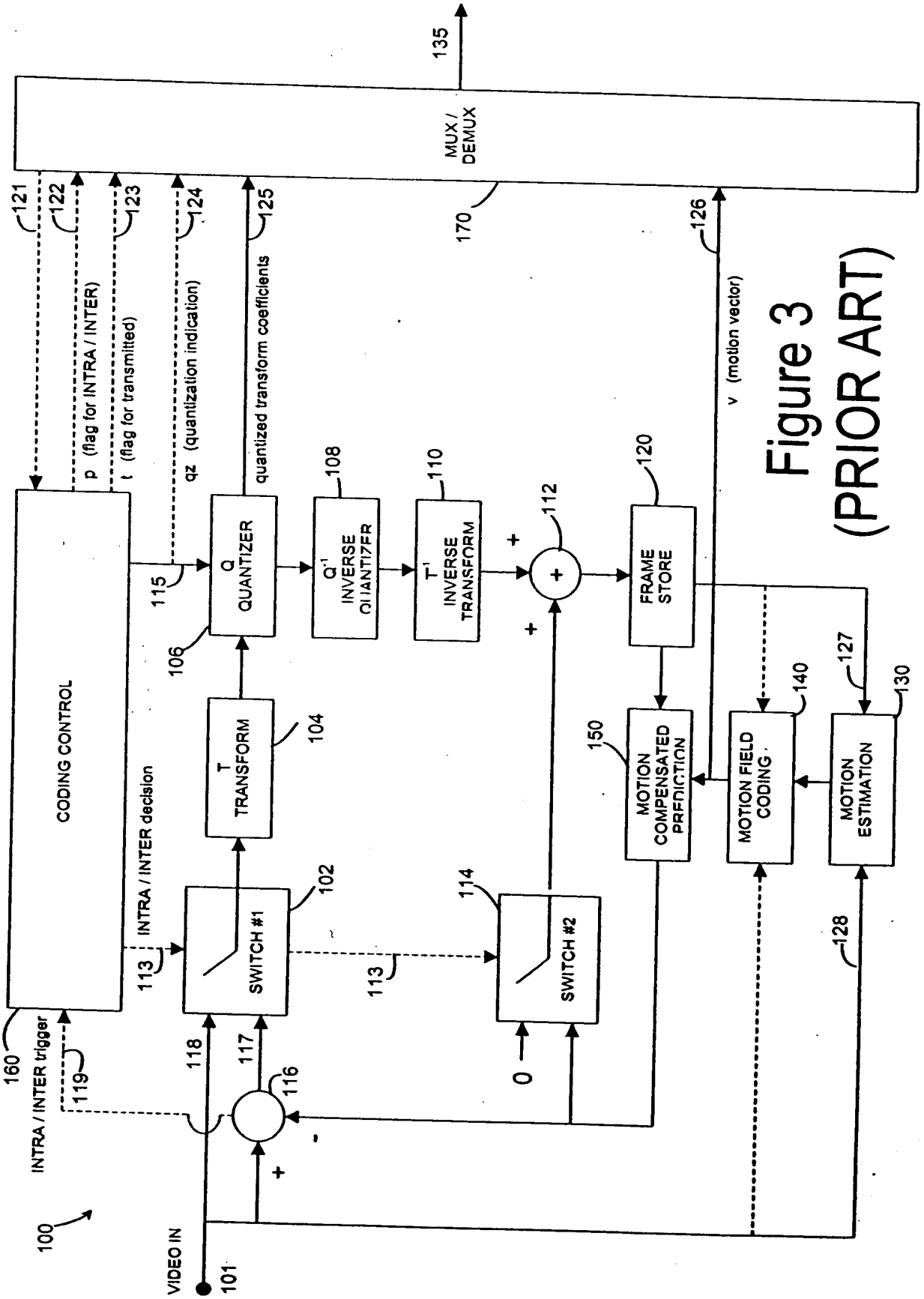


Figure 3
(PRIOR ART)

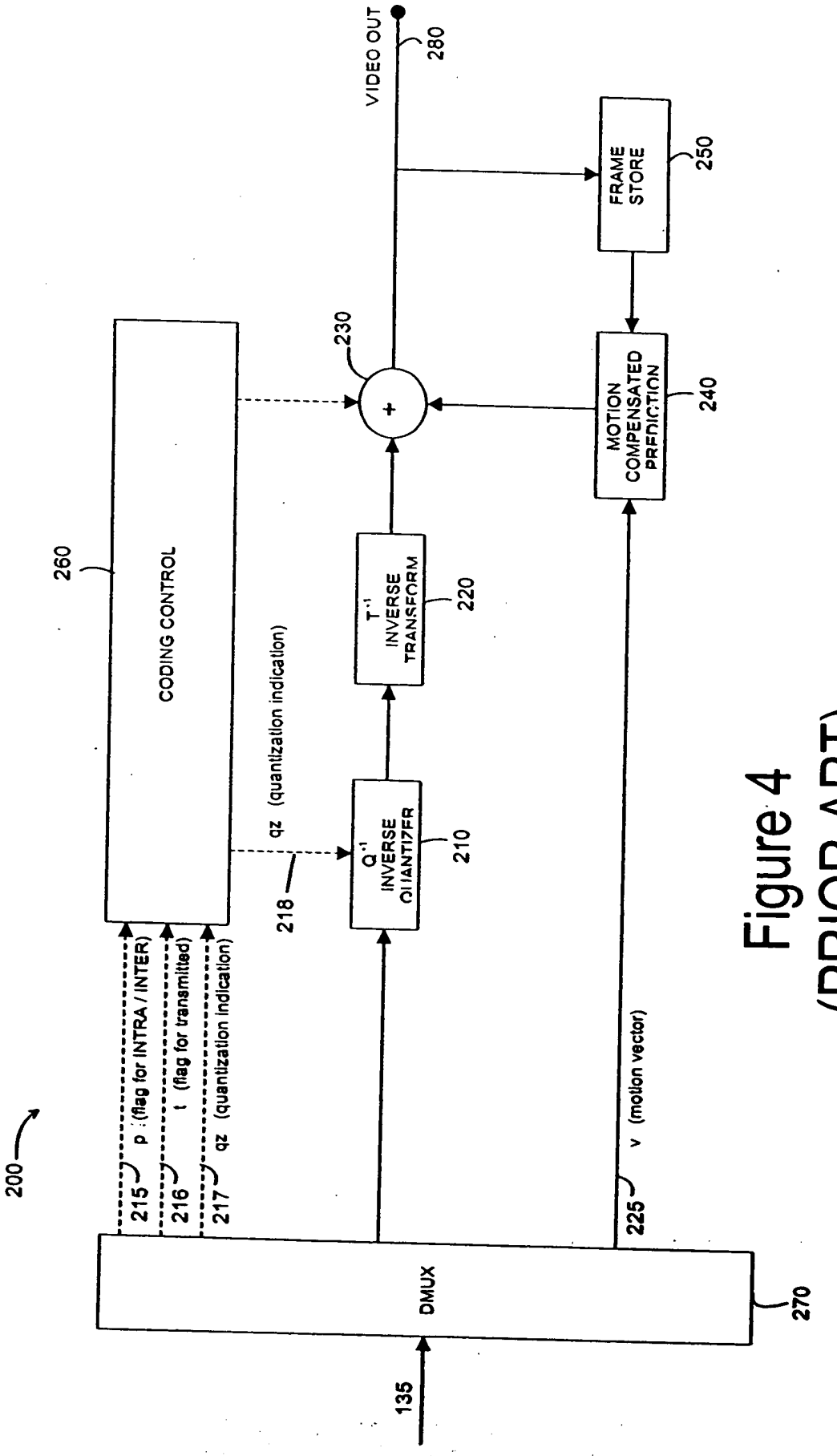


Figure 4
(PRIOR ART)

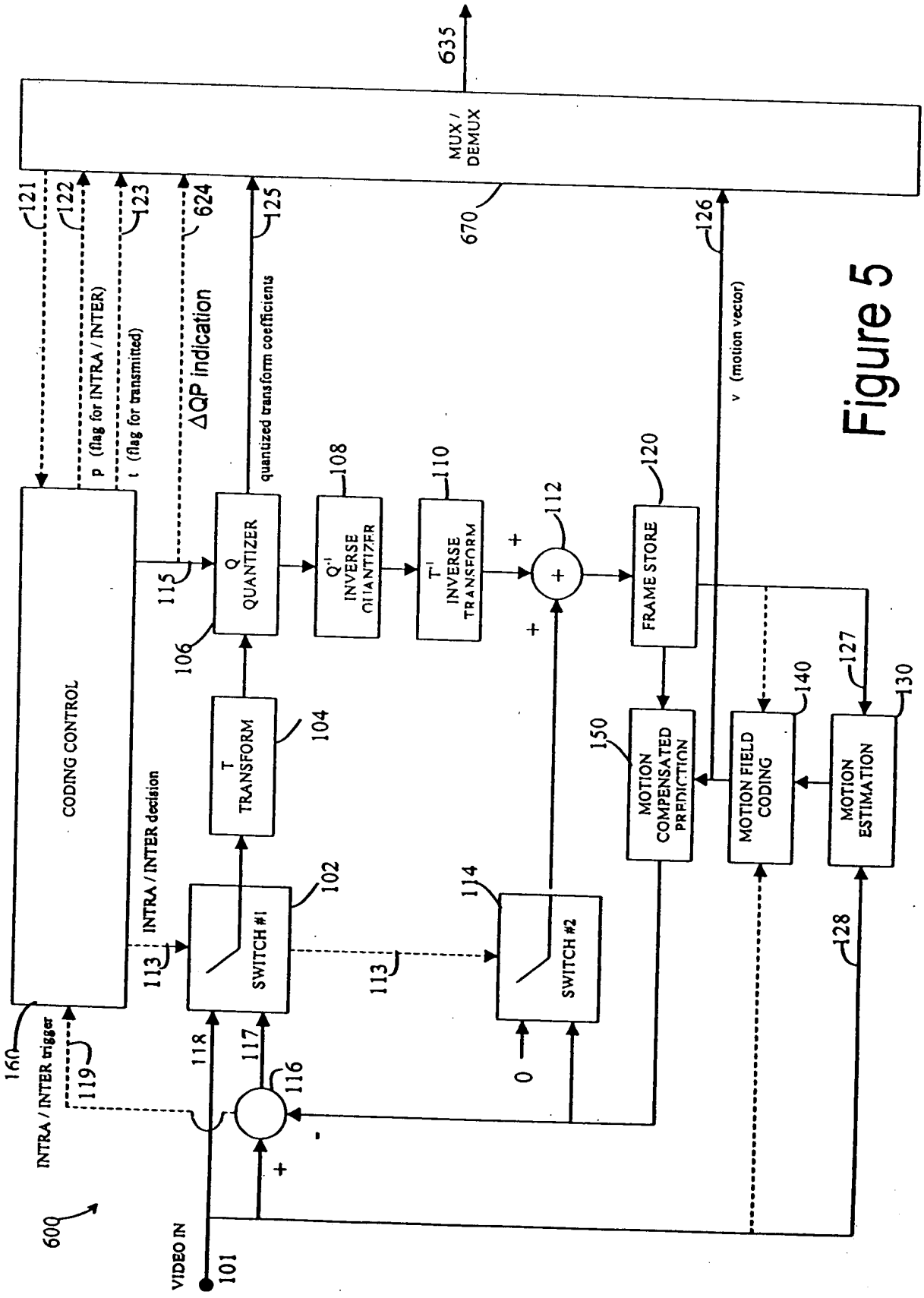

635
MUX / DEMUX
670
121
122
123
624
125
126
p (flag for INTRA / INTER)
t (flag for transmitted)
ΔQP indication
quantized transform coefficients
v (motion vector)
CODING CONTROL
Q QUANTIZER
Q⁻¹ INVERSE QUANTIZER
T⁻¹ INVERSE TRANSFORM
FRAME STORE
T TRANSFORM
MOTION COMPENSATED PREDICTION
MOTION FIELD CODING
MOTION ESTIMATION
INTRA / INTER decision
SWITCH #1
SWITCH #2
INTRA / INTER trigger
VIDEO IN
600
101
102
104
106
108
110
112
113
114
115
116
117
118
119
120
127
128
130
140
150
160
0
+
-

Figure 5

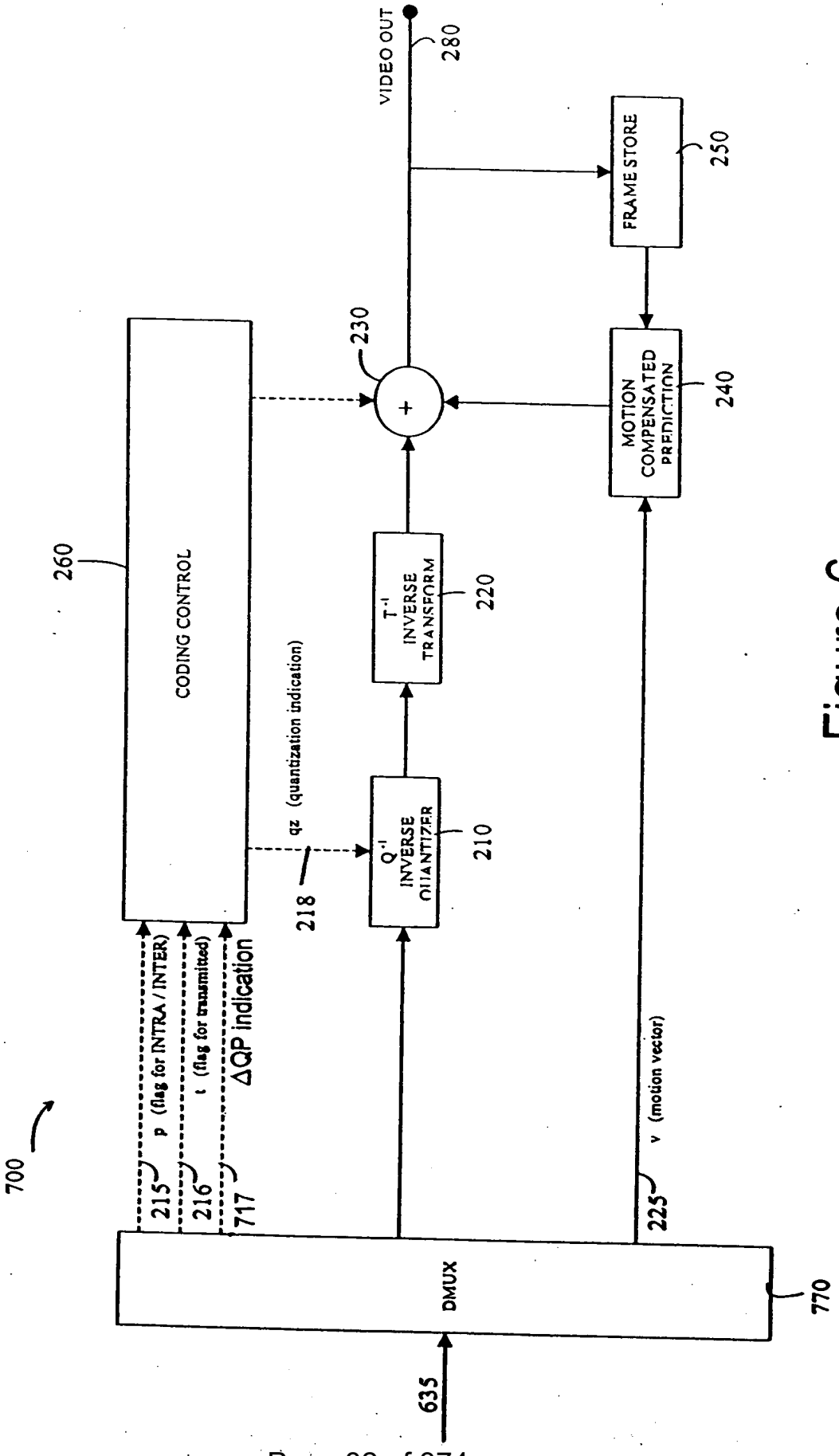

700
635
DMUX
770
215
p (flag for INTRA / INTER)
216
t (flag for transmitted)
717
ΔQP indication
CODING CONTROL
260
218
qz (quantization indication)
Q⁻¹ INVERSE QUANTIZER
210
T⁻¹ INVERSE TRANSFORM
220
230
+
VIDEO OUT
280
FRAME STORE
250
MOTION COMPENSATED PREDICTION
240
225
v (motion vector)

Figure 6

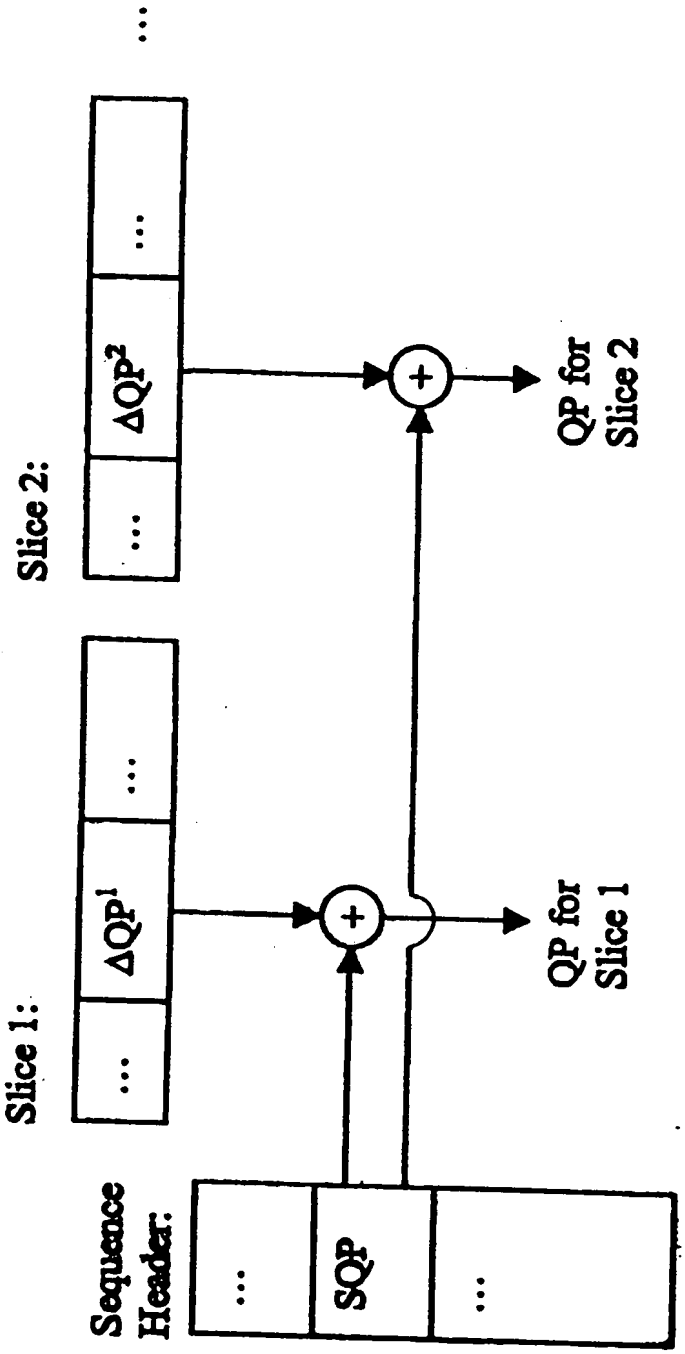

Sequence Header:
...
SQP
...
Slice 1:
...
ΔQP1
...
Slice 2:
...
ΔQP2
...
QP for Slice 1
QP for Slice 2

Figure 7

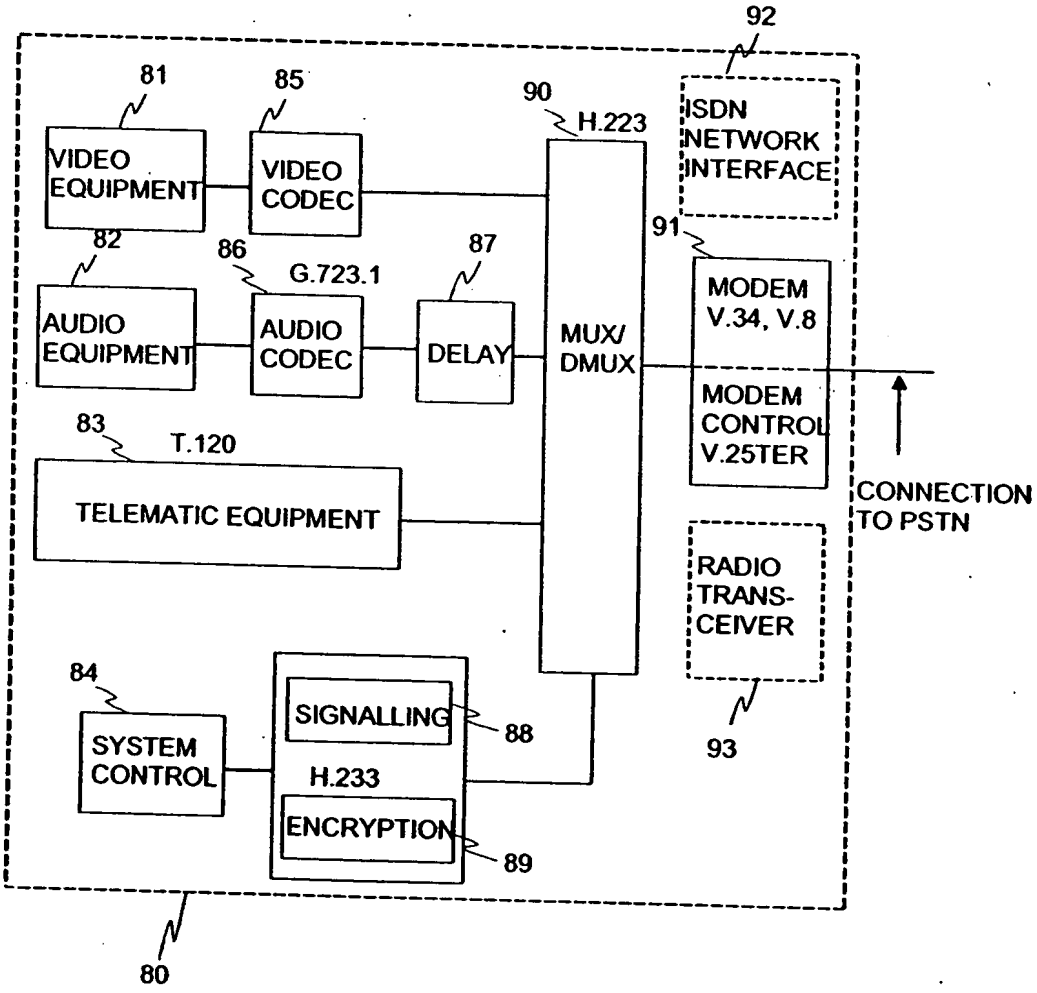

92
81
85
90
H.223
ISDN NETWORK INTERFACE
VIDEO EQUIPMENT
VIDEO CODEC
91
82
86
G.723.1
87
MODEM V.34, V.8
AUDIO EQUIPMENT
AUDIO CODEC
DELAY
MUX/ DMUX
MODEM CONTROL V.25TER
83
T.120
CONNECTION TO PSTN
TELEMATIC EQUIPMENT
RADIO TRANS-CEIVER
84
SIGNALLING
88
SYSTEM CONTROL
H.233
93
ENCRYPTION
89
80

Figure 8

Best Available Copy

COMBINED DECLARATION AND POWER OF ATTORNEY

944-001.107
(Docket Number)

As a below named inventor, I hereby declare that:

- my residence, post office address and citizenship are as stated below next to my name;
- I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled: METHOD AND DEVICE FOR INDICATING QUANTIZER PARAMETERS IN A VIDEO CODING SYSTEM;
- the specification of which is attached hereto unless the following box is checked: ☒. If the box is checked,

  the application was filed on April 23, 2003,
  as U.S. Application Number 10/421,629,
  or PCT International Application Number
  and was amended on (if applicable).

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

I acknowledge the duty to disclose information which is material to patentability as defined in 37 CFR §1.56.

I hereby claim foreign priority benefits under 35 U.S.C. §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, listed below and have also identified below, by checking the box, any foreign application for patent or inventor's certificate, or PCT International application having a filing date before that of the application on which priority is claimed.

Prior Foreign Application			Priority Not Claimed
(Application Number)	(Country)	(Day/Month/Year Filed)	☐
(Application Number)	(Country)	(Day/Month/Year Filed)	☐

To the extent permitted by rule or law, I hereby incorporate by reference the Prior Foreign Application(s) listed above.

I hereby claim the benefits under 35 U.S.C. §119(e) of any United States provisional application(s) listed below:

60/374,667 (Provisional Application Number)	23.04.2003 (Day/Month/Year Filed)
(Provisional Application Number)	(Day/Month/Year Filed)

I hereby claim the benefits under 35 U.S.C. §120 of any United States application(s), or §365(c) of any PCT International application designating the United States, 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 35 U.S.C. §112, I acknowledge the duty to disclose information which is material to patentability as defined in 37 CFR §1.56, which became available between the filing date of the prior application and the national or PCT International filing date of this application.

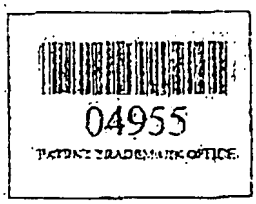
(Application Number)	(Day/Month/Year Filed)	(Status - patented, pending, abandoned)
(Application Number)	(Day/Month/Year Filed)	(Status - patented, pending, abandoned)

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I hereby appoint the attorney(s) and/or agent(s) assigned to the customer number listed below, as may from time to time be amended, belonging to the firm of Ware, Fressola, Van Der Sluys & Adolphson LLP, to prosecute this application and to transact all business in the Patent and Trademark Office connected therewith.

Customer Number

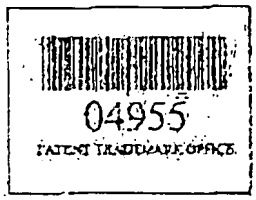
4955



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Customer Number

4955



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

Jani LAINEMA Full name of sole or first inventor (given name, middle initial, FAMILY NAME(S) IN UPPER CASE)	
Inventor's Signature	20/5/2003 Date
Irving, Texas, USA Residence	FINLAND Citizenship
Post Office Address: 6219 Love Drive, Apt. 2226, Irving, Texas 75039, USA	

Full name of second inventor (given name, middle initial, FAMILY NAME(S) IN UPPER CASE)	
Inventor's Signature	Date
Residence	Citizenship
Post Office Address:	

Full name of third inventor (given name, middle initial, FAMILY NAME(S) IN UPPER CASE)	
Inventor's Signature	Date
Residence	Citizenship
Post Office Address:	

☐ Additional inventors are being named on separately numbered sheets attached hereto

Best Available Copy

ASSIGNMENT AND AGREEMENT

FOR VALUE RECEIVED, I, JANI LAINEMA, a citizen of Finland and residing at 6219 Love Drive, Apt. 2226, Irving, TX 75039, hereby sell, assign and transfer to NOKIA CORPORATION, a corporation duly organized and existing under the laws of Finland, and having a principal place of business at Keilalahdentie 4, FIN-02150 Espoo, Finland, as assignee, and its successors, assigns and legal representatives, the entire right, title and interest, for all countries in and to certain inventions relating to improvements in a METHOD AND DEVICE FOR INDICATING QUANTIZER PARAMETERS IN A VIDEO CODING SYSTEM, which is described in an application for Letters Patent of the United States, Serial No. 10/421,629 filed April 23, 2003, and all the rights and privileges under any and all Letters Patent that may be granted therefor.

I request that any and all patents for said inventions be issued to said assignee, its successors, assigns and legal representatives, or to such nominees as it may designate.

I agree that, when requested, I will, without charge to said assignee but at its expense, sign all papers, take all rightful oaths, and do all acts which may be necessary, desirable or convenient for securing and maintaining patents for said inventions in any and all countries and for vesting title thereto in said assignee, its successors, assigns and legal representatives or nominees.

I authorize and empower the said assignee, its successors, assigns and legal representatives or nominees, to invoke and claim for any application for patent or other form of protection for said inventions filed by it or them, the benefit of the right of priority provided by: (a) the International Convention for the Protection of Industrial Property, as amended, or by convention which may henceforth be substituted for it, and (b) the Patent Cooperation Treaty, as amended, or by any treaty which may hence forth be substituted for it, and to invoke and claim such right of priority without further written or oral authorization from us.

I hereby consent that a copy of this assignment shall be deemed a full legal and formal equivalent of any assignment, consent to file or like document which may be required in any country for any purpose and more particularly in proof of the right of the said assignee or nominee to claim the aforesaid benefit of the right of priority.

provided by: (a) the International Convention for the protection of Industrial Property, as amended, or by any convention which may henceforth be substituted for it; and (b) the Patent Cooperation Treaty, as amended, or by any treaty which may henceforth be substituted for it.

I covenant with said assignee, it successors and assigns and legal representatives, that the rights and property herein conveyed are free and clear of any encumbrance, and that I have full right to convey the same as herein expressed.

Signed at IRVING, TX this 20th day of May, in the year 2003.

Jan Lamerna

Signed in our presence and acknowledged to be an assignment of the application (invention) herein above referred to.

Witness _____ Date 05/20/03

Witness _____ Date 05/20/03

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APPLICATION NUMBER	FILING or 371(c) DATE	GRP ART UNIT	FIL FEE REC'D	ATTY.DOCKET.NO	TOT CLAIMS	IND CLAIMS
11/881,367	07/26/2007		1150	944-001.107-2	23	3

CONFIRMATION NO. 1389

FILING RECEIPT

4955
WARE FRESSOLA VAN DER SLUYS &
ADOLPHSON, LLP
BRADFORD GREEN, BUILDING 5
755 MAIN STREET, P O BOX 224
MONROE, CT06468

Date Mailed: 08/15/2007

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

Applicant(s)

Jani Lainema, Irving, TX;

Power of Attorney: The patent practitioners associated with Customer Number 4955

Domestic Priority data as claimed by applicant

This application is a DIV of 10/421,629 04/23/2003 PAT 7,263,125 *
which claims benefit of 60/374,667 04/23/2002
(*)Data provided by applicant is not consistent with PTO records.

Foreign Applications

If Required, Foreign Filing License Granted: 08/15/2007

The country code and number of your priority application, to be used for filing abroad under the Paris Convention, is **US11/881,367**

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

Non-Publication Request: No

Early Publication Request: No

Title

Preliminary Class

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.

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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.

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Title 37, Code of Federal Regulations, 5.11 & 5.15

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APPLICATION NUMBER	FILING OR 371 (c) DATE	FIRST NAMED APPLICANT	ATTORNEY DOCKET NUMBER
11/881,367	07/26/2007	Jani Lainema	944-001.107-2

CONFIRMATION NO. 1389

FORMALITIES LETTER

4955
WARE FRESSOLA VAN DER SLUYS &
ADOLPHSON, LLP
BRADFORD GREEN, BUILDING 5
755 MAIN STREET, P O BOX 224
MONROE, CT 06468

Date Mailed: 08/15/2007

NOTICE TO FILE CORRECTED APPLICATION PAPERS

Filing Date Granted

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

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

- A substitute specification excluding claims in compliance with 37 CFR 1.52, 1.121(b)(3), and 1.125 is required. The substitute specification must be submitted with markings and be accompanied by a clean version (without markings) as set forth in 37 CFR 1.125(c) and a statement that the substitute specification contains no new matter (see 37 CFR 1.125(b)). Since a preliminary amendment was present on the filing date of the application and such amendment is part of the original disclosure of the application, the substitute specification must include all of the desired changes made in the preliminary amendment. See 37 CFR 1.115 and 1.215.

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

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Office of Initial Patent Examination (571) 272-4000, or 1-800-PTO-9199
PART 3 - OFFICE COPY

ITL

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In Re Application Of: Lainema : Attorney Docket No. 944-001.107-2

Application Serial No.: 11/881,367 : Art Unit: 2621

Filing Date: July 26, 2007 : Examiner: to be assigned

OIPE IAP76 AUG 24 2007 PATENT & TRADEMARK OFFICE

Title: METHOD AND DEVICE FOR INDICATING QUANTIZER PARAMETERS IN A VIDEO CODING SYSTEM

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Alexandria, VA 22313-1450

RESPONSE TO NOTICE TO FILE CORRECTED APPLICATION PAPERS

Sir:

In response to the Notice to File Corrected Application Papers mailed August 15, 2007, please see the attached substitute specification (one clean copy, one marked-up copy).

It is believed that the application is now in condition for examination, and early passage to allowance is earnestly solicited.

The Examiner is invited to contact applicant's attorney at the number below if there are any questions.

******If any fee and/or extension is required in addition to any enclosed herewith, please charge Deposit Account No. 23-0442.***

Respectfully submitted,

Dated: August 21, 2007

Kenneth Q. Lao
Attorney for Applicant
Reg. No. 40,061

WARE, FRESSOLA, VAN DER SLUYS
& ADOLPHSON LLP
Bradford Green, Building Five
755 Main Street, P.O. Box 224
Monroe, CT 06468
Telephone: (203) 261-1234
Facsimile: (203) 261-5676
USPTO Customer No. 004955

I hereby certify that this communication is being deposited with the United States Postal Service today, **August 20, 2007**, in an envelope with sufficient postage as first-class mail addressed to Mail Stop Missing Parts, Commissioner of Patents, P.O. Box 1450, Alexandria, VA 22313-1450.

Cathy Sturmer

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APPLICATION NUMBER	FILING OR 371 (c) DATE	FIRST NAMED APPLICANT	ATTORNEY DOCKET NUMBER
11/881,367	07/26/2007	Jani Lainema	944-001.107-2

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OIPE IAP76 AUG 24 2007 PATENT & TRADEMARK OFFICE

METHOD AND DEVICE FOR INDICATING QUANTIZER PARAMETERS IN A VIDEO CODING SYSTEM

This application is a divisional application of and claims priority to a co-pending U.S. paten application Serial No. 10/421,629, filed April 23, 2003, which is based on and claims priority to U.S. provisional application No. 60/374,667, filed April 23, 2002.

Field of the Invention

The invention relates to a method, an encoder, a decoder and a device for the coding of digital video. More specifically, the invention relates to the indication of quantization parameter (QP) values in a video coding system.

Background of the Invention

Digital video sequences, like ordinary motion pictures recorded on film, comprise a sequence of still images, the illusion of motion being created by displaying the images one after the other, typically at a rate between 15 and 30 frames per second.

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

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

The lower spatial resolution of the chrominance components is usually attained by sub-sampling. Typically, each frame of a video sequence is divided into so-called "macroblocks", which comprise luminance (Y) information and associated chrominance (U, V) information, which is spatially sub-sampled. Figure 1 illustrates one way in which macroblocks can be formed. As shown in Figure 1, a frame of a video sequence represented using a YUV color model, each component having the same spatial resolution. Macroblocks are formed by representing a region of 16x16 image pixels in the original image as four blocks of luminance information, each luminance block comprising an 8x8 array of luminance (Y) values and two, spatially corresponding, chrominance components (U and V) which are sub-sampled by a factor of two in both the horizontal and vertical directions to yield corresponding arrays of 8x8 chrominance (U, V) values. According to certain video coding recommendations, such as International Telecommunications Union (ITU-T) recommendation H.26L, the block size used within the macroblocks can be other than 8x8, for example 4x8 or 4x4 (see T. Wiegand, "Joint Model Number 1", Doc. JVT-A003, Joint Video Team (JVT) of ISO/IEC MPEG and ITU-T VCEG, Jan. 2002, Sections 2.2 and 2.3). ITU-T recommendation H.26L also allows macroblocks to be organized together to form so-called "slices". More specifically, each slice is formed from a number of consecutive macroblocks in coding order and is encoded in such a way that it can be decoded independently without making reference to any other slice of the same frame. This arrangement is advantageous, as it tends to limit the propagation of artefacts in the decoded video that may arise due to transmission errors. While there is no specific limitation on the way in which slices may be constructed, one straightforward scheme is to group all the macroblocks in a single row of a frame together as a slice. This arrangement, together with the division of a QCIF format image into 16x16 macroblocks is illustrated in Figure 2.

As can be seen from Figure 2, a QCIF image comprises 11x9 macroblocks (in this case grouped into 9 slices of 11 consecutive macroblocks each). If the luminance blocks and chrominance blocks are represented with 8 bit resolution (that is by numbers in the range 0 to 255), the total number of bits required per macroblock is (16x16x8)+2x(8x8x8) = 3072 bits. The number of bits needed to represent a video frame in QCIF format is thus 99x3072 = 304,128 bits. This means that the amount of data required to transmit/record/display an uncompressed video sequence in QCIF format, represented using a YUV colour model, at a rate of 30 frames per second, is more than 9 Mbps

(million bits per second). This is an extremely high data rate and is impractical for use in video recording, transmission and display applications because of the very large storage capacity, transmission channel capacity and hardware performance required.

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

Video compression methods are based on reducing the redundant and perceptually irrelevant parts of video sequences. The redundancy in video sequences can be categorised into spatial, temporal and spectral redundancy. "Spatial redundancy" is the term used to describe the correlation (similarity) between neighbouring pixels within a frame. The term "temporal redundancy" expresses the fact that objects appearing in one frame of a sequence are likely to appear in subsequent frames, while "spectral redundancy" refers to the correlation between different colour components of the same image.

There is often a significant amount of spatial redundancy between the pixels that make up each frame of a digital video sequence. In other words, the value of any pixel within a frame of the sequence is substantially the same as the value of other pixels in its immediate vicinity. Typically, video coding systems reduce spatial redundancy using a technique known as "block-based transform coding", in which a mathematical transformation, such as a two-dimensional Discrete Cosine Transform (DCT), is applied to blocks of image pixels. This transforms the image data from a representation comprising pixel values to a form comprising a set of coefficient values representative of spatial frequency components. This alternative representation of the image data reduces spatial redundancy significantly and thereby produces a more compact representation of the image data.

Frames of a video sequence which are compressed using block-based transform coding, without reference to any other frame within the sequence, are referred to as INTRA-coded or I-frames.

Generally, video coding systems not only reduce the spatial redundancy within individual frames of a video sequence, but also make use of a technique known as "motion-compensated prediction", to reduce the temporal redundancy in the sequence. Using motion-compensated prediction, the image content of some (often many) of the frames in a digital video sequence is "predicted" from one or more other frames in the sequence, known as "reference" frames. Prediction of image content is achieved by tracking the motion of objects or regions of an image between a frame to be coded (compressed) and the reference frame(s) using "motion vectors". As in the case of INTRA-coding, motion compensated prediction of a video frame is typically performed macroblock-by-macroblock.

Frames of a video sequence, compressed using motion-compensated prediction, are generally referred to as INTER-coded or P-frames. Motion-compensated prediction alone rarely provides a sufficiently precise representation of the image content of a video frame and therefore it is typically necessary to provide a so-called "prediction error" (PE) frame with each INTER-coded frame. The prediction error frame represents the difference between a decoded version of the INTER-coded frame and the image content of the frame to be coded. More specifically, the prediction error frame comprises values that represent the difference between pixel values in the frame to be coded and corresponding reconstructed pixel values formed on the basis of a predicted version of the frame in question. Consequently, the prediction error frame has characteristics similar to a still image and block-based transform coding can be applied in order to reduce its spatial redundancy and hence the amount of data (number of bits) required to represent it.

In order to illustrate the operation of a video coding system in greater detail, reference will now be made to Figures 3 and 4. Figure 3 is a schematic diagram of a generic video encoder that employs a combination of INTRA- and INTER-coding to produce a compressed (encoded) video bit-stream. A corresponding decoder is illustrated in Figure 4 and will be described later in the text.

The video encoder 100 comprises an input 101 for receiving a digital video signal from a camera or other video source (not shown). It also comprises a transformation unit 104 which is arranged to perform a block-based discrete cosine transform (DCT), a

quantizer 106, an inverse quantizer 108, an inverse transformation unit 110, arranged to perform an inverse block-based discrete cosine transform (IDCT), combiners 112 and 116, and a frame store 120. The encoder further comprises a motion estimator 130, a motion field coder 140 and a motion compensated predictor 150. Switches 102 and 114 are operated co-operatively by control manager 160 to switch the encoder between an INTRA-mode of video encoding and an INTER-mode of video encoding. The encoder 100 also comprises a video multiplex coder 170 which forms a single bit-stream from the various types of information produced by the encoder 100 for further transmission to a remote receiving terminal or, for example, for storage on a mass storage medium, such as a computer hard drive (not shown).

Encoder 100 operates as follows. Each frame of uncompressed video provided from the video source to input 101 is received and processed macroblock by macroblock, preferably in raster-scan order. When the encoding of a new video sequence starts, the first frame to be encoded is encoded as an INTRA-coded frame. Subsequently, the encoder is programmed to code each frame in INTER-coded format, unless one of the following conditions is met: 1) it is judged that the current macroblock of the frame being coded is so dissimilar from the pixel values in the reference frame used in its prediction that excessive prediction error information is produced, in which case the current macroblock is coded in INTRA-coded format; 2) a predefined INTRA frame repetition interval has expired; or 3) feedback is received from a receiving terminal indicating a request for a frame to be provided in INTRA-coded format.

Operation of the encoder 100 in INTRA-coding mode will now be described. In INTRA-coding mode, the control manager 160 operates the switch 102 to accept video input from input line 118. The video signal input is received macroblock by macroblock and the blocks of luminance and chrominance values which make up each macroblock are passed to the DCT transformation block 104. Here a 2-dimensional discrete cosine transform is performed and a 2-dimensional array of DCT coefficients is formed for each block.

The DCT coefficients for each block are passed to the quantizer 106, where they are quantized using a quantization parameter QP. Selection of the quantization parameter QP is controlled by the control manager 160 via control line 115.

In more detail, quantization of the DCT coefficients is performed by dividing each coefficient value by the quantization parameter QP and rounding the result to the nearest

integer. In this way the quantization process yields a set of quantized DCT coefficient values that have a reduced numerical precision compared with the coefficient values originally generated by DCT transformation block 104. Thus, in general, each of the quantized DCT coefficients may be represented by a smaller number of data bits than required to represent the corresponding coefficient before quantization. Furthermore, certain DCT coefficients are reduced to zero by the quantization process, thus reducing the number of coefficients that must be coded. Both these effects result in a reduction in the amount of data (i.e. data bits) required to represent the DCT coefficients for an image block. Thus, quantization provides a further mechanism by which the amount of data required to represent each image of the video sequence can be reduced. It also introduces an irreversible loss of information, which leads to a corresponding reduction in image quality. While this reduction in image quality may not always be desirable, quantization of DCT coefficient values does provide the possibility to adjust the number of bits required to encode a video sequence to take into account e.g. the bandwidth available for transmission of the encoded sequence or the desired quality of the coded video. More specifically, by increasing the value of QP used to quantize the DCT coefficients, a lower quality, but more compact representation of the video sequence can be created. Conversely, by reducing the value of QP, a higher quality but less compressed encoded bit-stream can be formed.

The quantized DCT coefficients for each block are passed from the quantizer 106 to the video multiplex coder 170, as indicated by line 125 in Figure 1. The video multiplex coder 170 orders the quantized transform coefficients for each block using a zigzag scanning procedure, thereby converting the two-dimensional array of quantized transform coefficient values into a one-dimensional array. [[.]] Typically, the video multiplex coder 170 next represents each non-zero quantized coefficient in the one-dimensional array by a pair of values, referred to as *level* and *run*, *level* being the value of the quantized coefficient and *run* being the number of consecutive zero-valued coefficients preceding the coefficient in question. The *run* and *level* values are further compressed using entropy coding. For example, a method such as variable length coding (VLC) may be used to produce a set of variable length codewords representative of each (*run*, *level*) pair.

Once the (*run*, *level*) pairs have been entropy (e.g. variable length) coded, the video multiplex coder 170 further combines them with control information, also entropy coded, for example, using a variable length coding method appropriate for the kind of

information in question, to form a single compressed bit-stream of coded image information 135. It is this bit-stream, including the variable length codewords representative of the (*run, level*) pairs and control information relating, among other things, to the quantization parameter QP used for quantizing the DCT coefficients, which is transmitted from the encoder.

A locally decoded version of the macroblock is also formed in the encoder 100. This is done by passing the quantized transform coefficients for each block, output by quantizer 106, through inverse quantizer 108 and applying an inverse DCT transform in inverse transformation block 110. Inverse quantization is performed by reversing the quantization operation performed in quantizer 106. More specifically, inverse quantizer 108 attempts to recover the original DCT coefficient values for a given image block by multiplying each quantized DCT coefficient value by quantization parameter QP. Because of the rounding operation performed as part of the quantization process in quantizer 106, it is generally not possible to recover the original DCT coefficient values exactly. This results in a discrepancy between the recovered DCT coefficient values and those originally produced by DCT transformation block 104 (hence the irreversible loss of information referred to above).

The operations performed by inverse quantizer 108 and inverse transformation block 110 yield a reconstructed array of pixel values for each block of the macroblock. The resulting decoded image data is input to combiner 112. In INTRA-coding mode, switch 114 is set so that the input to the combiner 112 via switch 114 is zero. In this way, the operation performed by combiner 112 is equivalent to passing the decoded image data unaltered.

As subsequent macroblocks of the current frame are received and undergo the previously described encoding and local decoding steps in blocks 104, 106, 108, 110 and 112, a decoded version of the INTRA-coded frame is built up in frame store 120. When the last macroblock of the current frame has been INTRA-coded and subsequently decoded, the frame store 120 contains a completely decoded frame, available for use as a prediction reference frame in coding a subsequently received video frame in INTER-coded format. The flag indicating INTRA or INTER-code format is provided in line 122.

Operation of the encoder 100 in INTER-coding mode will now be described. In INTER-coding mode, the control manager 160 operates switch 102 to receive its input from line 117, which comprises the output of combiner 116. The combiner 116 receives

the video input signal macroblock by macroblock from input 101. As combiner 116 receives the blocks of luminance and chrominance values which make up the macroblock, it forms corresponding blocks of prediction error information. The prediction error information represents the difference between the block in question and its prediction, produced in motion compensated prediction block 150. More specifically, the prediction error information for each block of the macroblock comprises a two-dimensional array of values, each of which represents the difference between a pixel value in the block of luminance or chrominance information being coded and a decoded pixel value obtained by forming a motion-compensated prediction for the block, according to the procedure described below.

The prediction error information for each block of the macroblock is passed to DCT transformation block 104, which performs a two-dimensional discrete cosine transform on each block of prediction error values to produce a two-dimensional array of DCT transform coefficients for each block.

The transform coefficients for each prediction error block are passed to quantizer 106 where they are quantized using a quantization parameter QP, in a manner analogous to that described above in connection with operation of the encoder in INTRA-coding mode. Again, selection of the quantization parameter QP is controlled by the control manager 160 via control line 115. The accuracy of prediction error coding can be adjusted depending on the available bandwidth and/or required quality of the coded video. In a typical Discrete Cosine Transform (DCT) based system this is done by varying the Quantizer Parameter (QP) used in quantizing the DCT coefficients the DCT coefficients to a specific accuracy.

The quantized DCT coefficients representing the prediction error information for each block of the macroblock are passed from quantizer 106 to video multiplex coder 170, as indicated by line 125 in Figure 1. As in INTRA-coding mode, the video multiplex coder 170 orders the transform coefficients for each prediction error block using a zigzag scanning procedure and then represents each non-zero quantized coefficient as a (*run, level*) pair. It further compresses the (*run, level*) pairs using entropy coding, in a manner analogous to that described above in connection with INTRA-coding mode. Video multiplex coder 170 also receives motion vector information (described in the following) from motion field coding block 140 via line 126 and control information (e.g. including an indication of the quantization parameter QP) from control manager 160. It entropy codes

the motion vector information and control information and forms a single bit-stream of coded image information, 135 comprising the entropy coded motion vector, prediction error and control information. The indication, qz, of the quantization parameter QP is provided to multiplex xoswe 170 via line 124.

The quantized DCT coefficients representing the prediction error information for each block of the macroblock are also passed from quantizer 106 to inverse quantizer 108. Here they are inverse quantized, in a manner analogous to that previously described in connection with operation of the encoder in INTRA-coding mode. In INTER-coding mode, the quality of the encoded video bit-stream and the number of bits required to represent the video sequence can be adjusted by varying the degree of quantization applied to the DCT coefficients representing the prediction error information.

The resulting blocks of inverse quantized DCT coefficients are applied to inverse DCT transform block 110, where they undergo inverse DCT transformation to produce locally decoded blocks of prediction error values. The locally decoded blocks of prediction error values are then input to combiner 112. In INTER-coding mode, switch 114 is set so that the combiner 112 also receives predicted pixel values for each block of the macroblock, generated by motion-compensated prediction block 150. The combiner 112 combines each of the locally decoded blocks of prediction error values with a corresponding block of predicted pixel values to produce reconstructed image blocks and stores them in frame store 120.

As subsequent macroblocks of the video signal are received from the video source and undergo the previously described encoding and decoding steps in blocks 104, 106, 108, 110, 112, a decoded version of the frame is built up in frame store 120. When the last macroblock of the frame has been processed, the frame store 120 contains a completely decoded frame, available for use as a prediction reference frame in encoding a subsequently received video frame in INTER-coded format.

Formation of a prediction for a macroblock of the current frame will now be described. Any frame encoded in INTER-coded format requires a reference frame for motion-compensated prediction. This means, necessarily, that when encoding a video sequence, the first frame to be encoded, whether it is the first frame in the sequence, or some other frame, must be encoded in INTRA-coded format. This, in turn, means that when the video encoder 100 is switched into INTER-coding mode by control manager 160, a complete reference frame, formed by locally decoding a previously encoded frame,

is already available in the frame store 120 of the encoder. In general, the reference frame is formed by locally decoding either an INTRA-coded frame or an INTER-coded frame.

The first step in forming a prediction for a macroblock of the current frame is performed by motion estimation block 130. The motion estimation block 130 receives the blocks of luminance and chrominance values which make up the current macroblock of the frame to be coded via line 128. It then performs a block matching operation in order to identify a region in the reference frame which corresponds substantially with the current macroblock. In order to perform the block matching operation, motion estimation block accesses reference frame data stored in frame store 120 via line 127. More specifically, motion estimation block 130 performs block-matching by calculating difference values (e.g. sums of absolute differences) representing the difference in pixel values between the macroblock under examination and candidate best-matching regions of pixels from a reference frame stored in the frame store 120. A difference value is produced for candidate regions at all possible positions within a predefined search region of the reference frame and motion estimation block 130 determines the smallest calculated difference value. The offset between the macroblock in the current frame and the candidate block of pixel values in the reference frame that yields the smallest difference value defines the motion vector for the macroblock in question.

Once the motion estimation block 130 has produced a motion vector for the macroblock, it outputs the motion vector to the motion field coding block 140. The motion field coding block 140 approximates the motion vector received from motion estimation block 130 using a motion model comprising a set of basis functions and motion coefficients. More specifically, the motion field coding block 140 represents the motion vector as a set of motion coefficient values which, when multiplied by the basis functions, form an approximation of the motion vector. Typically, a translational motion model having only two motion coefficients and basis functions is used, but motion models of greater complexity may also be used.

The motion coefficients are passed from motion field coding block 140 to motion compensated prediction block 150. Motion compensated prediction block 150 also receives the best-matching candidate region of pixel values identified by motion estimation block 130 from frame store 120. Using the approximate representation of the motion vector generated by motion field coding block 140 and the pixel values of the best-matching candidate region from the reference frame, motion compensated prediction

block 150 generates an array of predicted pixel values for each block of the macroblock. Each block of predicted pixel values is passed to combiner 116 where the predicted pixel values are subtracted from the actual (input) pixel values in the corresponding block of the current macroblock, thereby forming a set of prediction error blocks for the macroblock.

Operation of the video decoder 200, shown in Figure 2 will now be described. The decoder 200 comprises a video multiplex decoder 270, which receives an encoded video bit-stream 135 from the encoder 100 and demultiplexes it into its constituent parts, an inverse quantizer 210, an inverse DCT transformer 220, a motion compensated prediction block 240, a frame store 250, a combiner 230, a control manager 260, and an output 280.

The control manager 260 controls the operation of the decoder 200 in response to whether an INTRA- or an INTER-coded frame is being decoded. An INTRA / INTER trigger control signal, which causes the decoder to switch between decoding modes is derived, for example, from picture type information associated with each compressed video frame received from the encoder. The INTRA / INTER trigger control signal is extracted from the encoded video bit-stream by the video multiplex decoder 270 and is passed to control manager 260 via control line 215.

Decoding of an INTRA-coded frame is performed macroblock-by-macroblock. The video multiplex decoder 270 separates the encoded information for the blocks of the macroblock from possible control information relating to the macroblock in question. The encoded information for each block of an INTRA-coded macroblock comprises variable length codewords representing the VLC coded *level* and *run* values for the non-zero quantized DCT coefficients of the block. The video multiplex decoder 270 decodes the variable length codewords using a variable length decoding method corresponding to the encoding method used in the encoder 100 and thereby recovers the (*run*, *level*) pairs. It then reconstructs the array of quantized transform coefficient values for each block of the macroblock and passes them to inverse quantizer 210. Any control information relating to the macroblock is also decoded in the video multiplex decoder using an appropriate decoding method and is passed to control manager 260. In particular, information relating to the level of quantization applied to the transform coefficients (i.e. quantization parameter QP) is extracted from the encoded bit-stream by video multiplex decoder 270 and provided to control manager 260 via control line 217. The control manager, in turn, conveys this information to inverse quantizer 210 via control line 218. Inverse quantizer 210 inverse quantizes the quantized DCT coefficients for each block of the macroblock

according to the control information relating to quantization parameter QP and provides the now inverse quantized DCT coefficients to inverse DCT transformer 220. The inverse quantization operation performed by inverse quantizer 210 is identical to that performed by inverse quantizer 108 in the encoder.

Inverse DCT transformer 220 performs an inverse DCT transform on the inverse quantized DCT coefficients for each block of the macroblock to form a decoded block of image information comprising reconstructed pixel values. The reconstructed pixel values for each block of the macroblock are passed via combiner 230 to the video output 280 of the decoder where, for example, they can be provided to a display device (not shown). The reconstructed pixel values for each block of the macroblock are also stored in frame store 250. Because motion-compensated prediction is not used in the encoding/decoding of INTRA coded macroblocks control manager 260 controls combiner 230 to pass each block of pixel values as such to the video output 280 and frame store 250. As subsequent macroblocks of the INTRA-coded frame are decoded and stored, a decoded frame is progressively assembled in the frame store 250 and thus becomes available for use as a reference frame for motion compensated prediction in connection with the decoding of subsequently received INTER-coded frames.

INTER-coded frames are also decoded macroblock by macroblock. The video multiplex decoder 270 receives the encoded video bit-stream 135 and separates the encoded prediction error information for each block of an INTER-coded macroblock from encoded motion vector information and possible control information relating to the macroblock in question. As explained in the foregoing, the encoded prediction error information for each block of the macroblock typically comprises variable length codewords representing the *level* and *run* values for the non-zero quantized transform coefficients of the prediction error block in question. The video multiplex decoder 270 decodes the variable length codewords using a variable length decoding method corresponding to the encoding method used in the encoder 100 and thereby recovers the (*run*, *level*) pairs. It then reconstructs an array of quantized transform coefficient values for each prediction error block and passes them to inverse quantizer 210. Control information relating to the INTER-coded macroblock is also decoded in the video multiplex decoder 270 using an appropriate decoding method and is passed to control manager 260. Information relating to the level of quantization (QP) applied to the transform coefficients of the prediction error blocks is extracted from the encoded bit-

stream and provided to control manager 260 via control line 217. The control manager, in turn, conveys this information to inverse quantizer 210 via control line 218. Inverse quantizer 210 inverse quantizes the quantized DCT coefficients representing the prediction error information for each block of the macroblock according to the control information relating to quantization parameter QP and provides the now inverse quantized DCT coefficients to inverse DCT transformer 220. Again, the inverse quantization operation performed by inverse quantizer 210 is identical to that performed by inverse quantizer 108 in the encoder. The INTRA/INTER flag is provided in line 215.

The inverse quantized DCT coefficients representing the prediction error information for each block are then inverse transformed in the inverse DCT transformer 220 to yield an array of reconstructed prediction error values for each block of the macroblock.

The encoded motion vector information associated with the macroblock is extracted from the encoded video bit-stream 135 by video multiplex decoder 270 and is decoded. The decoded motion vector information thus obtained is passed via control line 225 to motion compensated prediction block 240, which reconstructs a motion vector for the macroblock using the same motion model as that used to encode the INTER-coded macroblock in encoder 100. The reconstructed motion vector approximates the motion vector originally determined by motion estimation block 130 of the encoder. The motion compensated prediction block 240 of the decoder uses the reconstructed motion vector to identify the location of a region of reconstructed pixels in a prediction reference frame stored in frame store 250. The region of pixels indicated by the reconstructed motion vector is used to form a prediction for the macroblock in question. More specifically, the motion compensated prediction block 240 forms an array of pixel values for each block of the macroblock by copying corresponding pixel values from the region of pixels identified in the reference frame. These blocks of pixel values, derived from the reference frame, are passed from motion compensated prediction block 240 to combiner 230 where they are combined with the decoded prediction error information. In practice, the pixel values of each predicted block are added to corresponding reconstructed prediction error values output by inverse DCT transformer 220. In this way, an array of reconstructed pixel values for each block of the macroblock is obtained. The reconstructed pixel values are passed to the video output 280 of the decoder and are also stored in frame store 250.

As subsequent macroblocks of the INTER-coded frame are decoded and stored, a decoded frame is progressively assembled in the frame store 250 and thus becomes available for use as a reference frame for motion-compensated prediction of other INTER-coded frames.

As described above, typical video encoding and decoding systems (commonly referred to as video codecs) are based on motion compensated prediction and prediction error coding. Motion compensated prediction is obtained by analyzing and coding motion between video frames and reconstructing image segments using the motion information. Prediction error coding is used to code the difference between motion compensated image segments and corresponding segments of the original image. The accuracy of prediction error coding can be adjusted depending on the available bandwidth and required quality of the coded video. In a typical Discrete Cosine Transform (DCT) based system this is done by varying the quantization parameter (QP) used in quantizing the DCT coefficients to a specific accuracy.

It should be noted that, in order to stay in synchronization with the encoder, the decoder has to know the exact value of the QP used in the coded video sequence. Typically, the QP value is transmitted once per slice leading to increase in the number of bits needed to encode the image. (As previously explained, a slice contains part of the image and is coded independently from other slices in order to avoid propagation of possible transmission errors inside the picture). For example, if the coding of a single QP value takes 6 bits and 20 images, each divided into 10 slices, are transmitted every second, 1.2kbps is spent for the QP information alone.

Prior art solutions (for example, the H.26L video coding recommendation presented in the document by T. Wiegand, "Joint Model Number 1", Doc. JVT-A003, Joint Video Team (JVT) of ISO/IEC MPEG and ITU-T VCEG, Jan. 2002) code the picture/slice QP parameters independently with a fixed or variable length code. This leads to increased transmission bit-rate as described above. More specifically, according to H.26L Joint Model Number 1, the quantization parameter value QP used in quantizing the DCT coefficient values is typically indicated in the encoded bit-stream at the beginning of each picture (see T. Wiegand, "Joint Model Number 1", Doc. JVT-A003, Joint Video Team (JVT) of ISO/IEC MPEG and ITU-T VCEG, Jan. 2002, Section 3.3.1). If the macroblocks within a frame are arranged into slices then the QP value is also indicated at the beginning of each slice of the frame (e.g. in an optional slice header portion of the encoded bit-

stream). In both cases, the QP value is indicated as such or is coded using an appropriate variable length coding scheme. As stated above, it should be realized that this scheme is very costly in terms of the number of bits required to represent the quantization parameter information, particularly in situations where frames are divided into many slices and / or the available bandwidth available for transmission of the encoded video sequence is low. This is a particularly significant problem in mobile video applications in which the encoded video bit-stream is transmitted over a radio communications link. In this situation, the bandwidth available for transmission of the encoded video bit-stream may be as low as 20kbits/s and the QP information included in the bit-stream may represent a significant proportion of the overall available bandwidth.

Furthermore, according to H.26L, the value of QP may optionally be varied at the macroblock level by inserting a quantizer change parameter (Dquant) in the portion of the encoded bit-stream representative of the macroblock in question (see T. Wiegand, "Joint Model Number 1", Doc. JVT-A003, Joint Video Team (JVT) of ISO/IEC MPEG and ITU-T VCEG, Jan. 2002, Section 3.4.7). This leads to a further increase in the amount of information in the encoded bit-stream that is devoted to the indication of QP related information.

In view of the foregoing, it should be realised that there is a significant need for an improved mechanism for indicating information relating to quantization parameter values in video coding systems.

Summary of the Invention

The present invention improves prior art solutions for indicating QP related information by introducing a sequence level QP. This allows the encoder application to decide a video sequence dependent reference QP to be used in coding of the picture / slice QPs. Now, according to the invention, instead of coding the absolute values of picture / slice QPs, it is enough to code the difference between the reference sequence QP and the actually used picture / slice QP. In this way there is no need to transmit a full QP for every picture / slice, but a statistically smaller difference value is transmitted and used to reconstruct the picture / slice QP, thus leading to reduction in transmission bit-rate.

The bit-rate savings are most evident in the case of constant QP. In this case, it is sufficient to send just one bit per slice to indicate that the sequence QP is to be used when decoding the slice. For example, in the previously described example, the bit-rate for QP

is reduced from 1.2kbps to 0.2kbps (now only one bit needs to be sent instead of six for each slice).

According to a first aspect of the invention, there is provided a method of encoding a digital video sequence, the method being applied in a video coding application to produce an encoded video bit-stream representative of the digital video sequence. The digital video sequence comprises a number of frames, each frame of the sequence comprising an array of pixels and is divided into a plurality of blocks, each block comprising a certain number of pixels. The method comprises encoding a frame of the digital video sequence by applying motion compensated prediction to blocks of pixels, thereby producing corresponding blocks of prediction error values. A transform coding technique is applied to the blocks of prediction error values to produce sets of transform coefficient values representative of the blocks of prediction error values and a level of quantization is applied to the sets of transform coefficient values to yield sets of quantized transform coefficient values. According to the invention, the method further comprises defining a default level of quantization to be used throughout encoding of the digital video sequence to quantize the sets of transform coefficient values.

Advantageously, the method according to the first aspect of the invention is also used to indicate quantization parameter (QP) values used to quantize sets of transform coefficient values representative of blocks of pixel values produced for frames coded in INTRA-coding mode in a manner analogous to that described above for indicating the quantization parameter values used to quantize sets of transform coefficient values representative of prediction error values produced for frames coded in INTER-coding mode.

Advantageously, the default level of quantization to be used throughout encoding of the digital video sequence is specific to the video sequence being encoded. Alternatively, the default level of quantization is specific to the video coding application.

Preferably, an indication of the default level of quantization to be used throughout encoding of the digital video sequence is provided. Even more preferably, an indication of the default level of quantization is provided in the encoded bit-stream representative of the digital video sequence, advantageously[[.]] ~~Advantaegously~~, the encoded bit-stream, including the indication of the default level of quantization to be used throughout encoding of the digital video sequence, is transmitted to a video decoding device.

Advantageously, the default level of quantization to be used throughout encoding of the digital video sequence to quantize the sets of transform coefficient values can be updated during encoding of the digital video sequence and a further indication indicative of the updated default level of quantization is provided.

The indication of the updated default level of quantization is preferably transmitted to a video decoding device, advantageously, in the encoded bit-stream representative of the digital video sequence.

Advantageously, the level of quantization applied to said sets of transform coefficient values can be adjusted such that the actual level of quantization applied to the sets of transform coefficient values is different from the default level of quantization to be used throughout encoding of the video sequence. Preferably, the actual level of quantization applied is represented as a difference with respect to the default level of quantization. Advantageously, an indication of the difference with respect to the default level of quantization is provided in the encoded bit-stream representative of the digital video sequence.

In an embodiment of the video encoding method according to the first aspect of the invention, the level of quantization applied to the sets of transform coefficient values can be adjusted from one frame of the digital video sequence to another such that an actual level of quantization applied to the sets of transform coefficients for a particular frame of the digital video sequence is different from the default level of quantization to be used throughout encoding of the digital video sequence. Advantageously, in this embodiment, the actual level of quantization to be used in the particular frame is represented as a difference with respect to the default level of quantization and an indication of the difference with respect to the default level of quantization is provided in the encoded bit-stream representative of the digital video sequence.

In an alternative embodiment of the video encoding method according to the first aspect of the invention, the plurality of blocks into which a frame of the digital video sequence is divided are grouped into one or more segments and the level of quantization applied to the sets of transform coefficient values can be adjusted from one segment of a frame to another such that an actual level of quantization applied to the sets of transform coefficients for a particular segment of a frame is different from the default level of quantization to be used throughout encoding of the digital video sequence. Advantageously, in this alternative embodiment, the actual level of quantization to be

used in the particular segment is represented as a difference with respect to the default level of quantization and an indication of the difference with respect to the default level of quantization is provided in the encoded bit-stream representative of the digital video sequence.

Advantageously, if the default level of quantization is to be used to quantize all sets of transform coefficient values throughout the digital video sequence, an indication of the default level of quantization is provided together with an indication that said default level is to be used to quantize all sets of transform coefficient values throughout the digital video sequence.

According to a second aspect of the invention, there is provided a method of decoding an encoded digital video sequence, the method being applied in a video decoding application to produce a decoded digital video sequence. The digital video sequence comprises a number of frames, each frame of the sequence comprising an array of pixels and being divided into a plurality of blocks, each block comprising a certain number of pixels, frames of the digital video sequence having been encoded by applying motion compensated prediction to blocks of pixels to produce corresponding blocks of prediction error values and applying a transform coding technique to the blocks of prediction error values to produce sets of transform coefficient values representative of the blocks of prediction error values and applying a level of quantization to the sets of transform coefficient values to yield sets of quantized transform coefficient values representative of the blocks of prediction error values. According to the invention, the decoding method comprises defining a default level of inverse quantization to be used throughout decoding of the encoded digital video sequence to inverse quantize the sets of quantized transform coefficient values.

Advantageously, the default level of inverse quantization is identical to a default level of quantization used to quantize the sets of transform coefficient values during encoding of the video sequence.

Advantageously, the default level of inverse quantization defined to be used throughout decoding of the encoded digital video sequence is specific to the encoded video sequence being decoded. Alternatively, the default level of inverse quantization is specific to the video decoding application.

Advantageously, the decoding method comprises retrieving an indication of the default level of inverse quantization, preferably from a bit-stream representative of the encoded digital video sequence.

Advantageously, the default level of inverse quantization can be updated during decoding of the digital video sequence. Preferably, updating of the default level of inverse quantization is performed responsive to an indication of an updated default level of quantization used during encoding of the video sequence, retrieved from a bit-stream representative of the encoded digital video sequence. Alternatively, the default level of inverse quantization is updated responsive to an indication of an updated default level of quantization used during encoding of the video sequence, transmitted from a video encoding device.

Advantageously, the level of inverse quantization applied to the sets of quantized transform coefficient values can be adjusted such that an actual level of inverse quantization applied to the sets of quantized transform coefficient values is different from the default level of inverse quantization to be used throughout decoding of the encoded digital video sequence. In this case, the actual level of inverse quantization is determined by adding a difference value to the default level of inverse quantization, the difference value being representative of the difference between the default level of inverse quantization and the actual level of inverse quantization to be applied. Preferably, an indication of the difference value is retrieved from a bit-stream representative of the encoded digital video sequence.

In an embodiment of the video decoding method according to the second aspect of the invention, the level of inverse quantization applied to the sets of quantized transform coefficient values is adjusted from one frame of the digital video sequence to another such that an actual level of inverse quantization applied to the sets of quantized transform coefficients for a particular frame of the digital video sequence is different from the default level of inverse quantization to be used throughout decoding of the encoded digital video sequence. Advantageously, in this embodiment, the actual level of inverse quantization to be used in the particular frame is determined by adding a frame-specific difference value to the default level of inverse quantization, the frame-specific difference value being representative of the difference between the default level of inverse quantization and the actual level of inverse quantization to be used in the particular frame.

Preferably, an indication of said frame-specific difference value is retrieved from a bit-stream representative of the encoded digital video sequence.

In an alternative embodiment of the video decoding method according to the second aspect of the invention, the plurality of blocks into which a frame of said digital video sequence is divided are grouped into one or more segments and the level of inverse quantization applied to the sets of quantized transform coefficient values is adjusted from one segment of a frame to another such that an actual level of inverse quantization applied to the sets of quantized transform coefficients for a particular segment of a frame is different from the default level of inverse quantization to be used throughout decoding of the encoded digital video sequence. Advantageously, in this alternative embodiment, the actual level of inverse quantization to be used in the particular segment is determined by adding a segment-specific difference value to the default level of inverse quantization, the segment-specific difference value being representative of the difference between the default level of inverse quantization and the actual level of inverse quantization to be used in the particular segment. Preferably, an indication of the segment-specific difference value is retrieved from a bit-stream representative of the encoded digital video sequence.

According to a third aspect of the invention, there is provided an encoder for encoding a digital video sequence to produce an encoded video bit-stream representative of the digital video sequence, the digital video sequence comprising a number of frames, each frame of the sequence comprising an array of pixels and being divided into a plurality of blocks, each block comprising a certain number of pixels. The video encoder according to the third aspect of the invention is arranged to encode a frame of the digital video sequence by applying motion compensated prediction to blocks of pixels, thereby producing corresponding blocks of prediction error values. It is further arranged to apply a transform coding technique to blocks of prediction error values to produce sets of transform coefficient values representative of said blocks of prediction error values and to apply a level of quantization to said sets of transform coefficient values to yield sets of quantized transform coefficient values. According to the invention, the video encoder is further arranged to define a default level of quantization to be used throughout encoding of the digital video sequence to quantize the sets of transform coefficient values.

Advantageously, the encoder according to the third aspect of the invention is also arranged to indicate quantization parameter (QP) values used to quantize sets of transform coefficient values representative of blocks of pixel values produced for frames coded in

INTRA-coding mode in a manner analogous to that described above for indicating the quantization parameter values used to quantize sets of transform coefficient values representative of prediction error values produced for frames coded in INTER-coding mode.

Advantageously, the default level of quantization defined by the video encoder is specific to the video sequence being encoded.

Advantageously, the video encoder is further arranged to provide an indication of the default level of quantization in the encoded bit-stream representative of the digital video sequence. Even more advantageously, it is arranged to transmit the encoded bit-stream to a corresponding video decoder.

Advantageously the video encoder is further arranged to update the default level of quantization during encoding of the digital video sequence and to provide an indication of the updated default level of quantization. Preferably, the encoder is also arranged to transmit the indication of the updated default level of quantization to a corresponding video decoder. Advantageously, the encoder includes the indication of the updated default level of quantization in the encoded bit-stream representative of the digital video sequence.

Preferably, the video encoder is further arranged to adjust the level of quantization applied to the sets of transform coefficient values and thereby to apply an actual level of quantization that is different from the default level of quantization. Preferably, the video encoder is still further arranged to represent the actual level of quantization as a difference with respect to the default level of quantization and to provide an indication of the difference with respect to the default level of quantization in the encoded bit-stream representative of the digital video sequence.

In one embodiment, a video encoder according to the third aspect of the invention is arranged to adjust the level of quantization applied to the sets of transform coefficient values from one frame of the digital video sequence to another. In this way it is arranged to apply an actual level of quantization to the sets of transform coefficients for a particular frame that is different from the default level of quantization to be used throughout encoding of the digital video sequence. Advantageously, the video encoder according to this embodiment is further arranged to represent the actual level of quantization to be used in the particular frame as a difference with respect to the default level of quantization and

to provide an indication of the difference with respect to the default level of quantization in the encoded bit-stream representative of the digital video sequence.

In an alternative embodiment, a video encoder according to the third aspect of the invention is further arranged to group the plurality of blocks into which a frame of the digital video sequence is divided into one or more segments and to adjust the level of quantization applied to the sets of transform coefficient values from one segment of a frame to another. In this way the video encoder is arranged to apply an actual level of quantization to the sets of transform coefficients for a particular segment of a frame that is different from the default level of quantization to be used throughout encoding of the digital video sequence. Advantageously, the video encoder according to this alternative embodiment is further arranged to represent the actual level of quantization to be used in the particular segment as a difference with respect to the default level of quantization and to provide an indication of the difference with respect to the default level of quantization in the encoded bit-stream representative of the digital video sequence.

In a particular embodiment, the video encoder is arranged to provide an indication of the default level of quantization and an indication that the default level is to be used to quantize all sets of transform coefficient values throughout the digital video sequence.

Advantageously, the video encoder according to the third aspect of the invention is provided in a multimedia terminal. Even more preferably, it is implemented in a radio telecommunications device.

According to a fourth aspect of the invention, there is provided a decoder for decoding an encoded digital video sequence to produce a decoded digital video sequence. The digital video sequence comprises a number of frames, each frame of the sequence comprising an array of pixels and being divided into a plurality of blocks, each block comprising a certain number of pixels, frames of the digital video sequence having been encoded by applying motion compensated prediction to blocks of pixels to produce corresponding blocks of prediction error values and applying a transform coding technique to the blocks of prediction error values to produce sets of transform coefficient values representative of said blocks of prediction error values and applying a level of quantization to the sets of transform coefficient values to yield sets of quantized transform coefficient values representative of the blocks of prediction error values. According to the invention, the video decoder is arranged to define a default level of inverse quantization to

be used throughout decoding of the encoded digital video sequence to inverse quantize the sets of quantized transform coefficient values.

Preferably, the default level of inverse quantization is identical to a default level of quantization used to quantize the sets of transform coefficient values during encoding of the video sequence.

Advantageously, the default level of inverse quantization defined to be used throughout decoding of the encoded digital video sequence is specific to the encoded video sequence being decoded.

Advantageously, the video decoder is arranged to retrieve an indication of the default level of inverse quantization, preferably from a bit-stream representative of the encoded digital video sequence.

Advantageously, the video decoder is arranged to update the default level of inverse quantization during decoding of the digital video sequence, preferably by retrieving an indication of an updated default level of quantization from a bit-stream representative of the encoded digital video sequence. Alternatively, the video decoder is arranged to receive an indication of an updated default level of quantization transmitted from a video encoding device.

Preferably, the video decoder is arranged to adjust the level of inverse quantization applied to the sets of quantized transform coefficient values and to apply an actual level of inverse quantization to the sets of quantized transform coefficient values that is different from the default level of inverse quantization. Advantageously, the decoder is arranged to determine the actual level of inverse quantization by adding a difference value to the default level of inverse quantization, the difference value being representative of the difference between the default level of inverse quantization and the actual level of inverse quantization to be applied. Preferably, the video decoder is arranged to retrieve an indication of the difference value from a bit-stream representative of the encoded digital video sequence.

In one embodiment, a video decoder according to the fourth aspect of the invention is arranged to adjust the level of inverse quantization applied to the sets of quantized transform coefficient values from one frame of the digital video sequence to another and to apply an actual level of inverse quantization to the sets of quantized transform coefficients for a particular frame of the digital video sequence that is different from the default level of inverse quantization to be used throughout decoding of the encoded digital

video sequence. Advantageously, the decoder is arranged to determine the actual level of inverse quantization to be used in the particular frame by adding a frame-specific difference value to the default level of inverse quantization, the frame-specific difference value being representative of the difference between the default level of inverse quantization and the actual level of inverse quantization to be used in the particular frame. Preferably, the video decoder is arranged to retrieve an indication of the frame-specific difference value from a bit-stream representative of the encoded digital video sequence.

In an alternative embodiment, a video decoder according to the fourth aspect of the invention is arranged to decode an encoded video sequence in which the plurality of blocks into which a frame of said digital video sequence is divided are grouped into one or more segments and is further arranged to adjust the level of inverse quantization applied to the sets of quantized transform coefficient values from one segment of a frame to another and to apply an actual level of inverse quantization to the sets of quantized transform coefficients for a particular segment of a frame that is different from the default level of inverse quantization to be used throughout decoding of the encoded digital video sequence. Preferably, the decoder is arranged to determine the actual level of inverse quantization to be used in the particular segment by adding a segment-specific difference value to the default level of inverse quantization, the segment-specific difference value being representative of the difference between the default level of inverse quantization and the actual level of inverse quantization to be used in the particular segment. Preferably, the video decoder is arranged to retrieve an indication of the segment-specific difference value from a bit-stream representative of the encoded digital video sequence.

According to a fifth aspect of the invention, there is provided a multimedia terminal comprising an encoder according the third aspect of the invention.

According to a sixth aspect of the invention, there is provided a multimedia terminal comprising a decoder according to the fourth aspect of the invention.

Preferably, the multimedia terminal according to the fifth and / or sixth aspects of the invention is a mobile multimedia terminal arranged to communicate with a mobile telecommunications network by means of a radio connection.

Brief Description of the Drawings

Figure 1 illustrates the formation of a 16x16 macroblock according to prior art.

Figure 2 illustrates subdivision of a QCIF picture into 16x16 macroblocks and grouping of consecutive macroblocks into slices.

Figure 3 is a schematic block diagram of a generic video encoder according to prior art.

Figure 4 is a schematic block diagram of a generic video decoder according to prior art and corresponding to the encoder shown in Figure 3.

Figure 5 is a schematic block diagram of a video encoder according to an embodiment of the invention.

Figure 6 is a schematic block diagram of a video decoder according to an embodiment of the invention and corresponding to the encoder shown in Figure 5.

Figure 7 illustrates a decoding process according to one possible embodiment of the invention. Quantization parameters (QP) for each slice are obtained by adding the Sequence QP (SQP) to slice specific difference QP values (ΔQP^n).

Figure 8 is a schematic block diagram of a multimedia communications terminal in which the method according to the invention may be implemented.

Detailed Description of the Invention

In a preferred embodiment of the invention a video sequence specific quantization parameter (QP) is transmitted and used as a reference when coding and decoding the actual picture / slice quantization parameters. In this way there is no need to transmit a full QP for every picture / slice, but a statistically smaller difference value is transmitted and used to reconstruct the picture / slice QP, thus leading to reduction in transmission bit-rate.

Embodiments of the invention will now be described with reference to Figures 5 through 8.

Figure 5 is a schematic block diagram of a video encoder 600 implemented according to the preferred embodiment of the invention. The structure of the video encoder shown in Figure 5 is substantially identical to that of the prior art video encoder illustrated in Figure 3, with appropriate modifications to those parts of the encoder that perform operations relating to the quantization of DCT transform coefficients and the signalling of quantization parameter (QP) values used in the video encoding process. All parts of the video encoder that implement functions and operate in a manner identical to the previously described prior art video encoder are identified with identical reference

numbers. As the invention is particularly relevant to the signalling of quantization parameter (QP) values at the slice or frame level, it will be assumed throughout the following description that video encoder 600 according to the preferred embodiment of the invention is specifically adapted to apply a video coding method in which the frames of a video sequence to be coded are divided into macroblocks and the macroblocks are further grouped into slices, an indication of the quantization parameter being provided at the beginning of each frame and at the beginning of each new slice within a frame. An example of such a video coding method is the previously cited ITU-T H.26L video coding recommendation, as described in T. Wiegand, "Joint Model Number 1", Doc. JVT-A003, Joint Video Team (JVT) of ISO/IEC MPEG and ITU-T VCEG, Jan. 2002. Alternatively, the method can be applied in a video coding system in which an indication of the quantization parameter is given only at the beginning of a frame. While the following detailed description is written specifically to illustrate application of the method according to the invention in the indication and signalling of slice level quantization parameters, it should be appreciated that the method can applied in an exactly analogous manner to the representation of frame (picture) level quantization parameters.

Operation of video encoder 600 will now be considered in detail. When encoding a digital video sequence, encoder 600 operates in a manner similar to that previously described in connection with Figure 3 to generate INTRA-coded and INTER-coded compressed video frames. As explained earlier in the text, in INTRA-coding mode, a Discrete Cosine Transform (DCT) is applied to each block of image data (pixel values) in order to produce a corresponding two-dimensional array of transform coefficient values. The DCT operation is performed in transform block 104 and the coefficients thus produced are subsequently passed to quantizer 106, where they are quantized. In INTER-coding mode, the DCT transform performed in block 104 is applied to blocks of prediction error values. The transform coefficients produced as a result of this operation are also passed to quantizer 106 where they too are quantized.

According to the invention, when starting to encode a new video sequence, encoder 600 determines a default or reference level of quantization that is to be used throughout encoding of the video sequence to quantize the DCT coefficient values generated in quantizer 106. Throughout the following description, this default or reference level of quantization will be termed a "sequence level quantization parameter", or SQP for short. The choice of an SQP for a given video sequence is controlled by control manager 660

and, for example, may be based on consideration of the properties of the sequence to be encoded and the bandwidth available for transmission of the encoded bit-stream produced by the encoder.

In the preferred embodiment of the invention, encoder 600 determines SQP as the default or reference level of quantization to be used when operating in INTER-coding mode, i.e. in situations when the DCT coefficients generated in transform block 104 are representative of prediction error values. It should be appreciated that the method according to the invention can also be applied to the quantization of DCT coefficient values produced in traditional INTRA-coding mode utilizing no spatial prediction. However, given the different origins of the transform coefficients in INTRA- and INTER-coding modes (the DCT coefficients produced in INTRA-coding mode are derived from pixel values, while those generated in INTER-coding mode are produced by applying a DCT transform to prediction error values) it is unlikely that a single SQP value can be determined that is optimum for quantization of DCT coefficients in both INTRA- and INTER-coding modes. Therefore, in an embodiment in which the method according to the invention is used in both INTRA- and INTER-coding mode, two SQP values are preferably be used, one that provides the most efficient representation of QP value information in INTRA-coding mode and another that provides the most efficient representation of QP values used during INTER-coding. In all other respects, the method according to the invention may be applied in a directly analogous way in both INTRA-and INTER-coding modes. Of course, in an alternative embodiment, a single SQP value may be defined and used as the sequence level quantization parameter for both INTRA- and INTER-coded frames. This is a practical approach especially in modern video coding systems, such as the one described in T. Wiegand, "Joint Model Number 1", Doc. JVT-A003, Joint Video Team (JVT) of ISO/IEC MPEG and ITU-T VCEG, Jan. 2002, where spatial prediction is applied to the INTRA coded macroblocks before coding the INTRA rediction error with DCT.

It should further be noted that as the majority of frames in a typical video sequence are encoded as INTER frames, the greatest saving in bit-rate is achieved by applying the method according to the invention to the representation of QP values in INTER-coding mode. Thus, in the preferred embodiment of the invention, a single SQP value is used, this value being indicative of a default or reference value of quantization to be used in

quantizing DCT coefficients representative of prediction error values in INTER-coding mode.

Having determined the SQP value to be used for the sequence, control manager 660 provides an indication of the selected SQP value via control line 122 to video multiplex coder 670 which, in turn, inserts an indication of the SQP value into the bit-stream 635 of coded image information representative of the video sequence. Preferably, this indication is provided in a sequence header portion of the encoded video bit-stream 635.

Video encoder 600 then starts to encode the video sequence. As explained in connection with the description of prior art video encoder 100, illustrated in Figure 3, the first frame of the sequence to be encoded is encoded in INTRA-format. As the SQP value defined according to the preferred embodiment of the invention is specific to the quantization of DCT coefficient values produced in INTER-coding mode, operation of encoder 600 in INTRA-coding mode is entirely analogous to that of prior art video encoder 100 and will not be considered in further detail here.

Once encoding of the first frame is complete, control manager 660 switches video encoder 600 into INTER-coding mode. In INTER-coding mode, switch 102 is operated to receive its input from line 117, which comprises the output of combiner 116. Combiner 116 receives the video input signal macroblock by macroblock from input 101 and forms a block of prediction error information for each block of the macroblock. The prediction error information for each block is passed to DCT transformer 104, which performs a two-dimensional discrete cosine transform on each block of prediction error values to produce a two-dimensional array of DCT transform coefficients for the block in question. The transform coefficients for each prediction error block are then passed to quantizer 106 where they are quantized, as previously described, using a quantization parameter QP. The rest of the INTER-coding process continues as previously described in connection with prior art video encoder 100.

As each macroblock is received, control manager 660 determines whether the macroblock currently being processed is the first macroblock of a slice. If it is, the control manager determines a quantization parameter value QP to be used in quantizing the DCT coefficient values generated in DCT transformer 104. It should be noted that it is possible to make an estimation about the QP based on the bit-budget allowed for the frame, bits already spent in the previous slices or the same frame and possibly the bits spent for slices in the previous frame. Having done this, control manager 660 determines a difference

(ΔQP) between the previously defined sequence level quantization parameter value SQP and the actual QP value to be used for the slice in question. It then passes an indication of this difference via control line 624 to video multiplex coder 670, which further includes an indication of the difference value ΔQP in bit-stream 635. Preferably, this indication is provided in a slice header portion of the encoded video bit-stream 635 containing control information specific to the slice in question. This process is repeated until all slices of the current frame have been encoded in INTER-coded format, at which point the video encoder starts to encode the next frame of the video sequence.

A video decoder 700 implemented according to a preferred embodiment of the invention will now be described with reference to Figure 6. The structure of the video decoder illustrated in Figure 6 is substantially identical to that of the prior art video decoder shown in Figure 4, with appropriate modifications to those parts of the decoder that perform operations relating to the inverse quantization of DCT transform coefficients. All parts of the video decoder that implement functions and operate in a manner identical to the previously described prior art video decoder are identified with identical reference numbers.

Here it is assumed that the video decoder of Figure 6 corresponds to the encoder described in connection with Figure 5 and is therefore capable of receiving and decoding the bit-stream 635 transmitted by encoder 600. As previously described, in the preferred embodiment of the invention, encoder 600 determines a sequence level quantization parameter SQP to be used in INTER-coding mode. Correspondingly, decoder 700 is adapted to receive an indication of this SQP value and to use the sequence level quantization parameter SQP in the determination of inverse quantization parameters to be applied to blocks of quantized transform coefficient values (representative of prediction error values) received in the encoded bit-stream for INTER-coded frames. In an alternative embodiment of the invention, the same process may also be applied to quantized transform coefficient values extracted from the bit-stream for INTRA-coded frames. As explained above, in this alternative embodiment, an indication of two SQP values may be provided, one for INTRA-coded frames of the sequence and one for INTER-coded frames. In a further alternative embodiment, a single sequence level quantization parameter may be indicated for frames coded in both INTRA- and INTER-coding modes.

Operation of a video decoder according to the preferred embodiment of the invention will now be described in detail. Decoder 700 receives bit-stream 635 and separates it into its constituent parts. This operation is performed by video multiplex decoder 770.

When starting to decode a new sequence, video multiplex decoder 770 first extracts information and parameters relating to the sequence as a whole from the sequence header portion of the received bit-stream 635. As explained above in connection with the description of encoder 600, according to the preferred embodiment of the invention, the sequence header portion of the bit-stream is modified to contain an indication of the sequence level quantization parameter SQP used in quantization of DCT coefficient values produced in INTER-coding mode. Video multiplex decoder extracts the indication of the SQP value from the bit-stream and, if it was encoded, for example using variable length coding, applies appropriate decoding to recover the SQP value. It then passes the SQP value to the decoder's control manager 760, which stores it in the decoder's memory.

Video decoder 700 then starts to decode the encoded frames of the video sequence, the decoding of each frame commencing as soon as the video decoder starts receiving information relating to the frame in video bit-stream 635. Video multiplex decoder 770 extracts an INTRA / INTER trigger control signal from picture type information associated with each compressed video frame received in the encoded bit-stream 635 and passes it to control manager 760 via control line 215. The control manager 760 controls the operation of the decoder responsive to the INTRA / INTER trigger control signal, so as to switch the decoder into the correct decoding mode.

In the preferred embodiment of the invention, the decoding of frames coded in INTRA-format is performed in a manner analogous to that previously described in connection with the operation of prior art video decoder 200. The decoding of frames encoded in INTER-format, on the other hand, proceeds as described in the following.

When it receives an indication that the next frame to be decoded is an INTER-coded frame, extracted from the received bit-stream by video multiplex decoder 770, control manager 760 switches decoder 700 into INTER-mode. As explained in connection with the description of encoder 600, according to the preferred embodiment of the invention, in which the macroblocks of each frame are grouped into slices, encoded bit-stream 635 comprises certain slice-specific control information, which includes an indication of a slice-specific QP value, represented as a difference value ΔQP with respect to the

sequence level quantization parameter SQP. Advantageously, the control information specifically related to each slice is provided in the bit-stream as a header portion specific to the slice in question. On receiving such a portion of the bit-stream, video multiplex decoder extracts the slice-specific control information from the slice header portion of the bit-stream and passes the indication of ΔQP for the slice, retrieved from the bit-stream, to control manager 760 via control line 717.

Next, control manager 760 determines a level of inverse quantization to be applied to the quantized DCT coefficients of the macroblocks in the slice. This is done by combining the ΔQP value for the slice with the sequence specific quantization parameter SQP, previously received and stored in the decoder's memory. As described earlier in the text, the inverse quantization operation performed in the decoder involves multiplying each quantized DCT coefficient by a value equal to the level of quantization originally applied, that is, by the QP value used in the corresponding encoder to quantize the DCT coefficients. Thus, according to the preferred embodiment of the invention, control manager 760 determines the level of inverse quantization for the macroblocks of the slice by adding the received ΔQP value for the slice to SQP. It then passes this value to inverse quantizer 210 via control line 218.

As encoded information for each macroblock of the slice is received in the bit-stream 635, video multiplex decoder 770 separates the encoded prediction error information for each block of the macroblock from encoded motion vector information. It reconstructs the quantized DCT transform coefficients representative of the prediction error values for each block and passes them to inverse quantizer 210. Inverse quantizer 210 then inverse quantizes the quantized DCT coefficients according to the slice QP constructed from the ΔQP and SQP values by control manager 760. It then provides the inverse quantized DCT coefficients to inverse DCT transformer 220. The rest of the decoding process continues as previously described in connection with prior art video decoder 200.

The steps of receiving a slice-specific ΔQP value, combining ΔQP with SQP and inverse quantizing the qauntized DCT coefficients for each block of the macroblocks within the slice is repeated for each slice of the frame until all slices of the current INTER-coded frame have been decoded. At this point video encoder 700 starts decoding the next frame of the encoded video sequence.

Figure 7 illustrates the way in which slice-specific QP values are reconstructed according to the preferred embodiment of the invention. As can be seen from the figure, the process comprises the steps of:

1. retrieving a sequence level quantization parameter (SQP);
2. retrieving a picture or slice level difference quantization parameter (ΔQP);
3. adding the difference quantization parameters to the sequence level quantization parameter to obtain the quantization parameters for a picture or a slice;
4. constructing the received prediction error-coding coefficients by means of said picture or slice quantization parameter.

Figure 8 presents a terminal device comprising video encoding and decoding equipment which may be adapted to operate in accordance with the present invention. More precisely, the figure illustrates a multimedia terminal 80 implemented according to ITU-T recommendation H.324. The terminal can be regarded as a multimedia transceiver device. It includes elements that capture, encode and multiplex multimedia data streams for transmission via a communications network, as well as elements that receive, de-multiplex, decode and display received multimedia content. ITU-T recommendation H.324 defines the overall operation of the terminal and refers to other recommendations that govern the operation of its various constituent parts. This kind of multimedia terminal can be used in real-time applications such as conversational videotelephony, or non real-time applications such as the retrieval and / or streaming of video clips, for example from a multimedia content server in the Internet.

In the context of the present invention, it should be appreciated that the H.324 terminal shown in Figure 8 is only one of a number of alternative multimedia terminal implementations suited to application of the inventive method. It should also be noted that a number of alternatives exist relating to the location and implementation of the terminal equipment. As illustrated in Figure 8, the multimedia terminal may be located in communications equipment connected to a fixed line telephone network such as an analogue PSTN (Public Switched Telephone Network). In this case the multimedia terminal is equipped with a modem 91, compliant with ITU-T recommendations V.8, V.34 and optionally V.8bis. Alternatively, the multimedia terminal may be connected to an external modem. The modem enables conversion of the multiplexed digital data and

control signals produced by the multimedia terminal into an analogue form suitable for transmission over the PSTN. It further enables the multimedia terminal to receive data and control signals in analogue form from the PSTN and to convert them into a digital data stream that can be demultiplexed and processed in an appropriate manner by the terminal.

An H.324 multimedia terminal may also be implemented in such a way that it can be connected directly to a digital fixed line network, such as an ISDN (Integrated Services Digital Network). In this case the modem 91 is replaced with an ISDN user-network interface. In Figure 8, this ISDN user-network interface is represented by alternative block 92.

H.324 multimedia terminals may also be adapted for use in mobile communication applications. If used with a wireless communication link, the modem 91 can be replaced with any appropriate wireless interface, as represented by alternative block 93 in Figure 8. For example, an H.324/M multimedia terminal can include a radio transceiver enabling connection to the current 2nd generation GSM mobile telephone network, or the proposed 3rd generation UMTS (Universal Mobile Telephone System).

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

A typical H.324 multimedia terminal will now be described in further detail with reference to Figure 8.

The multimedia terminal 80 includes a variety of elements referred to as "terminal equipment". This includes video, audio and telematic devices, denoted generically by reference numbers 81, 82 and 83, respectively. The video equipment 81 may include, for example, a video camera for capturing video images, a monitor for displaying received video content and optional video processing equipment. The audio equipment 82 typically includes a microphone, for example for capturing spoken messages, and a loudspeaker for reproducing received audio content. The audio equipment may also include additional audio processing units. The telematic equipment 83, may include a data terminal, keyboard, electronic whiteboard or a still image transceiver, such as a fax unit.

The video equipment 81 is coupled to a video codec 85. The video codec 85 comprises a video encoder 600 and a corresponding video decoder 700 both implemented

according to the invention (see Figures 5 and 6). The video codec 85 is responsible for encoding captured video data in an appropriate form for further transmission over a communications link and decoding compressed video content received from the communications network. In the example illustrated in Figure 8, the video codec is implemented according to ITU-T recommendation H.26L, with appropriate modifications to implement the method according to the invention in both the encoder and the decoder of the video codec.

The terminal's audio equipment is coupled to an audio codec, denoted in Figure 8 by reference number 86. Like the video codec, the audio codec comprises an encoder/decoder pair. It converts audio data captured by the terminal's audio equipment into a form suitable for transmission over the communications link and transforms encoded audio data received from the network back into a form suitable for reproduction, for example on the terminal's loudspeaker. The output of the audio codec is passed to a delay block 87. This compensates for the delays introduced by the video coding process and thus ensures synchronisation of audio and video content.

The system control block 84 of the multimedia terminal controls end-to-network signalling using an appropriate control protocol (signalling block 88) to establish a common mode of operation between a transmitting and a receiving terminal. The signalling block 88 exchanges information about the encoding and decoding capabilities of the transmitting and receiving terminals and can be used to enable the various coding modes of the video encoder. The system control block 84 also controls the use of data encryption. Information regarding the type of encryption to be used in data transmission is passed from encryption block 89 to the multiplexer/de-multiplexer (MUX/DMUX unit) 90.

During data transmission from the multimedia terminal, the MUX/DMUX unit 90 combines encoded and synchronised video and audio streams with data input from the telematic equipment 83 and possible control data, to form a single bit-stream. Information concerning the type of data encryption (if any) to be applied to the bit-stream, provided by encryption block 89, is used to select an encryption mode. Correspondingly, when a multiplexed and possibly encrypted multimedia bit-stream is being received, MUX/DMUX unit 90 is responsible for decrypting the bit-stream, dividing it into its constituent multimedia components and passing those components to the appropriate codec(s) and/or terminal equipment for decoding and reproduction.

If the multimedia terminal 80 is a mobile terminal, that is, if it is equipped with a radio transceiver 93, it will be understood by those skilled in the art that it may also comprise additional elements. In one embodiment it comprises a user interface having a display and a keyboard, which enables operation of the multimedia terminal 80 by a user, a central processing unit, such as a microprocessor, which controls the blocks responsible for different functions of the multimedia terminal, a random access memory RAM, a read only memory ROM, and a digital camera. The microprocessor's operating instructions, that is program code corresponding to the basic functions of the multimedia terminal 80, is stored in the read-only memory ROM and can be executed as required by the microprocessor, for example under control of the user. In accordance with the program code, the microprocessor uses the radio transceiver 93 to form a connection with a mobile communication network, enabling the multimedia terminal 80 to transmit information to and receive information from the mobile communication network over a radio path.

The microprocessor monitors the state of the user interface and controls the digital camera. In response to a user command, the microprocessor instructs the camera to record digital images into the RAM. Once an image is captured, or alternatively during the capturing process, the microprocessor segments the image into image segments (for example macroblocks) and uses the encoder to perform motion compensated encoding of the segments in order to generate a compressed image sequence, as explained in the foregoing description. A user may command the multimedia terminal 80 to display the captured images on its display or to send the compressed image sequence using the radio transceiver 93 to another multimedia terminal, a video telephone connected to a fixed line network (PSTN) or some other telecommunications device. In a preferred embodiment, transmission of image data is started as soon as the first segment is encoded so that the recipient can start a corresponding decoding process with a minimum delay.

Although described in the context of particular embodiments, it will apparent to those skilled in the art that a number of modifications and various changes to these teachings may be made. Thus, while the invention has been particularly shown and described with respect to one or more preferred embodiments thereof, it will be understood by those skilled in the art that certain modifications or changes may be made therein without departing from the scope and spirit of the invention as set forth above.

In particular, according to a second possible embodiment of the invention, a sequence QP is not transmitted but an application specific constant is used as sequence QP instead.

In a third possible embodiment of the invention the sequence QP can be updated depending on the changing characteristics of the video sequence if a reliable way of transmitting the new sequence QP is available. The updated SQP value can be either included in the encoded bit-stream representative of the video sequence or can be transmitted directly from encoder to decoder in an associated control channel.

In a fourth possible embodiment of the invention, if QP is constant for the whole video sequence only the value of the sequence QP is transmitted together with the information that it should be used as the QP for all the pictures / slices.

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METHOD AND DEVICE FOR INDICATING QUANTIZER PARAMETERS IN A VIDEO CODING SYSTEM

This application is a divisional application of and claims priority to a co-pending U.S. paten application Serial No. 10/421,629, filed April 23, 2003, which is based on and claims priority to U.S. provisional application No. 60/374,667, filed April 23, 2002.

Field of the Invention

The invention relates to a method, an encoder, a decoder and a device for the coding of digital video. More specifically, the invention relates to the indication of quantization parameter (QP) values in a video coding system.

Background of the Invention

Digital video sequences, like ordinary motion pictures recorded on film, comprise a sequence of still images, the illusion of motion being created by displaying the images one after the other, typically at a rate between 15 and 30 frames per second.

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

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

The lower spatial resolution of the chrominance components is usually attained by sub-sampling. Typically, each frame of a video sequence is divided into so-called "macroblocks", which comprise luminance (Y) information and associated chrominance (U, V) information, which is spatially sub-sampled. Figure 1 illustrates one way in which macroblocks can be formed. As shown in Figure 1, a frame of a video sequence represented using a YUV color model, each component having the same spatial resolution. Macroblocks are formed by representing a region of 16x16 image pixels in the original image as four blocks of luminance information, each luminance block comprising an 8x8 array of luminance (Y) values and two, spatially corresponding, chrominance components (U and V) which are sub-sampled by a factor of two in both the horizontal and vertical directions to yield corresponding arrays of 8x8 chrominance (U, V) values. According to certain video coding recommendations, such as International Telecommunications Union (ITU-T) recommendation H.26L, the block size used within the macroblocks can be other than 8x8, for example 4x8 or 4x4 (see T. Wiegand, "Joint Model Number 1", Doc. JVT-A003, Joint Video Team (JVT) of ISO/IEC MPEG and ITU-T VCEG, Jan. 2002, Sections 2.2 and 2.3). ITU-T recommendation H.26L also allows macroblocks to be organized together to form so-called "slices". More specifically, each slice is formed from a number of consecutive macroblocks in coding order and is encoded in such a way that it can be decoded independently without making reference to any other slice of the same frame. This arrangement is advantageous, as it tends to limit the propagation of artefacts in the decoded video that may arise due to transmission errors. While there is no specific limitation on the way in which slices may be constructed, one straightforward scheme is to group all the macroblocks in a single row of a frame together as a slice. This arrangement, together with the division of a QCIF format image into 16x16 macroblocks is illustrated in Figure 2.

As can be seen from Figure 2, a QCIF image comprises 11x9 macroblocks (in this case grouped into 9 slices of 11 consecutive macroblocks each). If the luminance blocks and chrominance blocks are represented with 8 bit resolution (that is by numbers in the range 0 to 255), the total number of bits required per macroblock is (16x16x8)+2x(8x8x8) = 3072 bits. The number of bits needed to represent a video frame in QCIF format is thus 99x3072 = 304,128 bits. This means that the amount of data required to transmit/record/display an uncompressed video sequence in QCIF format, represented using a YUV colour model, at a rate of 30 frames per second, is more than 9 Mbps

(million bits per second). This is an extremely high data rate and is impractical for use in video recording, transmission and display applications because of the very large storage capacity, transmission channel capacity and hardware performance required.

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

Video compression methods are based on reducing the redundant and perceptually irrelevant parts of video sequences. The redundancy in video sequences can be categorised into spatial, temporal and spectral redundancy. "Spatial redundancy" is the term used to describe the correlation (similarity) between neighbouring pixels within a frame. The term "temporal redundancy" expresses the fact that objects appearing in one frame of a sequence are likely to appear in subsequent frames, while "spectral redundancy" refers to the correlation between different colour components of the same image.

There is often a significant amount of spatial redundancy between the pixels that make up each frame of a digital video sequence. In other words, the value of any pixel within a frame of the sequence is substantially the same as the value of other pixels in its immediate vicinity. Typically, video coding systems reduce spatial redundancy using a technique known as "block-based transform coding", in which a mathematical transformation, such as a two-dimensional Discrete Cosine Transform (DCT), is applied to blocks of image pixels. This transforms the image data from a representation comprising pixel values to a form comprising a set of coefficient values representative of spatial frequency components. This alternative representation of the image data reduces spatial redundancy significantly and thereby produces a more compact representation of the image data.

Frames of a video sequence which are compressed using block-based transform coding, without reference to any other frame within the sequence, are referred to as INTRA-coded or I-frames.

Generally, video coding systems not only reduce the spatial redundancy within individual frames of a video sequence, but also make use of a technique known as "motion-compensated prediction", to reduce the temporal redundancy in the sequence. Using motion-compensated prediction, the image content of some (often many) of the frames in a digital video sequence is "predicted" from one or more other frames in the sequence, known as "reference" frames. Prediction of image content is achieved by tracking the motion of objects or regions of an image between a frame to be coded (compressed) and the reference frame(s) using "motion vectors". As in the case of INTRA-coding, motion compensated prediction of a video frame is typically performed macroblock-by-macroblock.

Frames of a video sequence, compressed using motion-compensated prediction, are generally referred to as INTER-coded or P-frames. Motion-compensated prediction alone rarely provides a sufficiently precise representation of the image content of a video frame and therefore it is typically necessary to provide a so-called "prediction error" (PE) frame with each INTER-coded frame. The prediction error frame represents the difference between a decoded version of the INTER-coded frame and the image content of the frame to be coded. More specifically, the prediction error frame comprises values that represent the difference between pixel values in the frame to be coded and corresponding reconstructed pixel values formed on the basis of a predicted version of the frame in question. Consequently, the prediction error frame has characteristics similar to a still image and block-based transform coding can be applied in order to reduce its spatial redundancy and hence the amount of data (number of bits) required to represent it.

In order to illustrate the operation of a video coding system in greater detail, reference will now be made to Figures 3 and 4. Figure 3 is a schematic diagram of a generic video encoder that employs a combination of INTRA- and INTER-coding to produce a compressed (encoded) video bit-stream. A corresponding decoder is illustrated in Figure 4 and will be described later in the text.

The video encoder 100 comprises an input 101 for receiving a digital video signal from a camera or other video source (not shown). It also comprises a transformation unit 104 which is arranged to perform a block-based discrete cosine transform (DCT), a

quantizer 106, an inverse quantizer 108, an inverse transformation unit 110, arranged to perform an inverse block-based discrete cosine transform (IDCT), combiners 112 and 116, and a frame store 120. The encoder further comprises a motion estimator 130, a motion field coder 140 and a motion compensated predictor 150. Switches 102 and 114 are operated co-operatively by control manager 160 to switch the encoder between an INTRA-mode of video encoding and an INTER-mode of video encoding. The encoder 100 also comprises a video multiplex coder 170 which forms a single bit-stream from the various types of information produced by the encoder 100 for further transmission to a remote receiving terminal or, for example, for storage on a mass storage medium, such as a computer hard drive (not shown).

Encoder 100 operates as follows. Each frame of uncompressed video provided from the video source to input 101 is received and processed macroblock by macroblock, preferably in raster-scan order. When the encoding of a new video sequence starts, the first frame to be encoded is encoded as an INTRA-coded frame. Subsequently, the encoder is programmed to code each frame in INTER-coded format, unless one of the following conditions is met: 1) it is judged that the current macroblock of the frame being coded is so dissimilar from the pixel values in the reference frame used in its prediction that excessive prediction error information is produced, in which case the current macroblock is coded in INTRA-coded format; 2) a predefined INTRA frame repetition interval has expired; or 3) feedback is received from a receiving terminal indicating a request for a frame to be provided in INTRA-coded format.

Operation of the encoder 100 in INTRA-coding mode will now be described. In INTRA-coding mode, the control manager 160 operates the switch 102 to accept video input from input line 118. The video signal input is received macroblock by macroblock and the blocks of luminance and chrominance values which make up each macroblock are passed to the DCT transformation block 104. Here a 2-dimensional discrete cosine transform is performed and a 2-dimensional array of DCT coefficients is formed for each block.

The DCT coefficients for each block are passed to the quantizer 106, where they are quantized using a quantization parameter QP. Selection of the quantization parameter QP is controlled by the control manager 160 via control line 115.

In more detail, quantization of the DCT coefficients is performed by dividing each coefficient value by the quantization parameter QP and rounding the result to the nearest

integer. In this way the quantization process yields a set of quantized DCT coefficient values that have a reduced numerical precision compared with the coefficient values originally generated by DCT transformation block 104. Thus, in general, each of the quantized DCT coefficients may be represented by a smaller number of data bits than required to represent the corresponding coefficient before quantization. Furthermore, certain DCT coefficients are reduced to zero by the quantization process, thus reducing the number of coefficients that must be coded. Both these effects result in a reduction in the amount of data (i.e. data bits) required to represent the DCT coefficients for an image block. Thus, quantization provides a further mechanism by which the amount of data required to represent each image of the video sequence can be reduced. It also introduces an irreversible loss of information, which leads to a corresponding reduction in image quality. While this reduction in image quality may not always be desirable, quantization of DCT coefficient values does provide the possibility to adjust the number of bits required to encode a video sequence to take into account e.g. the bandwidth available for transmission of the encoded sequence or the desired quality of the coded video. More specifically, by increasing the value of QP used to quantize the DCT coefficients, a lower quality, but more compact representation of the video sequence can be created. Conversely, by reducing the value of QP, a higher quality but less compressed encoded bit-stream can be formed.

The quantized DCT coefficients for each block are passed from the quantizer 106 to the video multiplex coder 170, as indicated by line 125 in Figure 1. The video multiplex coder 170 orders the quantized transform coefficients for each block using a zigzag scanning procedure, thereby converting the two-dimensional array of quantized transform coefficient values into a one-dimensional array. Typically, the video multiplex coder 170 next represents each non-zero quantized coefficient in the one-dimensional array by a pair of values, referred to as *level* and *run*, *level* being the value of the quantized coefficient and *run* being the number of consecutive zero-valued coefficients preceding the coefficient in question. The *run* and *level* values are further compressed using entropy coding. For example, a method such as variable length coding (VLC) may be used to produce a set of variable length codewords representative of each (*run*, *level*) pair.

Once the (*run*, *level*) pairs have been entropy (e.g. variable length) coded, the video multiplex coder 170 further combines them with control information, also entropy coded, for example, using a variable length coding method appropriate for the kind of

information in question, to form a single compressed bit-stream of coded image information 135. It is this bit-stream, including the variable length codewords representative of the (*run, level*) pairs and control information relating, among other things, to the quantization parameter QP used for quantizing the DCT coefficients, which is transmitted from the encoder.

A locally decoded version of the macroblock is also formed in the encoder 100. This is done by passing the quantized transform coefficients for each block, output by quantizer 106, through inverse quantizer 108 and applying an inverse DCT transform in inverse transformation block 110. Inverse quantization is performed by reversing the quantization operation performed in quantizer 106. More specifically, inverse quantizer 108 attempts to recover the original DCT coefficient values for a given image block by multiplying each quantized DCT coefficient value by quantization parameter QP. Because of the rounding operation performed as part of the quantization process in quantizer 106, it is generally not possible to recover the original DCT coefficient values exactly. This results in a discrepancy between the recovered DCT coefficient values and those originally produced by DCT transformation block 104 (hence the irreversible loss of information referred to above).

The operations performed by inverse quantizer 108 and inverse transformation block 110 yield a reconstructed array of pixel values for each block of the macroblock. The resulting decoded image data is input to combiner 112. In INTRA-coding mode, switch 114 is set so that the input to the combiner 112 via switch 114 is zero. In this way, the operation performed by combiner 112 is equivalent to passing the decoded image data unaltered.

As subsequent macroblocks of the current frame are received and undergo the previously described encoding and local decoding steps in blocks 104, 106, 108, 110 and 112, a decoded version of the INTRA-coded frame is built up in frame store 120. When the last macroblock of the current frame has been INTRA-coded and subsequently decoded, the frame store 120 contains a completely decoded frame, available for use as a prediction reference frame in coding a subsequently received video frame in INTER-coded format. The flag indicating INTRA or INTER-code format is provided in line 122.

Operation of the encoder 100 in INTER-coding mode will now be described. In INTER-coding mode, the control manager 160 operates switch 102 to receive its input from line 117, which comprises the output of combiner 116. The combiner 116 receives

the video input signal macroblock by macroblock from input 101. As combiner 116 receives the blocks of luminance and chrominance values which make up the macroblock, it forms corresponding blocks of prediction error information. The prediction error information represents the difference between the block in question and its prediction, produced in motion compensated prediction block 150. More specifically, the prediction error information for each block of the macroblock comprises a two-dimensional array of values, each of which represents the difference between a pixel value in the block of luminance or chrominance information being coded and a decoded pixel value obtained by forming a motion-compensated prediction for the block, according to the procedure described below.

The prediction error information for each block of the macroblock is passed to DCT transformation block 104, which performs a two-dimensional discrete cosine transform on each block of prediction error values to produce a two-dimensional array of DCT transform coefficients for each block.

The transform coefficients for each prediction error block are passed to quantizer 106 where they are quantized using a quantization parameter QP, in a manner analogous to that described above in connection with operation of the encoder in INTRA-coding mode. Again, selection of the quantization parameter QP is controlled by the control manager 160 via control line 115. The accuracy of prediction error coding can be adjusted depending on the available bandwidth and/or required quality of the coded video. In a typical Discrete Cosine Transform (DCT) based system this is done by varying the Quantizer Parameter (QP) used in quantizing the DCT coefficients the DCT coefficients to a specific accuracy.

The quantized DCT coefficients representing the prediction error information for each block of the macroblock are passed from quantizer 106 to video multiplex coder 170, as indicated by line 125 in Figure 1. As in INTRA-coding mode, the video multiplex coder 170 orders the transform coefficients for each prediction error block using a zigzag scanning procedure and then represents each non-zero quantized coefficient as a (*run, level*) pair. It further compresses the (*run, level*) pairs using entropy coding, in a manner analogous to that described above in connection with INTRA-coding mode. Video multiplex coder 170 also receives motion vector information (described in the following) from motion field coding block 140 via line 126 and control information (e.g. including an indication of the quantization parameter QP) from control manager 160. It entropy codes

the motion vector information and control information and forms a single bit-stream of coded image information, 135 comprising the entropy coded motion vector, prediction error and control information. The indication, qz, of the quantization parameter QP is provided to multiplex xoswe 170 via line 124.

The quantized DCT coefficients representing the prediction error information for each block of the macroblock are also passed from quantizer 106 to inverse quantizer 108. Here they are inverse quantized, in a manner analogous to that previously described in connection with operation of the encoder in INTRA-coding mode. In INTER-coding mode, the quality of the encoded video bit-stream and the number of bits required to represent the video sequence can be adjusted by varying the degree of quantization applied to the DCT coefficients representing the prediction error information.

The resulting blocks of inverse quantized DCT coefficients are applied to inverse DCT transform block 110, where they undergo inverse DCT transformation to produce locally decoded blocks of prediction error values. The locally decoded blocks of prediction error values are then input to combiner 112. In INTER-coding mode, switch 114 is set so that the combiner 112 also receives predicted pixel values for each block of the macroblock, generated by motion-compensated prediction block 150. The combiner 112 combines each of the locally decoded blocks of prediction error values with a corresponding block of predicted pixel values to produce reconstructed image blocks and stores them in frame store 120.

As subsequent macroblocks of the video signal are received from the video source and undergo the previously described encoding and decoding steps in blocks 104, 106, 108, 110, 112, a decoded version of the frame is built up in frame store 120. When the last macroblock of the frame has been processed, the frame store 120 contains a completely decoded frame, available for use as a prediction reference frame in encoding a subsequently received video frame in INTER-coded format.

Formation of a prediction for a macroblock of the current frame will now be described. Any frame encoded in INTER-coded format requires a reference frame for motion-compensated prediction. This means, necessarily, that when encoding a video sequence, the first frame to be encoded, whether it is the first frame in the sequence, or some other frame, must be encoded in INTRA-coded format. This, in turn, means that when the video encoder 100 is switched into INTER-coding mode by control manager 160, a complete reference frame, formed by locally decoding a previously encoded frame,

is already available in the frame store 120 of the encoder. In general, the reference frame is formed by locally decoding either an INTRA-coded frame or an INTER-coded frame.

The first step in forming a prediction for a macroblock of the current frame is performed by motion estimation block 130. The motion estimation block 130 receives the blocks of luminance and chrominance values which make up the current macroblock of the frame to be coded via line 128. It then performs a block matching operation in order to identify a region in the reference frame which corresponds substantially with the current macroblock. In order to perform the block matching operation, motion estimation block accesses reference frame data stored in frame store 120 via line 127. More specifically, motion estimation block 130 performs block-matching by calculating difference values (e.g. sums of absolute differences) representing the difference in pixel values between the macroblock under examination and candidate best-matching regions of pixels from a reference frame stored in the frame store 120. A difference value is produced for candidate regions at all possible positions within a predefined search region of the reference frame and motion estimation block 130 determines the smallest calculated difference value. The offset between the macroblock in the current frame and the candidate block of pixel values in the reference frame that yields the smallest difference value defines the motion vector for the macroblock in question.

Once the motion estimation block 130 has produced a motion vector for the macroblock, it outputs the motion vector to the motion field coding block 140. The motion field coding block 140 approximates the motion vector received from motion estimation block 130 using a motion model comprising a set of basis functions and motion coefficients. More specifically, the motion field coding block 140 represents the motion vector as a set of motion coefficient values which, when multiplied by the basis functions, form an approximation of the motion vector. Typically, a translational motion model having only two motion coefficients and basis functions is used, but motion models of greater complexity may also be used.

The motion coefficients are passed from motion field coding block 140 to motion compensated prediction block 150. Motion compensated prediction block 150 also receives the best-matching candidate region of pixel values identified by motion estimation block 130 from frame store 120. Using the approximate representation of the motion vector generated by motion field coding block 140 and the pixel values of the best-matching candidate region from the reference frame, motion compensated prediction

block 150 generates an array of predicted pixel values for each block of the macroblock. Each block of predicted pixel values is passed to combiner 116 where the predicted pixel values are subtracted from the actual (input) pixel values in the corresponding block of the current macroblock, thereby forming a set of prediction error blocks for the macroblock.

Operation of the video decoder 200, shown in Figure 2 will now be described. The decoder 200 comprises a video multiplex decoder 270, which receives an encoded video bit-stream 135 from the encoder 100 and demultiplexes it into its constituent parts, an inverse quantizer 210, an inverse DCT transformer 220, a motion compensated prediction block 240, a frame store 250, a combiner 230, a control manager 260, and an output 280.

The control manager 260 controls the operation of the decoder 200 in response to whether an INTRA- or an INTER-coded frame is being decoded. An INTRA / INTER trigger control signal, which causes the decoder to switch between decoding modes is derived, for example, from picture type information associated with each compressed video frame received from the encoder. The INTRA / INTER trigger control signal is extracted from the encoded video bit-stream by the video multiplex decoder 270 and is passed to control manager 260 via control line 215.

Decoding of an INTRA-coded frame is performed macroblock-by-macroblock. The video multiplex decoder 270 separates the encoded information for the blocks of the macroblock from possible control information relating to the macroblock in question. The encoded information for each block of an INTRA-coded macroblock comprises variable length codewords representing the VLC coded *level* and *run* values for the non-zero quantized DCT coefficients of the block. The video multiplex decoder 270 decodes the variable length codewords using a variable length decoding method corresponding to the encoding method used in the encoder 100 and thereby recovers the (*run*, *level*) pairs. It then reconstructs the array of quantized transform coefficient values for each block of the macroblock and passes them to inverse quantizer 210. Any control information relating to the macroblock is also decoded in the video multiplex decoder using an appropriate decoding method and is passed to control manager 260. In particular, information relating to the level of quantization applied to the transform coefficients (i.e. quantization parameter QP) is extracted from the encoded bit-stream by video multiplex decoder 270 and provided to control manager 260 via control line 217. The control manager, in turn, conveys this information to inverse quantizer 210 via control line 218. Inverse quantizer 210 inverse quantizes the quantized DCT coefficients for each block of the macroblock

according to the control information relating to quantization parameter QP and provides the now inverse quantized DCT coefficients to inverse DCT transformer 220. The inverse quantization operation performed by inverse quantizer 210 is identical to that performed by inverse quantizer 108 in the encoder.

Inverse DCT transformer 220 performs an inverse DCT transform on the inverse quantized DCT coefficients for each block of the macroblock to form a decoded block of image information comprising reconstructed pixel values. The reconstructed pixel values for each block of the macroblock are passed via combiner 230 to the video output 280 of the decoder where, for example, they can be provided to a display device (not shown). The reconstructed pixel values for each block of the macroblock are also stored in frame store 250. Because motion-compensated prediction is not used in the encoding/decoding of INTRA coded macroblocks control manager 260 controls combiner 230 to pass each block of pixel values as such to the video output 280 and frame store 250. As subsequent macroblocks of the INTRA-coded frame are decoded and stored, a decoded frame is progressively assembled in the frame store 250 and thus becomes available for use as a reference frame for motion compensated prediction in connection with the decoding of subsequently received INTER-coded frames.

INTER-coded frames are also decoded macroblock by macroblock. The video multiplex decoder 270 receives the encoded video bit-stream 135 and separates the encoded prediction error information for each block of an INTER-coded macroblock from encoded motion vector information and possible control information relating to the macroblock in question. As explained in the foregoing, the encoded prediction error information for each block of the macroblock typically comprises variable length codewords representing the *level* and *run* values for the non-zero quantized transform coefficients of the prediction error block in question. The video multiplex decoder 270 decodes the variable length codewords using a variable length decoding method corresponding to the encoding method used in the encoder 100 and thereby recovers the (*run*, *level*) pairs. It then reconstructs an array of quantized transform coefficient values for each prediction error block and passes them to inverse quantizer 210. Control information relating to the INTER-coded macroblock is also decoded in the video multiplex decoder 270 using an appropriate decoding method and is passed to control manager 260. Information relating to the level of quantization (QP) applied to the transform coefficients of the prediction error blocks is extracted from the encoded bit-

stream and provided to control manager 260 via control line 217. The control manager, in turn, conveys this information to inverse quantizer 210 via control line 218. Inverse quantizer 210 inverse quantizes the quantized DCT coefficients representing the prediction error information for each block of the macroblock according to the control information relating to quantization parameter QP and provides the now inverse quantized DCT coefficients to inverse DCT transformer 220. Again, the inverse quantization operation performed by inverse quantizer 210 is identical to that performed by inverse quantizer 108 in the encoder. The INTRA/INTER flag is provided in line 215.

The inverse quantized DCT coefficients representing the prediction error information for each block are then inverse transformed in the inverse DCT transformer 220 to yield an array of reconstructed prediction error values for each block of the macroblock.

The encoded motion vector information associated with the macroblock is extracted from the encoded video bit-stream 135 by video multiplex decoder 270 and is decoded. The decoded motion vector information thus obtained is passed via control line 225 to motion compensated prediction block 240, which reconstructs a motion vector for the macroblock using the same motion model as that used to encode the INTER-coded macroblock in encoder 100. The reconstructed motion vector approximates the motion vector originally determined by motion estimation block 130 of the encoder. The motion compensated prediction block 240 of the decoder uses the reconstructed motion vector to identify the location of a region of reconstructed pixels in a prediction reference frame stored in frame store 250. The region of pixels indicated by the reconstructed motion vector is used to form a prediction for the macroblock in question. More specifically, the motion compensated prediction block 240 forms an array of pixel values for each block of the macroblock by copying corresponding pixel values from the region of pixels identified in the reference frame. These blocks of pixel values, derived from the reference frame, are passed from motion compensated prediction block 240 to combiner 230 where they are combined with the decoded prediction error information. In practice, the pixel values of each predicted block are added to corresponding reconstructed prediction error values output by inverse DCT transformer 220. In this way, an array of reconstructed pixel values for each block of the macroblock is obtained. The reconstructed pixel values are passed to the video output 280 of the decoder and are also stored in frame store 250.

As subsequent macroblocks of the INTER-coded frame are decoded and stored, a decoded frame is progressively assembled in the frame store 250 and thus becomes available for use as a reference frame for motion-compensated prediction of other INTER-coded frames.

As described above, typical video encoding and decoding systems (commonly referred to as video codecs) are based on motion compensated prediction and prediction error coding. Motion compensated prediction is obtained by analyzing and coding motion between video frames and reconstructing image segments using the motion information. Prediction error coding is used to code the difference between motion compensated image segments and corresponding segments of the original image. The accuracy of prediction error coding can be adjusted depending on the available bandwidth and required quality of the coded video. In a typical Discrete Cosine Transform (DCT) based system this is done by varying the quantization parameter (QP) used in quantizing the DCT coefficients to a specific accuracy.

It should be noted that, in order to stay in synchronization with the encoder, the decoder has to know the exact value of the QP used in the coded video sequence. Typically, the QP value is transmitted once per slice leading to increase in the number of bits needed to encode the image. (As previously explained, a slice contains part of the image and is coded independently from other slices in order to avoid propagation of possible transmission errors inside the picture). For example, if the coding of a single QP value takes 6 bits and 20 images, each divided into 10 slices, are transmitted every second, 1.2kbps is spent for the QP information alone.

Prior art solutions (for example, the H.26L video coding recommendation presented in the document by T. Wiegand, "Joint Model Number 1", Doc. JVT-A003, Joint Video Team (JVT) of ISO/IEC MPEG and ITU-T VCEG, Jan. 2002) code the picture/slice QP parameters independently with a fixed or variable length code. This leads to increased transmission bit-rate as described above. More specifically, according to H.26L Joint Model Number 1, the quantization parameter value QP used in quantizing the DCT coefficient values is typically indicated in the encoded bit-stream at the beginning of each picture (see T. Wiegand, "Joint Model Number 1", Doc. JVT-A003, Joint Video Team (JVT) of ISO/IEC MPEG and ITU-T VCEG, Jan. 2002, Section 3.3.1). If the macroblocks within a frame are arranged into slices then the QP value is also indicated at the beginning of each slice of the frame (e.g. in an optional slice header portion of the encoded bit-

stream). In both cases, the QP value is indicated as such or is coded using an appropriate variable length coding scheme. As stated above, it should be realized that this scheme is very costly in terms of the number of bits required to represent the quantization parameter information, particularly in situations where frames are divided into many slices and / or the available bandwidth available for transmission of the encoded video sequence is low. This is a particularly significant problem in mobile video applications in which the encoded video bit-stream is transmitted over a radio communications link. In this situation, the bandwidth available for transmission of the encoded video bit-stream may be as low as 20kbits/s and the QP information included in the bit-stream may represent a significant proportion of the overall available bandwidth.

Furthermore, according to H.26L, the value of QP may optionally be varied at the macroblock level by inserting a quantizer change parameter (Dquant) in the portion of the encoded bit-stream representative of the macroblock in question (see T. Wiegand, "Joint Model Number 1", Doc. JVT-A003, Joint Video Team (JVT) of ISO/IEC MPEG and ITU-T VCEG, Jan. 2002, Section 3.4.7). This leads to a further increase in the amount of information in the encoded bit-stream that is devoted to the indication of QP related information.

In view of the foregoing, it should be realised that there is a significant need for an improved mechanism for indicating information relating to quantization parameter values in video coding systems.

Summary of the Invention

The present invention improves prior art solutions for indicating QP related information by introducing a sequence level QP. This allows the encoder application to decide a video sequence dependent reference QP to be used in coding of the picture / slice QPs. Now, according to the invention, instead of coding the absolute values of picture / slice QPs, it is enough to code the difference between the reference sequence QP and the actually used picture / slice QP. In this way there is no need to transmit a full QP for every picture / slice, but a statistically smaller difference value is transmitted and used to reconstruct the picture / slice QP, thus leading to reduction in transmission bit-rate.

The bit-rate savings are most evident in the case of constant QP. In this case, it is sufficient to send just one bit per slice to indicate that the sequence QP is to be used when decoding the slice. For example, in the previously described example, the bit-rate for QP

is reduced from 1.2kbps to 0.2kbps (now only one bit needs to be sent instead of six for each slice).

According to a first aspect of the invention, there is provided a method of encoding a digital video sequence, the method being applied in a video coding application to produce an encoded video bit-stream representative of the digital video sequence. The digital video sequence comprises a number of frames, each frame of the sequence comprising an array of pixels and is divided into a plurality of blocks, each block comprising a certain number of pixels. The method comprises encoding a frame of the digital video sequence by applying motion compensated prediction to blocks of pixels, thereby producing corresponding blocks of prediction error values. A transform coding technique is applied to the blocks of prediction error values to produce sets of transform coefficient values representative of the blocks of prediction error values and a level of quantization is applied to the sets of transform coefficient values to yield sets of quantized transform coefficient values. According to the invention, the method further comprises defining a default level of quantization to be used throughout encoding of the digital video sequence to quantize the sets of transform coefficient values.

Advantageously, the method according to the first aspect of the invention is also used to indicate quantization parameter (QP) values used to quantize sets of transform coefficient values representative of blocks of pixel values produced for frames coded in INTRA-coding mode in a manner analogous to that described above for indicating the quantization parameter values used to quantize sets of transform coefficient values representative of prediction error values produced for frames coded in INTER-coding mode.

Advantageously, the default level of quantization to be used throughout encoding of the digital video sequence is specific to the video sequence being encoded. Alternatively, the default level of quantization is specific to the video coding application.

Preferably, an indication of the default level of quantization to be used throughout encoding of the digital video sequence is provided. Even more preferably, an indication of the default level of quantization is provided in the encoded bit-stream representative of the digital video sequence, advantageously, the encoded bit-stream, including the indication of the default level of quantization to be used throughout encoding of the digital video sequence, is transmitted to a video decoding device.

Advantageously, the default level of quantization to be used throughout encoding of the digital video sequence to quantize the sets of transform coefficient values can be updated during encoding of the digital video sequence and a further indication indicative of the updated default level of quantization is provided.

The indication of the updated default level of quantization is preferably transmitted to a video decoding device, advantageously, in the encoded bit-stream representative of the digital video sequence.

Advantageously, the level of quantization applied to said sets of transform coefficient values can be adjusted such that the actual level of quantization applied to the sets of transform coefficient values is different from the default level of quantization to be used throughout encoding of the video sequence. Preferably, the actual level of quantization applied is represented as a difference with respect to the default level of quantization. Advantageously, an indication of the difference with respect to the default level of quantization is provided in the encoded bit-stream representative of the digital video sequence.

In an embodiment of the video encoding method according to the first aspect of the invention, the level of quantization applied to the sets of transform coefficient values can be adjusted from one frame of the digital video sequence to another such that an actual level of quantization applied to the sets of transform coefficients for a particular frame of the digital video sequence is different from the default level of quantization to be used throughout encoding of the digital video sequence. Advantageously, in this embodiment, the actual level of quantization to be used in the particular frame is represented as a difference with respect to the default level of quantization and an indication of the difference with respect to the default level of quantization is provided in the encoded bit-stream representative of the digital video sequence.

In an alternative embodiment of the video encoding method according to the first aspect of the invention, the plurality of blocks into which a frame of the digital video sequence is divided are grouped into one or more segments and the level of quantization applied to the sets of transform coefficient values can be adjusted from one segment of a frame to another such that an actual level of quantization applied to the sets of transform coefficients for a particular segment of a frame is different from the default level of quantization to be used throughout encoding of the digital video sequence. Advantageously, in this alternative embodiment, the actual level of quantization to be

used in the particular segment is represented as a difference with respect to the default level of quantization and an indication of the difference with respect to the default level of quantization is provided in the encoded bit-stream representative of the digital video sequence.

Advantageously, if the default level of quantization is to be used to quantize all sets of transform coefficient values throughout the digital video sequence, an indication of the default level of quantization is provided together with an indication that said default level is to be used to quantize all sets of transform coefficient values throughout the digital video sequence.

According to a second aspect of the invention, there is provided a method of decoding an encoded digital video sequence, the method being applied in a video decoding application to produce a decoded digital video sequence. The digital video sequence comprises a number of frames, each frame of the sequence comprising an array of pixels and being divided into a plurality of blocks, each block comprising a certain number of pixels, frames of the digital video sequence having been encoded by applying motion compensated prediction to blocks of pixels to produce corresponding blocks of prediction error values and applying a transform coding technique to the blocks of prediction error values to produce sets of transform coefficient values representative of the blocks of prediction error values and applying a level of quantization to the sets of transform coefficient values to yield sets of quantized transform coefficient values representative of the blocks of prediction error values. According to the invention, the decoding method comprises defining a default level of inverse quantization to be used throughout decoding of the encoded digital video sequence to inverse quantize the sets of quantized transform coefficient values.

Advantageously, the default level of inverse quantization is identical to a default level of quantization used to quantize the sets of transform coefficient values during encoding of the video sequence.

Advantageously, the default level of inverse quantization defined to be used throughout decoding of the encoded digital video sequence is specific to the encoded video sequence being decoded. Alternatively, the default level of inverse quantization is specific to the video decoding application.

Advantageously, the decoding method comprises retrieving an indication of the default level of inverse quantization, preferably from a bit-stream representative of the encoded digital video sequence.

Advantageously, the default level of inverse quantization can be updated during decoding of the digital video sequence. Preferably, updating of the default level of inverse quantization is performed responsive to an indication of an updated default level of quantization used during encoding of the video sequence, retrieved from a bit-stream representative of the encoded digital video sequence. Alternatively, the default level of inverse quantization is updated responsive to an indication of an updated default level of quantization used during encoding of the video sequence, transmitted from a video encoding device.

Advantageously, the level of inverse quantization applied to the sets of quantized transform coefficient values can be adjusted such that an actual level of inverse quantization applied to the sets of quantized transform coefficient values is different from the default level of inverse quantization to be used throughout decoding of the encoded digital video sequence. In this case, the actual level of inverse quantization is determined by adding a difference value to the default level of inverse quantization, the difference value being representative of the difference between the default level of inverse quantization and the actual level of inverse quantization to be applied. Preferably, an indication of the difference value is retrieved from a bit-stream representative of the encoded digital video sequence.

In an embodiment of the video decoding method according to the second aspect of the invention, the level of inverse quantization applied to the sets of quantized transform coefficient values is adjusted from one frame of the digital video sequence to another such that an actual level of inverse quantization applied to the sets of quantized transform coefficients for a particular frame of the digital video sequence is different from the default level of inverse quantization to be used throughout decoding of the encoded digital video sequence. Advantageously, in this embodiment, the actual level of inverse quantization to be used in the particular frame is determined by adding a frame-specific difference value to the default level of inverse quantization, the frame-specific difference value being representative of the difference between the default level of inverse quantization and the actual level of inverse quantization to be used in the particular frame.

Preferably, an indication of said frame-specific difference value is retrieved from a bit-stream representative of the encoded digital video sequence.

In an alternative embodiment of the video decoding method according to the second aspect of the invention, the plurality of blocks into which a frame of said digital video sequence is divided are grouped into one or more segments and the level of inverse quantization applied to the sets of quantized transform coefficient values is adjusted from one segment of a frame to another such that an actual level of inverse quantization applied to the sets of quantized transform coefficients for a particular segment of a frame is different from the default level of inverse quantization to be used throughout decoding of the encoded digital video sequence. Advantageously, in this alternative embodiment, the actual level of inverse quantization to be used in the particular segment is determined by adding a segment-specific difference value to the default level of inverse quantization, the segment-specific difference value being representative of the difference between the default level of inverse quantization and the actual level of inverse quantization to be used in the particular segment. Preferably, an indication of the segment-specific difference value is retrieved from a bit-stream representative of the encoded digital video sequence.

According to a third aspect of the invention, there is provided an encoder for encoding a digital video sequence to produce an encoded video bit-stream representative of the digital video sequence, the digital video sequence comprising a number of frames, each frame of the sequence comprising an array of pixels and being divided into a plurality of blocks, each block comprising a certain number of pixels. The video encoder according to the third aspect of the invention is arranged to encode a frame of the digital video sequence by applying motion compensated prediction to blocks of pixels, thereby producing corresponding blocks of prediction error values. It is further arranged to apply a transform coding technique to blocks of prediction error values to produce sets of transform coefficient values representative of said blocks of prediction error values and to apply a level of quantization to said sets of transform coefficient values to yield sets of quantized transform coefficient values. According to the invention, the video encoder is further arranged to define a default level of quantization to be used throughout encoding of the digital video sequence to quantize the sets of transform coefficient values.

Advantageously, the encoder according to the third aspect of the invention is also arranged to indicate quantization parameter (QP) values used to quantize sets of transform coefficient values representative of blocks of pixel values produced for frames coded in

INTRA-coding mode in a manner analogous to that described above for indicating the quantization parameter values used to quantize sets of transform coefficient values representative of prediction error values produced for frames coded in INTER-coding mode.

Advantageously, the default level of quantization defined by the video encoder is specific to the video sequence being encoded.

Advantageously, the video encoder is further arranged to provide an indication of the default level of quantization in the encoded bit-stream representative of the digital video sequence. Even more advantageously, it is arranged to transmit the encoded bit-stream to a corresponding video decoder.

Advantageously the video encoder is further arranged to update the default level of quantization during encoding of the digital video sequence and to provide an indication of the updated default level of quantization. Preferably, the encoder is also arranged to transmit the indication of the updated default level of quantization to a corresponding video decoder. Advantageously, the encoder includes the indication of the updated default level of quantization in the encoded bit-stream representative of the digital video sequence.

Preferably, the video encoder is further arranged to adjust the level of quantization applied to the sets of transform coefficient values and thereby to apply an actual level of quantization that is different from the default level of quantization. Preferably, the video encoder is still further arranged to represent the actual level of quantization as a difference with respect to the default level of quantization and to provide an indication of the difference with respect to the default level of quantization in the encoded bit-stream representative of the digital video sequence.

In one embodiment, a video encoder according to the third aspect of the invention is arranged to adjust the level of quantization applied to the sets of transform coefficient values from one frame of the digital video sequence to another. In this way it is arranged to apply an actual level of quantization to the sets of transform coefficients for a particular frame that is different from the default level of quantization to be used throughout encoding of the digital video sequence. Advantageously, the video encoder according to this embodiment is further arranged to represent the actual level of quantization to be used in the particular frame as a difference with respect to the default level of quantization and

to provide an indication of the difference with respect to the default level of quantization in the encoded bit-stream representative of the digital video sequence.

In an alternative embodiment, a video encoder according to the third aspect of the invention is further arranged to group the plurality of blocks into which a frame of the digital video sequence is divided into one or more segments and to adjust the level of quantization applied to the sets of transform coefficient values from one segment of a frame to another. In this way the video encoder is arranged to apply an actual level of quantization to the sets of transform coefficients for a particular segment of a frame that is different from the default level of quantization to be used throughout encoding of the digital video sequence. Advantageously, the video encoder according to this alternative embodiment is further arranged to represent the actual level of quantization to be used in the particular segment as a difference with respect to the default level of quantization and to provide an indication of the difference with respect to the default level of quantization in the encoded bit-stream representative of the digital video sequence.

In a particular embodiment, the video encoder is arranged to provide an indication of the default level of quantization and an indication that the default level is to be used to quantize all sets of transform coefficient values throughout the digital video sequence.

Advantageously, the video encoder according to the third aspect of the invention is provided in a multimedia terminal. Even more preferably, it is implemented in a radio telecommunications device.

According to a fourth aspect of the invention, there is provided a decoder for decoding an encoded digital video sequence to produce a decoded digital video sequence. The digital video sequence comprises a number of frames, each frame of the sequence comprising an array of pixels and being divided into a plurality of blocks, each block comprising a certain number of pixels, frames of the digital video sequence having been encoded by applying motion compensated prediction to blocks of pixels to produce corresponding blocks of prediction error values and applying a transform coding technique to the blocks of prediction error values to produce sets of transform coefficient values representative of said blocks of prediction error values and applying a level of quantization to the sets of transform coefficient values to yield sets of quantized transform coefficient values representative of the blocks of prediction error values. According to the invention, the video decoder is arranged to define a default level of inverse quantization to

be used throughout decoding of the encoded digital video sequence to inverse quantize the sets of quantized transform coefficient values.

Preferably, the default level of inverse quantization is identical to a default level of quantization used to quantize the sets of transform coefficient values during encoding of the video sequence.

Advantageously, the default level of inverse quantization defined to be used throughout decoding of the encoded digital video sequence is specific to the encoded video sequence being decoded.

Advantageously, the video decoder is arranged to retrieve an indication of the default level of inverse quantization, preferably from a bit-stream representative of the encoded digital video sequence.

Advantageously, the video decoder is arranged to update the default level of inverse quantization during decoding of the digital video sequence, preferably by retrieving an indication of an updated default level of quantization from a bit-stream representative of the encoded digital video sequence. Alternatively, the video decoder is arranged to receive an indication of an updated default level of quantization transmitted from a video encoding device.

Preferably, the video decoder is arranged to adjust the level of inverse quantization applied to the sets of quantized transform coefficient values and to apply an actual level of inverse quantization to the sets of quantized transform coefficient values that is different from the default level of inverse quantization. Advantageously, the decoder is arranged to determine the actual level of inverse quantization by adding a difference value to the default level of inverse quantization, the difference value being representative of the difference between the default level of inverse quantization and the actual level of inverse quantization to be applied. Preferably, the video decoder is arranged to retrieve an indication of the difference value from a bit-stream representative of the encoded digital video sequence.

In one embodiment, a video decoder according to the fourth aspect of the invention is arranged to adjust the level of inverse quantization applied to the sets of quantized transform coefficient values from one frame of the digital video sequence to another and to apply an actual level of inverse quantization to the sets of quantized transform coefficients for a particular frame of the digital video sequence that is different from the default level of inverse quantization to be used throughout decoding of the encoded digital

video sequence. Advantageously, the decoder is arranged to determine the actual level of inverse quantization to be used in the particular frame by adding a frame-specific difference value to the default level of inverse quantization, the frame-specific difference value being representative of the difference between the default level of inverse quantization and the actual level of inverse quantization to be used in the particular frame. Preferably, the video decoder is arranged to retrieve an indication of the frame-specific difference value from a bit-stream representative of the encoded digital video sequence.

In an alternative embodiment, a video decoder according to the fourth aspect of the invention is arranged to decode an encoded video sequence in which the plurality of blocks into which a frame of said digital video sequence is divided are grouped into one or more segments and is further arranged to adjust the level of inverse quantization applied to the sets of quantized transform coefficient values from one segment of a frame to another and to apply an actual level of inverse quantization to the sets of quantized transform coefficients for a particular segment of a frame that is different from the default level of inverse quantization to be used throughout decoding of the encoded digital video sequence. Preferably, the decoder is arranged to determine the actual level of inverse quantization to be used in the particular segment by adding a segment-specific difference value to the default level of inverse quantization, the segment-specific difference value being representative of the difference between the default level of inverse quantization and the actual level of inverse quantization to be used in the particular segment. Preferably, the video decoder is arranged to retrieve an indication of the segment-specific difference value from a bit-stream representative of the encoded digital video sequence.

According to a fifth aspect of the invention, there is provided a multimedia terminal comprising an encoder according the third aspect of the invention.

According to a sixth aspect of the invention, there is provided a multimedia terminal comprising a decoder according to the fourth aspect of the invention.

Preferably, the multimedia terminal according to the fifth and / or sixth aspects of the invention is a mobile multimedia terminal arranged to communicate with a mobile telecommunications network by means of a radio connection.

Brief Description of the Drawings

Figure 1 illustrates the formation of a 16x16 macroblock according to prior art.

Figure 2 illustrates subdivision of a QCIF picture into 16x16 macroblocks and grouping of consecutive macroblocks into slices.

Figure 3 is a schematic block diagram of a generic video encoder according to prior art.

Figure 4 is a schematic block diagram of a generic video decoder according to prior art and corresponding to the encoder shown in Figure 3.

Figure 5 is a schematic block diagram of a video encoder according to an embodiment of the invention.

Figure 6 is a schematic block diagram of a video decoder according to an embodiment of the invention and corresponding to the encoder shown in Figure 5.

Figure 7 illustrates a decoding process according to one possible embodiment of the invention. Quantization parameters (QP) for each slice are obtained by adding the Sequence QP (SQP) to slice specific difference QP values (ΔQP^n).

Figure 8 is a schematic block diagram of a multimedia communications terminal in which the method according to the invention may be implemented.

Detailed Description of the Invention

In a preferred embodiment of the invention a video sequence specific quantization parameter (QP) is transmitted and used as a reference when coding and decoding the actual picture / slice quantization parameters. In this way there is no need to transmit a full QP for every picture / slice, but a statistically smaller difference value is transmitted and used to reconstruct the picture / slice QP, thus leading to reduction in transmission bit-rate.

Embodiments of the invention will now be described with reference to Figures 5 through 8.

Figure 5 is a schematic block diagram of a video encoder 600 implemented according to the preferred embodiment of the invention. The structure of the video encoder shown in Figure 5 is substantially identical to that of the prior art video encoder illustrated in Figure 3, with appropriate modifications to those parts of the encoder that perform operations relating to the quantization of DCT transform coefficients and the signalling of quantization parameter (QP) values used in the video encoding process. All parts of the video encoder that implement functions and operate in a manner identical to the previously described prior art video encoder are identified with identical reference

numbers. As the invention is particularly relevant to the signalling of quantization parameter (QP) values at the slice or frame level, it will be assumed throughout the following description that video encoder 600 according to the preferred embodiment of the invention is specifically adapted to apply a video coding method in which the frames of a video sequence to be coded are divided into macroblocks and the macroblocks are further grouped into slices, an indication of the quantization parameter being provided at the beginning of each frame and at the beginning of each new slice within a frame. An example of such a video coding method is the previously cited ITU-T H.26L video coding recommendation, as described in T. Wiegand, "Joint Model Number 1", Doc. JVT-A003, Joint Video Team (JVT) of ISO/IEC MPEG and ITU-T VCEG, Jan. 2002. Alternatively, the method can be applied in a video coding system in which an indication of the quantization parameter is given only at the beginning of a frame. While the following detailed description is written specifically to illustrate application of the method according to the invention in the indication and signalling of slice level quantization parameters, it should be appreciated that the method can applied in an exactly analogous manner to the representation of frame (picture) level quantization parameters.

Operation of video encoder 600 will now be considered in detail. When encoding a digital video sequence, encoder 600 operates in a manner similar to that previously described in connection with Figure 3 to generate INTRA-coded and INTER-coded compressed video frames. As explained earlier in the text, in INTRA-coding mode, a Discrete Cosine Transform (DCT) is applied to each block of image data (pixel values) in order to produce a corresponding two-dimensional array of transform coefficient values. The DCT operation is performed in transform block 104 and the coefficients thus produced are subsequently passed to quantizer 106, where they are quantized. In INTER-coding mode, the DCT transform performed in block 104 is applied to blocks of prediction error values. The transform coefficients produced as a result of this operation are also passed to quantizer 106 where they too are quantized.

According to the invention, when starting to encode a new video sequence, encoder 600 determines a default or reference level of quantization that is to be used throughout encoding of the video sequence to quantize the DCT coefficient values generated in quantizer 106. Throughout the following description, this default or reference level of quantization will be termed a "sequence level quantization parameter", or SQP for short. The choice of an SQP for a given video sequence is controlled by control manager 660

and, for example, may be based on consideration of the properties of the sequence to be encoded and the bandwidth available for transmission of the encoded bit-stream produced by the encoder.

In the preferred embodiment of the invention, encoder 600 determines SQP as the default or reference level of quantization to be used when operating in INTER-coding mode, i.e. in situations when the DCT coefficients generated in transform block 104 are representative of prediction error values. It should be appreciated that the method according to the invention can also be applied to the quantization of DCT coefficient values produced in traditional INTRA-coding mode utilizing no spatial prediction. However, given the different origins of the transform coefficients in INTRA- and INTER-coding modes (the DCT coefficients produced in INTRA-coding mode are derived from pixel values, while those generated in INTER-coding mode are produced by applying a DCT transform to prediction error values) it is unlikely that a single SQP value can be determined that is optimum for quantization of DCT coefficients in both INTRA- and INTER-coding modes. Therefore, in an embodiment in which the method according to the invention is used in both INTRA- and INTER-coding mode, two SQP values are preferably be used, one that provides the most efficient representation of QP value information in INTRA-coding mode and another that provides the most efficient representation of QP values used during INTER-coding. In all other respects, the method according to the invention may be applied in a directly analogous way in both INTRA-and INTER-coding modes. Of course, in an alternative embodiment, a single SQP value may be defined and used as the sequence level quantization parameter for both INTRA- and INTER-coded frames. This is a practical approach especially in modern video coding systems, such as the one described in T. Wiegand, "Joint Model Number 1", Doc. JVT-A003, Joint Video Team (JVT) of ISO/IEC MPEG and ITU-T VCEG, Jan. 2002, where spatial prediction is applied to the INTRA coded macroblocks before coding the INTRA rediction error with DCT.

It should further be noted that as the majority of frames in a typical video sequence are encoded as INTER frames, the greatest saving in bit-rate is achieved by applying the method according to the invention to the representation of QP values in INTER-coding mode. Thus, in the preferred embodiment of the invention, a single SQP value is used, this value being indicative of a default or reference value of quantization to be used in

quantizing DCT coefficients representative of prediction error values in INTER-coding mode.

Having determined the SQP value to be used for the sequence, control manager 660 provides an indication of the selected SQP value via control line 122 to video multiplex coder 670 which, in turn, inserts an indication of the SQP value into the bit-stream 635 of coded image information representative of the video sequence. Preferably, this indication is provided in a sequence header portion of the encoded video bit-stream 635.

Video encoder 600 then starts to encode the video sequence. As explained in connection with the description of prior art video encoder 100, illustrated in Figure 3, the first frame of the sequence to be encoded is encoded in INTRA-format. As the SQP value defined according to the preferred embodiment of the invention is specific to the quantization of DCT coefficient values produced in INTER-coding mode, operation of encoder 600 in INTRA-coding mode is entirely analogous to that of prior art video encoder 100 and will not be considered in further detail here.

Once encoding of the first frame is complete, control manager 660 switches video encoder 600 into INTER-coding mode. In INTER-coding mode, switch 102 is operated to receive its input from line 117, which comprises the output of combiner 116. Combiner 116 receives the video input signal macroblock by macroblock from input 101 and forms a block of prediction error information for each block of the macroblock. The prediction error information for each block is passed to DCT transformer 104, which performs a two-dimensional discrete cosine transform on each block of prediction error values to produce a two-dimensional array of DCT transform coefficients for the block in question. The transform coefficients for each prediction error block are then passed to quantizer 106 where they are quantized, as previously described, using a quantization parameter QP. The rest of the INTER-coding process continues as previously described in connection with prior art video encoder 100.

As each macroblock is received, control manager 660 determines whether the macroblock currently being processed is the first macroblock of a slice. If it is, the control manager determines a quantization parameter value QP to be used in quantizing the DCT coefficient values generated in DCT transformer 104. It should be noted that it is possible to make an estimation about the QP based on the bit-budget allowed for the frame, bits already spent in the previous slices or the same frame and possibly the bits spent for slices in the previous frame. Having done this, control manager 660 determines a difference

(ΔQP) between the previously defined sequence level quantization parameter value SQP and the actual QP value to be used for the slice in question. It then passes an indication of this difference via control line 624 to video multiplex coder 670, which further includes an indication of the difference value ΔQP in bit-stream 635. Preferably, this indication is provided in a slice header portion of the encoded video bit-stream 635 containing control information specific to the slice in question. This process is repeated until all slices of the current frame have been encoded in INTER-coded format, at which point the video encoder starts to encode the next frame of the video sequence.

A video decoder 700 implemented according to a preferred embodiment of the invention will now be described with reference to Figure 6. The structure of the video decoder illustrated in Figure 6 is substantially identical to that of the prior art video decoder shown in Figure 4, with appropriate modifications to those parts of the decoder that perform operations relating to the inverse quantization of DCT transform coefficients. All parts of the video decoder that implement functions and operate in a manner identical to the previously described prior art video decoder are identified with identical reference numbers.

Here it is assumed that the video decoder of Figure 6 corresponds to the encoder described in connection with Figure 5 and is therefore capable of receiving and decoding the bit-stream 635 transmitted by encoder 600. As previously described, in the preferred embodiment of the invention, encoder 600 determines a sequence level quantization parameter SQP to be used in INTER-coding mode. Correspondingly, decoder 700 is adapted to receive an indication of this SQP value and to use the sequence level quantization parameter SQP in the determination of inverse quantization parameters to be applied to blocks of quantized transform coefficient values (representative of prediction error values) received in the encoded bit-stream for INTER-coded frames. In an alternative embodiment of the invention, the same process may also be applied to quantized transform coefficient values extracted from the bit-stream for INTRA-coded frames. As explained above, in this alternative embodiment, an indication of two SQP values may be provided, one for INTRA-coded frames of the sequence and one for INTER-coded frames. In a further alternative embodiment, a single sequence level quantization parameter may be indicated for frames coded in both INTRA- and INTER-coding modes.

Operation of a video decoder according to the preferred embodiment of the invention will now be described in detail. Decoder 700 receives bit-stream 635 and separates it into its constituent parts. This operation is performed by video multiplex decoder 770.

When starting to decode a new sequence, video multiplex decoder 770 first extracts information and parameters relating to the sequence as a whole from the sequence header portion of the received bit-stream 635. As explained above in connection with the description of encoder 600, according to the preferred embodiment of the invention, the sequence header portion of the bit-stream is modified to contain an indication of the sequence level quantization parameter SQP used in quantization of DCT coefficient values produced in INTER-coding mode. Video multiplex decoder extracts the indication of the SQP value from the bit-stream and, if it was encoded, for example using variable length coding, applies appropriate decoding to recover the SQP value. It then passes the SQP value to the decoder's control manager 760, which stores it in the decoder's memory.

Video decoder 700 then starts to decode the encoded frames of the video sequence, the decoding of each frame commencing as soon as the video decoder starts receiving information relating to the frame in video bit-stream 635. Video multiplex decoder 770 extracts an INTRA / INTER trigger control signal from picture type information associated with each compressed video frame received in the encoded bit-stream 635 and passes it to control manager 760 via control line 215. The control manager 760 controls the operation of the decoder responsive to the INTRA / INTER trigger control signal, so as to switch the decoder into the correct decoding mode.

In the preferred embodiment of the invention, the decoding of frames coded in INTRA-format is performed in a manner analogous to that previously described in connection with the operation of prior art video decoder 200. The decoding of frames encoded in INTER-format, on the other hand, proceeds as described in the following.

When it receives an indication that the next frame to be decoded is an INTER-coded frame, extracted from the received bit-stream by video multiplex decoder 770, control manager 760 switches decoder 700 into INTER-mode. As explained in connection with the description of encoder 600, according to the preferred embodiment of the invention, in which the macroblocks of each frame are grouped into slices, encoded bit-stream 635 comprises certain slice-specific control information, which includes an indication of a slice-specific QP value, represented as a difference value ΔQP with respect to the

sequence level quantization parameter SQP. Advantageously, the control information specifically related to each slice is provided in the bit-stream as a header portion specific to the slice in question. On receiving such a portion of the bit-stream, video multiplex decoder extracts the slice-specific control information from the slice header portion of the bit-stream and passes the indication of ΔQP for the slice, retrieved from the bit-stream, to control manager 760 via control line 717.

Next, control manager 760 determines a level of inverse quantization to be applied to the quantized DCT coefficients of the macroblocks in the slice. This is done by combining the ΔQP value for the slice with the sequence specific quantization parameter SQP, previously received and stored in the decoder's memory. As described earlier in the text, the inverse quantization operation performed in the decoder involves multiplying each quantized DCT coefficient by a value equal to the level of quantization originally applied, that is, by the QP value used in the corresponding encoder to quantize the DCT coefficients. Thus, according to the preferred embodiment of the invention, control manager 760 determines the level of inverse quantization for the macroblocks of the slice by adding the received ΔQP value for the slice to SQP. It then passes this value to inverse quantizer 210 via control line 218.

As encoded information for each macroblock of the slice is received in the bit-stream 635, video multiplex decoder 770 separates the encoded prediction error information for each block of the macroblock from encoded motion vector information. It reconstructs the quantized DCT transform coefficients representative of the prediction error values for each block and passes them to inverse quantizer 210. Inverse quantizer 210 then inverse quantizes the quantized DCT coefficients according to the slice QP constructed from the ΔQP and SQP values by control manager 760. It then provides the inverse quantized DCT coefficients to inverse DCT transformer 220. The rest of the decoding process continues as previously described in connection with prior art video decoder 200.

The steps of receiving a slice-specific ΔQP value, combining ΔQP with SQP and inverse quantizing the qauntized DCT coefficients for each block of the macroblocks within the slice is repeated for each slice of the frame until all slices of the current INTER-coded frame have been decoded. At this point video encoder 700 starts decoding the next frame of the encoded video sequence.

Figure 7 illustrates the way in which slice-specific QP values are reconstructed according to the preferred embodiment of the invention. As can be seen from the figure, the process comprises the steps of:

1. retrieving a sequence level quantization parameter (SQP);
2. retrieving a picture or slice level difference quantization parameter (ΔQP);
3. adding the difference quantization parameters to the sequence level quantization parameter to obtain the quantization parameters for a picture or a slice;
4. constructing the received prediction error-coding coefficients by means of said picture or slice quantization parameter.

Figure 8 presents a terminal device comprising video encoding and decoding equipment which may be adapted to operate in accordance with the present invention. More precisely, the figure illustrates a multimedia terminal 80 implemented according to ITU-T recommendation H.324. The terminal can be regarded as a multimedia transceiver device. It includes elements that capture, encode and multiplex multimedia data streams for transmission via a communications network, as well as elements that receive, de-multiplex, decode and display received multimedia content. ITU-T recommendation H.324 defines the overall operation of the terminal and refers to other recommendations that govern the operation of its various constituent parts. This kind of multimedia terminal can be used in real-time applications such as conversational videotelephony, or non real-time applications such as the retrieval and / or streaming of video clips, for example from a multimedia content server in the Internet.

In the context of the present invention, it should be appreciated that the H.324 terminal shown in Figure 8 is only one of a number of alternative multimedia terminal implementations suited to application of the inventive method. It should also be noted that a number of alternatives exist relating to the location and implementation of the terminal equipment. As illustrated in Figure 8, the multimedia terminal may be located in communications equipment connected to a fixed line telephone network such as an analogue PSTN (Public Switched Telephone Network). In this case the multimedia terminal is equipped with a modem 91, compliant with ITU-T recommendations V.8, V.34 and optionally V.8bis. Alternatively, the multimedia terminal may be connected to an external modem. The modem enables conversion of the multiplexed digital data and

control signals produced by the multimedia terminal into an analogue form suitable for transmission over the PSTN. It further enables the multimedia terminal to receive data and control signals in analogue form from the PSTN and to convert them into a digital data stream that can be demultiplexed and processed in an appropriate manner by the terminal.

An H.324 multimedia terminal may also be implemented in such a way that it can be connected directly to a digital fixed line network, such as an ISDN (Integrated Services Digital Network). In this case the modem 91 is replaced with an ISDN user-network interface. In Figure 8, this ISDN user-network interface is represented by alternative block 92.

H.324 multimedia terminals may also be adapted for use in mobile communication applications. If used with a wireless communication link, the modem 91 can be replaced with any appropriate wireless interface, as represented by alternative block 93 in Figure 8. For example, an H.324/M multimedia terminal can include a radio transceiver enabling connection to the current 2nd generation GSM mobile telephone network, or the proposed 3rd generation UMTS (Universal Mobile Telephone System).

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

A typical H.324 multimedia terminal will now be described in further detail with reference to Figure 8.

The multimedia terminal 80 includes a variety of elements referred to as "terminal equipment". This includes video, audio and telematic devices, denoted generically by reference numbers 81, 82 and 83, respectively. The video equipment 81 may include, for example, a video camera for capturing video images, a monitor for displaying received video content and optional video processing equipment. The audio equipment 82 typically includes a microphone, for example for capturing spoken messages, and a loudspeaker for reproducing received audio content. The audio equipment may also include additional audio processing units. The telematic equipment 83, may include a data terminal, keyboard, electronic whiteboard or a still image transceiver, such as a fax unit.

The video equipment 81 is coupled to a video codec 85. The video codec 85 comprises a video encoder 600 and a corresponding video decoder 700 both implemented

according to the invention (see Figures 5 and 6). The video codec 85 is responsible for encoding captured video data in an appropriate form for further transmission over a communications link and decoding compressed video content received from the communications network. In the example illustrated in Figure 8, the video codec is implemented according to ITU-T recommendation H.26L, with appropriate modifications to implement the method according to the invention in both the encoder and the decoder of the video codec.

The terminal's audio equipment is coupled to an audio codec, denoted in Figure 8 by reference number 86. Like the video codec, the audio codec comprises an encoder/decoder pair. It converts audio data captured by the terminal's audio equipment into a form suitable for transmission over the communications link and transforms encoded audio data received from the network back into a form suitable for reproduction, for example on the terminal's loudspeaker. The output of the audio codec is passed to a delay block 87. This compensates for the delays introduced by the video coding process and thus ensures synchronisation of audio and video content.

The system control block 84 of the multimedia terminal controls end-to-network signalling using an appropriate control protocol (signalling block 88) to establish a common mode of operation between a transmitting and a receiving terminal. The signalling block 88 exchanges information about the encoding and decoding capabilities of the transmitting and receiving terminals and can be used to enable the various coding modes of the video encoder. The system control block 84 also controls the use of data encryption. Information regarding the type of encryption to be used in data transmission is passed from encryption block 89 to the multiplexer/de-multiplexer (MUX/DMUX unit) 90.

During data transmission from the multimedia terminal, the MUX/DMUX unit 90 combines encoded and synchronised video and audio streams with data input from the telematic equipment 83 and possible control data, to form a single bit-stream. Information concerning the type of data encryption (if any) to be applied to the bit-stream, provided by encryption block 89, is used to select an encryption mode. Correspondingly, when a multiplexed and possibly encrypted multimedia bit-stream is being received, MUX/DMUX unit 90 is responsible for decrypting the bit-stream, dividing it into its constituent multimedia components and passing those components to the appropriate codec(s) and/or terminal equipment for decoding and reproduction.

If the multimedia terminal 80 is a mobile terminal, that is, if it is equipped with a radio transceiver 93, it will be understood by those skilled in the art that it may also comprise additional elements. In one embodiment it comprises a user interface having a display and a keyboard, which enables operation of the multimedia terminal 80 by a user, a central processing unit, such as a microprocessor, which controls the blocks responsible for different functions of the multimedia terminal, a random access memory RAM, a read only memory ROM, and a digital camera. The microprocessor's operating instructions, that is program code corresponding to the basic functions of the multimedia terminal 80, is stored in the read-only memory ROM and can be executed as required by the microprocessor, for example under control of the user. In accordance with the program code, the microprocessor uses the radio transceiver 93 to form a connection with a mobile communication network, enabling the multimedia terminal 80 to transmit information to and receive information from the mobile communication network over a radio path.

The microprocessor monitors the state of the user interface and controls the digital camera. In response to a user command, the microprocessor instructs the camera to record digital images into the RAM. Once an image is captured, or alternatively during the capturing process, the microprocessor segments the image into image segments (for example macroblocks) and uses the encoder to perform motion compensated encoding of the segments in order to generate a compressed image sequence, as explained in the foregoing description. A user may command the multimedia terminal 80 to display the captured images on its display or to send the compressed image sequence using the radio transceiver 93 to another multimedia terminal, a video telephone connected to a fixed line network (PSTN) or some other telecommunications device. In a preferred embodiment, transmission of image data is started as soon as the first segment is encoded so that the recipient can start a corresponding decoding process with a minimum delay.

Although described in the context of particular embodiments, it will apparent to those skilled in the art that a number of modifications and various changes to these teachings may be made. Thus, while the invention has been particularly shown and described with respect to one or more preferred embodiments thereof, it will be understood by those skilled in the art that certain modifications or changes may be made therein without departing from the scope and spirit of the invention as set forth above.

In particular, according to a second possible embodiment of the invention, a sequence QP is not transmitted but an application specific constant is used as sequence QP instead.

In a third possible embodiment of the invention the sequence QP can be updated depending on the changing characteristics of the video sequence if a reliable way of transmitting the new sequence QP is available. The updated SQP value can be either included in the encoded bit-stream representative of the video sequence or can be transmitted directly from encoder to decoder in an associated control channel.

In a fourth possible embodiment of the invention, if QP is constant for the whole video sequence only the value of the sequence QP is transmitted together with the information that it should be used as the QP for all the pictures / slices.

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APPLICATION NUMBER	FILING or 371(c) DATE	GRP ART UNIT	FIL FEE REC'D	ATTY.DOCKET.NO	TOT CLAIMS	IND CLAIMS
11/881,367	07/26/2007	2621	1150	944-001.107-2	23	3

CONFIRMATION NO. 1389

UPDATED FILING RECEIPT

4955
WARE FRESSOLA VAN DER SLUYS & ADOLPHSON, LLP
BRADFORD GREEN, BUILDING 5
755 MAIN STREET, P O BOX 224
MONROE, CT06468

Date Mailed: 09/11/2007

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

Applicant(s)

Jani Lainema, Irving, TX;

Power of Attorney: The patent practitioners associated with Customer Number 4955

Domestic Priority data as claimed by applicant

This application is a DIV of 10/421,629 04/23/2003 PAT 7,263,125 *
which claims benefit of 60/374,667 04/23/2002
(*)Data provided by applicant is not consistent with PTO records.

Foreign Applications

If Required, Foreign Filing License Granted: 08/15/2007

The country code and number of your priority application, to be used for filing abroad under the Paris Convention, is **US11/881,367**

Projected Publication Date: 12/20/2007

Non-Publication Request: No

Early Publication Request: No

Title

Method and device for indicating quantizer parameters in a video coding system

Preliminary Class

375

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PTO/SB/06 (02-07)
Approved for use through 02/28/2007. OMB 0651-0032
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PATENT APPLICATION FEE DETERMINATION RECORD
Substitute for Form PTO-875

Application or Docket Number: 11881367

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	$150		N/A	$300
SEARCH FEE (37 CFR 1.16(k), (l), or (m))	N/A	N/A	N/A	$250		N/A	$500
EXAMINATION FEE (37 CFR 1.16(o), (p), or (q)) 7-26-07	N/A	N/A	N/A	$100		N/A	$200
TOTAL CLAIMS (37 CFR 1.16(i))	23 minus 20 =	3	x $25 =	150	OR	x $50 =	150
INDEPENDENT CLAIMS (37 CFR 1.16(h))	3 minus 3 =	0	x $100 =			x $200 =	
APPLICATION SIZE FEE (37 CFR 1.16(s))	If the specification and drawings exceed 100 sheets of paper, the application size fee due is $250 ($125 for small entity) for each additional 50 sheets or fraction thereof. See 35 U.S.C. 41(a)(1)(G) and 37 CFR 1.16(s).		$125			$250	
MULTIPLE DEPENDENT CLAIM PRESENT (37 CFR 1.16(j))			+180 =			+360 =	
* If the difference in column 1 is less than zero, enter "0" in column 2.			TOTAL			TOTAL	150

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 ($)	SMALL ENTITY ADDITIONAL FEE ($)	OR	OTHER THAN SMALL ENTITY RATE ($)	OTHER THAN SMALL ENTITY ADDITIONAL FEE ($)
Total (37 CFR 1.16(i))		Minus	**	=	x $25 =		OR	x $50 =	
Independent (37 CFR 1.16(h))		Minus	***	=	x $100 =		OR	x $200 =	
Application Size Fee (37 CFR 1.16(s))					$125			$250	
FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))					+180 =		OR	+360 =	
					TOTAL ADD'L FEE		OR	TOTAL ADD'L FEE	

AMENDMENT B	(Column 1) CLAIMS REMAINING AFTER AMENDMENT		(Column 2) HIGHEST NUMBER PREVIOUSLY PAID FOR	(Column 3) PRESENT EXTRA	RATE ($)	ADDITIONAL FEE ($)	OR	RATE ($)	ADDITIONAL FEE ($)
Total (37 CFR 1.16(i))		Minus	**	=	x $25 =		OR	x $50 =	
Independent (37 CFR 1.16(h))		Minus	***	=	x $100 =		OR	x $200 =	
Application Size Fee (37 CFR 1.16(s))					$125			$250	
FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))					+180 =		OR	+360 =	
					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".
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APPLICATION NUMBER	FILING OR 371(c) DATE	FIRST NAMED APPLICANT	ATTY. DOCKET NO./TITLE
11/881,367	07/26/2007	Jani Lainema	944-001.107-2

CONFIRMATION NO. 1389

4955
WARE FRESSOLA VAN DER SLUYS & ADOLPHSON, LLP
BRADFORD GREEN, BUILDING 5
755 MAIN STREET, P O BOX 224
MONROE, CT06468

Title: Method and device for indicating quantizer parameters in a video coding system

Publication No. US-2007-0291849-A1
Publication Date: 12/20/2007

NOTICE OF PUBLICATION OF APPLICATION

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

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

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

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Pre-Grant Publication Division, 703-605-4283

OIPE IAP13 JUN 16 2008 PATENT & TRADEMARK OFFICE

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IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Re: Application of: Jani Lainema

Attorney Docket: 944-001-107-2

Serial No.: 11/881,367

Group Art Unit: 2621

Filed: July 26, 2007

Examiner: to be assigned

For: **METHOD AND DEVICE FOR INDICATING QUANTIZER PARAMETERS IN A VIDEO CODING SYSTEM**

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

SUPPLEMENTAL INFORMATION DISCLOSURE STATEMENT

Sir:

Applicant submits herewith references of which they are aware, which they believe may be material to the examination of this application and in respect of which they may have a duty to disclose in accordance with 37 C.F.R. 1.56.

This Supplemental Information Disclosure Statement is timely since it is certified by the undersigned that each item of information contained in the Supplemental Information Disclosure Statement was first cited in any communication from a foreign patent office (copy enclosed) in a counterpart foreign application not more than three months prior to the filing of this Supplemental Information Disclosure Statement per 37 C.F.R. 1.97(c) and 37 C.F.R. 1.97 (e)(1), therefore, the undersigned respectfully submits that no fee is due. The Commissioner is hereby authorized to charge to Deposit Account 23-0442 any fee deficiency required to submit this Supplemental Information Disclosure Statement.

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Marie E. Forte — June 12, 2008

Marie E. Forte — Date

The references are listed in the enclosed translation of a foreign office action received by us on May 26, 2008. A PTO 1449 listing the cited references is also enclosed.

Respectfully submitted,

Kenneth Q. Lao
Registration No. 40,061

Date: June 12, 2008

WARE, FRESSOLA, VAN DER SLUYS
& ADOLPHSON LLP
Bradford Green, Building 5
755 Main Street, PO Box 224
Monroe, CT 06468
(203) 261-1234

OIPE IAP13 JUN 16 2008 PATENT & TRADEMARK OFFICE

INFORMATION DISCLOSURE CITATION FORM FOR PATENT APPLICATION (FORM PTO-1449) (Substitute)	Docket No.: 944-001.107-2	Serial No.: 11/881,367
	Applicant(s): Jani Lainema	
	Filing Date: July 26, 2007	Group: 2621

U.S. PATENTS

Initials	Patent Number	Issue Date	Name	Class	Sub-class	Filing date
	6,263,022	7/17/01	Yingwei Chen, et al	375	240	

U.S. PATENT PUBLICATIONS

Initials	Publication No.	Pub. Date	Name	Class	Sub-class	Filing Date

FOREIGN PATENT DOCUMENTS

Initials	Document Number	Date	Country	Name	Translation? Yes/No/n/a
	WO 01/26381 A1	4/12/01	WIPO	Koninklijke Philips Elec-Tronics N.V.	English

OTHER DOCUMENTS (Title, Author, Date, Pages, Etc., if known)

Examiner's Signature:	Date Considered:

Initial if reference was considered, whether or not citation is in conformance with MPEP. Mark through citation if not considered. Include a copy of this citation form with your next correspondence to the Applicant(s).

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(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
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(10) International Publication Number
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(71) Applicant: KONINKLIJKE PHILIPS ELECTRONICS N.V. [NL/NL]; Groenewoudseweg 1, NL-5621 BA Eindhoven (NL).

(72) Inventors: VAN DER SCHAAR, Mihaela; Prof. Holstlaan 6, NL-5656 AA Eindhoven (NL). CHEN, Yingwei; Prof. Holstlaan 6, NL-5656 AA Eindhoven (NL). RADHA, Hayder; Prof. Holstlaan 6, NL-5656 AA Eindhoven (NL).

(74) Agent: LANDOUSY, Christian; Internationaal Octrooibureau B.V., Prof Holstlaan 6, NL-5656 AA Eindhoven (NL).

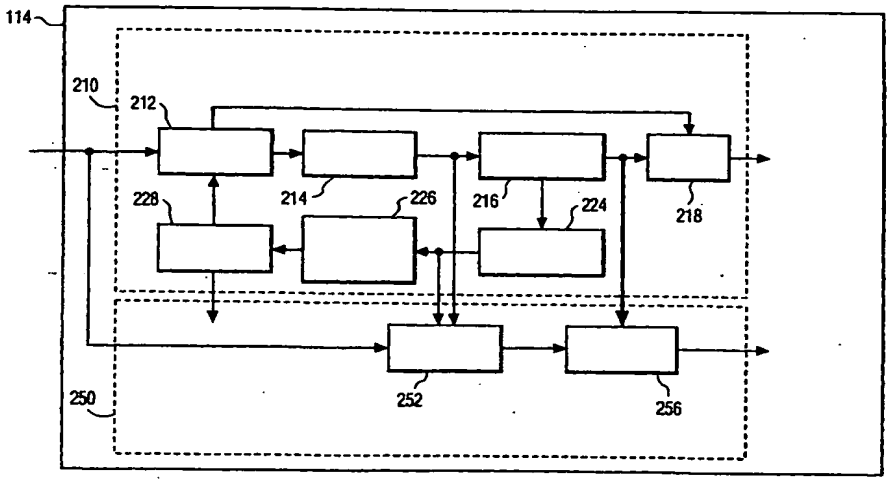
(81) Designated States *(national)*: CN, JP, KR.

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Published:
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For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

(54) Title: SYSTEM AND METHOD FOR ENCODING AND DECODING ENHANCEMENT LAYER DATA USING BASE LAYER QUANTIZATION DATA



(57) Abstract: There is disclosed a video encoder comprising a base layer encoder and an enhancement layer encoder. The base layer encoder receives an input stream of video frames and generates compressed base layer video data suitable for transmission to a streaming video receiver. The enhancement layer encoder receives the input stream of video frames and a decoded version of the compressed base layer video data and generates enhancement layer video data associated with the compressed base layer video data and suitable for transmission to the streaming video receiver. The video encoder also comprises a controller associated with the enhancement layer circuitry for receiving a quantization parameter associated with the base layer video data and determining therefrom at least one all-zero bit plane associated with at least one block of the enhancement layer video data. The controller is capable of causing the enhancement layer circuitry not to transmit the at least one all-zero bit plane to the streaming video receiver.

WO 01/26381 A1

System and method for encoding and decoding enhancement layer data using base layer quantization data.

The present invention is related to those disclosed in United States Patent Application No. (Docket No. 700752), entitled ASYSTEM AND METHOD FOR FINE GRANULAR SCALABLE VIDEO WITH SELECTIVE QUALITY ENHANCEMENT,@ and in United States Patent Application No. (Docket No. 700736), entitled ASYSTEM AND METHOD FOR IMPROVED FINE GRANULAR SCALABLE VIDEO USING BASE LAYER CODING INFORMATION.@ The foregoing applications were filed on July 6, 1999 and are commonly assigned to the assignee of the present invention. The disclosures of the related patent applications are incorporated herein by reference for all purposes as if fully set forth herein.

The present invention is directed, in general, to video encoding systems and, more specifically, to an encoding system and a decoding system for streaming video data.

Real-time streaming of multimedia content over data networks, including the Internet, has become an increasingly common application in recent years. A wide range of interactive and non-interactive multimedia applications, such as news-on-demand, live network television viewing, video conferencing, among others, rely on end-to-end streaming video techniques. Unlike a Adownloaded@ video file, which may be retrieved first in Anon-real@ time and viewed or played back later in Areal@ time, streaming video applications require a video transmitter that encodes and transmits a video signal over a data network to a video receiver, which must decode and display the video signal in real time.

Scalable video coding is a desirable feature for many multimedia applications and services that are used in systems employing decoders with a wide range of processing power. Scalability allows processors with low computational power to decode only a subset of the scalable video stream. Another use of scalable video is in environments with a variable transmission bandwidth. In those environments, receivers with low-access

bandwidth receive, and consequently decode, only a subset of the scalable video stream, where the amount of that subset is proportional to the available bandwidth.

Several video scalability approaches have been adopted by lead video compression standards such as MPEG-2 and MPEG-4. Temporal, spatial and quality (e.g., signal-noise ratio (SNR)) scalability types have been defined in these standards. All of these approaches consist of a base layer (BL) and an enhancement layer (EL). The base layer part of the scalable video stream represents, in general, the minimum amount of data needed for decoding that stream. The enhanced layer part of the stream represents additional information, and therefore enhances the video signal representation when decoded by the receiver.

For example, in a variable bandwidth system, such as the Internet, the base layer transmission rate may be established at the minimum guaranteed transmission rate of the variable bandwidth system. Hence, if a subscriber has a minimum guaranteed bandwidth of 256 kbps, the base layer rate may be established at 256 kbps also. If the actual available bandwidth is 384 kbps, the extra 128 kbps of bandwidth may be used by the enhancement layer to improve on the basic signal transmitted at the base layer rate.

For each type of video scalability, a certain scalability structure is identified. The scalability structure defines the relationship among the pictures of the base layer and the pictures of the enhanced layer. One class of scalability is fine-granular scalability. Images coded with this type of scalability can be decoded progressively. In other words, the decoder may decode and display the image with only a subset of the data used for coding that image. As more data is received, the quality of the decoded image is progressively enhanced until the complete information is received, decoded, and displayed.

The proposed MPEG-4 standard is directed to video streaming applications based on very low bit rate coding, such as video-phone, mobile multimedia/ audio-visual communications, multimedia e-mail, remote sensing, interactive games, and the like. Within the MPEG-4 standard, fine-granular scalability (FGS) has been recognized as an essential technique for networked video distribution. FGS primarily targets applications where video is streamed over heterogeneous networks in real-time. It provides bandwidth adaptivity by encoding content once for a range of bit rates, and enabling the video transmission server to change the transmission rate dynamically without in-depth knowledge or parsing of the video bit stream.

An important priority within conventional FGS techniques is improving coding efficiency and visual quality of the intra-frame coded enhancement layer. This is

necessary to justify the adoption of FGS techniques for the compression of the enhancement layer in place of non-scalable (e.g., single layer) or less granular (e.g., multi-level SNR scalability) coding methods.

Many video coding techniques have been proposed for the FGS compression of the enhancement layer, including wavelets, bit-plane DCT and matching pursuits. At the MPEG-4 meeting in Seoul, Korea in March 1999, the bit-plane DCT solution proposed by Optivision was selected as a reference. The bit-plane coding scheme adopted as reference for FGS includes the following steps at the encoder side:

1. residual computation in the DCT domain, by subtracting from each original DCT coefficient the reconstructed DCT coefficient after base-layer quantization and dequantization;
2. determining the maximum value of all of the absolute values of the residual signal in a video object plane (VOP) and the maximum number of bits n to represent this maximum value;
3. for each block within the VOP, representing each absolute value of the residual signal with n bits in the binary format and forming n bit-planes;
4. bit-plane encoding of the residual signal absolute values; and
5. sign encoding of the DCT coefficients which are quantized to zero in the base-layer.

These coding steps are reversed at the decoder side. It is important to notice that the current implementation of the bit-plane coding of DCT coefficients is done independently of the base-layer (coding) information. The quantized base-layer DCT coefficients, which are employed for the residual layer computation in the DCT domain, are the only information of the base-layer that is re-used for the compression of the enhancement layer. However, additional base-layer information that could be used to further compress the enhancement layer data is unused.

There is therefore a need in the art for improved encoders and encoding techniques for use in streaming video systems. In particular, there is a need for encoders and decoders that use base-layer information to increase the efficiency of the encoding and decoding of enhancement layer data. More particularly, there is a need for encoding techniques that use base-layer information to eliminate as much redundant information as possible from the enhancement layer data. There is a further need for decoding techniques that are able to use the base-layer information to predict as much enhancement layer data as possible.

To address the above-discussed deficiencies of the prior art, it is a primary object of the present invention to provide a new technique for improving the coding efficiency of an enhancement layer compression scheme. The present invention proposes a technique for enhancing the coding efficiency of the bit-plane compression scheme of, for example, the residual DCT coefficients currently adopted as a reference within the MPEG-4 standard. However, it is important to realize that the proposed improvements are not limited to the DCT transform. Those skilled in the art will readily understand that the principles of the present invention may also be successfully applied to other transforms (e.g., wavelets) for the compression of the base and enhancement layer. However, in the descriptions that follow, DCT coefficients are employed for illustration purposes only.

The proposed algorithm employs base-layer quantization parameters to predict a range of the residual DCT coefficients (i.e., a maximum number of significant bit-planes for each residual coefficient) and to avoid the unnecessary transmission of certain zero-valued bit-planes of the DCT coefficients.

While the adopted FGS scheme eliminates most of the temporal dependencies between consecutive enhancement-layer frames by adopting a motion-compensation prediction-based scheme at the base-layer, unexploited redundancies still remain at the enhancement-layer level. Using base-layer coding information, certain characteristics of the enhancement-layer (residual) DCT coefficients can be predicted, thereby improving coding efficiency.

Accordingly, in an advantageous embodiment of the present invention, there is provided a video encoder comprising: 1) base layer circuitry capable of receiving an input stream of video frames and generating therefrom compressed base layer video data suitable for transmission to a streaming video receiver; 2) enhancement layer circuitry capable of receiving the input stream of video frames and a decoded version of the compressed base layer video data and generating therefrom enhancement layer video data associated with the compressed base layer video data and suitable for transmission to the streaming video receiver; and 3) a controller associated with the enhancement layer circuitry capable of receiving a quantization parameter associated with the base layer video data and determining therefrom at least one all-zero bit plane associated with at least one block of the enhancement layer video data, wherein the controller is capable of causing the enhancement layer circuitry not to transmit the at least one all-zero bit plane to the streaming video receiver.

According to one embodiment of the present invention, the quantization parameter is associated with a frame of the base layer video data.

According to another embodiment of the present invention, the controller determines an upper boundary of a quantization parameter associated with the at least one block.

According to still another embodiment of the present invention, the controller is further capable of receiving a weighting matrix associated with the base-layer video data and determining the at least one all-zero bit plane as a function of the quantization parameter and the weighting matrix.

According to yet another embodiment of the present invention, the controller is capable of determining a second all-zero bit plane associated with the at least one block of the enhancement layer video data, based on an upper bound of the at least one block and a value of at least one previously transmitted bit plane associated with the at least one block, wherein the controller is capable of causing the enhancement layer circuitry not to transmit the second all-zero bit plane to the streaming video receiver.

The present invention also may be embodied in a decoder. According to an advantageous embodiment of the present invention, there is provided a video decoder comprising: 1) base layer circuitry capable of receiving compressed base layer video data; 2) enhancement layer circuitry capable of receiving enhancement layer video data associated with the compressed base layer video data; and 3) a controller associated with the enhancement layer circuitry capable of receiving a quantization parameter associated with the compressed base layer video data and predicting therefrom at least one all-zero bit plane associated with at least one block of the enhancement layer video data, wherein the controller is capable of inserting the at least one all-zero bit plane into the enhancement layer video data.

According to one embodiment of the present invention, the quantization parameter is associated with a frame of the base layer video data.

According to another embodiment of the present invention, the controller determines an upper boundary of a quantization parameter associated with the at least one block.

According to yet another embodiment of the present invention, the controller is further capable of receiving a weighting matrix associated with the base-layer video data and determining the at least one all-zero bit plane as a function of the quantization parameter and the weighting matrix.

According to still another embodiment of the present invention, the controller is capable of determining a second all-zero bit plane associated with the at least one block of the enhancement layer video data, based on an upper bound of the at least one block and a value of at least one previously received bit plane associated with the at least one block, wherein the controller is capable of inserting the second all-zero bit plane into the enhancement layer video data.

The foregoing has outlined rather broadly the features and technical advantages of the present invention so that those skilled in the art may better understand THE DETAILED DESCRIPTION OF THE INVENTION that follows. Additional features and advantages of the invention will be described hereinafter that form the subject of the claims of the invention. Those skilled in the art should appreciate that they may readily use the conception and the specific embodiment disclosed as a basis for modifying or designing other structures for carrying out the same purposes of the present invention. Those skilled in the art should also realize that such equivalent constructions do not depart from the spirit and scope of the invention in its broadest form.

Before undertaking the DETAILED DESCRIPTION OF THE INVENTION, it may be advantageous to set forth definitions of certain words and phrases used throughout this patent document: the terms "include" and "comprise" and derivatives thereof, mean inclusion without limitation; the term "or," is inclusive, meaning and/or; the phrases "associated with" and "associated therewith," as well as derivatives thereof, may mean to include, be included within, interconnect with, contain, be contained within, connect to or with, couple to or with, be communicable with, cooperate with, interleave, juxtapose, be proximate to, be bound to or with, have, have a property of, or the like; and the term "controller," "processor," or "apparatus" means any device, system or part thereof that controls at least one operation, such a device may be implemented in hardware, firmware or software, or some combination of at least two of the same. It should be noted that the functionality associated with any particular controller may be centralized or distributed, whether locally or remotely. Definitions for certain words and phrases are provided throughout this patent document, those of ordinary skill in the art should understand that in many, if not most instances, such definitions apply to prior, as well as future uses of such defined words and phrases.

For a more complete understanding of the present invention, and the advantages thereof, reference is now made to the following descriptions taken in conjunction with the accompanying drawings, wherein like numbers designate like objects, and in which:

FIGURE 1 illustrates an endCto-end transmission of streaming video from a streaming video transmitter through a data network to a streaming video receiver, according to one embodiment of the present invention;

FIGURE 2 illustrates an exemplary video encoder in accordance with one embodiment of the present invention;

FIGURE 3 illustrates an exemplary video decoder in accordance with one embodiment of the present invention;

FIGURE 4 is a flow diagram illustrating the operation of an exemplary video encoder in accordance with one embodiment of the present invention; and

FIGURE 5 is a flow diagram illustrating the operation of an exemplary video decoder in accordance with one embodiment of the present invention.

FIGURES 1 through 5, discussed below, and the various embodiments used to describe the principles of the present invention in this patent document are by way of illustration only and should not be construed in any way to limit the scope of the invention. Those skilled in the art will understand that the principles of the present invention may be implemented in any suitably arranged video encoder and video decoder.

FIGURE 1 illustrates an endCto-end transmission of streaming video from streaming video transmitter 110 through data network 120 to streaming video receiver 130, according to one embodiment of the present invention. Depending on the application, streaming video transmitter 110 may be any one of a wide variety of sources of video frames, including a data network server, a television station transmitter, a cable network, a desktop personal computer (PC), or the like.

Streaming video transmitter 110 comprises video frame source 112, video encoder 114, storage 115, and encoder buffer 116. Video frame source 112 may be any device capable of generating a sequence of uncompressed video frames, including a television antenna and receiver unit, a video cassette player, a video camera, a disk storage device capable of storing a Araw@ video clip, and the like. The uncompressed video frames enter video encoder 114 at a given picture rate (or Astreaming rate@) and are compressed according to any known compression algorithm or device, such as an MPEG-4 encoder.

Video encoder 114 then transmits the compressed video frames to encoder buffer 116 for buffering in preparation for transmission across data network 120. Data network 120 may be any suitable network and may include portions of both public data networks, such as the Internet, and private data networks, such as an enterprise-owned local area network (LAN) or wide area network (WAN).

Streaming video receiver 130 comprises decoder buffer 132, video decoder 134, storage 135, and video display 136. Depending on the application, streaming video receiver may be any one of a number of a wide variety of receivers of video frames, including a television receiver, a desktop personal computer (PC), a video cassette recorder (VCR), or the like. Decoder buffer 132 receives and stores streaming compressed video frames from data network 120. Decoder buffer 132 then transmits the compressed video frames to video decoder 134 as required. Video decoder 134 decompresses the video frames at the same rate (ideally) at which the video frames were compressed by video encoder 114. Video decoder 134 sends the decompressed frames to video display 136 for play-back on the screen of video display 134.

In an advantageous embodiment of the present invention, video encoder 114 may be implemented as a software program executed by a conventional data processor, such as a standard MPEG encoder. In such an implementation, video encoder 114 may comprise a plurality of computer executable instructions stored in storage 115. Storage 115 may comprise any type of computer storage medium, including a fixed magnetic disk, a removable magnetic disk, a CD-ROM, magnetic tape, video disk, and the like. Furthermore, in an advantageous embodiment of the present invention, video decoder 134 also may be implemented as a software program executed by a conventional data processor, such as a standard MPEG decoder. In such an implementation, video decoder 134 may comprise a plurality of computer executable instructions stored in storage 135. Storage 135 also may comprise any type of computer storage medium, including a fixed magnetic disk, a removable magnetic disk, a CD-ROM, magnetic tape, video disk, and the like.

FIGURE 2 illustrates exemplary video encoder 114 in accordance with one embodiment of the present invention. Video encoder 114 comprises base layer encoding unit 210 and enhancement layer encoding unit 250. Video encoder 114 receives an original video signal that is transferred to base layer encoding unit 210 for generation of a base layer bit stream. Base layer encoding unit 210 contains a main processing branch, comprising motion estimator 212, transform circuit 214, quantization circuit 216, and entropy coder 218 that generates the base layer bit stream. Base layer encoding unit 210 also contains a

feedback branch comprising inverse quantization circuit 224, inverse transform circuit 226, and frame store circuit 228.

Motion estimator 212 compares the original video signal input with the received output from frame store 228 to estimate the amount of motion between the present video frame and the reference frame as represented by changes in pixel characteristics. The amount of motion or change is also known as the residue. The MPEG standard specifies that motion information may be represented by one to four spatial motion vectors per 16x16 sub-block (or macro-block) of a frame.

Transform circuit 214 receives the resultant motion or residue estimate output from motion estimator 212 and transforms it from a spatial domain to a frequency domain using known de-correlation techniques, such as a discrete cosine transform (DCT). In the case of DCT, motion information is typically based on 16x16 macro-blocks. The motion information associated with each group of 16x16 macro-blocks in the present original video is coded differentially with respect to the motion information in the previous adjacent block from frame store 228. Thus, transform circuit 214 provides a motion compensated residue output coefficient represented as coeff(i) for each sample block or area of a particular video object plane (VOP), where $0 \leq i < 64$ for an 8x8 DCT. During the decode process, coeff(i) may serve as a predictor of whether a particular segment of the present original video frame has no all-zero bit planes (all-zero planes) or one or more all-zero planes. The transform circuit 214 output is connected to quantization circuit 216 and to the enhancement layer encoding unit 250.

Quantization circuit 216 receives the frequency domain outputs (DCT coefficient outputs coeff(i)) from transform circuit 214 and further compresses the motion compensation prediction information. Quantization circuit 216 quantisizes each coeff(i) with a quantization parameter step-size (QP) to produce a quantization value coefficient (qcoeff(i)) as its output. To illustrate the relationships between qcoeff(i), coeff(i), and QP, consider the quantization of the transformed coefficients at the base-layer for the non-intra case (i.e., B- and P- macroblocks). For the intra-blocks, a similar relationship can be determined.

The non-intra-blocks relationship between qcoeff(i), coeff(i), and QP, is provided by the following equation:

qcoeff[i] = #{ABS((ABS(coeff[i])-QP/2)/(2QP))}#

where QP for this case employs the H263 quantization type, ABS represents the absolute value and #(a)# equals the closest integer value smaller than "a" (i.e., $n \leq a < (n + 1)$, where a is a real-number and n an integer.

Quantization circuit 216 provides inputs for the base layer feedback path, entropy coder 218, and enhancement layer encoding unit. Depending upon the application and video quality, quantization circuit 216 may also use a weighting factor to adjust quantization of the transform output.

The feedback path of the base layer encoding unit begins with inverse quantization circuit 224. Inverse quantization circuit 224 de-quantizes the output of quantization circuit 216 to produce a signal (dqcoeff(i)) that is representative of the transform input to quantization circuit 216. For DCT intra-blocks and prior QP, the relationships between dqcoeff(i), qcoeff(i), coeff(i), and QP are shown below:

dqcoeff(i) = qcoeff(i) after de-quantization

= (2QP)(qcoeff(i))

= (2QP)#{ABS((ABS(coeff[i])-QP/2)/(2QP))}#

>(2QP)ABS(coeff(i) - (2QP-1) - QP/2)/(2QP)

>ABS(coeff(i) – 2.5QP + 1)

Inverse transform circuit 226 converts the output of inverse quantization circuit 224 to produce a signal which provides a representation of the original video signal as modified by the transform and quantization processes. Frame store circuit 228 receives the decoded representative frame from inverse transform circuit 226 and stores the frame as a reference signal for output to motion estimator circuit 212. As previously discussed, motion estimator circuit 212 uses the resultant stored frame signal as the comparison signal for determining differences between the stored frame and the present original video signal.

Entropy coder circuit 218 receives quantized coefficients from quantization circuit 216 and the motion estimator 212 output and further compresses the data using variable length coding techniques that represent areas with a high probability of occurrence with a relatively short code and areas of lower probability of occurrence with a relatively long code. The output of entropy coder 218 forms the base layer bit stream for transfer to encoder buffer 116 as shown by FIGURE 1.

Enhancement layer encoding unit 250 contains a main processing branch, comprising residual calculator 252 and fine granular scalability (FGS) encoder 256. Residual calculator circuit 252 compares the original video signal with the frames stored in frame store 228 to generate a residual signal based on the difference between the two input signals.

Residual calculator also receives coefficient data from the output of transform circuit 214 (coeff(i)) and coefficient data from the output of inverse quantization circuit 224 (dqcoeff(i)) to produce a residual output signal representing image information (DCT coefficients, for example) which is missing in the base layer frames as a result of the transform, quantization, and de-quantization processes. The output of residual calculator circuit 252 may also be referred to as residual data or residual error data. The following equations show the relationships of the calculated residual, quantization parameter, image coefficients, quantized coefficients, and de-quantized coefficients for DCT and QP H263.

res(i) = residual between coeff(i) and dqcoeff(i).

res(i) = coeff(i) – dqcoeff(i)

= coeff(i) - (2QP) #{ABS((ABS(coeff(i))-QP/2)/(2QP))}#

< coeff(i)- (2QP)(coeff(i) - (2QP-1) - QP/2)/(2QP)

< 2QP - 1 + QP/2

< 2.5QP - 1

FGS frame encoder circuit 256 receives the residual signal from residual calculator 252 and receives quantization parameter (QP) information from quantization circuit 216. FGS frame encoder 256 combines, encodes, and compresses the received signals (DCT coefficients) to produce the compressed output for the enhancement layer bit stream. FGS frame encoder 256 receives the QP data associated with the base layer video data and determines therefrom one of more all-zero bit planes associated with one or more blocks of the enhancement layer video data. FGS frame encoder 256 suppresses transmission of the all-zero bit plane(s) to the streaming video receiver in order to conserve available bandwidth. The all-zero bit planes are redundant information that can be calculated in video decoder 134 using the QP data associated with the base layer video stream, as described below in greater detail. Encoder buffer 116 accepts the enhancement layer bit stream from video encoder 114 and transfers the data to streaming video receiver 130 through data network 120 for decoding by exemplary video decoder 134.

FIGURE 3 illustrates exemplary video decoder 134 in accordance with one embodiment of the present invention. Exemplary video decoder 134 comprises base layer decoding unit 310 and enhancement layer decoding unit 350. Base layer decoding unit 310 comprises a main decode processing path consisting of entropy decoding circuit 312, inverse quantization circuit 314, and inverse transform (e.g., inverse DCT) circuit 316 and a feedback path comprising motion compensation circuit 318 and frame store circuit 320.

Entropy decoding unit 312 receives the base layer bit stream and reverses the entropy coding process from the base layer in video encoder 114 to produce a quantized data signal similar to the output of quantization circuit 216 in base layer encoding unit 210. The quantized signal at the output of entropy decoding circuit 312 contains information such as motion information, quantization step size (i.e., QP data), and type of macro-block. Entropy decoding unit 312 transfers this data selectively to motion compensation circuit 318, inverse quantization circuit 314, and enhancement layer decoding unit 350.

Inverse quantization circuit 314 accepts the decoded quantized (de-quantized) output of entropy decoding circuit 312 and performs an inverse quantization to produce a partially de-compressed signal equivalent to the transform coefficient output (coeff(i)) of transform circuit 214. Inverse transform circuit 316 receives the output signal from inverse quantization circuit 314 and performs an inverse transform, such as an inverse discrete cosine transform (IDCT). The inverse transform produces an output signal representing the decompressed motion signal for the original video input signal to exemplary video encoder 114. The output of inverse transform circuit 316 and the output of motion compensation circuit 318 are combined in frame store circuit 320 to create a decoded base layer video frame. Frame store circuit 320 stores the base layer video frame for transfer to enhancement layer decoding unit 350 and for use by motion compensation circuit 318. Motion compensation circuit 318 re-combines the present decoded motion output from entropy decoding circuit 312 with the decoded base layer video frame from frame store circuit 320 to generate a base layer video frame output for use by the enhancement layer decoding unit 350.

Enhancement layer decoding unit 350 comprises FGS frame decoding unit 352, inverse transform circuit (IDCT) 354, and residual computation circuit 356. FGS frame decoding circuit 352 accepts the enhancement layer bit stream input from decoder buffer 132 and the QP data from entropy decoding circuit 312 and generates an output representing the transformed (DCT) coefficients for the enhancement layer. FGS frame decoding circuit 352 uses the QP data from entropy decoding circuit 312 to identify and re-insert all-zero bit planes that were deleted from the enhancement layer bitstream by video encoder 114. Inverse transform circuit 354 then performs an inverse transform, such as an IDCT, on the output of FGS frame decoding circuit 352 to generate an output signal representing the enhancement layer video frames. Residual computation circuit 356 combines the outputs of inverse transform 354 and frame store 320 to generate a decoded version of the original video signal as an input to video display 136.

FIGURE 4 is a flow diagram illustrating the operation of exemplary video encoder 114 in accordance with one embodiment of the present invention. As shown by FIGURE 2, video encoder 114 determines quantization parameters (QPs) for the frames, blocks, and/or macro-blocks in the base layer video frames and outputs these from quantization circuit 216 (step 405). Depending upon whether MPEG-quantization type is used, video encoder 114 may apply a weighting matrix to quantize the various DCT coefficients at the base-layer on a frequency-adaptive fashion (step 410).

Video encoder 114 uses the QP data and weighting matrix, if present, to determine the upper bounds on residue coefficient values in selected blocks of the enhancement layer data (step 415). To illustrate the upper boundary determination, consider the residue (res(i)) associated with the (DCT) transformed coefficients at the base-layer for the non-intra case (i.e., B and P-Macro-blocks) and QP H263:

$$res(i) < 2.5QP - 1$$

$$Ubound(i) = 2.5QP - 1$$

Similar upper boundaries can be determined for a different quantization rule (i.e., qcoeff determination) or another transform (e.g., wavelet). The lower bound for res(i) is always zero.

If adaptive quantization plus frequency dependent weighting is-used, QP in the previous equations may be substituted with $[(QP)W(i)]/16$, where W(i) is frequency dependent weighting, which varies per transformed coefficient. The upper bound for res[i] becomes $[[2.5(QP)W(i)]/16] - 1$, when frequency dependent weighting is used.

Continuing with the flow diagram, FGS frame encoder 256 analyzes the outputs from quantization circuit 216 and residual calculator 252 to determine the presence of all-zero planes in the enhancement layer data. FGS frame encoder 256 then suppresses transmission of data related to the all-zero planes so that only bit planes which can not be predicted as all-zero data are transmitted as part of the enhancement layer bit stream (step 420).

Next, FGS frame encoder 256 may compare the upper bounds of the residual transform coefficients with previously transmitted bit planes to determine the presence of all-zero planes in bit planes that are still to be transmitted (step 425). FGS frame encoder 256 uses this information to suppress transmission of the additional all-zero bit planes in the enhancement layer bit stream (step 430). For example, assume that the upper boundary for a DCT coefficient block is 26. Then the bit planes remaining to be transmitted cannot exceed the binary value "11010" (i.e., 26 decimal). If the first two bit planes have been transmitted

and both were equal to "1", then the next bit plane must be an all zero bit plane, or else the upper boundary will be exceeded (i.e., binary "111xx" is greater than 26). Thus, video encoder 114 and video decoder 134 may represent a certain bit-plane p of the coefficient "coeff(_)" with a minimum number of bit-planes n and an upper bound UB. Thus, the bit-plane p can be predicted by both video encoder 114 and video decoder 134 if and only if:

$$\text{coeff}(n\text{-}p) + 2^p > UB \text{ and } n \geq p \geq 0,$$

where n = number of significant bit-planes and coeff(n-p) = the integer formed by using the first (already transmitted) n – p bit-planes.

FIGURE 5 is a flow diagram illustrating the operation of exemplary video decoder 134 in accordance with one embodiment of the present invention. Initially, entropy decoding circuit 312 receives the base layer bit stream from decoder buffer 132 and extracts QP information for the frames, blocks, and macro-blocks in the base layer (step 505). In addition, entropy decoding circuit 312 examines the base layer bit stream and extracts weighting factors that may have been applied (step 510). The weighting factors, if any, and the QP information are transferred to FGS frame decoding unit 352.

FGS frame decoding circuit 352 uses the QP information and the weighting matrix, if present, to calculate the upper bounds on individual coefficient values for specific image blocks (step 515). FGS frame decoding circuit 352 uses the upper bounds of the coefficient values to predict the presence and location of all-zero planes and to subsequently insert the all-zero bit planes (which were deleted by video encoder 114) into the enhancement layer data (step 520). Next, FGS frame decoding circuit 352 compares the upper bounds of coefficient values with the previously received and decoded bit planes to predict additional all-zero bit planes in the rest of the incoming enhancement layer bit stream (step 525). FGS frame encoding circuit 352 then reinserts the missing bit planes in the enhancement layer data for subsequent processing by inverse transform circuit 354 and residual computation circuit 356 (step 530).

Although the present invention has been described in detail, those skilled in the art should understand that they can make various changes, substitutions and alterations herein without departing from the spirit and scope of the invention in its broadest form.

CLAIMS:

1. A video encoder (114) comprising:

base layer circuitry (210) capable of receiving an input stream of video frames and generating therefrom compressed base layer video data suitable for transmission to a streaming video receiver (130); and

enhancement layer circuitry (250) capable of receiving said input stream of video frames and a locally decoded version of said compressed base layer video data and generating therefrom enhancement layer video data associated with said compressed base layer video data and suitable for transmission to said streaming video receiver (130); and

a controller (256) associated with said enhancement layer circuitry (250) capable of receiving a quantization parameter associated with said base layer video data and determining therefrom at least one all-zero bit plane associated with at least one block of said enhancement layer video data, wherein said controller (256) is capable of causing said enhancement layer circuitry (250) not to transmit said at least one all-zero bit plane to said streaming video receiver (130).

2. The video encoder (114) set forth in Claim 1 wherein said quantization parameter is associated with a frame of said base layer video data.

3. The video encoder (114) set forth in Claim 2 wherein said controller (256) determines an upper boundary of a quantization parameter associated with said at least one block.

4. The video encoder (114) set forth in Claim 1 wherein said controller (256) is further capable of receiving a weighting matrix associated with said base-layer video data and determining said at least one all-zero bit plane as a function of said quantization parameter and said weighting matrix.

5. The video encoder (114) set forth in Claim 1 wherein said controller (256) is capable of determining a second all-zero bit plane associated with said at least one block of

said enhancement layer video data, based on an upper bound of said at least one block and a value of at least one previously transmitted bit plane associated with said at least one block, wherein said controller (256) is capable of causing said enhancement layer circuitry (250) not to transmit said second all-zero bit plane to said streaming video receiver (130).

6. A video decoder (134) comprising:

base layer circuitry (310) capable of receiving compressed base layer video data; and

enhancement layer circuitry (350) capable of receiving enhancement layer video data associated with said compressed base layer video data; and

a controller (352) associated with said enhancement layer circuitry (350) capable of receiving a quantization parameter associated with said compressed base layer video data and predicting therefrom at least one all-zero bit plane associated with at least one block of said enhancement layer video data, wherein said controller (352) is capable of inserting said at least one all-zero bit plane into said enhancement layer video data.

7. The video decoder (134) set forth in Claim 6 wherein said quantization parameter is associated with a frame of said base layer video data.

8. The video decoder (134) set forth in Claim 7 wherein said controller (352) determines an upper boundary of a quantization parameter associated with said at least one block.

9. The video decoder (134) set forth in Claim 6 wherein said controller (352) is further capable of receiving a weighting matrix associated with said base-layer video data and determining said at least one all-zero bit plane as a function of said quantization parameter and said weighting matrix.

10. The video decoder (134) set forth in Claim 6 wherein said controller (352) is capable of determining a second all-zero bit plane associated with said at least one block of said enhancement layer video data, based on an upper bound of said at least one block and a value of at least one previously received bit plane associated with said at least one block, wherein said controller (352) is capable of inserting said second all-zero bit plane into said enhancement layer video data.

11. For use in a video encoder (114) comprising 1) base layer circuitry (210) capable of receiving an input stream of video frames and generating therefrom compressed base layer video data suitable for transmission to a streaming video receiver (130) and 2) enhancement layer circuitry (250) capable of receiving the input stream of video frames and a decoded version of the compressed base layer video data and generating therefrom enhancement layer video data associated with the compressed base layer video data and suitable for transmission to the streaming video receiver (130), a method of compressing the enhancement layer video data comprising the steps of:

identifying a quantization parameter associated with the base layer video data;

determining from the quantization parameter at least one all-zero bit plane associated with at least one block of the enhancement layer video data; and

causing the enhancement layer circuitry (250) not to transmit the at least one all-zero bit plane to the streaming video receiver (130).

12. The method set forth in Claim 11 wherein the quantization parameter is associated with a frame of the base layer video data.

13. The method set forth in Claim 12 including the further step of determining an upper boundary of a quantization parameter associated with the at least one block.

14. The method set forth in Claim 11 including the further steps of identifying a weighting matrix associated with the base-layer video data and determining the at least one all-zero bit plane as a function of the quantization parameter and the weighting matrix.

15. The method set forth in Claim 11 further comprising the steps of:

determining a second all-zero bit plane associated with the at least one block of the enhancement layer video data, based on an upper bound of the at least one block and a value of at least one previously transmitted bit plane associated with the at least one block; and

causing the enhancement layer circuitry (250) not to transmit the second all-zero bit plane to the streaming video receiver (130).

16. For use in a video decoder (134) comprising 1) base layer circuitry (310) capable of receiving compressed base layer video data, and 2) enhancement layer circuitry (350) capable of receiving enhancement layer video data associated with the compressed base layer video data, a method of operating a controller (352) to decode the enhancement layer video data, the method comprising the steps of:

receiving a quantization parameter associated with the compressed base layer video data;

predicting therefrom at least one all-zero bit plane associated with at least one block of the enhancement layer video data; and

inserting the at least one all-zero bit plane into the enhancement layer video data.

17. The method set forth in Claim 16 wherein the quantization parameter is associated with a frame of the base layer video data.

18. The method set forth in Claim 17 including the further step of determining an upper boundary of a quantization parameter associated with the at least one block.

19. The method set forth in Claim 16 including the further step of receiving a weighting matrix associated with the base-layer video data and determining the at least one all-zero bit plane as a function of the quantization parameter and the weighting matrix.

20. The method set forth in Claim 16 including the further steps of determining a second all-zero bit plane associated with the at least one block of the enhancement layer video data, based on an upper bound of the at least one block and a value of at least one previously received bit plane associated with the at least one block; and inserting the second all-zero bit plane into the enhancement layer video data.

21. A television receiver (130) comprising:

a decoder buffer (132) capable of receiving and storing compressed base layer video data and compressed enhancement layer video data;

a video decoder (134) coupled to said decoder buffer (132) comprising:

base layer circuitry (310) capable of receiving said compressed base layer video data;

enhancement layer circuitry (350) capable of receiving said enhancement layer video data associated with said compressed base layer video data; and

a controller (352) associated with said enhancement layer circuitry (350) capable of receiving a quantization parameter associated with said compressed base layer video data and predicting therefrom at least one all-zero bit plane associated with at least one block of said enhancement layer video data, wherein said controller (352) is capable of inserting said at least one all-zero bit plane into said enhancement layer video data.

22. The television receiver set forth in Claim 21 wherein said quantization parameter is associated with a frame of said base layer video data.

23. The television receiver set forth in Claim 22 wherein said controller (352) determines an upper boundary of a quantization parameter associated with said at least one block.

24. The television receiver set forth in Claim 21 wherein said controller (352) is further capable of receiving a weighting matrix associated with said base-layer video data and determining said at least one all-zero bit plane as a function of said quantization parameter and said weighting matrix.

25. The television receiver set forth in Claim 21 wherein said controller (352) is capable of determining a second all-zero bit plane associated with said at least one block of said enhancement layer video data, based on an upper bound of said at least one block and a value of at least one previously received bit plane associated with said at least one block, wherein said controller (352) is capable of inserting said second all-zero bit plane into said enhancement layer video data.

26. For use in a video processing system (130) capable of receiving compressed base layer video data and enhancement layer video data associated with the compressed base layer video data, computer-executable process steps stored on a computer-readable storage medium (135) for decoding the enhancement layer video data, the computer executable process steps comprising the steps of:

receiving a quantization parameter associated with the compressed base layer video data;

predicting therefrom at least one all-zero bit plane associated with at least one block of the enhancement layer video data; and

inserting the at least one all-zero bit plane into the enhancement layer video data.

27. The computer-executable process steps stored on a computer-readable storage medium (135) set forth in Claim 26 wherein the quantization parameter is associated with a frame of the base layer video data.

28. The computer-executable process steps stored on a computer-readable storage medium (135) set forth in Claim 27 including the further step of determining an upper boundary of a quantization parameter associated with the at least one block.

29. The computer-executable process steps stored on a computer-readable storage medium (135) set forth in Claim 26 including the further step of receiving a weighting matrix associated with the base-layer video data and determining the at least one all-zero bit plane as a function of the quantization parameter and the weighting matrix.

30. The computer-executable process steps stored on a computer-readable storage medium (135) set forth in Claim 26 including the further steps of determining a second all-zero bit plane associated with the at least one block of the enhancement layer video data, based on an upper bound of the at least one block and a value of at least one previously received bit plane associated with the at least one block; and inserting the second all-zero bit plane into the enhancement layer video data.

31. A video system (130) comprising:

a television receiver comprising:

a decoder buffer (132) capable of receiving and storing compressed base layer video data and compressed enhancement layer video data; and

a video decoder (134) coupled to said decoder buffer (132) comprising:

base layer circuitry (310) capable of receiving said compressed base layer video data;

enhancement layer circuitry (350) capable of receiving said enhancement layer video data associated with said compressed base layer video data; and

a controller (352) associated with said enhancement layer circuitry (350) capable of receiving a quantization parameter associated with said compressed base layer video data and predicting therefrom at least one all-zero bit plane associated with at least one block of said enhancement layer video data, wherein said controller (352) is capable of inserting said at least one all-zero bit plane into said enhancement layer video data; and

a video display (136) coupled to said television receiver for displaying video images derived from said base layer video data and said enhancement layer video data containing said inserted all-zero bit plane.

32. The video system (130) set forth in Claim 31 wherein said quantization parameter is associated with a frame of said base layer video data.

33. The video system (130) set forth in Claim 32 wherein said controller (352) determines an upper boundary of a quantization parameter associated with said at least one block.

34. The video system (130) set forth in Claim 31 wherein said controller (352) is further capable of receiving a weighting matrix associated with said base-layer video data and determining said at least one all-zero bit plane as a function of said quantization parameter and said weighting matrix.

35. The video system (130) set forth in Claim 31 wherein said controller (352) is capable of determining a second all-zero bit plane associated with said at least one block of said enhancement layer video data, based on an upper bound of said at least one block and a value of at least one previously received bit plane associated with said at least one block, wherein said controller (352) is capable of inserting said second all-zero bit plane into said enhancement layer video data.

36. A transmittable enhancement layer video signal produced by the steps of:

receiving in base layer circuitry (210) of a video encoder (114) an input stream of video frames and generating therefrom compressed base layer video data suitable for transmission to a streaming video receiver (130);

receiving in enhancement layer circuitry (250) of the video encoder (114) the input stream of video frames and a decoded version of the compressed base layer video data and generating therefrom enhancement layer video data associated with the compressed base layer video data and suitable for transmission to the streaming video receiver (130);

compressing the enhancement layer video data by:

identifying a quantization parameter associated with the base layer video data;

determining from the quantization parameter at least one all-zero bit plane associated with at least one block of the enhancement layer video data; and

suppressing transmission of the at least one all-zero bit plane when the enhancement layer video data is transmitted to the streaming video receiver (130).

37. The transmittable enhancement layer video signal set forth in Claim 36 wherein the quantization parameter is associated with a frame of the base layer video data.

38. The transmittable enhancement layer video signal set forth in Claim 37 including the further step of determining an upper boundary of a quantization parameter associated with the at least one block.

39. The transmittable enhancement layer video signal set forth in Claim 36 including the further steps of identifying a weighting matrix associated with the base-layer video data and determining the at least one all-zero bit plane as a function of the quantization parameter and the weighting matrix.

40. The transmittable enhancement layer video signal set forth in Claim 36 further comprising the steps of:

determining a second all-zero bit plane associated with the at least one block of the enhancement layer video data, based on an upper bound of the at least one block and a value of at least one previously transmitted bit plane associated with the at least one block; and

suppressing transmission of the second all-zero bit plane when the enhancement layer video data is transmitted to the streaming video receiver (130).

41. A network system comprising:

a plurality of streaming video receivers (130);

a streaming video transmitter (110) comprising:

a video encoder (114) comprising:

base layer circuitry (210) capable of receiving an input stream of video frames from a video content source (112) and generating therefrom compressed base layer video data suitable for transmission to said plurality of streaming video receivers (130);

enhancement layer circuitry (250) capable of receiving said input stream of video frames and a locally decoded version of said compressed base layer video data and generating therefrom enhancement layer video data associated with said compressed base layer video data and suitable for transmission to said plurality of streaming video receivers (130); and

a controller (256) associated with said enhancement layer circuitry (250) capable of receiving a quantization parameter associated with said base layer video data and determining therefrom at least one all-zero bit plane associated with at least one block of said enhancement layer video data, wherein said controller (256) is capable of causing said enhancement layer circuitry (250) not to transmit said at least one all-zero bit plane to said plurality of streaming video receivers (130); and

a variable bandwidth network (120) capable of transporting said base layer video data and said enhancement layer video data from said streaming video transmitter (110) to said plurality of streaming video receivers (130).

42. The network system set forth in Claim 41 wherein said quantization parameter is associated with a frame of said base layer video data.

43. The network system set forth in Claim 42 wherein said controller (256) determines an upper boundary of a quantization parameter associated with said at least one block.

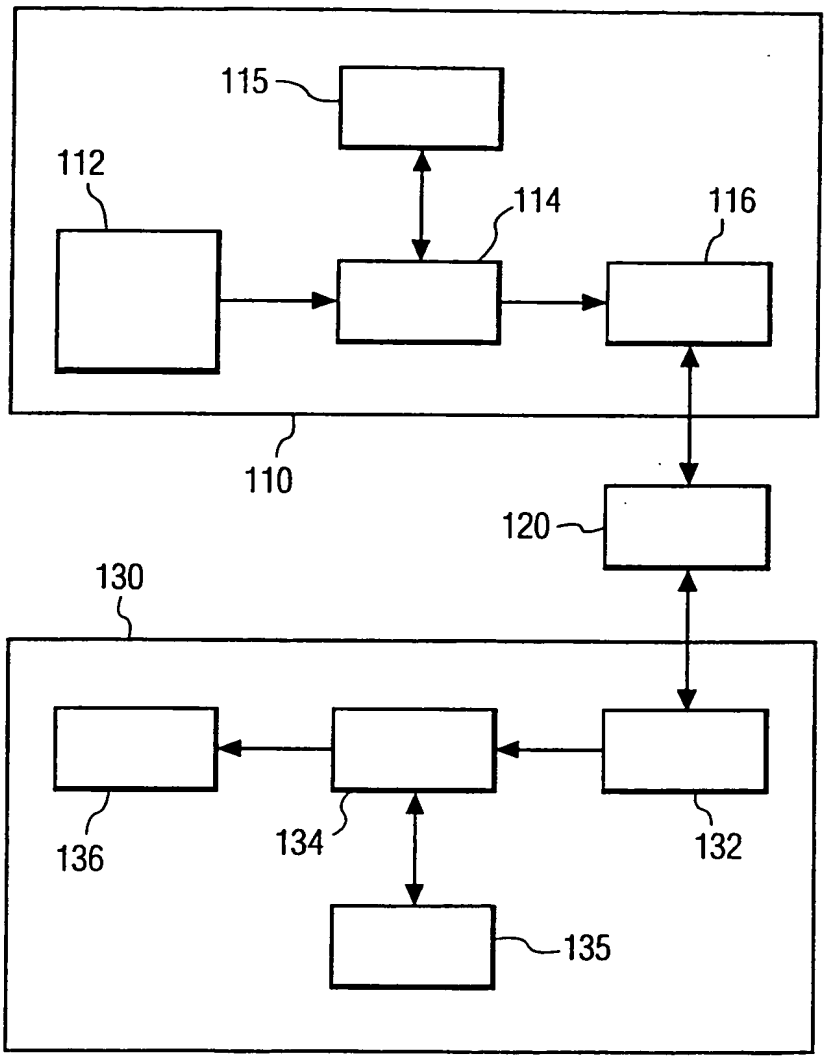


FIG. 1

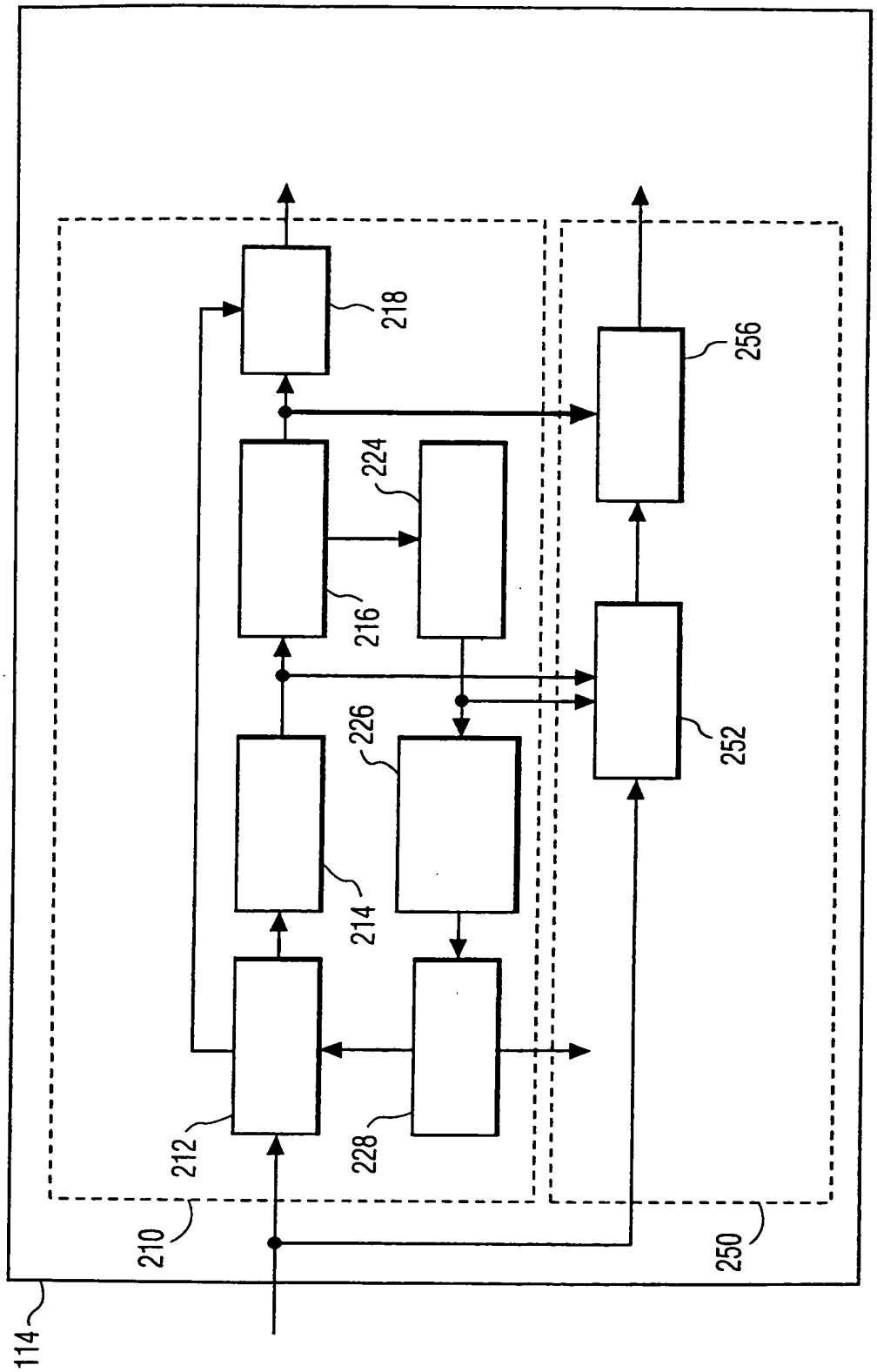


FIG. 2

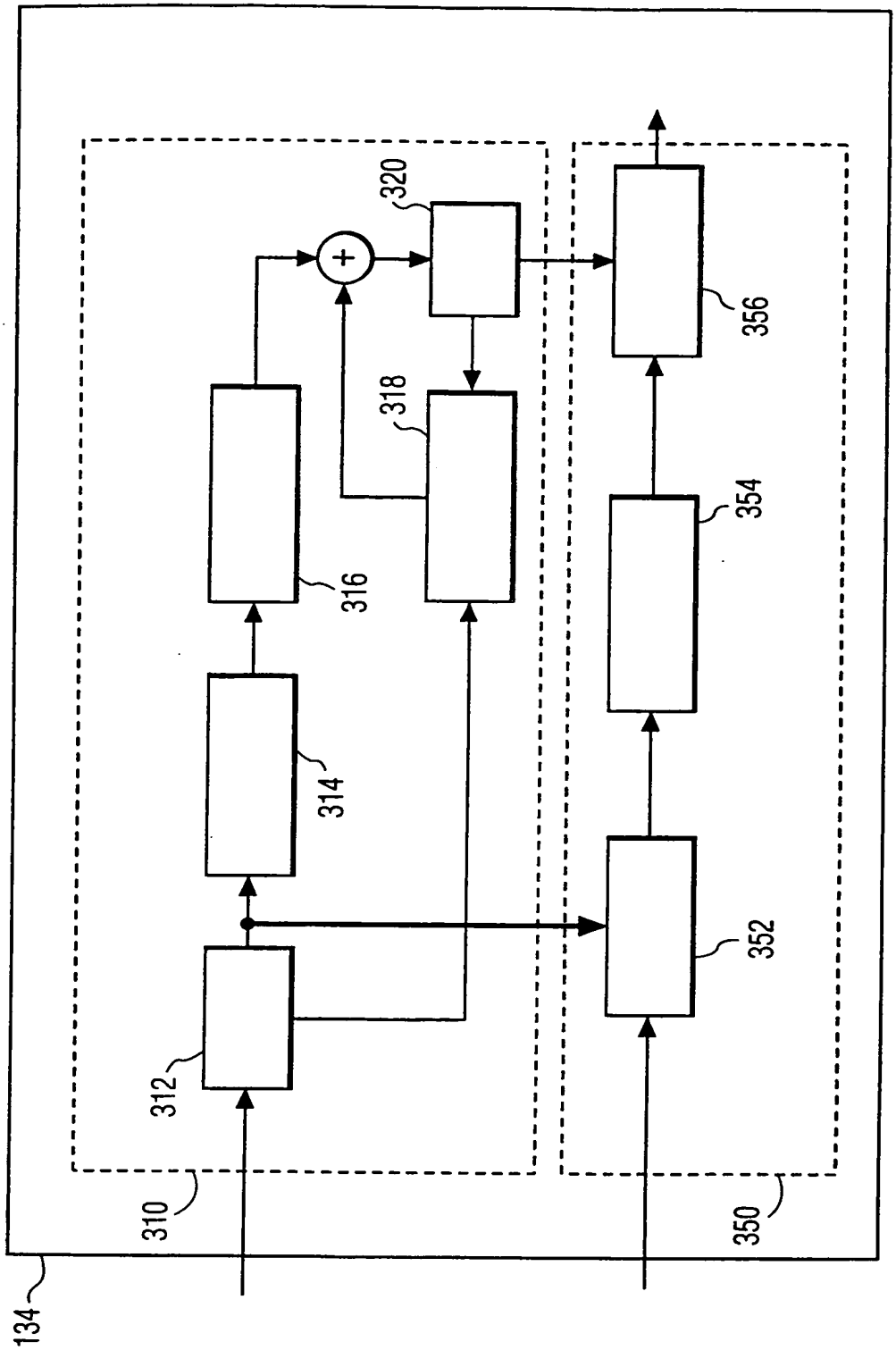


FIG. 3

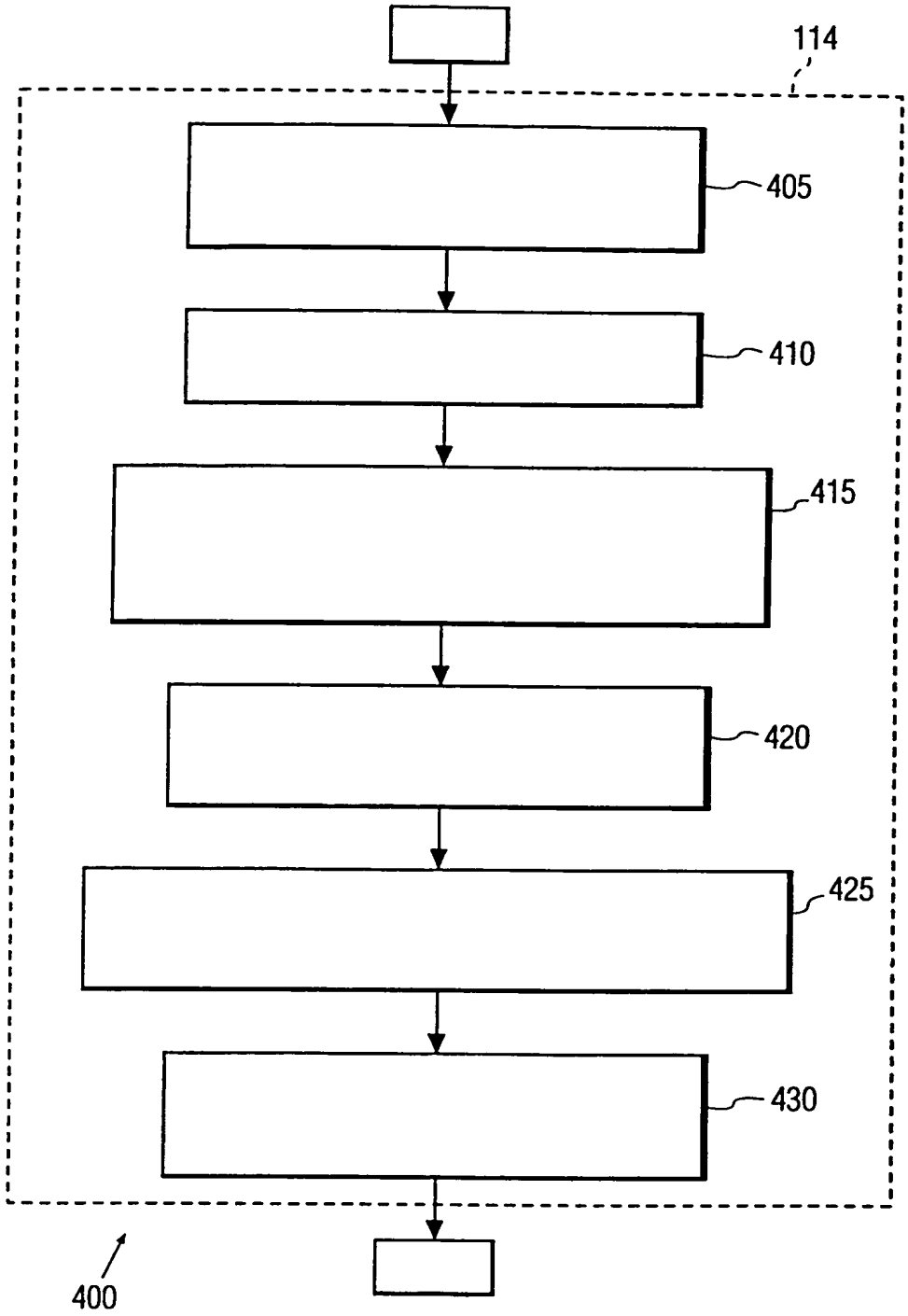


FIG. 4

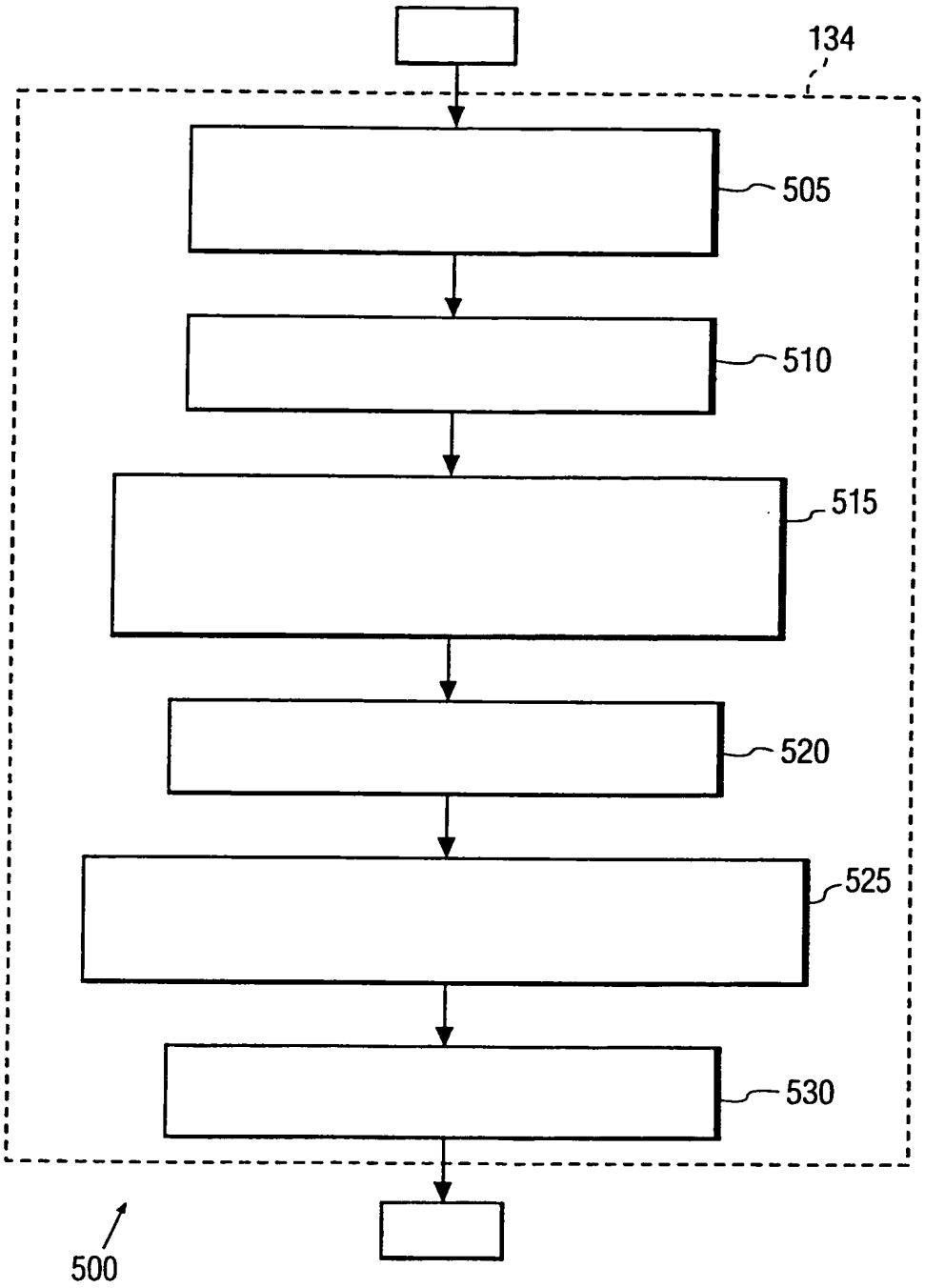


FIG. 5

INTERNATIONAL SEARCH REPORT

Interr nal Application No
PCT/EP 00/09487

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 H04N7/26 H04N7/30 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)
IPC 7 H04N

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	WEIPING LI: "Scalable video coding with fine granularity scalability" 1999 DIGEST OF TECHNICAL PAPERS. INTERNATIONAL CONFERENCE ON CONSUMER ELECTRONICS (CAT. NO.99CH36277), 1999 DIGEST OF TECHNICAL PAPERS. INTERNATIONAL CONFERENCE ON CONSUMER ELECTRONICS, LOS ANGELES, CA, USA, 22-24 JUNE 1999, pages 306-307, XP000965742 1999, Piscataway, NJ, USA, IEEE, USA ISBN: 0-7803-5123-1 section II. --- -/--	1-45

[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in 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

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"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
19 January 2001	26/01/2001

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Fassnacht, C

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Form PCT/ISA/210 (second sheet) (July 1992)

INTERNATIONAL SEARCH REPORT

Interr ·nal Application No
PCT/EP 00/09487

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication,where appropriate, of the relevant passages	Relevant to claim No.
A	LING F ET AL: "BITPLANE CODING OF DCT COEFFICIENTS FOR IMAGE AND VIDEO COMPRESSION" PROCEEDINGS OF THE SPIE, 25 - 27 January 1999, XP000892979 Visual Communications and Image Processing '99, San Jose, CA, USA * section "3. BITPLANE CODING" *	1-45
A	US 5 528 299 A (DUFOUR CECILE ET AL) 18 June 1996 (1996-06-18) column 7, line 42 -column 9, line 52 column 11, line 10 -column 11, line 23 figure 3	1-45
P,X	WO 00 05898 A (LI WEIPING ;OPTIVISION INC (US)) 3 February 2000 (2000-02-03) page 10, line 5 -page 13, line 23	1-45

1

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INTERNATIONAL SEARCH REPORT

..ormation on patent family members

Interr ..nal Application No
PCT/EP 00/09487

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 5528299 A	18-06-1996	FR 2667753 A	10-04-1992
		FR 2670646 A	19-06-1992
		FR 2678126 A	24-12-1992
		FR 2679092 A	15-01-1993
		CA 2070827 A	10-04-1992
		DE 69116128 D	15-02-1996
		DE 69116128 T	01-08-1996
		EP 0504376 A	23-09-1992
		FI 922648 A	08-06-1992
		JP 5503403 T	03-06-1993
		WO 9206563 A	16-04-1992
WO 0005898 A	03-02-2000	AU 5124799 A	14-02-2000

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PATENT & TRADEMARK OFFICE

INFORMATION DISCLOSURE CITATION FORM FOR PATENT APPLICATION (FORM PTO-1449) (Substitute)	Docket No.: 944-001.107-2	Serial No.: 11/881,367
	Applicant(s): Jani Lainema	
	Filing Date: July 26, 2007	Group: 2621

U.S. PATENTS

Initials	Patent Number	Issue Date	Name	Class	Sub-class	Filing date
	6,879,632 B1	4/12/05	Yutaka Yokoyama	375	240	
	7,367,041 B2	4/29/08	Taichiro Morishita, et al	725	37	

U.S. PATENT PUBLICATIONS

Initials	Publication No.	Pub. Date	Name	Class	Sub-class	Filing Date

FOREIGN PATENT DOCUMENTS

Initials	Document Number	Date	Country	Name	Translation? Yes/No/n/a
	JP 06-121171	4/28/94	Japan	Nippon Electric Co.	English Abstract Only
	JP11-004449	1/6/1999	Japan	Asahi Optical Co., Ltd.	English Abstract Only

OTHER DOCUMENTS (Title, Author, Date, Pages, Etc., if known)

Examiner's Signature:	Date Considered:

Initial if reference was considered, whether or not citation is in conformance with MPEP. Mark through citation if not considered. Include a copy of this citation form with your next correspondence to the Applicant(s).

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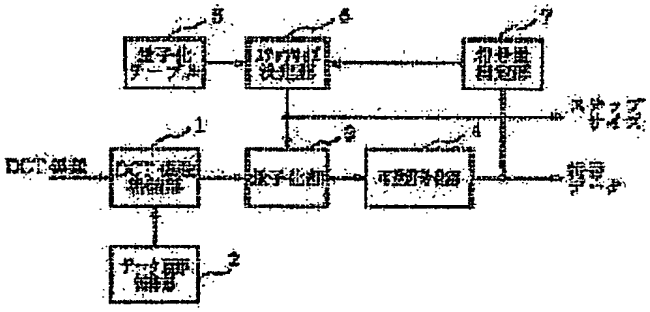
PICTURE ENCODER

Publication number: JP6121171 (A)
Publication date: 1994-04-28
Inventor(s): KITSUKI TOSHIAKI; SAWADA AKIRA
Applicant(s): NIPPON ELECTRIC CO
Classification:
- international: ***H03M7/30; G06T9/00; H04N1/41; H04N7/30;*** **H03M7/30; G06T9/00; H04N1/41; H04N7/30;** (IPC1-7): H04N1/41; G06F15/66; H03M7/30; H04N7/133
- European:
Application number: JP19920268291 19921007
Priority number(s): JP19920268291 19921007

Also published as:
JP2734905 (B2)

Abstract of **JP 6121171 (A)**

PURPOSE:To attain high precision, and to simplify a hard ware by controlling the code data amounts of one screen so as to be constant.
CONSTITUTION:This encoder is equipped with a memory 1 which stores the DCT coefficients of one screen, data sequence control part 2 which reads the DCT coefficients of one screen at every component from the memory 1, and step size deciding part 6 which decides a quantization step size by component units according to the generated code data amounts of the already encoded components. Thus, the quantization step size can be feedback-controlled by the actual code data amounts until the pre-components of the actual screen at every DCT component, during the encoding processing of one screen.



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(19)日本国特許庁（ＪＰ）　(12)公開特許公報（Ａ）　(11)特許出願公開番号

特開平6－121171

(43)公開日　平成６年(1994)４月28日

(51)Int.Cl.[5]		識別記号	庁内整理番号	Ｆ Ｉ	技術表示箇所
Ｈ０４Ｎ	1/41		Ｂ 9070－5Ｃ		
Ｇ０６Ｆ	15/66	３３０	Ｈ 8420－5Ｌ		
Ｈ０３Ｍ	7/30		Ａ 8522－5Ｊ		
Ｈ０４Ｎ	7/133		Ｚ		

審査請求　未請求　請求項の数５(全 11 頁)

(21)出願番号　特願平4－268291

(22)出願日　平成４年(1992)10月７日

(71)出願人　000004237
日本電気株式会社
東京都港区芝五丁目７番１号

(72)発明者　橘木　俊明
東京都港区芝五丁目７番１号日本電気株式会社内

(72)発明者　澤田　明
東京都港区芝五丁目７番１号日本電気株式会社内

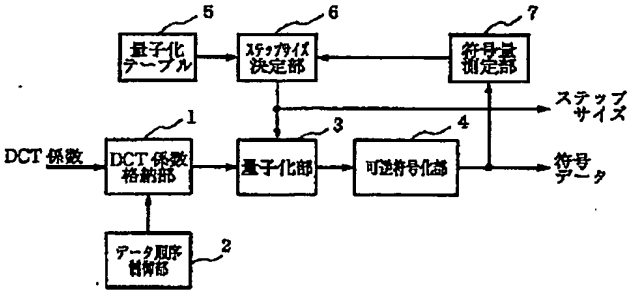
(74)代理人　弁理士　京本　直樹　(外２名)

(54)【発明の名称】　画像符号化装置

(57)【要約】

【目的】１画面の符号データ量が一定量になるように制御し、高精度化するとともに、ハードウェアを簡略化することにある。

【構成】１画面のＤＣＴ係数を格納するメモリ１と、このメモリ１から成分毎に１画面のＤＣＴ係数を読み出すデータ順序制御部２と、既に符号化された成分での発生符号データ量に応じて成分単位で量子化ステップサイズを決定するステップサイズ決定部６とを備えている。これにより、１画面の符号化処理中に、ＤＣＴ成分毎に量子化ステップサイズを現画面の前成分までの実際の符号データ量によりフィードバック制御することができる。



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【特許請求の範囲】

【請求項１】　１画面のＤＣＴ係数を格納するメモリと、前記メモリから成分毎に１画面のＤＣＴ係数を読み出すデータ順次制御部と、読み出された前記ＤＣＴ係数を量子化ステップサイズに従って量子化する量子化部と、既に符号化された成分での発生符号データ量に応じて成分単位で量子化ステップサイズを決定するステップサイズ決定部とを含むことを特徴とする画像符号化装置。

【請求項２】　前記ステップサイズ決定部は、既に符号化した画面での発生符号データ量に応じて、次に符号化する画面での量子化ステップサイズを決定するための既定値を修正する係数を変更する既定値変更手段を備えた請求項１記載の画像符号化装置。

【請求項３】　前記量子化部は、その出力側に量子化後のＤＣＴ係数および前画面の同位置の量子化後のＤＣＴ係数の差分をとる手段を備えた請求項１記載の画像符号化装置。

【請求項４】　複数画面のＤＣＴ係数を格納するメモリと、前記メモリから成分毎に複数画面のＤＣＴ係数を読み出すデータ順序制御部と、読み出された前記ＤＣＴ係数を量子化ステップサイズに従って量子化する量子化部と、既に符号化された成分での発生符号データ量に応じて成分単位で量子化ステップサイズを決定するステップサイズ決定部とを含むことを特徴とする画像符号化装置。

【請求項５】　１画面の入力ＤＣＴ係数データを格納する第１のメモリと、前記１画面の復元ＤＣＴ係数を格納する第２のメモリと、前記第１のメモリから成分毎に１画面のＤＣＴ係数を読み出すデータ順序制御部と、読み出された前記ＤＣＴ係数と前画面の同位置の復元ＤＣＴ係数との差分をとる差分手段と、前記差分手段により算出された差分ＤＣＴ係数データを量子化ステップサイズに従って量子化する量子化部と、量子化差分ＤＣＴ係数を逆量子化して復元差分ＤＣＴ係数を算出する逆量子化部と、前記復元差分ＤＣＴ係数と格納された前画面の復元ＤＣＴ係数に基づきＤＣＴ係数を復元する手段と、既に符号化された成分での発生符号データ量に応じて成分毎に量子化ステップサイズを決定するステップサイズ決定部とを含むことを特徴とする画像符号化装置。

【発明の詳細な説明】

【０００１】

【産業上の利用分野】本発明は画像符号化装置に関し、特に離散コサイン変換とスカラー量子化を用いて画像を符号化する際に発生する符号量を制御する画像符号化装置に関する。

【０００２】

【従来の技術】従来、画像データを離散コサイン変換とスカラー量子化によって圧縮符号化する画像符号化装置では、量子化ステップサイズを固定すると、画面の絵柄

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によって圧縮率が異なるので、発生する符号量が変化する。そこで、画像伝送やスチルカメラのように、符号量を一定にしたい用途においては、量子化ステップサイズを変更することにより発生符号量を制御している。

【０００３】図６は従来の一例を示す静止画像符号化装置のブロック図である。図６に示すように、従来の静止画像符号化装置は、複数の量子化ステップサイズテーブルを格納する量子化ステップサイズ格納部１６と、ＤＣＴ係数を量子化ステップサイズで除算することにより量子化を行う量子化部３と、量子化ＤＣＴ係数をハフマン符号などの手法により可逆符号化する可逆符号化部４と、符号量を計数する符号量測定部７と、発生符号量から量子化ステップサイズ格納部１６に格納された複数の量子化ステップサイズテーブルのうち１つの量子化ステップサイズテーブルを選択する量子化テーブル選択部１７とを含んでいる。

【０００４】先ず、１画面のＤＣＴ係数をブロック単位で順次量子化部３に入力する。一方、量子化テーブル格納部１６は、デフォールト量子化テーブルに格納された量子化ステップサイズを量子化部３に出力する。これにより、量子化部３はブロック毎に入力したＤＣＴ係数を、量子化テーブル格納部１６から入力した量子化ステップサイズで除算を行うことにより量子化を実行する。この量子化されたＤＣＴ係数は、可逆符号化部４において符号データに変換され出力される。また、符号量測定部７は可逆符号化部４で生成される符号量を計数し、１画面分のＤＣＴ係数全てを符号化した結果得られた符号データ量を、量子化テーブル選択部１７に出力する。従って、量子化テーブル選択部１７は、符号量測定部７から入力された符号データ量に基ずき決められた制御規則に従い、画像に適した量子化テーブルを決定し、そのテーブル番号を量子化テーブル格納部１６に出力する。

【０００５】次に、再度同じ画面のＤＣＴ係数をブロック単位で順次量子化部３に入力する。一方、量子化テーブル格納部１６は量子化テーブル選択部１７からのテーブル番号を入力し、指定された量子化テーブルに格納された量子化ステップサイズを量子化部３に出力する。しかる後、量子化部３と可逆符号化部４は、先の符号化処理と同様の処理により符号データを生成する。従って、画像圧縮データは、２度目の符号化処理で使用した量子化ステップサイズのテーブル番号と可逆符号可部４で生成した符号データとからなる。

【０００６】図７は従来の他の例を示す動画像符号化装置のブロック図である。図７に示すように、従来の動画像符号化装置は、入力ＤＣＴ係数を１画面分格納しておくＤＣＴ係数格納部１と、デフォールトの量子化ステップサイズを格納した量子化テーブル５と、１画面分のＤＣＴ係数を入力し且つその画面の符号データ量を推定する符号量推定部１８と、量子化テーブル５から入力したデフォールトの量子化ステップサイズに量子化スケーリ

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ングファクタを乗じて実際に使用する量子化ステップサイズを算出する乗算器２０と、ＤＣＴ係数格納部１からＤＣＴ係数を入力し且つそのＤＣＴ係数を乗算器２０で算出した量子化ステップサイズで除算することにより量子化する量子化部３と、この量子化部３から量子化ＤＣＴ係数を入力して符号データに変換する可逆符号化部４と、この可逆符号化部４が出力した符号データ量を計数する符号量測定部７と、前述した符号量推定部１８から出力される現画面の推定符号データ量と符号量測定部７からの前画面全体での符号データ量とを入力して前述したスケーリングファクタを決定するスケーリングファクタ決定部１９とを備えている。

【０００７】かかる動画像符号化装置において、入力されるＤＣＴ係数は、符号量推定部１８とＤＣＴ係数格納部１に入力される。このＤＣＴ係数格納部１は１画面分のＤＣＴ係数を格納しておく。また、符号量推定部１８は現画面のＡＣ成分の絶対値の総和を算出し、その値を基に発生する符号量を推定するものであり、その推定符号データ量はスケーリングファクタ決定部１９に出力される。

【０００８】一方、符号量測定部７は前画面での実際の符号データ量をスケーリングファクタ決定部１９に出力すると、スケーリングファクタ決定部１９は符号量推定部１８から入力される現画面の推定符号量と符号量測定部７から入力される前画面での符号量とを入力し、それを基に量子化スケーリングファクタを決定し乗算器２０に出力する。しかるに、量子化テーブル５はデフォールトの量子化ステップサイズを格納しているので、その量子化ステップサイズを乗算器２０に出力する。

【０００９】それ故、乗算器２０はデフォールト量子化ステップサイズを量子化スケーリングファクタで乗算したものを実際の現画面に対する量子化ステップサイズとして量子化部３に出力する。これを受けた量子化部３はＤＣＴ係数格納部１からブロック毎にＤＣＴ係数を入力し、乗算器２０から入力した量子化ステップサイズにより除算を行うことで量子化を実行して可逆符号化部４に出力する。この可逆符号化部４は量子化部３からの量子化されたＤＣＴ係数を入力して符号データに変換し出力する。一方、符号量測定部７は可逆符号化部４から出力された現画面の符号データのデータ量を計数し、次の画面の符号化時に、スケーリングファクタ決定部１９に出力する。要するに、画像圧縮データとしては、符号化で使用した量子化スケーリングファクタと可逆符号化部４で生成した符号データとを得る。

【００１０】図８は従来のまた別の例を示すプログレッシブ符号化を実現する静止画像符号化装置のブロック図である。図８に示すように、この静止画像符号化装置は、複数個の量子化テーブルを格納し且つ外部から入力されるテーブル選択信号で示される量子化テーブル内の量子化ステップサイズを出力する量子化テーブル格納部

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１６と、入力ＤＣＴ係数を量子化テーブル格納部１６から入力した量子化ステップサイズで除算することにより量子化する量子化部３と、この量子化部３から出力される量子化ＤＣＴ係数を１画面分格納する量子化ＤＣＴ係数格納部２１と、外部から入力されるバンド情報にしたがって量子化ＤＣＴ係数格納部２１の量子化ＤＣＴ計数出力順序を制御するバンド制御部２２と、量子化ＤＣＴ係数格納部２１から出力されたＤＣＴ係数を入力して符号データに変換する可逆符号化部４とを備えている。

【００１１】このうち、量子化テーブル格納部１６は複数個の量子化テーブルを格納し、指定された量子化テーブルに格納された量子化ステップサイズを量子化部３に出力する。量子化部３はブロック毎に入力されたＤＣＴ係数を量子化テーブル格納部１６から入力した量子化ステップサイズにより除算を行うことにより量子化を実行し、量子化ＤＣＴ係数格納部２１に出力する。これにより、量子化ＤＣＴ係数格納部２１は量子化部３より量子化されたＤＣＴ係数を入力し、１画面分格納する。

【００１２】一方、バンド制御部２２は、量子化ＤＣＴ係数格納部２１に１画面分のＤＣＴ係数が格納された後に、量子化ＤＣＴ係数格納部２１に制御信号を出力し、バンド情報で示されるバンド内のＤＣＴ係数を量子化ＤＣＴ係数格納部２１から可逆符号化部４に出力するように制御する。次に、可逆符号化部４は量子化ＤＣＴ係数格納部２１からバンド毎にＤＣＴ係数を入力し、バンド毎に符号データに変換する。

【００１３】このような従来のプログレッシブ符号化を行う静止画像符号化装置では、各バンドを符号化する前に量子化処理を行っており、各バンドの符号データ量による量子化ステップサイズのフィードバック制御は行われていない。

【００１４】図９は図８に示す静止画像符号化装置におけるＤＣＴ係数の処理手順を説明するための図である。図９に示すように、この静止画像符号化装置では、ＤＣＴ成分をいくつかの周波数バンドに分割し、バンド毎にＤＣＴ係数を可逆符号化する。特に、ＤＣＴ係数格納部２３はＤＣＴ係数をブロック単位で格納し、量子化部３へ読み出すときはバンド単位で出力する。

【００１５】

【発明が解決しようとする課題】上述した従来の静止画像符号化装置では、あらかじめ準備された数種類の量子化ステップサイズテーブルの中から量子化ステップサイズを決定するため、画像の特性に完全に適応した量子化ステップサイズを選択することができず、符号データ量を希望値に十分合わせられないという欠点がある。

【００１６】また、従来の動画像符号化装置では、現画面の符号化のための量子化ステップサイズを決定するにあたり、前画面での符号データ量によるフィードバック制御と、現画面のＤＣＴ係数の統計量測定によるフィードフォワード制御を行うが、前画面での符号データ量に

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よるフィードバック制御では、前画面と現画面とで画面の特性が大きく変化した場合、適切な制御が出来ない欠点がある。更に、現画面のＤＣＴ係数の統計量測定によるフィードフォワード制御では、統計量測定のために、ＤＣＴ係数を１画面分格納しておく必要があることに加え、累積加算器などの特別のハードウェアを必要とするという欠点がある。またその上、量子化ステップサイズの決定を画面単位に行うため、１画面内での符号量のきめ細かい制御が出来ないという欠点がある。

【００１７】本発明の目的は、かかる符号データ量の制御を高精度に行うとともに、ハードウェア量を減少させることのできる画像符号化装置を提供することにある。

【００１８】

【課題を解決するための手段】本発明の画像符号化装置は、１画面のＤＣＴ係数を格納するメモリと、前記メモリから成分毎に１画面のＤＣＴ係数を読み出すデータ順次制御部と、読み出された前記ＤＣＴ係数を量子化ステップサイズに従って量子化する量子化部と、既に符号化された成分での発生符号データ量に応じて成分単位で量子化ステップサイズを決定するステップサイズ決定部とを含んで構成される。

【００１９】また、本発明の画像符号化装置は、複数画面のＤＣＴ係数を格納するメモリと、前記メモリから成分毎に複数画面のＤＣＴ係数を読み出すデータ順序制御部と、読み出された前記ＤＣＴ係数を量子化ステップサイズに従って量子化する量子化部と、既に符号化された成分での発生符号データ量に応じて成分単位で量子化ステップサイズを決定するステップサイズ決定部とを含んで構成される。

【００２０】更に、本発明の画像符号化装置は、１画面の入力ＤＣＴ係数データを格納する第１のメモリと、前記１画面の復元ＤＣＴ係数を格納する第２のメモリと、前記第１のメモリから成分毎に１画面のＤＣＴ係数を読み出すデータ順序制御部と、読み出された前記ＤＣＴ係数と前画面の同位置の復元ＤＣＴ係数との差分をとる差分手段と、前記差分手段により算出された差分ＤＣＴ係数データを量子化ステップサイズに従って量子化する量子化部と、量子化差分ＤＣＴ係数を逆量子化して復元差分ＤＣＴ係数を算出する逆量子化部と、前記復元差分ＤＣＴ係数と格納された前画面の復元ＤＣＴ係数に基づきＤＣＴ係数を復元する手段と、既に符号化された成分での発生符号データ量に応じて成分毎に量子化ステップサイズを決定するステップサイズ決定部とを含んで構成される。

【００２１】このように、本発明はブロック毎に入力されるＤＣＴ係数を各ＤＣＴ成分毎に並び変え、各ＤＣＴ成分毎に量子化処理及び可逆符号化処理を行うことにより、現画面の前成分までの実際の符号データ量に基づきＤＣＴ成分毎に量子化ステップサイズをフィードバック制御することを可能にする。

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【００２２】

【実施例】次に、本発明の実施例について図面を参照して説明する。

【００２３】図１は本発明の第１の実施例を示す静止画像符号化装置のブロック図である。図１に示すように、本実施例はＤＣＴ係数を入力して１画面分格納するＤＣＴ係数格納部１と、このＤＣＴ係数格納部１に制御信号を出力してＤＣＴ係数の出力順序を制御するデータ順序制御部２と、ＤＣＴ係数格納部１からＤＣＴ係数を入力し量子化ステップサイズで量子化する量子化部３と、この量子化部３から量子化ＤＣＴ係数を入力し符号データに変換する可逆符号化部４と、可逆符号化部４が出力する符号データ量を計数する符号量測定部７と、デフォールト量子化ステップサイズを格納した量子化テーブル５と、この量子化テーブル５から入力したデフォールト量子化ステップサイズを符号量測定部７から入力した符号データ量に応じて調整し量子化ステップサイズを決定するステップサイズ決定部６とを備えている。しかも、ステップサイズ決定部６で決定した量子化ステップサイズは、前述したように量子化部３へ供給される。

【００２４】まず、ＤＣＴ係数格納部１はＤＣＴ係数を入力し、１画面分格納する。このとき、データ順序制御部２はＤＣＴ係数格納部１が画面分のＤＣＴ係数を格納された後に、ＤＣＴ係数格納部１に制御信号を出力し、ＤＣＴ係数格納部１がＤＣＴ係数を成分毎に出力するように制御する。

【００２５】次に、量子化部３はＤＣＴ係数格納部１からＤＣＴ係数を成分毎に入力し、そのＤＣＴ係数をステップサイズ決定部６から入力される量子化ステップで除算することにより量子化し、可逆符号化部４に出力する。この可逆符号化部４は量子化部３から入力した量子化されたＤＣＴ係数を符号データに変換して出力する。さらに、符号量測定部７は可逆符号化部４が出力する各成分の符号データ量を測定し、それをステップサイズ決定部６に出力する。

【００２６】一方、量子化テーブル５はデフォールトの量子化ステップサイズを格納しており、そのデフォールト量子化ステップサイズをステップサイズ決定部６に出力する。これにより、ステップサイズ決定部６は符号量測定部７から入力された前成分までの符号データ量に従って、量子化テーブル５から入力したデフォールト量子化ステップサイズを調整し、しかる後現成分の量子化ステップサイズを決定し、量子化部３に出力する。

【００２７】図２（ａ），（ｂ）はそれぞれ図１におけるＤＣＴ係数の処理順序および量子化ステップサイズの制御を説明するための図である。図２（ａ）に示すように、ＤＣＴ係数はＤＣＴ係数格納部１にブロック単位で入力される。また、出力するときは成分単位で量子化部３へ読み出される。本実施例において、入力されるＤＣＴ係数は低周波数成分から高周波数成分の順序に量子化

され、さらに可逆符号化されることにより符号化される。

【0028】次に、本実施例のステップサイズ決定部6での量子化ステップサイズの決定にあたっては、図2（b）に示すように行われる。すなわち、ここでは1画面を成分毎に符号化処理した際の発生符号データ量を表し、点線が各成分までの累積符号データ量の期待値を示し、実線が実際の符号化の結果発生した符号データ量の累積値を示す。例えば、A成分までの発生符号データ量は期待値よりも少なく、B成分までの発生符号データ量は期待値よりも多いことが分かる。かかるステップサイズ決定部6はA成分のように発生符号データ量が期待値よりも少ない場合は、次の成分で使用する量子化ステップサイズを量子化テーブル5から入力されるデフォールトの量子化ステップサイズより小さい値にする。また、逆にB成分のように発生符号データ量が期待値よりも少ない場合は、次の成分で使用する量子化ステップサイズを量子化テーブル5から入力されるデフォールトの量子化ステップサイズより大きい値にする。

【0029】図3は本発明の第2の実施例を示す動画像符号化装置のブロック図である。図3に示すように、本実施例は前述した第1の実施例と同様、DCT係数格納部1，データ順序制御部2，量子化部3，可逆符号化部4，符号量測定部7，ステップサイズ決定部6を備えているほかに、第1の実施例における量子化テーブル5の代わりに、符号量測定部7から前画面の符号データ量を入力し且つそれに従って仮の量子化ステップサイズを決定する量子化テーブル決定部8を備えている。

【0030】かかる動画像符号化装置において、各画面のデフォールト量子化ステップサイズを制御し変更することを除き、動画像内の各画面に対して第1の実施例と同様に動作する。以下、デフォールト量子化ステップサイズの制御に関する部分のみを説明する。

【0031】まず、符号量測定部7は可逆符号化部4が出力した符号データの量を計数し、各成分での符号データ量と1画面全体での符号データ量を測定する。その結果、1画面全体での符号データ量を量子化テーブル決定部8に出力し、また各成分での符号データ量をステップサイズ決定部6に出力する。この符号データを受けた量子化テーブル決定部8は、符号量測定部7から入力される前画面全体の符号量を基に仮の量子ステップサイズを決定し、それをステップサイズ決定部6に出力する。

【0032】次に、ステップサイズ決定部6は量子化テーブル決定部8から入力された仮の量子化ステップサイズを、符号量測定部7から入力された前成分までの符号データ量に従って、実際に使用する量子化ステップサイズを決定して量子化部3に出力する。

【0033】図4は本発明の第3の実施例を示す動画像符号化装置のブロック図である。図4に示すように、本実施例はフレーム間／フレーム内制御部10と、DCT

係数を入力して1画面分格納するDCT係数格納部1と、DCT係数格納部1に制御信号を出力してDCT係数の出力順序を制御するデータ順序制御部2と、DCT係数格納部1からのDCT係数を量子化ステップサイズで量子化する量子化部3と、この量子化部3が出力する量子化DCT係数を格納する1画面遅延回路9と、量子化部3から入力した量子化DCT係数から1画面遅延回路9より入力した前画面での量子化DCT係数を減算する減算器11と、この減算器11の出力データを符号データに変換する可逆符号化部4と、この可逆符号化部4が出力する符号データ量を計数する符号量測定部7と、この符号量測定部7から前画面の符号データ量を入力し且つそれに応じてデフォールト量子化ステップサイズを決定する量子化テーブル決定部8と、この量子化テーブル決定部8から入力したデフォールト量子化ステップサイズを符号量測定部7から入力した符号データ量に応じて調整し量子化ステップサイズを決定するステップサイズ決定部6とを備えている。

【0034】次に、本実施例の回路動作について説明する。まず、本実施例は量子化DCT係数をフレーム内で可逆符号化する画面と、量子化DCT係数を前フレームの量子化DCT係数と差分を取ったものを可逆符号化する画面とがある。フレーム間／フレーム内制御部10は、決められた制御規制にしたがって現画面の量子化DCT係数をフレーム内で可逆符号化するか、前フレームの量子化DCT係数と差分を取ったものを可逆符号化するかを示すフレーム内／間信号を出力する。

【0035】次に、DCT係数格納部1はDCT係数を入力し、1画面分のDCT係数を格納する。同様に、データ順序制御部2はDCT係数格納部に1画面分のDCT係数が格納された後、DCT係数格納部1に制御信号を出力し、前述した図2（a）に示すように、DCT係数格納部1がDCT係数を成分毎に出力するように制御する。さらに、量子化部3はDCT係数格納部1から成分毎に入力されるDCT係数をステップサイズ決定部6に入力される量子化ステップで除算することにより量子化し、その量子化係数を減算器11および1画面遅延回路9に出力する。この減算器11はフレーム間／フレーム内制御部10より出力されるフレーム内／間信号にしたがって、量子化部3から入力した量子化DCT係数をそのまま可逆符号化部4に出力するか、または量子化部3から入力した量子化DCT係数と1画面遅延回路9から入力した前画面の量子化DCT係数との差分を算出して可逆符号化部4に出力する。

【0036】この可逆符号化部4は減算器11から入力した量子化DCT係数または量子化DCT係数の差分を可逆符号化する。これにより、符号量測定部7は各成分の符号データ量と1画面全体での符号データ量を測定し、各成分の符号データ量をステップサイズ決定部6に出力する一方、1画面全体での符号データ量を量子化テ

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ーブル決定部８に出力する。この量子化テーブル決定部８は、符号量測定部７から入力した前画面全体の符号データ量を基に仮の量子ステップサイズを決定する。さらに、ステップサイズ決定部６は量子化テーブル決定部８から入力した仮の量子化ステップサイズを符号量測定部７から入力した前成分までの符号データ量に従って調整し、現成分の量子化ステップサイズを決定して量子化部３に出力する。

【００３７】要するに、量子化ＤＣＴ係数を前フレームの量子化ＤＣＴ係数と差分を取ったものを可逆符号化する画面において、前フレームと現フレームで異なる量子化スップサイズを使用することは、差分を取ることによるデータ圧縮効果を損なうことになる。そのため、量子化テーブル決定部８及びステップサイズ決定部６による量子化ステップサイズの変更は、量子化ＤＣＴ係数をフレーム内で可逆符号化する画面に対してのみ行う。それに続く量子化ＤＣＴ係数を前フレームの量子化ＤＣＴ係数と差分を取ったものを可逆符号化する画面では、量子化ＤＣＴ係数をフレーム内で可逆符号化する画面で使用したものと同じ量子化ステップサイズを使用する。

【００３８】図５は本発明の第４の実施例を示す動画像符号化装置のブロック図である。図５に示すように、本実施例はフレーム間／フレーム内制御部１０と、ＤＣＴ係数を入力して１画面分格納するＤＣＴ係数格納部１と、このＤＣＴ係数格納部１に制御信号を出力してＤＣＴ係数の出力順序を制御するデータ順序制御部２と、ＤＣＴ係数格納部１から入力したＤＣＴ係数を、前画面の復元ＤＣＴ係数で減算する減算器１２と、この減算器１２の出力データを量子化ステップサイズで量子化する量子化部３と、この量子化部３の出力データを逆量子化する逆量子化部１３と、逆量子化部１３の出力データに前画面の復元ＤＣＴ係数を加算する加算器１４と、この加算器１４が出力する復元ＤＣＴ係数を格納する復元ＤＣＴ係数格納部１５と、前述した量子化部３の出力データを符号データに変換する可逆符号化部４と、この可逆符号化部４が出力する符号データ量を計数する符号量測定部７と、この符号量測定部７から前画面の符号データ量を入力し且つそれに応じてデフォールト量子化ステップサイズを決定する量子化テーブル決定部８と、この量子化テーブル決定部８から入力したデフォールト量子化ステップサイズを符号量測定部７から入力した符号データ量に応じて調整し量子化ステップサイズを決定するステップサイズ決定部６とを備えている。本実施例では、特に復元ＤＣＴ係数格納部１５を設け、前画面の復元ＤＣＴ係数を作成している。

【００３９】次に、本実施例の回路動作について説明する。まず本実施例では、ＤＣＴ係数を量子化し可逆符号化する画面と、ＤＣＴ係数を前画面の復元ＤＣＴ係数と差分を取ったものを量子化し可逆符号化する画面とがある。フレーム間／フレーム内制御部１０は、決められた

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制御規則にしたがって現画面の量子化ＤＣＴ係数をフレーム内で可逆符号化するか、前フレームの量子化ＤＣＴ係数と差分を取ったものを可逆符号化するかを示すフレーム内／間信号を各回路に出力する。また、本実施例も前述した実施例と同様、ＤＣＴ係数格納部１はＤＣＴ係数を入力して１画面分のＤＣＴ係数を格納し、データ順序制御部２はＤＣＴ係数格納部１に１画面分のＤＣＴ係数が格納された後にＤＣＴ係数格納部１に制御信号を出力する。しかも、前述した図２（ａ）に示すように、ＤＣＴ係数格納部１がＤＣＴ係数を成分毎に出力するように制御する。

【００４０】以下、ＤＣＴ係数を量子化し可逆符号化する画面に対する動作と、ＤＣＴ係数を前画面の復元ＤＣＴ係数と差分を取ったものを量子化し可逆符号化する画面に対する動作とが異なるため、分けて説明する。

【００４１】まず、ＤＣＴ係数を量子化し可逆符号化する画面に対して、減算器１２はＤＣＴ係数格納部１から入力したＤＣＴ係数をそのまま量子化部３に出力する。量子化部３は減算器１２から入力したＤＣＴ係数をステップサイズ決定部６から入力した量子化ステップで除算することにより量子化し、可逆符号化部４と逆量子化部１３に出力する。可逆符号化部４は量子化部３から入力された量子化されたＤＣＴ係数を符号データに変換して出力する。一方、逆量子化部１３は量子化部３から入力された量子化されたＤＣＴ係数をステップサイズ決定部６から入力した量子化ステップで乗算することにより逆量子化し加算器１４に出力する。この加算器１４は逆量子化部１３から入力した復元されたＤＣＴ係数をそのまま復元ＤＣＴ係数格納部１５に格納する。復元ＤＣＴ係数格納部１５は、加算器１４から入力された復元ＤＣＴ係数を１画面分格納しておき、減算器１２と加算器１４に出力する。さらに、符号量測定部７は可逆符号化部４から出力される符号データの量を計数し且つ各成分の符号データ量と１画面全体での符号データ量を測定することにより、１画面全体での符号データ量を量子化テーブル決定部８に送出し、各成分での符号データ量をステップサイズ決定部６に出力する。量子化テーブル決定部８は、この符号量測定部７から入力される前画面全体の符号データ量を基に仮の量子ステップサイズを決定し、それをステップサイズ決定部６に出力する。このステップサイズ決定部６は、量子化テーブル決定部８から入力された仮の量子化ステップサイズを符号量測定部７から入力された前成分までの符号データ量に従って調整することにより、実際に使用する量子化ステップサイズを決定して量子化部３に出力する。

【００４２】次に、ＤＣＴ係数を前画面の復元ＤＣＴ係数と差分を取ったものを量子化し可逆符号化する画面に対しては、減算器１２がＤＣＴ係数格納部１から入力したＤＣＴ係数と復元ＤＣＴ係数格納部１５から入力した前画面の復元ＤＣＴ係数との差分を算出する。量子化部

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３は減算器１２から入力したＤＣＴ係数の差分をステップサイズで決定部６から入力した量子化ステップで除算することにより量子化する。また、可逆符号化部４は量子化部３から入力された量子化された差分ＤＣＴ係数を符号データに変換して出力する。一方、逆量子化部１３は量子化３から入力された量子化された差分ＤＣＴ係数をステップサイズ決定部６から入力した量子化ステップで乗算することにより逆量子化して加算器１４に出力する。さらに、加算器１４は逆量子化部１３から入力される復元されたＤＣＴ係数の差分と、復元ＤＣＴ係数格納部１５から入力される前画面の復元ＤＣＴ係数とを加算することによりＤＣＴ係数を復元し、復元ＤＣＴ係数格納部１５に格納する。復元ＤＣＴ係数格納部１５はこの加算器１４から入力された復元ＤＣＴ係数を１画面分格納しておき、それを減算器１２と加算期１４に出力する。また、符号量測定部７，量子化テーブル決定部８及びステップサイズ決定部６における動作は、先に説明したＤＣＴ係数を量子化して可逆符号化する画面に対する動作と同じであるので、説明を省略する。尚、量子化テーブル決定部８及びステップサイズ決定部６による量子化ステップサイズの決定においては、ＤＣＴ係数を量子化し可逆符号化する画面に対する量子化ステップサイズと、ＤＣＴ係数を前画面の復元ＤＣＴ係数と差分を取ったものを量子化し可逆符号化する画面に対する量子化ステップサイズとでは、異なるものにする。

【００４３】以上４つの実施例について説明したが、ＤＣＴ係数格納部１は１画面分のＤＣＴ係数を格納し且つこのＤＣＴ係数を成分毎に１画面分単位で処理して符号化するものであったが、かかるＤＣＴ係数格納部１において複数画面分のＤＣＴ係数を格納し、ＤＣＴ係数を成分毎に複数画面単位で処理して符号化することも同様に実現できる。

【００４４】

【発明の効果】以上説明したように、本発明の画像符号化装置は、各ＤＣＴ成分毎に１画面分の係数を処理することにより、１画面の符号化処理中にＤＣＴ成分毎に量子化ステップサイズを現画面の前成分までの実際の符号データ量によりフィードバック制御することができ、精度の高い符号データ量制御を実現できるという効果がある。

【００４５】また、本発明はＤＣＴ係数の入力順序を変

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えるため、ＤＣＴ係数を１画面分格納しておく記憶素子は必要であるが、量子化ステップサイズの制御には、現画面を符号化した結果生成された符号データ量のみを使っているので、符号データ量を計数するカウンタのみで実現でき、ハードウェア量も減らすことが出来るという効果がある。

【図面の簡単な説明】

【図１】本発明の第１の実施例を示す静止画像符号化装置のブロック図である。

【図２】図１におけるＤＣＴ係数の処理順序および量子化ステップサイズの制御を説明する図である。

【図３】本発明の第２の実施例を示す動画像符号化装置のブロック図である。

【図４】本発明の第３の実施例を示す動画像符号化装置のブロック図である。

【図５】本発明の第４の実施例を示す動画像符号化装置のブロック図である。

【図６】従来の一例を示す静止画像符号化装置のブロック図である。

【図７】従来の他の例を示す動画像符号化装置のブロック図である。

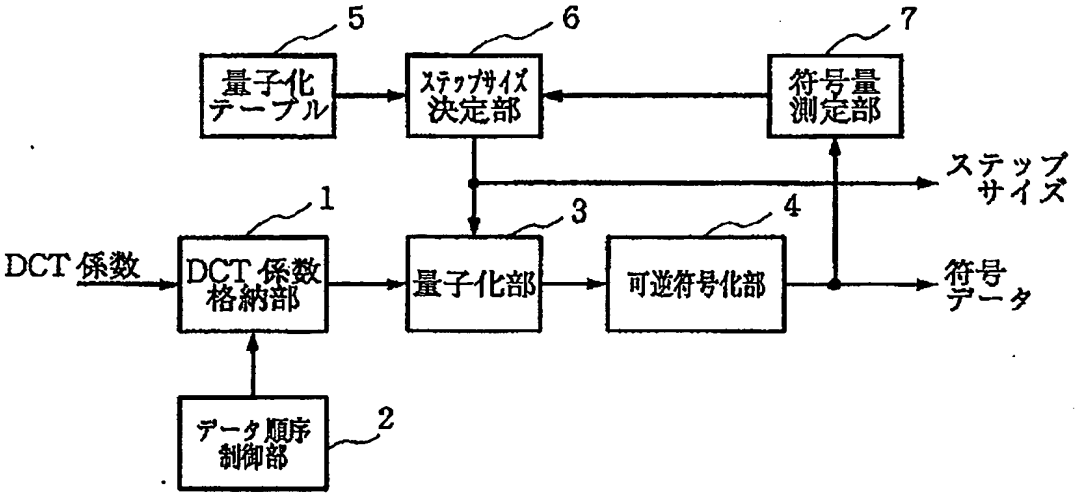
【図８】従来のまた別の例を示すプログレッシブ符号化を行う静止画像符号化装置のブロック図である。

【図９】図８に示す静止画像符号化装置におけるＤＣＴ係数の処理順序を説明するための図である。

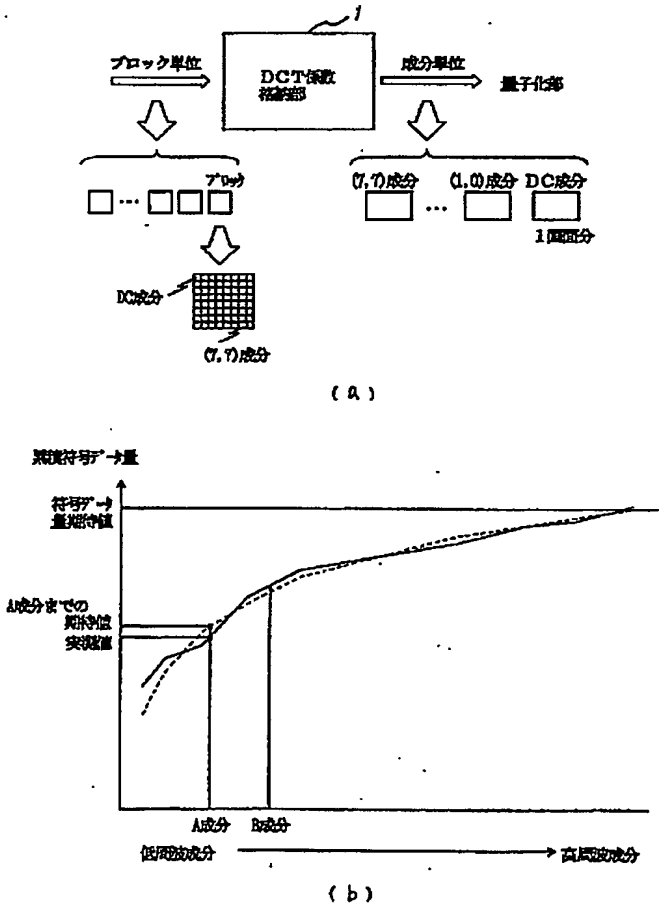
【符号の説明】

１　ＤＣＴ係数格納部
２　データ順序制御部
３　量子化部
４　可逆符号化部
５　量子化テーブル
６　ステップサイズ決定部
７　符号量測定部
８　量子化テーブル決定部
９　１画面遅延部
１０　フレーム間／フレーム内制御部
１１，１２　減算器
１３　逆量子化部
１４　加算器
１５　復元ＤＣＴ係数格納部

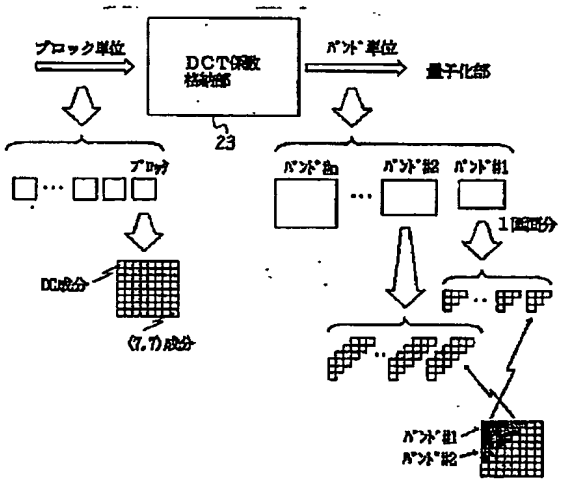
【図１】


5
6
7
量子化テーブル
ステップサイズ決定部
符号量測定部
ステップサイズ
1
3
4
DCT係数
DCT係数格納部
量子化部
可逆符号化部
符号データ
データ順序制御部
2

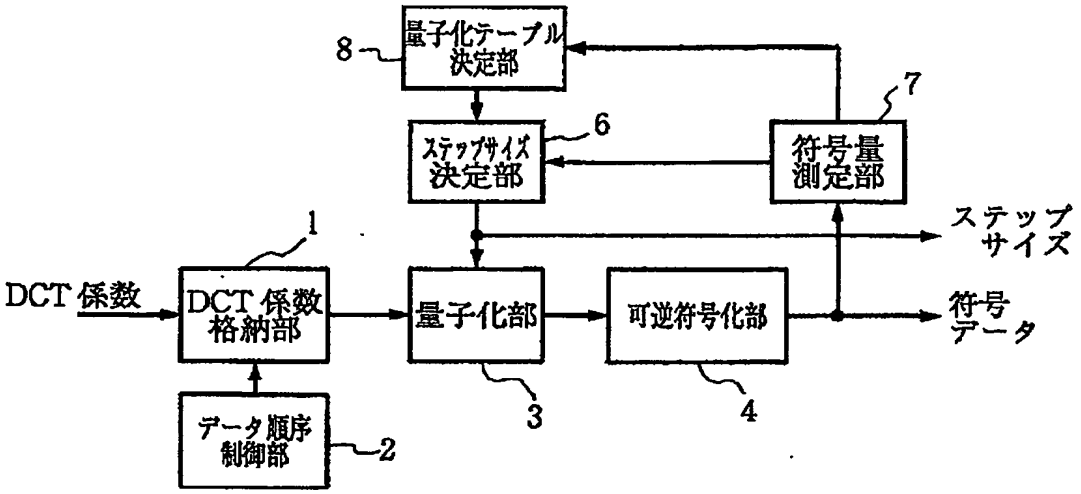
【図２】


1
ブロック単位
DCT係数格納部
成分単位
量子化部
ブロック
(7,7)成分
(1,0)成分
DC成分
1画面分
DC成分
(7,7)成分
(a)
実際符号データ量
符号データ量概算値
A成分までの概算値
実際値
A成分
B成分
低周波成分
高周波成分
(b)

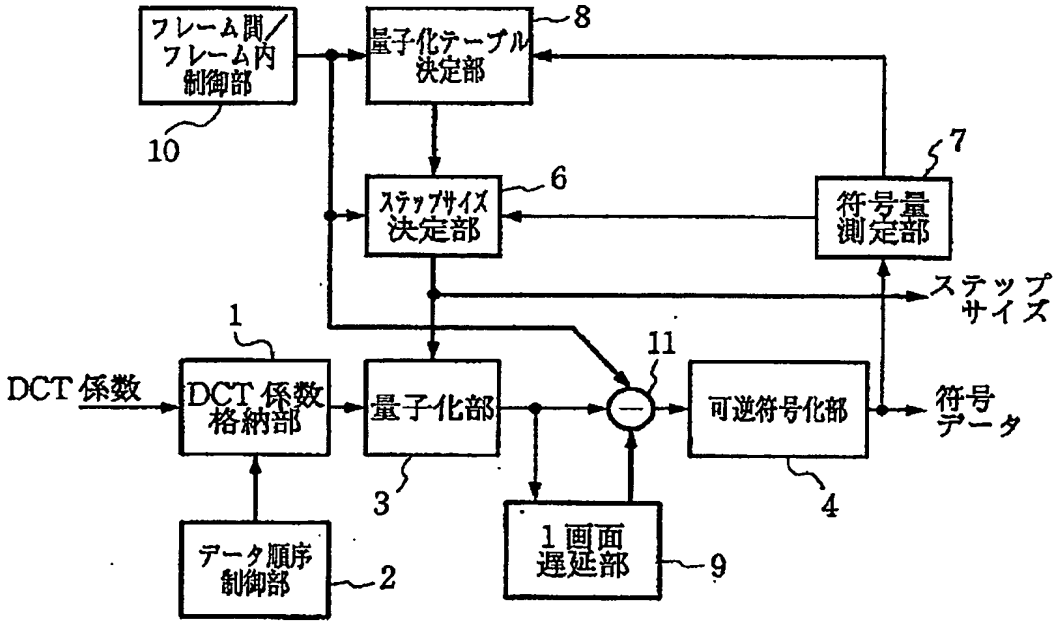
【図９】


ブロック単位
DCT係数格納部
バンド単位
量子化部
23
ブロック
バンドBn
バンドB2
バンドB1
1画面分
DC成分
(7,7)成分
バンドB1
バンドB2

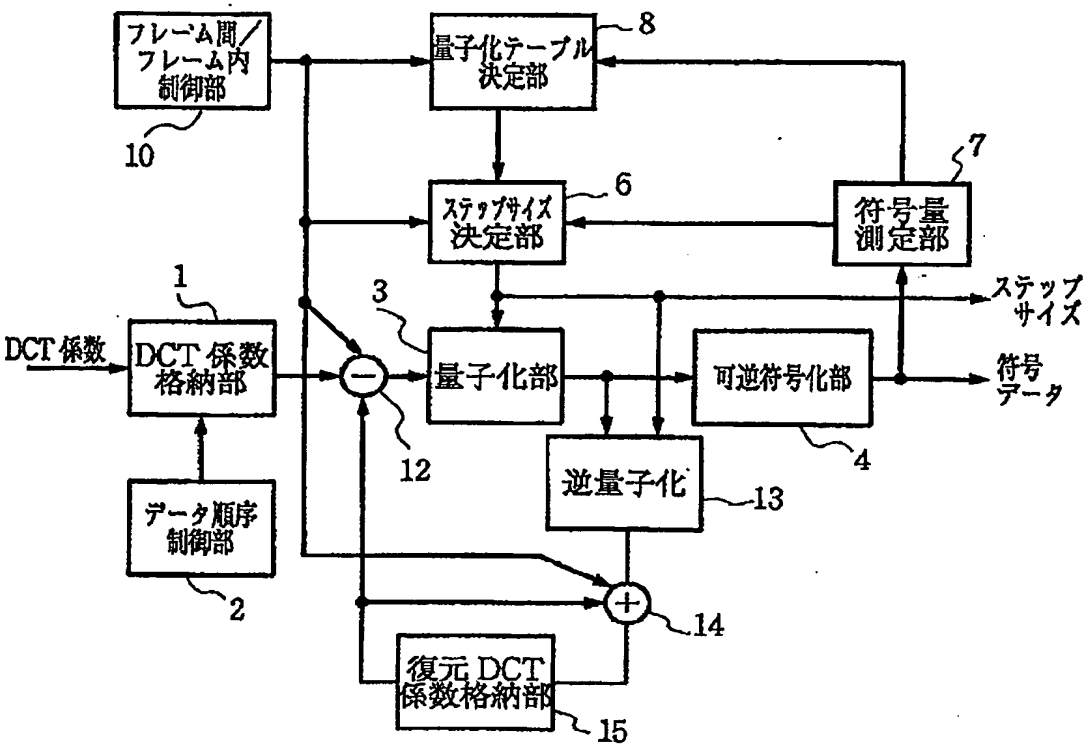
【図３】


量子化テーブル決定部
8
ステップサイズ決定部
6
符号量測定部
7
ステップサイズ
1
DCT係数
DCT係数格納部
量子化部
可逆符号化部
符号データ
3
4
データ順序制御部
2

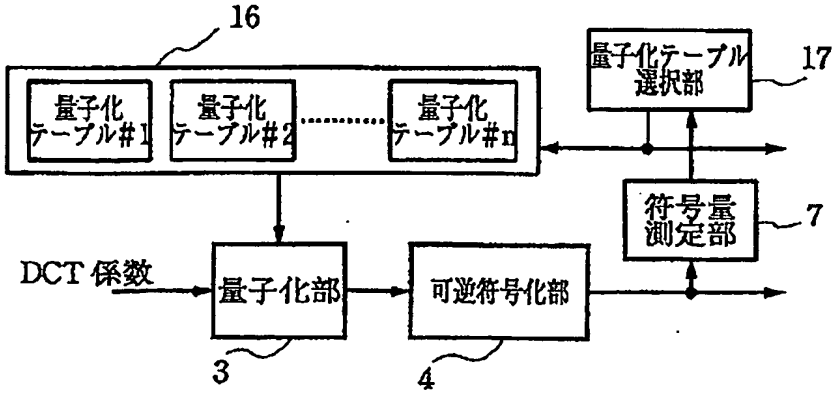
【図４】


フレーム間/フレーム内制御部
10
量子化テーブル決定部
8
ステップサイズ決定部
6
符号量測定部
7
ステップサイズ
1
11
DCT係数
DCT係数格納部
量子化部
可逆符号化部
符号データ
3
4
データ順序制御部
2
1画面遅延部
9

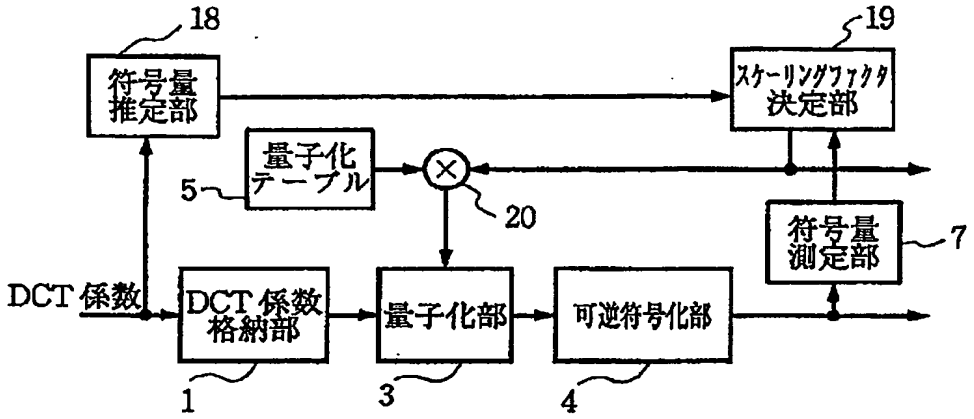
【図５】


フレーム間／フレーム内制御部
10
量子化テーブル決定部
8
ステップサイズ決定部
6
符号量測定部
7
ステップサイズ
1
DCT係数
DCT係数格納部
3
量子化部
可逆符号化部
符号データ
4
12
逆量子化
13
データ順序制御部
2
14
復元DCT係数格納部
15

【図６】


16
量子化テーブル#1
量子化テーブル#2
量子化テーブル#n
量子化テーブル選択部
17
符号量測定部
7
DCT係数
量子化部
可逆符号化部
3
4

【図7】


18
符号量
推定部
19
スケーリングファクタ
決定部
量子化
テーブル
5
20
符号量
測定部
7
DCT係数
DCT係数
格納部
量子化部
可逆符号化部
1
3
4

【図8】

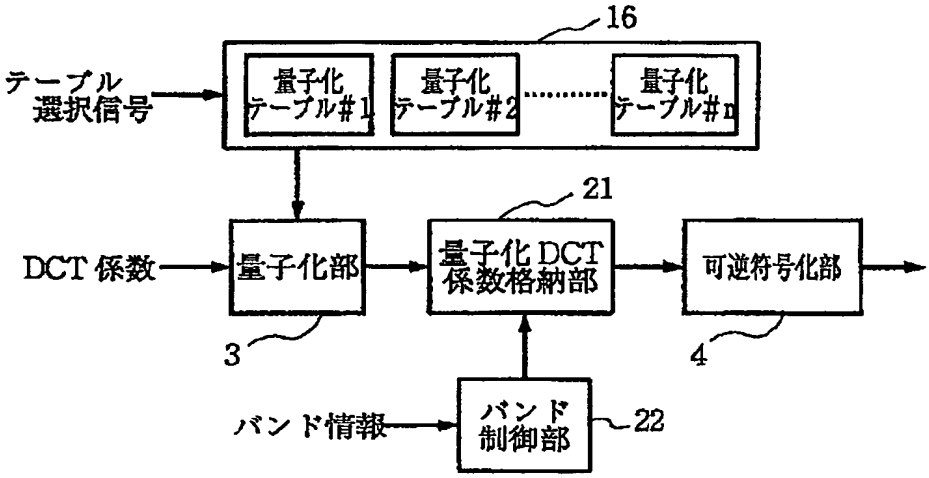
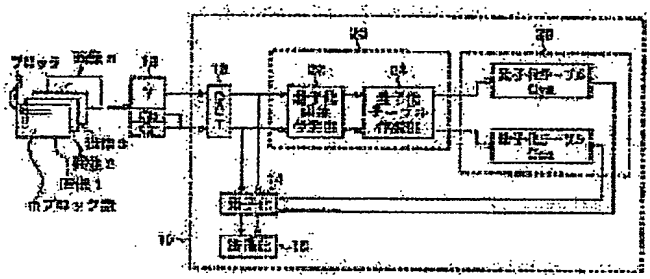

16
テーブル
選択信号
量子化
テーブル#1
量子化
テーブル#2
量子化
テーブル#n
21
DCT係数
量子化部
量子化DCT
係数格納部
可逆符号化部
3
4
バンド情報
バンド
制御部
22

IMAGE COMPRESSOR AND QUANTIZATION TABLE GENERATING DEVICE

Publication number: JP11004449 (A)
Publication date: 1999-01-06
Inventor(s): ABE NOBUSATO
Applicant(s): ASAHI OPTICAL CO LTD
Classification:
- international: ***H04N7/32; H03M7/30; H04N1/41; H04N7/30;*** **H04N7/32; H03M7/30; H04N1/41; H04N7/30;** (IPC1-7): H04N7/32; H03M7/30; H04N1/41
- European:
Application number: JP19970172917 19970613
Priority number(s): JP19970172917 19970613

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Abstract of **JP 11004449 (A)**
PROBLEM TO BE SOLVED: To compress an image by predicting a quantization error, so as to reduce image deterioration due to quantization and inverse quantization. SOLUTION: A DCT processing circuit 12 applies discrete cosine transformation(DCT) to image data of m&times n number of block, that is, a luminance signal and color difference signals Cb, Cr for converting the data into a DCT transform coefficient. A quantization table generator 25 is provided with a quantization error predict section 22 and a quantization table generating section 24. The quantization error prediction section 22 tentatively stores the DCT transform coefficient to apply quantization error prediction to the coefficient.; Based on the quantization error prediction result by the quantization error prediction section 22, the quantization table calculation section 24 generates quantization tables Qya, Qca and provides outputs of them to a memory 26. A quantization processing circuit 14 reads the quantization tables Qya, Qca from the memory 26 and conducts quantization by using the quantization tables Qya, Qyca.



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Ｈ０４Ｎ　1/41		Ｈ０４Ｎ　1/41	Ｂ

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(71)出願人　000000527
旭光学工業株式会社
東京都板橋区前野町２丁目36番９号

(72)発明者　阿部　紳聡
北海道札幌市厚別区下野幌テクノパーク１－１－10　札幌市エレクトロニクスセンター　313号室　旭光学工業株式会社ペンタックステクノロジー札幌内

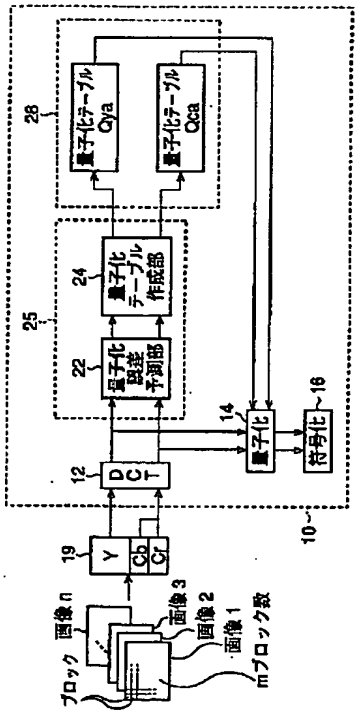
(74)代理人　弁理士　松浦　孝

(54)【発明の名称】　画像圧縮装置および量子化テーブル作成装置

(57)【要約】

【課題】　量子化誤差を予測し、量子化および逆量子化による画像劣化が少なくなるように画像を圧縮する。

【解決手段】　ＤＣＴ処理回路１２は、ｍ×ｎブロック数の画像データ、即ち輝度信号Ｙと色差信号Ｃｂ、ＣｒにＤＣＴを施し、ＤＣＴ変換係数に変換する。量子化テーブル作成装置２５は、量子化誤差予測部２２と、量子化テーブル作成部２４とを備える。量子化誤差予測部２２はＤＣＴ変換係数を一時的に記憶し、量子化誤差予測を行なう。量子化誤差予測部２２による量子化誤差予測結果に基づいて、量子化テーブル算出部２４は量子化テーブルＱｙａ、Ｑｃａを作成し、メモリ２６へ出力する。量子化処理回路１４は、メモリ２６から量子化テーブルＱｙａ、Ｑｃａを読み出し、この量子化テーブルＱｙａ、Ｑｃａを用いて量子化を行う。



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【特許請求の範囲】

【請求項１】　撮影光学系から得られた複数枚の原画像データに対応した直交変換係数を量子化テーブルを用いて量子化し、量子化直交変換係数を求める量子化手段と、

前記量子化直交変換係数を前記量子化テーブルを用いて逆量子化して求められる逆量子化直交変換係数と、前記直交変換係数との誤差を、前記直交変換係数に基づいて予測する量子化誤差予測手段と、

前記量子化誤差予測手段から得られた予測誤差値に基づいて前記量子化テーブルを作成する量子化テーブル作成手段とを備えることを特徴とする画像圧縮装置。

【請求項２】　前記予測誤差値が前記直交変換係数に対応してそれぞれ求められ、対応する前記各直交変換係数と前記各逆量子化直交変換係数とが取り得る係数値誤差の二乗平均の平方根（ｒｍｓ値）で表わされることを特徴とする請求項１に記載の画像圧縮装置。

【請求項３】　前記量子化テーブル作成手段によって作成される前記量子化テーブルが前記直交変換係数に対応する量子化係数から成り、

前記各量子化係数が、対応する前記ｒｍｓ値によって各量子化係数の初期値が補正されることにより求められることを特徴とする請求項２に記載の画像圧縮装置。

【請求項４】　前記量子化誤差予測手段が、前記直交変換係数の直流成分に対応する前記ｒｍｓ値から予測誤差合計値を求め、前記直流成分の前記予測誤差合計値に基づいて、交流成分に対応した前記ｒｍｓ値をそれぞれ求めることを特徴とする請求項３に記載の画像圧縮装置。

【請求項５】　前記直流成分において、前記予測誤差合計値が、前記量子化係数の初期値から予測される係数値誤差のｒｍｓ値と、絶対値が２よりも大きい直交変換係数の数との乗算により求められることを特徴とする請求項４に記載の画像圧縮装置。

【請求項６】　前記交流成分に対応する前記係数値誤差のｒｍｓ値が、前記予測誤差合計値を、絶対値が２よりも大きい前記各空間周波数成分における直交変換係数の数で除算することにより求められ、

算出された前記ｒｍｓ値によって、前記各交流成分に対応する前記各量子化係数初期値が補正されることにより、前記各量子化係数がそれぞれ求められることを特徴とする請求項５に記載の画像圧縮装置。

【請求項７】　撮影光学系から得られた複数枚の原画像データに対応した直交変換係数と、この直交変換係数に量子化テーブルを用いて量子化と逆量子化とを施すことにより求められる逆量子化直交変換係数との誤差を、前記直交変換係数に基づいて予測する量子化誤差予測手段と、

前記量子化誤差予測手段から得られた予測誤差値に基づいて、前記量子化テールを作成する量子化テーブル作成手段とを備えることを特徴とする量子化テーブル作成装

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置。

【請求項８】　前記予測誤差値が前記直交変換係数に対応してそれぞれ求められ、対応する前記各直交変換係数と前記各逆量子化直交変換係数とが取り得る係数値誤差の二乗平均の平方根（ｒｍｓ値）で表わされることを特徴とする請求項７に記載の量子化テーブル作成装置。

【請求項９】　前記量子化テーブル作成手段によって作成される前記量子化テーブルが前記直交変換係数に対応する量子化係数から成り、

前記各量子化係数が、対応する前記ｒｍｓ値によって各量子化係数の初期値が補正されることにより求められることを特徴とする請求項８に記載の量子化テーブル作成装置。

【請求項１０】　前記量子化誤差予測手段が、前記直交変換係数の直流成分に対応する前記ｒｍｓ値から予測誤差合計値を求め、前記直流成分の前記予測誤差合計値に基づいて、交流成分に対応した前記ｒｍｓ値をそれぞれ求めることを特徴とする請求項９に記載の量子化テーブル作成装置。

【請求項１１】　前記直流成分において、前記予測誤差合計値が、前記量子化係数初期値から予測される係数値誤差のｒｍｓ値と、絶対値が２よりも大きい直交変換係数の数との乗算により求められることを特徴とする請求項１０に記載の量子化テーブル作成装置。

【請求項１２】　前記交流成分に対応する前記係数値誤差のｒｍｓ値が、前記予測誤差合計値を、絶対値が２よりも大きい前記各空間周波数成分における直交変換係数の数で除算することにより求められ、

算出された前記ｒｍｓ値によって、前記各交流成分に対応する前記各量子化係数初期値が補正されることにより、前記各量子化係数がそれぞれ求められることを特徴とする請求項１１に記載の量子化テーブル作成装置。

【発明の詳細な説明】

【０００１】

【発明の属する技術分野】本発明は、カラー静止画像をＪＰＥＧアルゴリズムに準拠して情報圧縮する画像圧縮装置に関する。

【０００２】

【従来の技術】高解像度画像を符号化（圧縮）して、情報の授受を通信伝送路を介して行なう標準化アルゴリズムがＪＰＥＧ（Joint Photographic Expert Group）から勧告されている。このＪＰＥＧアルゴリズムのプロセスでは、原画像データを２次元離散コサイン変換（以下、２次元ＤＣＴという）によって空間周波数軸上の成分に分解し、この空間周波数軸上で表された各データを量子化し、量子化した各データを符号化することにより、大幅な情報圧縮を行なっている。また、圧縮された画像データを復号化、逆量子化することにより伸張している。

【０００３】ＪＰＥＧでは、量子化あるいは逆量子化の

ために、所定の量子化テーブルを推奨している。このＤＣＴと量子化による画像圧縮は、広範な被写体において効率の良い画像圧縮であるが、原画像データと伸張された再生画像データとの間に誤差を伴う非可逆方式である。

【０００４】

【発明が解決しようとする課題】画像圧縮の量子化あるいは逆量子化において、被写体の多様性にも関わらず、単一の量子化テーブルを使用するため、被写体によっては再生画像データの劣化が大きくなることが問題である。

【０００５】本発明は、この様な問題点に鑑み、量子化誤差を予測し、量子化と逆量子化による画像劣化が少ない画像圧縮を容易にする画像圧縮装置を提供することが目的である。

【０００６】

【課題を解決するための手段】本発明による画像圧縮装置は、撮影光学系から得られた複数枚の原画像データに対応した直交変換係数を量子化テーブルを用いて量子化し、量子化直交変換係数を求める量子化手段と、量子化直交変換係数を量子化テーブルを用いて逆量子化して求められる逆量子化直交変換係数と、直交変換係数との誤差を、直交変換係数に基づいて予測する量子化誤差予測手段と、量子化誤差予測手段から得られた予測誤差値に基づいて量子化テーブルを作成する量子化テーブル作成手段とを備えることを特徴としている。

【０００７】画像圧縮装置において、好ましくは、予測誤差値が直交変換係数に対応してそれぞれ求められ、対応する各直交変換係数と各逆量子化直交変換係数とが取り得る係数値誤差の二乗平均の平方根（ｒｍｓ値）で表わされる。

【０００８】画像圧縮装置において、好ましくは、量子化テーブル作成手段によって作成される量子化テーブルが直交変換係数に対応する量子化係数から成り、各量子化係数が、対応するｒｍｓ値によって各量子化係数の初期値が補正されることにより求められる。

【０００９】画像圧縮装置において、好ましくは、量子化誤差予測手段が、直交変換係数の直流成分に対応するｒｍｓ値から予測誤差合計値を求め、直流成分の予測誤差合計値に基づいて、交流成分に対応したｒｍｓ値をそれぞれ求める。

【００１０】画像圧縮装置において、好ましくは、直流成分において、予測誤差合計値が、量子化係数の初期値から予測される係数値誤差のｒｍｓ値と、絶対値が２よりも大きい直交変換係数の数との乗算により求められる。さらに好ましくは、交流成分に対応する係数値誤差のｒｍｓ値が、予測誤差合計値を、絶対値が２よりも大きい各空間周波数成分における直交変換係数の数で除算することにより求められ、算出されたｒｍｓ値によって、各交流成分に対応する各量子化係数初期値が補正されることにより、各量子化係数がそれぞれ求められる。

【００１１】また、本発明による量子化テーブル作成装置は、撮影光学系から得られた複数枚の原画像データに対応した直交変換係数と、この直交変換係数に量子化テーブルを用いて量子化と逆量子化とを施すことにより求められる逆量子化直交変換係数との誤差を、直交変換係数に基づいて予測する量子化誤差予測手段と、量子化誤差予測手段から得られた予測誤差値に基づいて、量子化テールを作成する量子化テーブル作成手段とを備えることを特徴としている。

【００１２】量子化テーブル作成装置において、好ましくは、予測誤差値が直交変換係数に対応してそれぞれ求められ、対応する各直交変換係数と各逆量子化直交変換係数とが取り得る係数値誤差の二乗平均の平方根（ｒｍｓ値）で表わされる。

【００１３】量子化テーブル作成装置において、好ましくは、量子化テーブル作成手段によって作成される量子化テーブルが直交変換係数に対応する量子化係数から成り、各量子化係数が対応するｒｍｓ値によって各量子化係数の初期値が補正されることにより求められる。

【００１４】量子化テーブル作成装置において、好ましくは、量子化誤差予測手段が、直交変換係数の直流成分に対応するｒｍｓ値から予測誤差合計値を求め、直流成分の予測誤差合計値に基づいて、交流成分に対応したｒｍｓ値をそれぞれ求める。

【００１５】量子化テーブル作成装置において、好ましくは、直流成分において、予測誤差合計値が、量子化係数初期値から予測される係数値誤差のｒｍｓ値と、絶対値が２よりも大きい直交変換係数の数との乗算により求められる。さらに好ましくは、交流成分に対応する係数値誤差のｒｍｓ値が、予測誤差合計値を、絶対値が２よりも大きい各空間周波数成分における直交変換係数の数で除算することにより求められ、算出されたｒｍｓ値によって、各交流成分に対応する各量子化係数初期値が補正されることにより、各量子化係数がそれぞれ求められる。

【００１６】

【発明の実施の形態】以下、本発明による画像圧縮装置の実施形態について添付図面を参照して説明する。

【００１７】図１には実施形態である画像圧縮装置の概略構成が示される。被写体Ｓの撮影光学系１１を介して得られる被写体像（静止画）は、色分解光学系１３によってレッド（Ｒ）、グリーン（Ｇ）およびブルー（Ｂ）の画像に分解され、例えばＣＣＤから成る３枚の撮像素子１５上に結像される。即ち、各撮像素子にはそれぞれＲ、Ｇ、Ｂの画像が形成される。これらＲ、Ｇ、Ｂの画像信号は信号処理回路１７において所定の処理を施され、輝度データＹ、色差データＣｂ、Ｃｒに変換されて、画像メモリ１９に入力される。画像メモリ１９は輝度データＹおよび色差データＣｂ、Ｃｒをそれぞれ格納

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するために、相互に独立したメモリ領域に分割されており、各メモリ領域は１画像分の記憶容量を有している。輝度データＹ、色差データＣｂ、Ｃｒは、画像圧縮装置１０に対する入力データ（原画像データ）である。

【００１８】輝度データＹ、あるいは色差データＣｂ、Ｃｒは、ＤＣＴ処理回路１２において２次元ＤＣＴを施され、空間周波数毎にＤＣＴ係数に変換される。輝度データＹのＤＣＴ係数は量子化処理回路１４において、量子化テーブルＱｙを用いて量子化され、量子化ＤＣＴ係数に変換される。同様に、色差データＣｂ、ＣｒのＤＣＴ係数は量子化処理回路１４において、量子化テーブルＱｃを用いて量子化され、量子化ＤＣＴ係数に変換される。輝度データＹ、あるいは色差データＣｂ、Ｃｒの量子化ＤＣＴ係数は符号化処理回路１６において、ＪＰＥＧアルゴリズムに従って符号化（圧縮）され、圧縮画像データとして記録媒体Ｍの圧縮画像データ記録領域Ｍ１に記録される。量子化処理回路１４において用いられた量子化テーブルＱｙ、Ｑｃは、記録媒体Ｍのテーブル記録領域Ｍ２に記録される。

【００１９】図２は、ＪＰＥＧの推奨する従来の量子化テーブルを示す。図２（ａ）は輝度値Ｙ用の量子化テーブルＱｙであり、図２（ｂ）は色差Ｃｂ、Ｃｒ用の量子化テーブルＱｃである。

【００２０】図３を参照して、量子化と逆量子化について説明する。図３には、一例として、８×８画素の原画像データ、すなわち輝度データＹのＤＣＴ係数F_{vu}と、

$$R_{vu} = \mathrm{round}\ (F_{vu} / Q_{vu})$$

$|0 \leq u, v \leq 7|$

【００２５】このように、量子化処理回路１４において求められた量子化ＤＣＴ係数R_{vu}は、例えばＪＰＥＧに準拠したハフマン符号化を用いて、符号化処理回路１６においてＤＣ成分、ＡＣ成分毎に符号化され、記録媒体Ｍに記録される。ハフマン符号化については、従来公知のため詳細な説明は省略する。

【００２６】符号化された圧縮画像信号を伸張して、画面に表示するためには、復号化、逆量子化、２次元ＤＣＴの逆変換（以下、２次元ＩＤＣＴという）の処理が必要である。この復号化は、ハフマン符号化とは逆の作用であり、従来公知であるため詳述しない。復号化によって得られた量子化ＤＣＴ係数は、量子化に用いた量子化テーブルＱｙ、Ｑｃを用いてそれぞれ逆量子化され、逆量子化ＤＣＴ係数に変換される。これらの逆量子化ＤＣＴ係数は２次元ＤＣＴの逆変換（以下、２次元ＩＤＣＴという）を施され、それぞれ輝度データＹ’、色差データＣｂ’、Ｃｒ’に変換される。２次元ＩＤＣＴについても公知であるのでここでは詳述しない。

【００２７】例えば、図３に示すＤＣＴ係数Ｆ００（＝２６１）を、量子化係数ｑ００（＝１６）を用いて（１）式により求めると、量子化係数Ｒ００は１６になり、この量子化係数Ｒ００（＝１６）にｑ００（＝１６）を掛け合わせ

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＊量子化ＤＣＴ係数R_{vu}と、逆量子化ＤＣＴ係数F'_{vu}、および量子化テーブルＱｙが示される。添字ｖ，ｕは、６４個のＤＣＴ係数を８×８のマトリクスの形式で表示したときの縦および横方向の位置をそれぞれ示し、添字ｖは上から０，１，２，．．．７であり、添字ｕは左から０，１，２，．．．７である。

【００２１】原画像データは、ＤＣＴ処理回路１２における２次元ＤＣＴによって、８×８＝６４個のＤＣＴ係数F_{vu}に変換される。２次元ＤＣＴは公知であるため、ここでは詳述しない。

【００２２】６４個のＤＣＴ係数のうち、位置（０，０）にあるＤＣＴ係数Ｆ００はＤＣ（直流）成分であり、残り６３個のＤＣＴ係数F_{vu}はＡＣ（交流）成分である。ＡＣ成分は、係数Ｆ０１もしくは係数Ｆ１０から係数Ｆ７７に向かって、より高い空間周波数成分が８×８画素ブロックの原画像データ中にどのくらいあるかを示している。ＤＣ成分は８×８画素のブロック全体の画素値の平均値（直流成分）を表している。すなわち、各ＤＣＴ係数F_{vu}はそれぞれ所定の空間周波数に対応している。

【００２３】量子化テーブルQ_{vu}を用いてＤＣＴ係数F_{vu}を量子化する式は（１）式により定義される。この式におけるround は、最も近い整数への近似を意味する。すなわち、ＤＣＴ係数F_{vu}および量子化テーブルQ_{vu}の各要素同士の割算と、四捨五入とによって、量子化ＤＣＴ係数R_{vu}が求められる。

【００２４】

・・・（１）

ると、逆量子化係数Ｆ’００（=16 ×16=256）が求められる。なお、ＤＣＴ係数Ｆ００（＝２６１）と、逆量子化係数Ｆ’００（＝２５６）との差分値ｉ００（256−261=−5）を係数値誤差とする。このように量子化では除算の余りを丸めるため、圧縮画像データの伸張（逆量子化）において係数値誤差ｉを生じる。これが量子化誤差の原因である。

【００２８】図４は、ＤＣＴ係数F_{vu}と、量子化および逆量子化した後の逆量子化ＤＣＴ係数F'_{vu}との各係数毎の係数値誤差i_{vu}を示す図である。本実施形態は、このように量子化、あるいは逆量子化によって生じる係数値誤差i_{vu}を予測し、各量子化係数q_{vu}を算出して量子化テーブルＱｙ、Ｑｃを作成することにより、量子化誤差を小さくする構成を備えている。

【００２９】図５は画像圧縮装置１０を詳細に示すブロック図である。画像圧縮装置１０には、ＤＣＴ処理回路１２、量子化処理回路１４、符号化処理回路と、さらに量子化テーブル作成装置２５とメモリ２６とが設けられる。量子化テーブル作成装置２５には、量子化誤差予測部２２と、量子化テーブル作成部２４とが設けられる。例えば１枚当たりｍブロック数であるｎ枚の画像データが画像１から順に画像単位毎に入力されると、まず輝度データＹと色差データＣｂ、Ｃｒに変換され、画像メモ

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リ１９に１画像分が記録される。画像メモリ１９から読み出された１枚分の画像データは、ＤＣＴ処理回路１２においてＤＣＴが施され、ＤＣＴ係数に変換される。画像単位で処理された画像データのＤＣＴ係数の統計量は、量子化誤差予測部２２に一時的に全画像（ｎ枚）分が記憶され、全ブロック（ｍ×ｎブロック数）のＤＣＴ係数の統計量から量子化誤差予測が行なわれる。その後、量子化誤差予測部２２による量子化誤差予測結果に基づいて、量子化テーブル作成部２４において量子化テーブルＱｙａ、Ｑｃａが算出され、メモリ２６に記録される。量子化処理回路１４はメモリ２６から量子化テーブルＱｙａ、Ｑｃａを読み取り、これらを量子化テーブルＱｙ、Ｑｃとして用い、量子化を行う。

【００３０】量子化誤差予測部２２における量子化誤差予測について詳述する。量子化テーブルＱｙにおける量子化係数をq_{vu}とすると、ＤＣＴ係数F_{vu}と逆量子化ＤＣＴ係数F'_{vu}との係数値誤差i_{vu}の範囲は、次の＊

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＊（２）式により表される。

【００３１】

$$-q_{vu}/2 \leq i_{vu} \leq q_{vu}/2 \quad \cdots (2)$$

【００３２】例えば量子化係数$q_{vu}=6$であれば、係数値誤差i_{vu}は－３、－２、－１、０、１、２、３の何れかに相当する。係数値誤差i_{vu}の範囲は、量子化係数q_{vu}が大きくなるにつれ拡大する。

【００３３】次にｍ×ｎブロックの係数値誤差i_{vu}が、（２）式に示した範囲内で平均的に分布すると予測し、（３）式によって係数値誤差i_{vu}の予測値rms_{vu}を求める。なお（３）式において、ｉは係数値誤差i_{vu}、ｑは量子化係数q_{vu}、ｒｍｓは各空間周波数における係数値誤差i_{vu}の二乗平均値の平方根、即ちｒｍｓ値を示す。例えばｑ＝６であれば、ｒｍｓ＝約１．７７９５である。

【００３４】

【数１】

$$rms = \sqrt{\left\{2\sum_{i=1}^{q/2-1} i^2 + (q/2)^2\right\} / q} \quad : q\text{は偶数} \quad \cdots (3)$$

$$rms = \sqrt{\left(2\sum_{i=1}^{(q-1)/2} i^2\right) / q} \quad : q\text{は奇数}$$

【００３５】図６に、量子化係数ｑとｒｍｓ値との対応表を示す。本実施形態では、輝度データＹは８ビット（２５６段階）で表され、量子化係数ｑは１から２５５まで変化することとする。この表によく示されるように、量子化係数ｑが大きくなると、係数値誤差ｉの範囲も大きくなるため、ｒｍｓ値は拡大する。

【００３６】本実施形態では、ｍ×ｎ個の全ブロックにおいて所定の条件を満たす、例えば各空間周波数におけるＤＣＴ係数F_{vu}の絶対値が２より大きいＤＣＴ係数の数を、標本数E_{vu}とする（$0 \leq E_{vu} \leq m \times n$）。本実施形態ではＤＣＴ係数$F_{vu}$の絶対値が２より大きい場合、量子化係数$q_{vu}$の値が大きくなるにつれ係数値誤差$i_{vu}$が大きくなる、また標本数$E_{vu}$が多くなるにつれ、画像全体の量子化誤差が拡大することに注目して、予測誤差合計値G_{vu}を次の（４）式で表している。

【００３７】

$$G_{vu} = rms_{vu} \times E_{vu} \quad \cdots (4)$$

【００３８】予測誤差合計値G_{vu}が各空間周波数について均一であれば、画像全体の量子化誤差は減少し、画像伸張時において復元性の高い再生画像データが得られる。従って本実施形態では、空間周波数の低い方、特にＤＣ成分に画像情報が集中する性質を利用して、まずＤＣ成分であるＤＣＴ係数Ｆ００の予測誤差合計値Ｇ００が、所定の量子化係数ｑ００から（３）式および（４）式により求められる。他のＤＣＴ係数F_{vu}（ｖ，ｕ≠０）、即ち６３個のＡＣ成分の予測誤差合計値G_{vu}は、ＤＣ成分の予測誤差合計値Ｇ００と同じ値として、（５）式により対応する予測誤差rms'_{vu}が算出され、量子化テーブル作成部２４に出力される。

【００３９】

$$rms'_{vu} = G00/E_{vu} \quad \cdots (5)$$

ただし　ｕ，ｖ≠０

【００４０】次に、量子化テーブル作成部２４における、量子化テーブル作成処理を説明する。前述の量子化誤差予測により得られた予測誤差rms'_{vu}は、（６）式に代入され、（６）式を満たすｑ’に最も近い整数である予測量子化係数q'_{vu}（ｖ，ｕ≠０）が求められる。

【００４１】

【数２】

$$rms' = \sqrt{\left\{2\sum_{i=1}^{q'/2-1} i^2 + (q'/2)^2\right\} / q'} \quad : q\text{は偶数}$$

・・・（６）

$$rms' = \sqrt{\left(2\sum_{i=1}^{(q'-1)/2} i^2\right) / q'} \quad : q\text{は奇数}$$

【００４２】例えば、480 ×720 画素の画像を２枚処理する場合、１枚の画像データ当たりのブロック数mは５４００なので、総ブロック数m×nは5400×2=10800 である。このときのＤＣ成分に対応する量子化係数ｑ00を６とし、ＤＣＴ係数Ｆ00の絶対値が２より大きい標本数Ｅ00を１０７８８とすると、（３）式および（４）式により予測誤差合計値Ｇ00＝１．７７９５×１０７８８＝１９１９７．２４６が求められる。ＡＣ成分、例えばＤＣＴ係数Ｆ77の絶対値が２より大きい標本数Ｅ77を６３０４とすると、（５）式により予測量子化係数ｒｍｓ’77＝１９１９７．２４６÷６３０４＝約３．０４５２が求められ、（６）式を満たす予測量子化係数ｑ’77＝１１が求められる。

【００４３】以上のように求められた各予測量子化係数ｑ’$_{vu}$は、所定の圧縮比に応じてスケーリングされ、８×８のマトリクスＱｙａの形で量子化処理回路１４に出力される。画像圧縮では、量子化係数ｑを大きくすると高圧縮ができるが、画質は劣化する。逆に量子化係数ｑを小さくすると画質は向上するが、圧縮後のデータ量が大きくなる。画質は、量子化係数ｑに所定の圧縮比をかけることによりコントロールされる。

【００４４】図７は作成された量子化テーブルを示す。図７（ａ）は輝度値Ｙ用の量子化テーブルＱｙａであり、図７（ｂ）は色差Ｃｂ、Ｃｒ用の量子化テーブルＱｃａである。図２と比較すると、特にＡＣ成分に対応する量子化係数に違いが見られる。

【００４５】図８、図９のフローチャートを参照して、量子化テーブル作成処理を説明する。図８および図９において、ＢＬＯＣＫＳはブロック数を示す変数であり、ＢＡは処理する総ブロック数（ｍ×ｎ）である。Ｆ$_{vu}$はＤＣＴ係数を示し、添字ｖ、ｕは、それぞれ０から７まで変化する。Ｅ$_{vu}$は標本数を示す変数である。

【００４６】まず図８を参照する。ステップＳ１０２では、変数ＢＬＯＣＫＳと変数Ｅ$_{vu}$との初期値がそれぞれ０に設定される。ステップＳ１０４では変数ｖの初期値が０、ステップＳ１０６では変数ｕの初期値が０に設定される。ステップＳ１０８ではＤＣＴ係数Ｆ$_{vu}$の絶対値が２よりも大きいか否かが判定される。ＤＣＴ係数Ｆ$_{vu}$の絶対値が２よりも大きければ、ステップＳ１１０において標本数Ｅ$_{vu}$が１インクリメントされステップＳ１１２に進む。ＤＣＴ係数Ｆ$_{vu}$の絶対値が２より大きくなければ、ステップＳ１１２に進み、変数ｕが１インクリメントされる。

【００４７】ステップＳ１１４では変数ｕが８であるか否かが判定され、ｕが８でない、即ち７以下であれば、ステップＳ１０８から再実行される。ｕ＝８であればステップＳ１１６に進み、変数ｖが１インクリメントされる。同様に、ステップＳ１１８では変数ｖが８であるか否かが判定され、ｖが８でない、即ち７以下であれば、ステップＳ１０６から再実行される。ｖ＝８であればステップＳ１２０に進む。

【００４８】ステップＳ１２０では、変数ＢＬＯＣＫＳが１インクリメントされ、ステップＳ１２２において変数ＢＬＯＣＫＳが総ブロック数ＢＡであるか否かが判定される。ＢＬＯＣＫＳがＢＡでなければ、ステップＳ１０４から再実行され、ＢＬＯＣＫＳ＝ＢＡであればステップＳ１２４に進む。

【００４９】このように、８×８のＤＣＴ係数のマトリクスＦ$_{vu}$において、まず一番上の横一列の標本数Ｅ$_{vu}$が左から順にカウントされ、順に次の横一列の標本数Ｅ$_{vu}$がカウントされる。即ち図８の処理では、６４個の各周波数成分において、ＤＣＴ係数Ｆ$_{vu}$の絶対値が２より大きい標本数Ｅ$_{vu}$がそれぞれカウントされる。

【００５０】次に図９を参照する。ステップＳ１２４では変数ｖの初期値が０、ステップＳ１２６では変数ｕの初期値が０に設定される。ステップＳ１２８では変数ｖ、ｕが共に０であるか否かが判定される。変数ｖ、ｕが共に０であればステップＳ１３０に進み、変数ｖ、ｕが共に０でなければ、ステップＳ１３２に進む。

【００５１】ステップＳ１３０では、所定の量子化係数ｑ00に基づいて、（３）式を用いてｑ00のｒｍｓ値、即ちｒｍｓ00が求められる。このｒｍｓ00と標本数Ｅ00との乗算により、予測誤差合計値Ｇ00が求められ、ステップＳ１３４に進む。

【００５２】ステップＳ１３２では、予測誤差合計値Ｇ00と標本数Ｅ$_{vu}$を（５）式に代入して、ｒｍｓ値であるｒｍｓ’$_{vu}$が求められる。その後、ｒｍｓ’$_{vu}$を（６）式に代入することにより予測量子化係数ｑ’$_{vu}$が求められ、ステップＳ１３４に進む。

【００５３】ステップＳ１３４では、変数ｕが１インク

リメントされ、ステップＳ１３６では変数ｕが８であるか否かが判定される。ｕが８でない、即ち７以下であれば、ステップＳ１２８から再実行される。ｕ＝８であればステップＳ１３８に進み、変数ｖが１インクリメントされる。同様に、ステップＳ１４０では変数ｖが８であるか否かが判定され、ｖが８でない、即ち７以下であれば、ステップＳ１２６から再実行される。ｖ＝８であれば処理は終了する。

【００５４】このように、まず量子化係数ｑ００によりＤＣ成分の予測誤差合計値Ｇ００を求め、ＤＣ成分のｒｍｓ００を決定する（ステップＳ１３０）。そして、ＡＣ成分の各ｒｍｓ値ｒｍｓ’$_{vu}$を、各標本数Ｅ$_{vu}$と予測誤差合計値Ｇ００とから求め、予測量子化係数ｑ’$_{vu}$（ｖ，ｕ≠０）を算出する（ステップＳ１３２）。即ち図９の処理では、ＤＣ成分の予測誤差合計値Ｇ００を基に、ＡＣ成分の各周波数成分に対応した６３個の予測量子化係数ｑ’$_{vu}$が決定される。

【００５５】再び図５を参照する。量子化テーブル作成部２４では、前述のように６４個の予測量子化係数ｑ’$_{vu}$が決定され、量子化テーブルＱｙａとして出力される。また輝度Ｙ用の量子化テーブルＱｙａと同様に、色差Ｃｒ、Ｃｂ用量子化テーブルＱｃａが作成され、出力される。このように量子化テーブル作成装置２５における量子化テーブル作成処理が終了する。

【００５６】量子化テーブル作成部２４から出力された量子化テーブルＱｙａ、Ｑｃａは、メモリ２６に記録される。量子化処理回路１４はこのメモリ２６から量子化テーブルＱｙａ、Ｑｃａを読み出して、量子化テーブルＱｙ、Ｑｃとして量子化を行う（図１参照）。なお、メモリ２６は複数組の量子化テーブルＱｙ、Ｑｃが記録可能であり、図示しないスイッチにより、何れかの量子化テーブルが選択される。

【００５７】図１０は画像と量子化テーブルとの関係を示すブロック図である。例えば風景画像ａ、ｂ、ｃ、．．を入力すれば、この風景画像に適した風景用量子化テーブルＱｙａ、Ｑｃａが作成される。同様に、風景画像ａ、ｂ、ｃ、．．と異なる画像、即ち人物画像１、２、３、．．を入力画像とすると、この人物画像に最適な人物用量子化テーブルＱｙｂ、Ｑｃｂが作成される。また、同様にスポーツ画像イ、ロ、ハ、．．に適したスポーツ用量子化テーブルＱｙｃ、Ｑｃｃを作成することができる。

【００５８】これら３組の量子化テーブル（Ｑｙａ，Ｑｃａ）、（Ｑｙｂ，Ｑｃｂ）、（Ｑｙｃ，Ｑｃｃ）は、メモリ２６に記録され、例えば人物画像を被写体とする場合は量子化テーブルＱｙｂ、Ｑｃｂが量子化処理回路１４により読み出される。このように画風に対応した量子化テーブルＱｙ、Ｑｃをスイッチを切り替えて選択することにより、量子化誤差のより少ない画像圧縮が可能になる。なお本実施形態では、画像の種類を風景、人物、スポーツの３種類に定めているが、特に種類や数に限定されず、例えば撮影者毎に量子化テーブルを変えるように構成してもよい。

【００５９】本実施形態では、入力された総ブロックのＤＣＴ係数から量子化誤差を予測する量子化誤差予測部を設けているので、入力された全ての画像に最適な単一の量子化テーブルを作成できる。従って広範な画像ファイルに対して、同じ圧縮画像データ量で量子化誤差の少ない再生画像データを得ることができる。また、本実施形態では、量子化誤差をＤＣＴ係数から予測処理することにより求めているので、一度逆量子化した値から量子化誤差を求める従来の方法に比べ、量子化テーブル作成処理が迅速に行われる。さらに、複数組の量子化テーブルをメモリに記録させることにより、複数の画風に適した再生画像データが得られる。

【００６０】

【発明の効果】本発明によると、量子化誤差を予測し、量子化と逆量子化による画像劣化が少ない画像圧縮を容易にする画像圧縮装置を提供することができる。

【図面の簡単な説明】

【図１】本発明による画像圧縮装置の実施形態を、カメラとともに示すブロック図である。

【図２】従来の量子化テーブルを示す図である。

【図３】輝度データＹのＤＣＴ係数Ｆ$_{vu}$と、量子化ＤＣＴ係数Ｒ$_{vu}$と、逆量子化ＤＣＴ係数Ｆ’$_{vu}$、および量子化テーブルＱｙを示す図である。

【図４】ＤＣＴ係数Ｆ$_{vu}$と、逆量子化ＤＣＴ係数Ｆ’$_{vu}$との各係数毎の係数値誤差ｉ$_{vu}$を示す図である。

【図５】画像圧縮装置の構成を示すブロック図である。

【図６】量子化係数ｑとｒｍｓ値との対応を示す表である。

【図７】作成された量子化テーブルＱｙａ、Ｑｃａを示す図である。

【図８】量子化テーブル作成処理のフローチャートの前半部分を示す図である。

【図９】量子化テーブル作成処理のフローチャートの後半部分を示す図である。

【図１０】画像と量子化テーブルの関係を示すブロック図である。

【符号の説明】

１０　圧縮画像装置
１１　撮影光学系
１３　色分解光学系
１５　撮像素子
１７　信号処理回路
１９　画像メモリ
１２　ＤＣＴ処理回路
１４　量子化処理回路
１６　符号化処理回路
２２　量子化誤差予測部

13

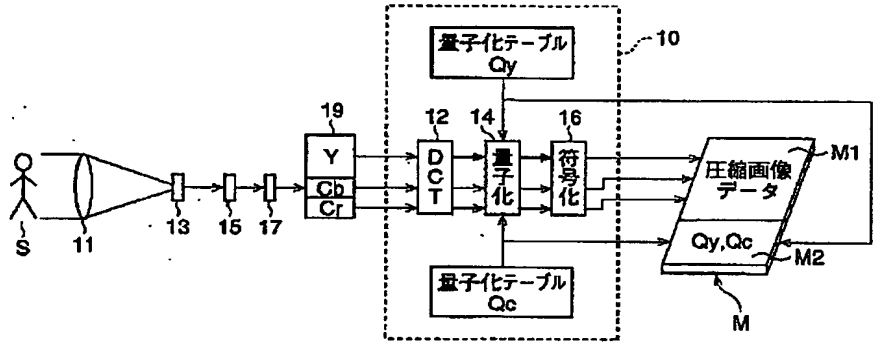
２４　量子化テーブル作成部

２５　量子化テーブル作成装置

14

２６　メモリ

【図１】



【図２】

(a)

16	11	10	16	24	40	51	61
12	12	14	19	26	58	60	55
14	13	16	24	40	57	69	56
14	17	22	29	51	87	80	62
18	22	37	56	68	109	103	77
24	35	55	64	81	104	113	92
49	64	78	87	103	121	120	101
72	92	95	98	112	100	103	99

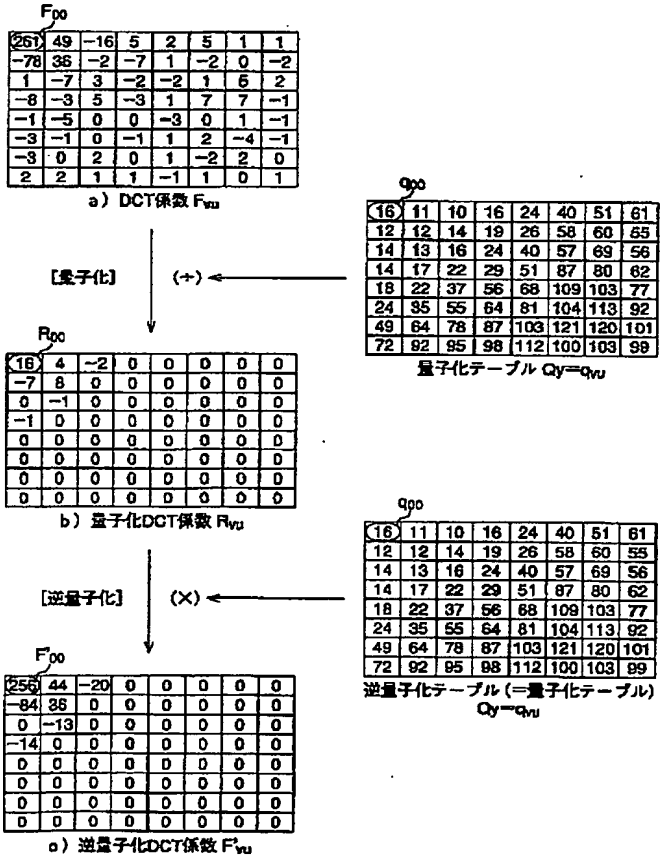
Qy

(b)

17	18	24	47	99	99	99	99
18	21	26	66	99	99	99	99
24	26	56	99	99	99	99	99
47	66	99	99	99	99	99	99
99	99	99	99	99	99	99	99
99	99	99	99	99	99	99	99
99	99	99	99	99	99	99	99
99	99	99	99	99	99	99	99

Qc

【図３】



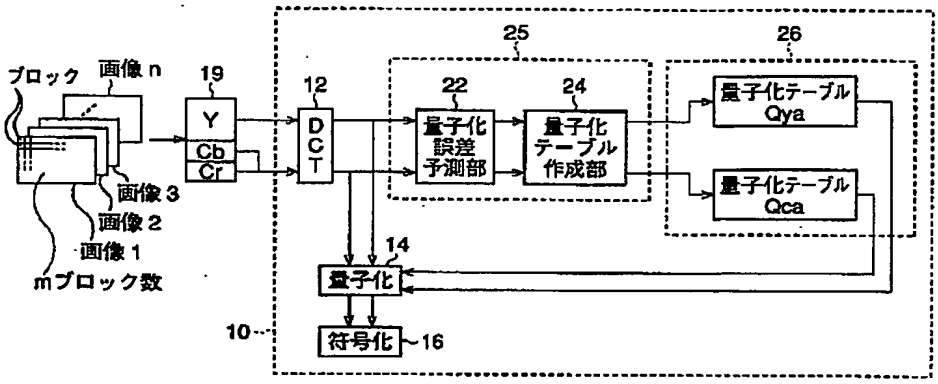
【図６】

q	rms
1	0
2	0.7071
3	0.8165
4	1.2247
5	1.4142
6	1.7795
7	2
8	2.3452
9	2.5820
10	2.9155
11	3.1623
12	3.4881
13	3.7417
14	4.0620
15	4.3205
16	4.6368
17	4.8990
⋮	⋮
253	72.7423
254	73.0342
255	73.3246

【図４】



【図５】



【図７】

(a)

16	11	10	16	20	25	30	42
12	12	14	19	23	37	40	41
14	13	16	20	30	38	44	42
14	17	22	25	35	44	48	42
18	22	29	33	42	51	54	44
20	27	30	35	40	53	52	42
35	42	44	46	53	67	70	54
42	44	50	52	54	57	58	60

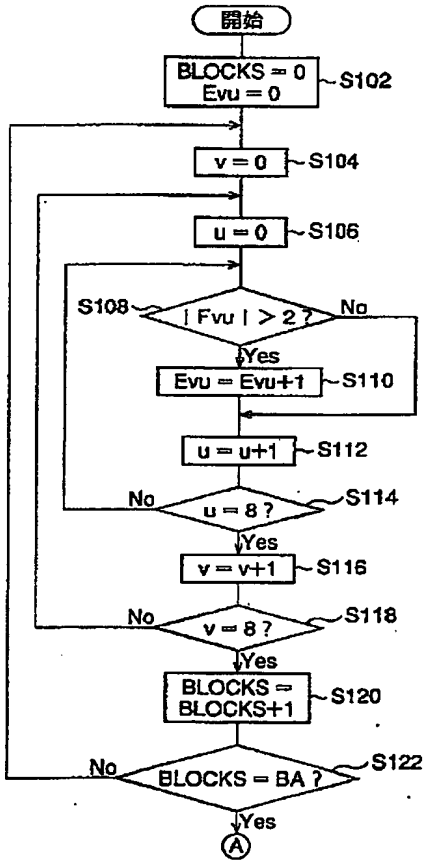
Qya

(b)

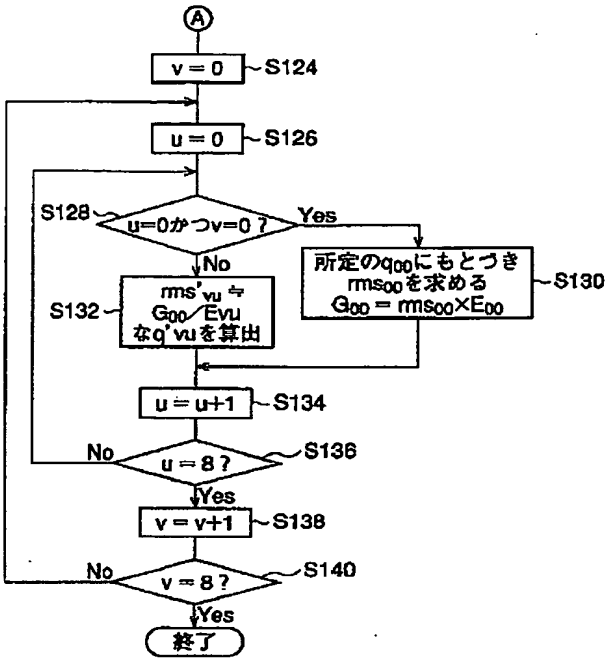
17	18	23	38	48	49	52	55
18	21	22	30	45	47	53	56
20	22	31	46	52	54	56	57
32	40	48	54	58	62	64	63
49	51	53	52	58	56	63	70
52	55	56	63	68	71	73	70
56	55	60	62	65	68	72	75
66	64	70	73	68	71	75	80

Qca

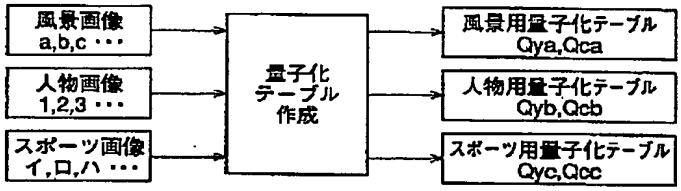
【図８】



【図９】



【図１０】



【手続補正書】
【提出日】平成９年１１月１９日
【手続補正１】
【補正対象書類名】明細書
【補正対象項目名】００２３
【補正方法】変更
【補正内容】
【００２３】量子化テーブルＱｙを用いてＤＣＴ係数Ｆvuを量子化する式は（１）式により定義される。この式におけるround は、最も近い整数への近似を意味する。

$$R_{vu} = \mathrm{round}\left(F_{vu} / q_{vu}\right) \quad \cdots (1)$$

｛0≦u,v ≦7｝
【手続補正３】
【補正対象書類名】明細書
【補正対象項目名】００２６
【補正方法】変更
【補正内容】
【００２６】符号化された圧縮画像信号を伸張して、画面に表示するためには、復号化、逆量子化、２次元ＤＣＴの逆変換（以下、２次元ＩＤＣＴという）の処理が必要である。この復号化は、ハフマン符号化とは逆の作用であり、従来公知であるため詳述しない。復号化によって得られた量子化ＤＣＴ係数は、量子化に用いた量子化テーブルＱｙ、Ｑｃを用いてそれぞれ逆量子化され、逆量子化ＤＣＴ係数に変換される。これらの逆量子化ＤＣＴ係数は２次元ＤＣＴの逆変換である２次元ＩＤＣＴをすなわち、ＤＣＴ係数Ｆvuおよび量子化テーブルＱｙの各要素同士の割算と、四捨五入とによって、量子化ＤＣＴ係数Ｒvuが求められる。
【手続補正２】
【補正対象書類名】明細書
【補正対象項目名】００２４
【補正方法】変更
【補正内容】
【００２４】
・・・（１）
施され、それぞれ輝度データＹ’、色差データＣｂ’、Ｃｒ’に変換される。２次元ＩＤＣＴについても公知であるのでここでは詳述しない。
【手続補正４】
【補正対象書類名】明細書
【補正対象項目名】００２９
【補正方法】変更
【補正内容】
【００２９】図５は画像圧縮装置１０を詳細に示すブロック図である。画像圧縮装置１０には、ＤＣＴ処理回路１２、量子化処理回路１４、符号化処理回路１６と、さらに量子化テーブル作成装置２５とメモリ２６とが設けられる。量子化テーブル作成装置２５には、量子化誤差予測部２２と、量子化テーブル作成部２４とが設けられる。例えば１枚当たりｍブロック数であるｎ枚の画像デ

ータが画像１から順に画像単位毎に入力されると、まず輝度データＹと色差データＣｂ、Ｃｒに変換され、画像メモリ１９に１画像分が記録される。画像メモリ１９から読み出された１枚分の画像データは、ＤＣＴ処理回路１２においてＤＣＴが施され、ＤＣＴ係数に変換される。画像単位で処理された画像データのＤＣＴ係数の統計量は、量子化誤差予測部２２に一時的に全画像（ｎ枚）分が記憶され、全ブロック（ｍ×ｎブロック数）のＤＣＴ係数の統計量から量子化誤差予測が行なわれる。その後、量子化誤差予測部２２による量子化誤差予測結果に基づいて、量子化テーブル作成部２４において量子化テーブルＱｙａ、Ｑｃａが算出され、メモリ２６に記＊録される。量子化処理回路１４はメモリ２６から量子化テーブルＱｙａ、Ｑｃａを読み取り、これらを量子化テーブルＱｙ、Ｑｃとして用い、量子化を行う。

【手続補正５】
【補正対象書類名】明細書
【補正対象項目名】００４１
【補正方法】変更
【補正内容】
【００４１】
【数２】

$$rms' = \sqrt{\left\{2\sum_{i=1}^{q'/2-1} i^2 + (q'/2)^2\right\} / q'} \quad : q' \text{は偶数}$$

・・・（６）

$$rms' = \sqrt{\left(2\sum_{i=1}^{(q'-1)/2} i^2\right) / q'} \quad : q' \text{は奇数}$$

【手続補正６】
【補正対象書類名】明細書
【補正対象項目名】符号の説明
【補正方法】変更
【補正内容】
【符号の説明】
１０　画像圧縮装置
１１　撮影光学系
１３　色分解光学系
１５　撮像素子
１７　信号処理回路
１９　画像メモリ
１２　ＤＣＴ処理回路
１４　量子化処理回路
１６　符号化処理回路
２２　量子化誤差予測部
２４　量子化テーブル作成部
２５　量子化テーブル作成装置
２６　メモリ

MAY 11 2009
PATENT & TRADEMARK OFFICE

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Re: Application of: Jani Lainema

Attorney Docket: 944-001-107-2

Serial No.: 11/881,367

Group Art Unit: 2621

Filed: July 26, 2007

Examiner: to be assigned

For: **METHOD AND DEVICE FOR INDICATING QUANTIZER PARAMETERS IN A VIDEO CODING SYSTEM**

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

SUPPLEMENTAL INFORMATION DISCLOSURE STATEMENT

Sir:

Applicant submits herewith references of which they are aware, which they believe may be material to the examination of this application and in respect of which they may have a duty to disclose in accordance with 37 C.F.R. 1.56.

I hereby certify that this correspondence is being deposited today with the United States Postal Service as first class mail in an envelope addressed to Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450

Marie E. Forte — May 6, 2009
Marie E. Forte — Date

This Supplemental Information Disclosure Statement is timely since it is certified by the undersigned that each item of information contained in the Supplemental Information Disclosure Statement was first cited in any communication from a foreign patent office (copy enclosed) in a counterpart foreign application not more than three months prior to the filing of this Supplemental Information Disclosure Statement per 37 C.F.R. 1.97(c) and 37 C.F.R. 1.97 (e)(1), therefore, the undersigned respectfully submits that no fee is due. The Commissioner is hereby authorized to charge to Deposit Account 23-0442 any fee deficiency required to submit this Supplemental Information Disclosure Statement.

The references are listed in the enclosed translation of a foreign office action dated 16 March 2009. A PTO 1449 listing the cited references is also enclosed. Please note that JP2000197049 is also published as US 6,879,632 B1 and JP2002044604 is published as US 7,367,041 B2.

Respectfully submitted,

Kenneth Q. Lao
Registration No. 40,061

Date: May 6, 2009

WARE, FRESSOLA, VAN DER SLUYS
& ADOLPHSON LLP
Bradford Green, Building 5
755 Main Street, PO Box 224
Monroe, CT 06468
(203) 261-1234

OPAP IAP15 JAN 20 2010 PATENT & TRADEMARK OFFICE

INFORMATION DISCLOSURE CITATION FORM FOR PATENT APPLICATION (FORM PTO-1449) (Substitute)	Docket No.: 944-001.107-2	Serial No.: 11/881,367
	Applicant(s): Jani Lainema	
	Filing Date: July 26, 2007	Group: 2621

U.S. PATENTS

Initials	Patent Number	Issue Date	Name	Class	Sub-class	Filing date
	US 5,835,030	11-10-1998	Tsutsui et al	341	51	

U.S. PATENT PUBLICATIONS

Initials	Publication No.	Pub. Date	Name	Class	Sub-class	Filing Date

FOREIGN PATENT DOCUMENTS

Initials	Document Number	Date	Country	Name	Translation? Yes/No/n/a

OTHER DOCUMENTS (Title, Author, Date, Pages, Etc., if known)

Examiner's Signature:	Date Considered:

Initial if reference was considered, whether or not citation is in conformance with MPEP. Mark through citation if not considered. Include a copy of this citation form with your next correspondence to the Applicant(s).

Customer No.: 4955

Patent Attorneys
Youngpil LEE *
Y.T. MOCK *

Trademarks & Litigation
Kyoojong YOO †
Howard JEAN *†‡
Hengsub JIN *†
Joonhyo KIM *†
Daesik KIM *
Taeho LEE *
Jordan Yongsik KIM *
Daeseong CHANG *
Younggi HONG *
Sunyoung MOCK *
S. Yong LEE *
Yoonkyung CHO *
Youngjoo KIM *
Hyounggeun YOON *
Taewhan JEONG
Hyongok KIM
Yegoo HA

Chemistry & Materials
Euibak KIM *
Yijoo PARK *
Hyunju KIM *
Hyesook PARK *
Chulwoong PARK *

Materials (cont'd)
Byeongmo LEE *
Dongjoon KANG *
Minyoung SHIN *
Kwonseok KIM *
Sungshig KANG *
Soyoung NAM *
Junhyeok CHOI *
Eungsoo KIM *
Jihyung BYUN *
Kwanho LEE
Gilja KWON
Jungsun KIM
Seokjin HWANG
Bohee CHAI
Burmtak HAN
Youngki MIN

Biotechnology & Pharmaceutics
Hyunsook HAN *§
Byungjae KIM *
Eunhui JOO *
Hyekyung LIM *
Somyoung RYU *
Woong KIM *
Hyuk PARK *

Mechanics
Eunwoo LEE *
Jeongkeun LEE *
Heuiyoung YANG *
Unsuk KOO *
Hyuntae CHA *
Taehyung KIM *
Jason Y. PAHNG #

* Korean Patent Bar
† Korean Bar
‡ U.S. State Bar
U.S. Patent Bar
§ Ph.D.

Y.P. LEE, MOCK & PARTNERS

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KORYO BUILDING
1575-1 SEOCHO-DONG, SEOCHO-GU
SEOUL, REPUBLIC OF KOREA 137-875

Telephone: (82) (2) 588-8585
Facsimile: (82) (2) 588-8586
(82) (2) 598-8586
(82) (2) 588-8547/8

E-mail: iplaw@leemock.com
Website: www.leemock.com

Sooyoung HA *
Kyuseung CHOI *
Joonhee JOO *
Youngjo PARK *
Kwangjae LEE *
Jaegab LEE *
Kwanho MIN *
Juhyun AHN *
Hoyong PAIK *
Eungsock KIM *
Sungpil CHUN *
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Joongkeun MOON
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Ohjoon KWON
Hyunjung KIM
Youngin SEO
Wanho KIM
Kyungah PARK
Jongho KIM
Sean BAXENDELL
Alan CASEY

December 4, 2009

Kenneth Q. Lao, Esq.
Ware, Fressola, Van Der Sluys & Adolphson LLP
Bradford Green, Building Five
755 Main Street, P.O. Box 224
Monroe, Connecticut 06468
U.S.A.

VIA E-MAIL

Your Ref.: 944-001.107-1-4
Our Ref.: PM04-20965PCT

Re: Nokia Corporation
Korean Patent Application No. 2004-7017070
(International Application No.PCT/IB03/01528)

Dear Mr. Lao:

We have received an Office action (Non-Final Rejection) from the Korean Intellectual Property Office (KIPO) with respect to the above-identified application. A copy of the Office action, English translation thereof and the cited reference are enclosed for your review. Either a full response to the Office action or a request for an extension of the term to respond must be filed by **January 16, 2010**. 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 be filed by the due date for filing a response and the due date for filing a response can only be extended for a maximum period of four months from the initial due date.

Claims 1, 7, 9, 13-15, 19, 20, 22-28, 31, 32 and 34-36 are currently pending in the present application. We also enclose herewith an English translation of the pending claims. In the outstanding Office action, all claims are rejected as being unpatentable in view of the prior art of record. We provide below, the Examiner's grounds of rejection and our comments thereon.

Grounds of Rejection. The present application is not in condition for allowance because claims 1, 7, 9, 13-15, 19, 20, 22-28, 31, 32 and 34-36 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.

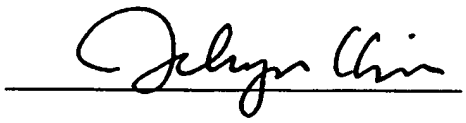
Claims 1, 7, 9, 13-15, 19, 20, 22-28, 31, 32 and 34-36 are rejected on the grounds that the claims would have been obvious over the cited reference (WO 1995/27336, published on October 12, 1995). We enclose herewith a copy of the cited reference without our detailed comments in order to comply with the Nokia Communication Guidelines for External Associates. Please review the cited reference and provide us with an explanation on how to distinguish the claimed inventions from the cited reference in terms of the objectives, technical features, and effects thereof, so as to clearly demonstrate the inventive step of the claimed invention.

Conclusion

We would like you to review our comments and provide us with your instructions and comments at least two weeks before the due date of **January 16, 2010,** so that we may have sufficient time to prepare a response. In the absence of your instructions by the due date, we will submit a request for a one-month extension of the term for filing a response to maintain pendency of this application.

Sincerely yours,

Y.P. LEE, MOCK & PARTNERS



Jehyun KIM

JHK/JHR/jc
Enclosures:
1. Pending Claims
2. Translation of Non-Final Rejection
3. Copy of Non-Final Rejection
4. Cited Reference

[translation]

Korean Intellectual Property Office

NON-FINAL REJECTION

Applicant
Name: Nokia Corporation (Applicant Code: 520000368439)
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.: 10-2004-7017070

Title: Method and Device for Indicating Quantizer Parameters in a Video Coding System

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 **January 16, 2010**. 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, 7, 9, 13, 14, 15, 19, 20, 22, 23, 24, 25, 26, 27, 28, 31, 32, 34, 35, and 36

□ Rejected parts of the present application and related articles of the Korean Patent Law

Number	Rejected Parts	Related Articles
1	Claims 1, 7, 9, 13, 14, 15, 19, 20, 22-28, 31, 32, and 34-36	Article 29, Paragraph 2 of the Korean Patent Law

[GROUNDS OF REJECTION]

1. The present application is not in condition for allowance because claims 1, 7, 9, 13, 14, 15, 19, 20, 22-28, 31, 32, and 34-36 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.

(1) Claim 1 of the present application is directed to:

a method of encoding a digital video sequence, the method comprising:

(a) defining a default level of quantization for use in encoding of the digital video sequence;

(b) encoding a frame of the digital video sequence by applying motion compensated prediction to blocks of pixels for producing corresponding blocks of prediction error values;

(c) applying a transform coding technique to said blocks of prediction error values to produce sets of transform coefficient values;

(d) selecting a level of quantization based on the default level of quantization;

(e) quantizing the sets of transform coefficient values based on the selected level of quantization; and

(f) providing an indication of the default level of quantization to the encoded video sequence.

also published as US 5,835,030

Meanwhile, International Patent Publication No. WO1995/27336 (published on October 12, 1995; referred hereinafter as a cited reference) ~~is related to:~~

an audio signal encoding method for encoding an input signal, the method comprising the steps of:

(a') transforming the input signal into spectrum signals;

(b') quantizing the spectrum signals by every unit;

(c') encoding at least a portion of the quantized spectrum signals by using one or more predetermined code tables;

(d') determining the extent of application of the selected code table to the quantized spectrum signals based on a predetermined criteria; and

(e') adding application status indicating the selected code table and the extent of application of the code table to the encoded spectrum signals of every predetermined data unit.

Here, the step (d) of claim 1 of the present application corresponds to the step (d') of the cited reference,

the step (e) of the claim 1 of the present application corresponds to the step (d') of the cited reference, and

the step (f) of the claim 1 of the present application corresponds to the step (e') of the cited reference.

Although the steps (a), (b), and (c) of claim 1 of the present application are not recited in the cited reference, the detailed description of the cited reference defines steps prior to the steps above, the steps including blocking every samples of time series sample

data, obtaining spectrum data by implementing MDCT, and calculating normalization coefficients for each of units and normalizing spectrums. Here,

the step (a) of claim 1 of the present application corresponds to the normalization in the cited reference, and

the steps (b) and (c) of the claim 1 of the present application correspond to the implementation of MDCT in the cited reference.

Accordingly, the differences between the technical features recited in claim 1 of the present application and the technical features disclosed in the cited reference are no more than simple modifications of each other. Therefore, it would have been obvious to one of ordinary skill in the art to invent the technical features recited in claim 1 in view of the cited reference.

(2) Claims 7, 9, 13, and 14 of the present application are dependent claims which add or further limits claim 1 of the present application to update the default level of quantization during the encoding of the digital video sequence and provide to a decoding process an indication of a difference between said level of quantization and the default level of quantization.

Meanwhile, according to the cited reference, a normalization level and a quantizing table during the encoding operation are adaptively changed and applied and table ID, and normalization coefficient used by each of units are provided by the units. Accordingly, claims 7, 9, 13, and 14 of the present application and the cited reference correspond to each other, and thus it would have been obvious to one of ordinary skill in the art to invent the technical features recited in claims 7, 9, 13, and 14 of the present application in view of the cited reference.

(3) A video encoder recited in claims 15, 19, 20, and 22-25 of the present application is an apparatus corresponding to the encoding method recited in claims 1, 7, 9, 13, and 14 of the present application, and the technical features of claims 15, 19, 20, and 22-25 of the present application and the technical features of claims 1, 7, 9, 13, and 14 of the present application are materially the same. Therefore, the correspondences of the technical features of the claims 15, 19, 20, and 22-25 of the present application to the technical features of the cited reference are the same as described above in (1) and (2).

(4) The technical features of claims 26 and 27 of the present application are applications of the video encoder recited in claim 15 of the present application to a multimedia terminal and a radio telecommunication device. Although the technical features of claims 26 and 27 of the present application are not clearly stated in the cited reference, application of video encoded signals and an encoder device to a multimedia terminal and a portable device are no more than a simple application of known techniques, and thus it would have been obvious to one of ordinary skill in the art to invent the technical features recited in claims 26 and 27 of the present application in view of the cited reference.

(5) A method of decoding an encoded digital video sequence recited in claims 28 and 31 of the present application is a method of decoding the 'method of encoding a video sequence' recited in claims 1 and 9 of the present application. Since encoding and decoding complement each other in video compression, and it would have been obvious to one of ordinary skill in the art that decoding is required after encoding in motion

picture transmission system. Therefore, the technical features recited in claims 29 and 31 of the present application are actually inversed configuration of the technical features recited in claims 1 and 9 of the present application, and correspondences of the technical features of claims 29 and 31 of the present application to the technical features of the cited reference are the same as described above in (1) and (2).

(6) A video decoder recited in claims 32 and 34 of the present application is a device for decoding the 'method of encoding a video sequence' recited in claims 1 and 9 of the present application. Since encoding and decoding complement each other in video compression, and it is obvious to one of ordinary skill in the art that decoding is required after encoding in motion picture transmission system. Therefore, the technical features recited in claims 32 and 34 of the present application are actually inversed configuration of the technical features recited in claims 1 and 9 of the present application, and the correspondences of the technical features of claims 32 and 34 of the present application to the technical features of the cited reference are the same as described above in (1) and (2).

(7) The Technical features of claims 35 and 36 of the present application are applications of the video decoder recited in claim 32 of the present application to a multimedia terminal and a radio telecommunication device. Although the technical features of claims 35 and 36 of the present application are not clearly stated in the cited reference, application of video encoded signals and an encoder device to a multimedia terminal and a portable device are no more than a simple application of known techniques, and thus it would have been obvious to one of ordinary skill in the art to invent the technical features recited in claims 35 and 36 of the present application in view of the cited reference.

Enclosure: 1. International Patent Publication No. WO1995/27336 (October 12, 1995)

November 16, 2009

KOREAN INTELLECTUAL PROPERTY OFFICE

Information and Communications Examinations Bureau
Digital Broadcasting Examination Division

Examiner: Wooyeon CHO

US005835030A

United States Patent [19]

Tsutsui et al.

[11] Patent Number: 5,835,030

[45] Date of Patent: Nov. 10, 1998

[54] **SIGNAL ENCODING METHOD AND APPARATUS USING SELECTED PREDETERMINED CODE TABLES**

[75] Inventors: **Kyoya Tsutsui**, Kanagawa; **Mito Sonohara**, Tokyo; **Osamu Shimoyoshi**, Kanagawa, all of Japan

[73] Assignee: **Sony Corporation**, Tokyo, Japan

[21] Appl. No.: **535,217**

[22] PCT Filed: **Apr. 3, 1995**

[86] PCT No.: **PCT/JP95/00644**

§ 371 Date: **Jan. 26, 1996**

§ 102(e) Date: **Jan. 26, 1996**

[87] PCT Pub. No.: **WO95/27336**

PCT Pub. Date: **Oct. 12, 1995**

[30] **Foreign Application Priority Data**

Apr. 1, 1994 [JP] Japan 6-065343

[51] **Int. Cl.**[6] **H03M 7/03**; G11B 20/10

[52] **U.S. Cl.** **341/51**; 341/106

[58] **Field of Search** 341/106, 67, 58, 341/59, 68, 51

[56] **References Cited**

U.S. PATENT DOCUMENTS

4,485,337	11/1984	Sandusky	318/314
4,669,120	5/1987	Ono	381/40
4,908,810	3/1990	Oie	369/50
4,972,484	11/1990	Theile	381/37
5,040,217	8/1991	Brandenburg	381/47
5,045,812	9/1991	Tateishi	331/10
5,063,550	11/1991	Watari et al.	369/44.36
5,109,417	4/1992	Fielder	381/36
5,204,677	4/1993	Akagiri et al.	341/118
5,223,926	6/1993	Stone et al. .	
5,301,205	4/1994	Tsutsui et al.	375/1
5,311,561	5/1994	Akagiri	375/122
5,365,530	11/1994	Yoshida	371/37.4
5,440,404	8/1995	Okamoto	358/432

FOREIGN PATENT DOCUMENTS

39 33974 A1	4/1990	Germany	B11B 19/274
3-72722	3/1991	Japan	H03M 7/30
4-343577	11/1992	Japan	H04N 1/41
2 252 002	7/1992	United Kingdom	H04N 7/133

OTHER PUBLICATIONS

T. Mochizuki et al., "Constraint Conditions for Multiple–Blocksize Modified–DCT," Technical Research Report of the Institute of Electronics and Communication Engineers of Japan, CAS90–10, DSP 90–14, pp. 55–60.

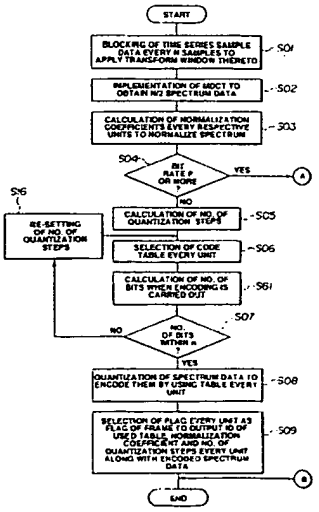
F. Hazu et al., "Adaptive Block Length Adaptive Transform Coding Using MDCT (ATC–ABS)," Society of Electronics and Information Communication Engineers of Japan, Spring National Meeting Lecture Collection of 1990, A–197.

Primary Examiner—Marc S. Hoff
Assistant Examiner—Peguy JeanPierre
Attorney, Agent, or Firm—Limbach & Limbach, LLP

[57] **ABSTRACT**

An apparatus for encoding data includes adaptive bit allocation encoding circuitry that normalizes frames of input spectrum data into transform frames in accordance with normalization coefficients and number of quantization step information. Quantized data encoding circuitry encodes each transform frame of normalized spectrum data with at least one selected code table of a plurality of code tables in accordance with a code table selection signal. Code train generation circuitry generates a code train that includes the encoded normalized spectrum data and information indicative of the at least one selected code table and of the normalization coefficients and number of quantization step information in accordance with which the encoding circuitry normalizes each frame of input spectrum data. Control circuitry generates the code table selection signal, the number of quantization step information, and the normalization coefficients in response to the input spectrum data.

19 Claims, 12 Drawing Sheets



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国 際 事 務 局

PCT

特許協力条約に基づいて公開された国際出願

(51) 国際特許分類6
H03M 7/30, G11B 20/10, H04B 14/04, G10L 7/04, 9/18

A1

(11) 国際公開番号 **WO 95/27336**

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(30) 優先権データ
特願平6/65343 1994年4月1日(01.04.94) JP

(71) 出願人（米国を除くすべての指定国について）
ソニー株式会社(SONY CORPORATION)[JP/JP]
〒141 東京都品川区北品川6丁目7番35号 Tokyo, (JP)
(72) 発明者；および
(75) 発明者／出願人（米国についてのみ）
筒井京弥(TSUTSUI, Kyoya)[JP/JP]
園原美冬(SONOHARA, Mito)[JP/JP]
下吉 修(SHIMOYOSHI, Osamu)[JP/JP]
〒141 東京都品川区北品川6丁目7番35号
ソニー株式会社内 Tokyo, (JP)

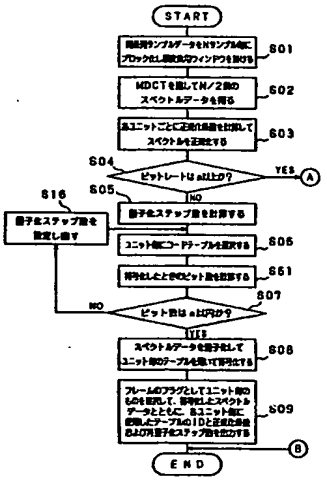
(74) 代理人
弁理士 小池 晃, 外(KOIKE, Akira et al.)
〒105 東京都港区虎ノ門二丁目6番4号
第11森ビル Tokyo, (JP)

(81) 指定国
KR, US, 欧州特許(DE, FR, GB).

添付公開書類 国際調査報告書

(54) Title : METHOD AND DEVICE FOR ENCODING SIGNAL, SIGNAL TRANSMITTING METHOD, SIGNAL RECORDING MEDIUM, AND METHOD AND DEVICE FOR DECODING SIGNAL

(54) 発明の名称 信号符号化方法及び装置、信号伝送方法、信号記録媒体、並びに信号復号化方法及び装置



S01 ... Divide time-series sampled data into groups of M samples, and put a window for forward conversion.
S02 ... Generate M/2 spectrum data by MDCT.
S03 ... Normalize spectrum by calculating normalization coefficients for every unit.
S04 ... The bit rate p?
S05 ... Calculate the number of steps of quantization.
S06 ... Select a code tabel for every unit.
S07 ... The number of bits n?
S08 ... Encode spectrum data by using a code table for every unit after quantization.
S09 ... Select a flag of a frame for every unit, and ouput the IDs of the tables, the normalization coefficients, and the number of steps of quantization for every unit together with encoded spectrum data.
S16 ... Reset the number of steps of quantization.
S61 ... Calculate the number of bits of when data are encoded.

(57) Abstract

Time-series sampled data of the input signal are grouped (SO1); the data are converted into spectrum data by MDCT (SO2); in order to divide the spectrum data into units, a code table is selected for every unit (SO6); the spectrum data are encoded by quantization using the code tables (SO8); and the encoded spectrum data, the identification signals of the code tables, the normalization coefficients and the number of steps of quantization are outputted (SO9). It is also possible to select a code table for every frame. Thus, the hardware scale of the encoder can be effectively reduced and the encoding efficiency of the encoder can be effectively improved.

OPAP IAP15 JAN 20 2010 PATENT & TRADEMARK OFFICE

1FW

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Re: Application of: Jani Lainema. Attorney Docket: 944-001.107-2

Serial No.: 11/881,367 Group Art Unit: 2621

Filed: July 26, 2007 Examiner: to be assigned

For: **METHOD AND DEVICE FOR INDICATING QUANTIZER PARAMETERS IN A VIDEO CODING SYSTEM**

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

SUPPLEMENTAL INFORMATION DISCLOSURE STATEMENT

Sir:

Applicant submits herewith references of which they are aware, which they believe may be material to the examination of this application and in respect of which they may have a duty to disclose in accordance with 37 C.F.R. 1.56.

This Supplemental Information Disclosure Statement is timely since it is certified by the undersigned that each item of information contained in the Supplemental Information Disclosure Statement was first cited in any communication from a foreign patent office (copy enclosed) in a counterpart foreign application not more than three months prior to the filing of this Supplemental Information Disclosure Statement per 37 C.F.R. 1.97(c) and 37 C.F.R. 1.97 (e)(1), therefore, the undersigned respectfully submits that no fee is due. The Commissioner is hereby authorized to charge to Deposit Account 23-0442 any fee deficiency required to submit this Supplemental Information Disclosure Statement.

I hereby certify that this correspondence is being deposited today with the United States Postal Service as first class mail in an envelope addressed to Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450

Marie E. Forte January 15, 2010
Marie E. Forte Date

The references are listed in the enclosed foreign search report dated November 16, 2010.

A PTO 1449 listing the cited references is also enclosed.

Respectfully submitted,

Kenneth Q. Lao
Registration No. 40,061

Date: January 13, 2010

WARE, FRESSOLA, VAN DER SLUYS
& ADOLPHSON LLP
Bradford Green, Building 5
755 Main Street, PO Box 224
Monroe, CT 06468
(203) 261-1234

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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
11/881,367	07/26/2007	Jani Lainema	944-001.107-2	1389

4955 7590 11/23/2010

WARE FRESSOLA VAN DER SLUYS & ADOLPHSON, LLP
BRADFORD GREEN, BUILDING 5
755 MAIN STREET, P O BOX 224
MONROE, CT 06468

EXAMINER	
PHILIPPE, GIMS S	

ART UNIT	PAPER NUMBER
2482	

MAIL DATE	DELIVERY MODE
11/23/2010	PAPER

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

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

Office Action Summary	Application No.	Applicant(s)	
	11/881,367	LAINEMA, JANI	
	Examiner	Art Unit	
	Gims S. Philippe	2482	

-- 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 *26 July 2007*.

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) *4-14,17-27 and 37* 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) *4-14, 17-27, 37* is/are rejected.

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

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

Application Papers

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

10)☐ The drawing(s) filed on _____ is/are: a)☐ accepted or b)☐ objected to by the Examiner.

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

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

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

Priority under 35 U.S.C. § 119

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

a)☐ All b)☐ Some * c)☐ None of:

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

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

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

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

Attachment(s)

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

Continuation of Attachment(s) 3). Information Disclosure Statement(s) (PTO/SB/08), Paper No(s)/Mail Date :07/26/07, 06/16/08, 05/11/09, 01/20/10.

DETAILED ACTION

1. This is a first office action in response to application no. 11/881,367 filed on July 26, 2007 in which claims 4-14, 17-27 and 37 are presented for examination.

Double Patenting

2. The nonstatutory double patenting rejection is based on a judicially created doctrine grounded in public policy (a policy reflected in the statute) so as to prevent the unjustified or improper timewise extension of the "right to exclude" granted by a patent and to prevent possible harassment by multiple assignees. A nonstatutory obviousness-type double patenting rejection is appropriate where the conflicting claims are not identical, but at least one examined application claim is not patentably distinct from the reference claim(s) because the examined application claim is either anticipated by, or would have been obvious over, the reference claim(s). See, e.g., *In re Berg*, 140 F.3d 1428, 46 USPQ2d 1226 (Fed. Cir. 1998); *In re Goodman*, 11 F.3d 1046, 29 USPQ2d 2010 (Fed. Cir. 1993); *In re Longi*, 759 F.2d 887, 225 USPQ 645 (Fed. Cir. 1985); *In re Van Ornum*, 686 F.2d 937, 214 USPQ 761 (CCPA 1982); *In re Vogel*, 422 F.2d 438, 164 USPQ 619 (CCPA 1970); and *In re Thorington*, 418 F.2d 528, 163 USPQ 644 (CCPA 1969).

A timely filed terminal disclaimer in compliance with 37 CFR 1.321(c) or 1.321(d) may be used to overcome an actual or provisional rejection based on a nonstatutory double patenting ground provided the conflicting application or patent either is shown to be commonly owned with this application, or claims an invention made as a result of activities undertaken within the scope of a joint research agreement.

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

3. Claims 4-14, 17-27 and 37 are rejected on the ground of nonstatutory obviousness-type double patenting as being unpatentable over claims 1-10 of U.S. Patent no. 7,263,125 to Lainema. Although the conflicting claims are not identical, they

are not patentably distinct from each other because the limitations of the present patent application are somewhat similar to the cited Patent no.

Therefore, it is considered obvious that one skilled in the art at the time of the invention would recognize the advantage of modifying the method of encoding digital video sequence of the present Patent Application by incorporating the teachings of Lainema US Patent no. 7,263, 125 for the same purpose of indicating quantization parameter related information by introducing a sequence level quantization parameter in order to allow the encoder application to decide a video sequence dependent reference QP(Quantization Parameter) to be used in coding of the picture/slice QPs as taught by Lainema (See Lainema col. 11, lines 36-40).

NOTE: The applicant is urged to review all co-pending applications with claims similar to those of the present application in order avoid the delays of a Terminal Disclaimer. It is the applicant's duty to disclose any evidence pertaining to the patentability of all applications submitted before the office.

4. The prior art made of record and not relied upon is considered pertinent to applicant's disclosure.

Inoue (US Patent no. 5237410) teaches video signal encoding apparatus utilizing control of quantization step size for improved picture quality.

Lin et al. (US Patent Application Publication no. 2003/0152146 A1) teaches motion compensation loop with filtering.

Kerofsky et al. (US Patent no. 6677868) teaches entropy coding with adaptive syntax to replace high probability symbols with lower probabilities symbols.

Any inquiry concerning this communication or earlier communications from the examiner should be directed to Gims S. Philippe whose telephone number is (571) 272-7336. The examiner can normally be reached on M-F (10:30-7:00).

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Banks-Harold Marsha can be reached on (571) 272-7905. 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). If you would like assistance from a USPTO Customer Service Representative or access to the automated information system, call 800-786-9199 (IN USA OR CANADA) or 571-272-1000.

Gims S Philippe
Primary Examiner
Art Unit 2482

/G. S. P./
/Gims S Philippe/
Primary Examiner, Art Unit 2482

Notice of References Cited	Application/Control No. 11/881,367	Applicant(s)/Patent Under Reexamination LAINEMA, JANI	
	Examiner Gims S. Philippe	Art Unit 2482	Page 1 of 1

U.S. PATENT DOCUMENTS

*		Document Number Country Code-Number-Kind Code	Date MM-YYYY	Name	Classification
*	A	US-7,263,125	08-2007	Lainema, Jani	375/240.04
*	B	US-2003/0152146	08-2003	Lin et al.	375/240.16
*	C	US-6,677,868	01-2004	Kerofsky et al.	341/107
	D	US-			
	E	US-			
	F	US-			
	G	US-			
	H	US-			
	I	US-			
	J	US-			
	K	US-			
	L	US-			
	M	US-			

FOREIGN PATENT DOCUMENTS

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

NON-PATENT DOCUMENTS

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

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

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BIB DATA SHEET

CONFIRMATION NO. 1389

SERIAL NUMBER	FILING or 371(c) DATE RULE	CLASS	GROUP ART UNIT	ATTORNEY DOCKET NO.
11/881,367	07/26/2007	375	2482	944-001.107-2

APPLICANTS

Jani Lainema, Irving, TX;

**** CONTINUING DATA ***************************

This application is a DIV of 10/421,629 04/23/2003 PAT 7,263,125 *
which claims benefit of 60/374,667 04/23/2002
(*)Data provided by applicant is not consistent with PTO records.

**** FOREIGN APPLICATIONS ***************************

**** IF REQUIRED, FOREIGN FILING LICENSE GRANTED ****

08/15/2007

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	/GIMS S PHILIPPE/ Examiner's Signature	/g.p./ Initials	TX	8	23	3

ADDRESS

WARE FRESSOLA VAN DER SLUYS & ADOLPHSON, LLP
BRADFORD GREEN, BUILDING 5
755 MAIN STREET, P O BOX 224
MONROE, CT 06468
UNITED STATES

TITLE

Method and device for indicating quantizer parameters in a video coding system

FILING FEE RECEIVED		
1150	FEES: Authority has been given in Paper No._____ to charge/credit DEPOSIT ACCOUNT No._____ for following:	❑ All Fees ❑ 1.16 Fees (Filing) ❑ 1.17 Fees (Processing Ext. of time) ❑ 1.18 Fees (Issue) ❑ Other _____ ❑ Credit

BIB (Rev. 05/07).

EAST Search History

EAST Search History (Prior Art)

Ref #	Hits	Search Query	DBs	Default Operator	Plurals	Time Stamp
L8	0	l6 and l7	US-PGPUB; USPAT; EPO; JPO; DERWENT	AND	ON	2010/11/20 22:11
L4	3	l2 and l3	US-PGPUB; USPAT; EPO; JPO; DERWENT	AND	ON	2010/11/20 22:05
L2	152	(transform$ with prediction with error) and l1	US-PGPUB; USPAT; EPO; JPO; DERWENT	AND	ON	2010/11/20 22:04
L9	75	(transform near4 coding) and l7	US-PGPUB; USPAT; EPO; JPO; DERWENT	AND	ON	2010/11/20 22:11
L10	34	(transform near3 coefficient with quantiz$3) and l9	US-PGPUB; USPAT; EPO; JPO; DERWENT	AND	ON	2010/11/20 22:12
L7	88	(set near3 transform near4 coding)	US-PGPUB; USPAT; EPO; JPO; DERWENT	AND	ON	2010/11/20 22:11
L12	1	(prediction near2 error near2 value) and l9	US-PGPUB; USPAT; EPO; JPO; DERWENT	AND	ON	2010/11/20 22:15
L13	1	(prediction near2 error near2 value) and l7	US-PGPUB; USPAT; EPO; JPO; DERWENT	AND	ON	2010/11/20 22:15
L14	4	(prediction near2 error near2 value) and l6	US-PGPUB; USPAT; EPO; JPO; DERWENT	AND	ON	2010/11/20 22:16
L6	22	(default near3 quantization near4 level)	US-PGPUB; USPAT; EPO; JPO; DERWENT	AND	ON	2010/11/20 22:10
L11	2	(array near3 pixel) and l10	US-PGPUB; USPAT; EPO; JPO; DERWENT	AND	ON	2010/11/20 22:12

L5	5	((video with sequence) same (array with pixel with divid$) same (prediction with error))	US-PGPUB; USPAT; EPO; JPO; DERWENT	AND	ON	2010/11/20 22:09
L1	441	((pixel near3 array) and (motion with predict$3 with error))	US-PGPUB; USPAT; EPO; JPO; DERWENT	AND	ON	2010/11/20 22:04
L3	15	((default with level with quantization) with (coding or encoding))	US-PGPUB; USPAT; EPO; JPO; DERWENT	AND	ON	2010/11/20 22:05

11/20/10 10:16:47 PM

Index of Claims	Application/Control No.	Applicant(s)/Patent Under Reexamination
	11881367	LAINEMA, JANI
	Examiner	Art Unit
	Gims S Philippe	2482

✓	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	11/20/2010								
	1	-								
	2	-								
	3	-								
	4	✓								
	5	✓								
	6	✓								
	7	✓								
	8	✓								
	9	✓								
	10	✓								
	11	✓								
	12	✓								
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	27	✓								
	28	-								
	29	-								
	30	-								
	31	-								
	32	-								
	33	-								
	34	-								
	35	-								
	36	-								

Index of Claims	Application/Control No.	Applicant(s)/Patent Under Reexamination
	11881367	LAINEMA, JANI
	Examiner	Art Unit
	Gims S Philippe	2482

✓	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	11/20/2010								
	37	✓								

Search Notes	Application/Control No.	Applicant(s)/Patent Under Reexamination
	11881367	LAINEMA, JANI
	Examiner	Art Unit
	Gims S Philippe	2482

SEARCHED

Class	Subclass	Date	Examiner
375	240.04, 240.16	11/20/10	GP
341	107	11/20/10	GP

SEARCH NOTES

Search Notes	Date	Examiner
Keyword searched; Inventor's name searched	11/20/10	GP

INTERFERENCE SEARCH

Class	Subclass	Date	Examiner

OPAP IAP15 JAN 20 2010 PATENT & TRADEMARK OFFICE

INFORMATION DISCLOSURE CITATION FORM FOR PATENT APPLICATION (FORM PTO-1449) (Substitute)	Docket No.: 944-001.107-2	Serial No.: 11/881,367
	Applicant(s): Jani Lainema	
	Filing Date: July 26, 2007	Group: 2621

U.S. PATENTS

Initials	Patent Number	Issue Date	Name	Class	Sub-class	Filing date
/GP/	US 5,835,030	11-10-1998	Tsutsui et al	341	51	

U.S. PATENT PUBLICATIONS

Initials	Publication No.	Pub. Date	Name	Class	Sub-class	Filing Date

FOREIGN PATENT DOCUMENTS

Initials	Document Number	Date	Country	Name	Translation? Yes/No/n/a

OTHER DOCUMENTS (Title, Author, Date, Pages, Etc., if known)

Examiner's Signature:	/Gims Philippe/	Date Considered:	11/20/2010

Initial if reference was considered, whether or not citation is in conformance with MPEP. Mark through citation if not considered. Include a copy of this citation form with your next correspondence to the Applicant(s).

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PATENT & TRADEMARK OFFICE

INFORMATION DISCLOSURE CITATION FORM FOR PATENT APPLICATION (FORM PTO-1449) (Substitute)	Docket No.: 944-001.107-2	Serial No.: 11/881,367
	Applicant(s): Jani Lainema	
	Filing Date: July 26, 2007	Group: 2621

U.S. PATENTS

Initials	Patent Number	Issue Date	Name	Class	Sub-class	Filing date
/GP/	6,879,632 B1	4/12/05	Yutaka Yokoyama	375	240	
/GP/	7,367,041 B2	4/29/08	Taichiro Morishita, et al	725	37	

U.S. PATENT PUBLICATIONS

Initials	Publication No.	Pub. Date	Name	Class	Sub-class	Filing Date

FOREIGN PATENT DOCUMENTS

Initials	Document Number	Date	Country	Name	Translation? Yes/No/n/a
/GP/	JP 06-121171	4/28/94	Japan	Nippon Electric Co.	English Abstract Only
/GP/	JP11-004449	1/6/1999	Japan	Asahi Optical Co., Ltd.	English Abstract Only

OTHER DOCUMENTS (Title, Author, Date, Pages, Etc., if known)

Examiner's Signature:	/Gims Philippe/	Date Considered: 11/20/2010

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Customer No.: 4955

OIPE IAP13 JUN 16 2008 PATENT & TRADEMARK OFFICE

INFORMATION DISCLOSURE CITATION FORM FOR PATENT APPLICATION (FORM PTO-1449) (Substitute)	Docket No.: 944-001.107-2	Serial No.: 11/881,367
	Applicant(s): Jani Lainema	
	Filing Date: July 26, 2007	Group: 2621

U.S. PATENTS

Initials	Patent Number	Issue Date	Name	Class	Sub-class	Filing date
/GP/	6,263,022	7/17/01	Yingwei Chen, et al	375	240	

U.S. PATENT PUBLICATIONS

Initials	Publication No.	Pub. Date	Name	Class	Sub-class	Filing Date

FOREIGN PATENT DOCUMENTS

Initials	Document Number	Date	Country	Name	Translation? Yes/No/n/a
/GP/	WO 01/26381 A1	4/12/01	WIPO	Koninklijke Philips Elec-Tronics N.V.	English

OTHER DOCUMENTS (Title, Author, Date, Pages, Etc., if known)

Examiner's Signature: /Gims Philippe/	Date Considered: 11/20/2010

Initial if reference was considered, whether or not citation is in conformance with MPEP. Mark through citation if not considered. Include a copy of this citation form with your next correspondence to the Applicant(s).

Express Mail No.: Customer No.: 4955

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Re: Application of: Jani Lainema

Attorney Docket: 944-001.107-2

Serial No.: to be assigned

Group Art Unit: to be assigned

Filed: herewith

Examiner: to be assigned

For: **METHOD AND DEVICE FOR INDICATING QUANTIZER PARAMETERS IN A VIDEO CODING SYSTEM**

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

INFORMATION DISCLOSURE STATEMENT

Sir:

Applicant submits herewith references of which they are aware, which they believe may be material to the examination of this application and in respect of which they may have a duty to disclose in accordance with 37 CFR 1.56.

While this Information Disclosure Statement may be "material" pursuant to 37 CFR 1.56, it is not intended to constitute an admission that any document referred to herein is "prior art" for this invention unless specifically designated as such.

In accordance with 37 CFR 1.97(g), the filing of this Information Disclosure Statement shall not be construed to mean that a search has been made or that no other material information as defined under 37 CFR 1.56(a) exists.

I hereby certify that this correspondence is being deposited with the United States Postal Service "Express Mail Post Office to Addressee" service under 37 C.F.R. 1.10, Express Mail Label No. EV914764379US, on the date indicated below and is addressed to Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.

7.25.07

Cathy Sturmer — Date

A PTO-1449 with cited reference is also enclosed.

This IDS is being submitted prior to receipt of a first Official Action in this matter; therefore, the undersigned respectfully submits that no fee is due for filing this IDS. Should any fees be due of which the undersigned is unaware, the Commissioner is hereby authorized to charge deposit account 23-0442 any fee deficiency required to submit this IDS.

Respectfully submitted,

Kenneth Q. Lao
Registration No. 40,061

Date: July 25, 2007

WARE, FRESSOLA, VAN DER SLUYS
& ADOLPHSON LLP
Bradford Green, Building 5
755 Main Street, PO Box 224
Monroe, CT 06468
(203) 261-1234

FORM PTO-1449 INFORMATION DISCLOSURE STATEMENT	ATTY DOCKET NO. 944-001.107-2	SERIAL NO. To be assigned
	APPLICANTS: Jani Lainema	
	FILING DATE: herewith	ART UNIT: to be assigned

UNITED STATES PATENT DOCUMENTS

EXAM. INITIAL		DOCUMENT NUMBER	DATE	INVENTOR/ASSIGNEE	CLASS	SUBCLASS	FILING DATE IF APPROPRIATE
/GP/		U.S. 5,231,484	July 27, 2991	Gonzales et al.	358	133	
		U.S. 5,751,358	May 12, 1998	Suzuki et al.	348	405	
		U.S. 5,054,103	Oct. 1, 1991	Yasuda et al.	382	56	
		U.S. 5,144,426	Sept. 1, 1992	Tanaka et al.	358	133	
		U.S. 5,715,009	Feb. 3, 1998	Tahara et al.	348	423	
		U.S. 6,256,349	July 3, 2001	Suzuki et al.	375	240.18	
		U.S. 5,237,410	Aug. 17, 1993	Inoue	358	136	
		U.S. 2003/152146	Aug. 14, 2003	Lin et al.	375	240.16	
/GP/		U.S. 6,677,868	Jan. 13, 2004	Kerofsky et al.	341	107	

FOREIGN PATENT DOCUMENTS

		DOCUMENT NUMBER	DATE	COUNTRY	CLASS	SUBCLASS	TRANSLATION YES/NO

OTHER DOCUMENTS (INCLUDING AUTHOR, TITLE, DATE, PERTINENT PAGES, ETC.)

/GP/		"Joint Model Number 1 (JM-1)", Doc. JVT-A003, Appendix B; Joint Video Team (JVT) of ISO/IEC MPEG and ITU-T VCEG; January 2002; pp. 1-79.

Examiner (To be assigned) /Gims Philippe/	Date: 11/20/2010

OPAP IAP14
FEB 28 2011
PATENT & TRADEMARK OFFICE

PTO/SB/26 (07-09)
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TERMINAL DISCLAIMER TO OBVIATE A DOUBLE PATENTING REJECTION OVER A "PRIOR" PATENT

Docket Number (Optional)
0944-001.107-2

In re Application of: Jani LAINEMA

Application No.: 11/881,367

Filed: July 26, 2007

For: METHOD AND DEVICE FOR INDICATING QUANTIZER PARAMETERS IN A VIDEO CODING SYSTEM

The owner*, Nokia Corporation, of 100 percent interest in the instant application hereby disclaims, except as provided below, the terminal part of the statutory term of any patent granted on the instant application which would extend beyond the expiration date of the full statutory term **prior patent** No. 7,263,125 as the term of said prior patent is defined in 35 U.S.C. 154 and 173, and as the term of said **prior patent** is presently shortened by any terminal disclaimer. The owner hereby agrees that any patent so granted on the instant application shall be enforceable only for and during such period that it and the **prior patent** are commonly owned. This agreement runs with any patent granted on the instant application and is binding upon the grantee, its successors or assigns.

In making the above disclaimer, the owner does not disclaim the terminal part of the term of any patent granted on the instant application that would extend to the expiration date of the full statutory term as defined in 35 U.S.C. 154 and 173 of the **prior patent**, "as the term of said **prior patent** is presently shortened by any terminal disclaimer," in the event that said **prior patent** later:

- expires for failure to pay a maintenance fee;
- is held unenforceable;
- is found invalid by a court of competent jurisdiction;
- is statutorily disclaimed in whole or terminally disclaimed under 37 CFR 1.321;
- has all claims canceled by a reexamination certificate;
- is reissued; or
- is in any manner terminated prior to the expiration of its full statutory term as presently shortened by any terminal disclaimer.

Check either box 1 or 2 below, if appropriate.

1. ☐ For submissions on behalf of a business/organization (e.g., corporation, partnership, university, government agency, etc.), the undersigned is empowered to act on behalf of the business/organization.

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

2. ☑ The undersigned is an attorney or agent of record. Reg. No. 40,061

Kenneth Lao — February 23, 2011
Signature — Date

Kennth Q. Lao
Typed or printed name

203-261-1234
Telephone Number

☑ Terminal disclaimer fee under 37 CFR 1.20(d) included.

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*Statement under 37 CFR 3.73(b) is required if terminal disclaimer is signed by the assignee (owner).
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This collection of information is required by 37 CFR 1.321. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.11 and 1.14. This collection is estimated to take 12 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

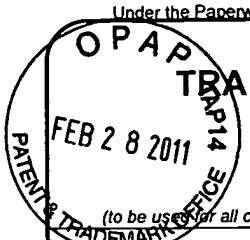
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02/28/2011 EHAILU 00000029 11881367
01 FC:1814 140.00 OP

Doc Code: TRAN.LET

Document Description: Transmittal Letter

PTO/SB/21 (07-09)
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TRANSMITTAL FORM

(to be used for all correspondence after initial filing)

Total Number of Pages in This Submission: 3

Application Number	11/881,367
Filing Date	July 26, 2007
First Named Inventor	Jani Lainema
Art Unit	2482
Examiner Name	Gims S. Philippe
Attorney Docket Number	944-001.107-2

ENCLOSURES *(Check all that apply)*

- [x] Fee Transmittal Form
  - [x] Fee Attached
- [ ] Amendment/Reply
  - [ ] After Final
  - [ ] Affidavits/declaration(s)
- [ ] Extension of Time Request
- [ ] Express Abandonment Request
- [ ] Information Disclosure Statement
- [ ] Certified Copy of Priority Document(s)
- [ ] Reply to Missing Parts/ Incomplete Application
  - [ ] Reply to Missing Parts under 37 CFR 1.52 or 1.53
- [ ] Drawing(s)
- [ ] Licensing-related Papers
- [ ] Petition
- [ ] Petition to Convert to a Provisional Application
- [ ] Power of Attorney, Revocation Change of Correspondence Address
- [x] Terminal Disclaimer
- [ ] Request for Refund
- [ ] CD, Number of CD(s) _____
  - [ ] Landscape Table on CD
- [ ] After Allowance Communication to TC
- [ ] Appeal Communication to Board of Appeals and Interferences
- [ ] Appeal Communication to TC **(Appeal Notice, Brief, Reply Brief)**
- [ ] Proprietary Information
- [ ] Status Letter
- [ ] Other Enclosure(s) (please Identify below):

Remarks

SIGNATURE OF APPLICANT, ATTORNEY, OR AGENT

Firm Name	Ware, Fressola, Van Der Sluys & Adolphson, LLP		
Signature	Ken Lao		
Printed name	Kenneth Q. Lao		
Date	February 23, 2011	Reg. No.	40,061

CERTIFICATE OF TRANSMISSION/MAILING

I hereby certify that this correspondence is being facsimile transmitted to the USPTO or deposited with the United States Postal Service with sufficient postage as first class mail in an envelope addressed to: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450 on the date shown below:

Signature	Marie E. Forte		
Typed or printed name	Marie E. Forte	Date	February 23, 2011

This collection of information is required by 37 CFR 1.5. 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 and1.14. This collection is estimated to 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, 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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OPAP IAP14
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Effective on 12/08/2004.
Fees pursuant to the Consolidated Appropriations Act, 2005 (H.R. 4818).

FEE TRANSMITTAL
For FY 2009

☐ Applicant claims small entity status. See 37 CFR 1.27

TOTAL AMOUNT OF PAYMENT	($)	140.00

Complete if Known	
Application Number	11/881,367
Filing Date	July 26, 2007
First Named Inventor	Jani Lainema
Examiner Name	Gims S. Philippe
Art Unit	2482
Attorney Docket No.	944-001.107-2

METHOD OF PAYMENT (check all that apply)

☑ Check ☐ Credit Card ☐ Money Order ☐ None ☐ Other (please identify): _____

☑ Deposit Account Deposit Account Number: 23-0442 Deposit Account Name: WFVA

For the above-identified deposit account, the Director is hereby authorized to: (check all that apply)

☐ Charge fee(s) indicated below ☐ Charge fee(s) indicated below, **except for the filing fee**

☑ Charge any additional fee(s) or underpayments of fee(s) under 37 CFR 1.16 and 1.17 ☐ Credit any overpayments

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FEE CALCULATION

1. BASIC FILING, SEARCH, AND EXAMINATION FEES

	FILING FEES		SEARCH FEES		EXAMINATION FEES		
		Small Entity		Small Entity		Small Entity	
Application Type	Fee ($)	Fee ($)	Fee ($)	Fee ($)	Fee ($)	Fee ($)	Fees Paid ($)
Utility	330	165	540	270	220	110	
Design	220	110	100	50	140	70	
Plant	220	110	330	165	170	85	
Reissue	330	165	540	270	650	325	
Provisional	220	110	0	0	0	0	

2. EXCESS CLAIM FEES

Fee Description	Fee ($)	Small Entity Fee ($)
Each claim over 20 (including Reissues)	52	26
Each independent claim over 3 (including Reissues)	220	110
Multiple dependent claims	390	195

Total Claims _____ - 20 or HP = _____ x _____ = _____ Extra Claims / Fee ($) / Fee Paid ($)

HP = highest number of total claims paid for, if greater than 20.

Indep. Claims _____ - 3 or HP = _____ x _____ = _____ Extra Claims / Fee ($) / Fee Paid ($)

HP = highest number of independent claims paid for, if greater than 3.

Multiple Dependent Claims — Fee ($) _____ Fee Paid ($) _____

3. APPLICATION SIZE FEE

If the specification and drawings exceed 100 sheets of paper (excluding electronically filed sequence or computer listings under 37 CFR 1.52(e)), the application size fee due is $270 ($135 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).

Total Sheets _____ - 100 = _____ Extra Sheets / 50 = _____ Number of each additional 50 or fraction thereof (round up to a whole number) x _____ Fee ($) = _____ Fee Paid ($)

4. OTHER FEE(S)

	Fees Paid ($)
Non-English Specification, $130 fee (no small entity discount)	
Other (e.g., late filing surcharge): Terminal Disclaimer Fee	140.00

SUBMITTED BY

Signature		Registration No. (Attorney/Agent) 40,061	Telephone 203-261-1234
Name (Print/Type)	Kenneth Q. Lao		Date February 23, 2011

This collection of information is required by 37 CFR 1.136. 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 30 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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PATENT AND TRADEMARK OFFICE

INFORMATION DISCLOSURE CITATION FORM FOR PATENT APPLICATION (FORM PTO-1449) (Substitute)	Docket No.: 944-001.107-2	Serial No.: 11/881,367
	Applicant(s): Jani Lainema	
	Filing Date: July 26, 2007	Group: 2621

U.S. PATENTS

Initials	Patent Number	Issue Date	Name	Class	Sub-class	Filing date
	US 5,907,362	5-25-1999	Yamamoto	348	405	

U.S. PATENT PUBLICATIONS

Initials	Publication No.	Pub. Date	Name	Class	Sub-class	Filing Date

FOREIGN PATENT DOCUMENTS

Initial	Document Number	Date	Country	Name	Translation? Yes/No/n/a
	WO 2000 21302 A1	4-13-00	International	Gen Instrument Corp.	English

OTHER DOCUMENTS (Title, Author, Date, Pages, Etc., if known)

	Single-pass constant-and variable-bit-rate MPEG-2 video compression, N. Mohsenian, R. Rajagopalan, C.A. Gonzales, July 4, 1999, XP-002216512
	A Video Compression Algorithm With Adaptive Bit Allocation and Quantization, Eric Viscito and Cesar Gonzales, November 11, 1991, Visual Communications and Image Processing '91: Visual Communication, Boston – SPIE Vol. 1605

Examiner's Signature:	Date Considered:

Initial if reference was considered, whether or not citation is in conformance with MPEP. Mark through citation if not considered. Include a copy of this citation form with your next correspondence to the Applicant(s).

Customer No.: 4955

METHOD AND APPARATUS FOR PROVIDING RATE CONTROL IN A VIDEO ENCODER

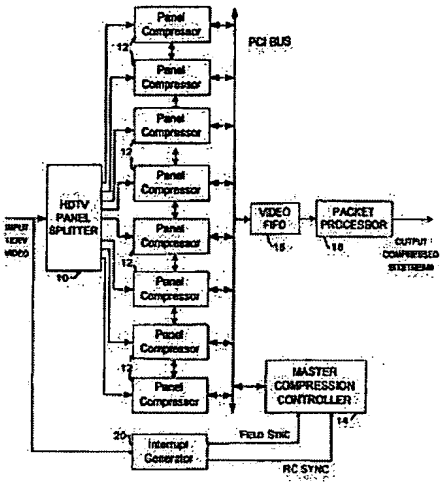
Publication number: WO0021302 (A1)
Publication date: 2000-04-13
Inventor(s): WU SIU-WAI [US] +
Applicant(s): GEN INSTRUMENT CORP [US]; WU SIU WAI [US] +
Classification:
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Abstract of **WO 0021302 (A1)**

A method and apparatus are provided for controlling the quantization level in a digital video encoder that comprises a plurality of parallel compression engines (12). The input picture is partitioned into a number of panels (10) and each panel is processed by a distinct compression engine (12). A reference quantizer scale is determined before encoding a frame of video. The reference quantizer scale is used at the first slice of every video image panel being processed by the video encoder. The quantizer scale at the last slice of the image panel is then forced to be the same as the first slice. The forcing step can use a piecewise-linear feedback formula. A group of pictures (GOP) target bit rate is adjusted based on the number of film pictures and non-film pictures currently in the processing pipeline of at least one of the compression engines. A higher target bit rate is provided for non-film pictures. A buffer (16) level of the video encoder is used to control the start of a new group of pictures (GOP). The start of a new GOP is delayed if the buffer (16) does not have sufficient space to accommodate an intra-coded (I) frame for the new GOP.



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(71) Applicant *(for all designated States except US)*: GENERAL INSTRUMENT CORPORATION [US/US]; 101 Tournament Drive, Horsham, PA 19044 (US).

(72) Inventor; and
(75) Inventor/Applicant *(for US only)*: WU, Siu-Wai [-/US]; 12655 Fairbrook Road, San Diego, CA 92131 (US).

(74) Agent: LIPSITZ, Barry, R.; Building No. 8, 755 Main Street, Monroe, CT 06468 (US).

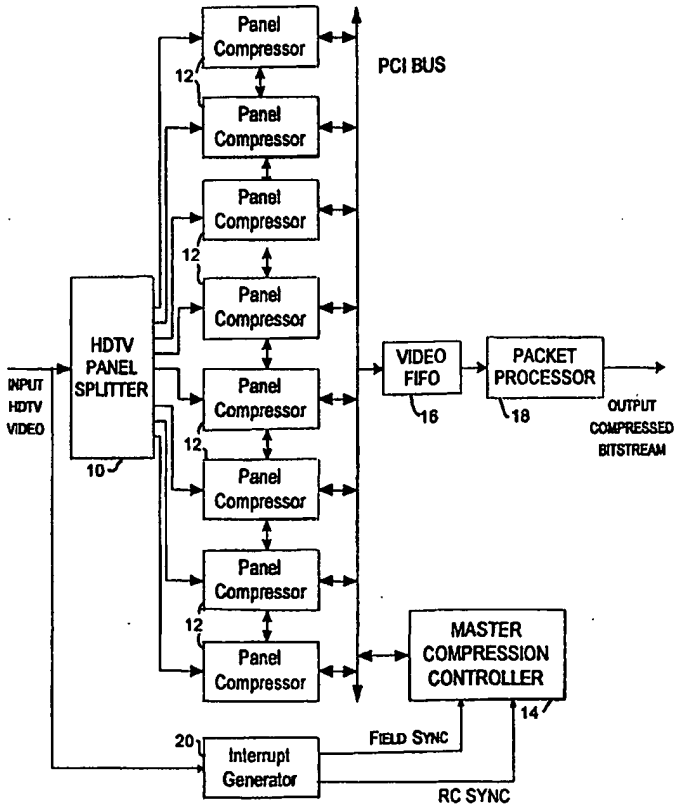
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(57) Abstract

A method and apparatus are provided for controlling the quantization level in a digital video encoder that comprises a plurality of parallel compression engines (12). The input picture is partitioned into a number of panels (10) and each panel is processed by a distinct compression engine (12). A reference quantizer scale is determined before encoding a frame of video. The reference quantizer scale is used at the first slice of every video image panel being processed by the video encoder. The quantizer scale at the last slice of the image panel is then forced to be the same as the first slice. The forcing step can use a piecewise-linear feedback formula. A group of pictures (GOP) target bit rate is adjusted based on the number of film pictures and non-film pictures currently in the processing pipeline of at least one of the compression engines. A higher target bit rate is provided for non-film pictures. A buffer (16) level of the video encoder is used to control the start of a new group of pictures (GOP). The start of a new GOP is delayed if the buffer (16) does not have sufficient space to accommodate an intra-coded (I) frame for the new GOP.



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METHOD AND APPARATUS FOR PROVIDING RATE CONTROL IN A VIDEO ENCODER

This application claims priority from U.S. provisional application no. 60/102,800 filed October 2, 1998.

BACKGROUND OF THE INVENTION

The present invention relates to video processing, and more particularly to a method and apparatus for controlling the rate of data production by multiple encoding engines provided to compress video in a television encoder, such as a digital high definition television (HDTV) or standard definition television (SDTV) encoder.

The following references are relevant to this disclosure:

1. Advanced Television Systems Committee (ATSC) A53 Standard entitled "ATSC Digital Television Standard."
2. ATSC A54 Standard entitled "Guide to the use of ATSC Digital Television Standard."
3. ISO/IEC 13818-2 "Generic Coding of Moving Pictures and Associated Audio: Video" (MPEG2).
4. ISO/IEC JTC1/SC29/WG11/MPEG93/457 "MPEG2 Test Model 5."
5. "Rate Control for the Grand Alliance Prototype Encoder," Siu-Wai Wu, memo distributed to the Grand Alliance Video Compression Specialist Group, November 1994.

Rate control is an essential part of a video encoder. In an HDTV encoder, the picture is processed using multiple encoding engines for data compression. These multiple encoding engines operate on the picture simultaneously, but share a common data buffer. Thus, the rate at which data is produced by the multiple engines must be carefully regulated in order to prevent buffer overflow, buffer underflow, and other problematic conditions.

In the past, rate control algorithms have been proposed for use in conjunction with a single video compressor. See, e.g., "MPEG2 Test Model 5" referred to above. In the approach adopted by the Grand Alliance for encoding HDTV, the parallel encoding engines are synchronized at the video slice instead of frame level; thus, the rate control can be treated as if only a single compressor were provided. None of the prior art schemes provide a robust solution to the problem of regulating the rate of data production by a plurality of compressors, in order to control the quantization of a digital video encoder that uses parallel compression engines.

It would be advantageous to provide an efficient rate control algorithm to regulate the rate of data production by multiple encoding engines to optimize video quality. It would be further advantageous to implement such an algorithm in the video encoder's existing controller microprocessor. The present invention provides a method and apparatus enjoying these and other advantages.

SUMMARY OF THE INVENTION

In accordance with the present invention, rate control is provided in a video encoder having multiple compression engines that process a picture simultaneously and share a common buffer. Nonlinear feedback is used to force a quantizer scale at the last slice of an image panel to be approximately the same as the quantizer scale at the first slice of the image panel. This avoids visible artifacts caused by abrupt changes in the quantizer scale at the panel boundaries.

A target bit rate for a group of pictures (GOP) is adjusted based on the number of film pictures and non-film pictures currently in the processing pipeline of the compression engines. Since non-film processing in general requires a higher target bit rate, this adjustment allows the rate control algorithm to adapt when the video switches from film to non-film or vice versa.

The buffer level is used to control the start of a new GOP. If there is not sufficient space in the buffer to accommodate the intra-coded (I) frame, the start of a new GOP is delayed.

More particularly, methods and apparatus are provided for controlling the quantization in a digital video encoder that comprises a plurality of parallel compression engines. A target quantization level is determined for a video frame. The target quantization level is applied to the first slice of every video image panel of a plurality of panels representing the video frame and being processed in parallel by the

video encoder. The quantization level is driven toward the target quantization level at the last slice of each of the image panels.

The driving step can use, for example, piecewise linear feedback to drive the quantization level of the last slice of each of the image panels toward the target quantization level. The feedback can compensate for variations in the quantization level between the first and last slice of each image panel.

A group of pictures (GOP) target bit rate can be adjusted based on a number of film pictures and non-film pictures currently in a processing pipeline of at least one of the compression engines. A higher target bit rate can be provided for non-film pictures.

A buffer level of the video encoder can be used to control the start of a new group of pictures (GOP). The start of a new GOP is delayed if there is not sufficient space in the buffer to accommodate an intra-coded (I) frame for the new GOP.

Every input picture can be partitioned into a fixed number of horizontal panels, wherein each of the panels is compressed by a separate compression engine. The panels can be simultaneously compressed during a frame time. The compressed panel data are stored locally at the compression engines for subsequent transfer to a video buffer of the video encoder within a next frame time. In order to form a transport packet, data are retrieved from the buffer at an average rate equal to a specified video bit rate whenever the buffer has at least one transport packet payload's worth of data. Null packets are substituted

for video packets to maintain a constant transport bit rate whenever the buffer level falls below one transport packet payload's worth of data.

A reference quantizer scale is calculated for each of the compression engines. The reference quantizer scale is calculated based on an accumulation of quantizer scale values for the compression engine (PanelSumQuant), an accumulation of the number of bits generated on that compression engine (PanelBitCount); an accumulation of the number of macroblocks processed on that compression engine (PanelMbCount); and a fullness level of a video buffer of the video encoder (VideoBufferLevel). The compression engine modifies its reference quantizer scale based on a local buffer fullness to generate a final quantizer scale value for use in quantization. A panic mode can be initiated by the compression engine if the final quantizer scale value is higher than a predetermined maximum value. The panic mode forces all or part of the DCT coefficient to take on a zero value.

A method is also provided for controlling the rate at which data is processed by a digital video encoder using a plurality of parallel compression engines to compress successive macroblocks of video data. Frame level rate control is provided for successive video frames in accordance with a picture start interrupt service routine once per coded picture. Macroblock level rate control is provided in accordance with a rate control interrupt service routine a plurality of times per coded picture.

The picture start interrupt routine updates frame level statistical variables by processing data collected from a prior coded frame. A target bit rate is calculated for a new group of pictures (GOP) if a new frame to be processed comprises an intra-coded (I) frame. For every frame to be encoded, upper and lower limits are calculated for the number of bits that a new frame is allowed to generate. A target number of bits is computed for each frame and for each of a plurality of panels into which each frame is divided. The target number of bits can be computed by distributing the bits in proportion to relative complexity values of the video frames being processed. A frame target quantizer scale is calculated from the target number of bits computed for a frame. The frame target quantizer scale is provided to each of the plurality of compression engines as an initial reference quantizer scale for use in commencing coding of the video frame.

In a preferred embodiment, the compression engines can force some of the Discrete Cosine Transform (DCT) coefficients of the video frame macroblocks to zero, if the reference quantizer scale is too high to maintain the number of bits that the new frame is allowed to generate within the applicable upper limit.

The rate control interrupt service routine provides interrupts which initiate a modulation of a frame target quantizer scale. The modulation can be based on feedback to attempt to bring the actual number of bits for each of the video frame panels to the corresponding target number of bits for the panel.

BRIEF DESCRIPTION OF THE DRAWING

Figure 1 is a block diagram illustrating an HDTV encoder with which the present invention may be utilized.

DETAILED DESCRIPTION OF THE INVENTION

The present invention provides a method and apparatus for rate control in a digital video encoder that uses multiple compression engines running in parallel. In accordance with a preferred embodiment of the invention as illustrated in Figure 1, every input picture is partitioned into eight horizontal panels by an HDTV panel splitter 10. Each panel is then compressed by an individual video panel compressor 12, for example, the DvXpert chip available from C-Cube Microsystems of 1778 McCarthy Blvd., Milpitas, CA 95035, USA. It should be appreciated that a different number of panels can be utilized, and that the invention can be implemented on video encoders other than the DvXpert encoder described herein.

The panels into which the input pictures are partitioned are simultaneously compressed during a frame time. The compressed panel data are stored locally on the panel compressor, and then transferred to the primary video FIFO 16 ("video buffer") within the next frame time. Whenever the video FIFO 16 has at least one transport packet payload's worth of data (184 bytes), the bits are retrieved from the FIFO by a packet processor 18 at an average rate equal to the user specified video bit rate (bit_rate). The retrieved bits are used to form a transport packet in accordance with the well known MPEG (Motion Picture Experts Group) standard. Whenever the FIFO level falls below 184 bytes, null packets will be substituted for video packets to maintain a constant

transport bit rate, effectively reducing the video bit rate. As illustrated in Figure 1, packet processor 18 outputs the compressed bitstream.

The rate control function is mainly performed by a master compression controller (MCC) 14. The MCC collects the statistics (PanelSumQuant, PanelBitCount, and PanelMbCount) from the panel compressors and the buffer level from the video FIFO, and then calculates an 8 bit reference quantizer scale (PanelQuant) for each panel compressor. The panel compressor then modifies the reference quantizer scale based on local activities and local buffer fullness to generate the final quantizer scale value to use for quantization. If the desired quantizer scale is higher than the maximum supported by the MPEG quantization table, the panel compressor may apply a panic mode and force some of the DCT (Discrete Cosine Transform) coefficients to zero.

A sync interrupt generator 20, which receives the input HDTV video, generates a field sync interrupt to the MCC at the beginning of every input field, and a Rate-Control (RC) Sync interrupt periodically (e.g., every 1.67 ms for 1080I mode) within a field time. A field sync interrupt is qualified as a picture start if the panel compressors are ready to encode a new picture at the current field time. Rate control by the MCC is performed in two parts: (1) Frame level rate control is carried out at the Picture Start interrupt service routine once per coded picture; (2) Macroblock level rate control is carried out at the RC interrupt service routine up to 20 times per coded picture for 1080 line

interlaced (1080I) mode (up to 10 times per coded picture for 720 line progressive scan (720P) mode). On average, only about eight RC interrupts are used to regulate the quantization because the panel compressor only uses a portion of the field time to carry out the encoding process.

The goal of rate control is to maintain a consistent video quality over time and over the picture. A basic assumption of the rate control algorithm is that the coding complexity of a particular picture type is approximately constant from frame to frame of a steady scene, and is measured by the product of the average quantizer scale and the number of bits generated over the frame (or a panel). The complexity of the current frame is normally estimated from that of the previous frame, except a when a scene change or fade-in from black is detected, in which case the complexity estimates are reset to some provisional values.

At picture start interrupt, the MCC first updates all frame level statistical variables by processing the data collected from the last coded frame. A target bit rate for the new GOP is calculated if the upcoming frame is an intra-coded frame (I frame). The GOP target bit rate calculation aims to bring the encoder buffer to a consistently low level at the beginning of every GOP so that there is enough room in the buffer to accommodate the surge of bits produced by the new I frame.

For every frame to be encoded, the MCC calculates the upper and lower limits on the number of bits that

the new frame is allowed to generate. These limits are based on the constraint that neither the encoder buffer nor the decoder buffer is allowed to overflow nor underflow. The MCC also computes the target number of bits to be generated for the frame and for each panel by distributing the bits in proportion to the relative complexity values. Then, a frame target quantizer scale is calculated from the target frame bit rate. The frame target quantizer scale is delivered to every one of the multiple panel compressors as the initial reference quantizer scale to start coding the frame.

At each Rate Control Sync interrupt, the MCC modulates the frame target quantizer scale by a feedback mechanism which tries to bring the panel bit count to a value that equals the targets. If the accumulated bit count is approaching the upper limit that is calculated at the picture start, the modulated quantizer scale is further increased to slow down the production of bits. The resulting reference quantizer scale value is then clipped to fit into an eight bit integer value for delivery to every panel compressor.

Upon receiving the reference quantizer scale, the panel compressor checks its local buffer level and increases the reference quantizer scale if needed to protect the buffer. The panel compressor may also force some DCT coefficients to be zero if the reference quantizer scale is too high. Then, adaptive quantization is performed in a manner similar to the MPEG Test Model 5 and the actual quantization scale is

looked up from the Moving Picture Experts Group (MPEG) quantization scale table.

The following sections detail the operation of the rate control algorithm.

1. List of variables

Name	Default Value	Description
BitRate	User define	Elementary video bit rate (bits per second)
N	User define	Nominal GOP Length
M	User define	Temporal distance between consecutive I or P frames
Nb	N/A	Nominal number of B frames in a GOP
Np	N/A	Nominal number of P frames in a GOP
FrameRate	User define	Frame rate of the input video
PanelSumQuant[0...7]	N/A	Accumulation of quantizer scale values on each panel compressor
PanelBitCount[0...7]	N/A	Accumulation of number of bits generated on each panel compressor
AvgQuant	N/A	Average quantizer scale value of the frame just coded
SumPanelBitCount	N/A	Total number of bits generated by all panel compressors combined for the frame just coded. In RC sync, this is the number of bits generated so far for the frame.
K[I,P,B]	0.75, 1.0, 0.75	Weighting of I, P and B frames
X[I,P,B]	N/A	Estimate of the coding complexity

StartupX[I,P,B]	N/A	Start up value of the coding complexity estimate.
StartupQuant	N/A	Approximate minimum quantizer scale value to use for startup or scene change or fade in.
HeaderBitCount	N/A	Number of bits in the picture and/or sequence header(s) of the frame just encoded.
FrameBitCount	N/A	Total number of bits generated by the frame just encoded.
VideoBufferLevel	N/A	Number of bits stored in the physical video FIFO
EncoderBufferLevel	N/A	Total number of bits store in the encoder's buffers combined
BufferDelay	N/A	Total buffer delay of the encoder and decoder combined.
TargetBufferLevel	N/A	Approximate level of encoder buffer at the start of a new GOP
GopDuration	N/A	Estimate duration of the current GOP
PipelineSize	N/A	Number of frames in the encoder's current processing pipeline
PipelineRepeatFields	N/A	Number of repeated fields (3:2 pulldown) in the encoder's current processing pipeline.
PictureDuration	N/A	Estimated duration of the current frame.
β	0.75	GOP feedback factor
MaxJitter	0.004 second	Maximum transport jitter in MPEG standard
FrameMaxDecoder	N/A	Maximum number of bits the current frame is allowed to generate, as constrained by decoder buffer.

FrameMaxEncoder	N/A	Maximum number of bits the current frame is allowed to generate, as constrained by encoder buffer.
VideoFifoSize	125829 12 bits	Size of encoder's physical video FIFO
FrameMaxBits	N/A	Maximum number of bits the current frame is allowed to generate, as constrained by both encoder and decoder.
InitialFrameTargetBits	N/A	Target number of bits to be generated by the current frame, without feedback.
FrameTargetBits	N/A	Target number of bits to be generated by the current frame.
AllocationFactor[P,B]	N/A	Ratio of bit allocation to P and B frames.
PictureFeedback	N/A	Feedback of surplus of deficit of bits at picture level.
α	N/A	Picture feedback factor
AccumulatedFrameTargetBits	N/A	Accumulation of frame target bits since the beginning of the current GOP
FrameMinTarget	N/A	Minimum number of bits to generate to prevent the encoder video FIFO from emptying.
MaxTarget [I,P,B]	N/A	Maximum allowable value of FrameTargetBits
MinTarget [I,P,B]	N/A	Minimum allowable value of FrameTargetBits
FrameQuant	N/A	Target quantizer value for the frame
MinFrameQuant	2	Smallest target quantizer value for the frame
LastFrameQuant	N/A	Target quantizer value of the last coded frame of the same picture type
LastAvgQuant	N/A	Average of the actual quantizer scale of the last coded frame of the same picture type.

PartialFrameTargetBits	N/A	Portion of the FrameTargetBits as scaled by the number of macroblocks coded so far in the frame.
PartialFrameMaxBits	N/A	Portion of the FrameMaxBits as scaled by the number of macroblocks coded so far in the frame.
SumPanelMbCount	N/A	Number of macroblocks coded so far in the frame by all the panel compressors combined
CurrentQuant	N/A	The modified quantizer scale value currently being used.
MacroblocksPerFrame	N/A	Number of macroblocks in a frame.
MaxRcQuant	144	Maximum quantizer scale value without invoking panic mode.
MaxQuantNonIntraDCMul	N/A	DC entry of the non intra quantization muliplication table for quantizer scale value of 112.
PanicNonIntraDCMul	N/A	DC entry of the non intra panic table
PanicThreshold1, PanicThreshold2, PanicThreshold3	{750000, 500000, 1500000} for P and B frames; {1500000, 1000000, 3000000} for I frame	Thresholds of FrameMaxBits for Panic mode.
LocalBufferSize	3452160 bits	Size of the panel compressor's local buffer

LocalBufferLevel	N/A	Fullness of the panel compressor's local buffer
PanelQuant	N/A	Actual quantizer scale value used by the panel compressor

2. Initialization

1) Set all parameters to default values according to Table 1 and Table 2.

2) The Packet Processor sends the data packet from the video FIFO as soon as the first 184 bytes of the compressed data packet are written into the FIFO.

3. Configuration

The rate control task receives the following configuration parameters:

1. Elementary video stream bit rate (BitRate).
2. Nominal GOP length (N).
3. Temporal distance between every pair of I/P frames (M).
4. Video Format (1920x1080I or 1440x1080I or 1280x720P).
5. Video frame rate (29.97 Hz or 30 Hz or 59.94 Hz or 60 Hz).

4. MCC Picture Start Interrupt

A) Update Complexity Estimate From The Last Coded Frame

First, the frame bit count and average quantizer scales are calculated from the data read from the panel compressors. The bit count used in the complexity calculation is only for the slice layer bits. The bits generated for the headers, which are generated by the MCC, are not included.

AvgQuant = sum of PanelSumQuant over all 8 panels / number of macroblocks per frame

SumPanelBitCount = sum of PanelBitCount over all 8 panels

These statistics are used to calculate the coding complexity of the previous coded picture as:

AvgQuant * SumPanelBitCount

It is assumed that the coding complexity for a particular picture type is relatively constant over a steady scene content, so that the complexity of a frame yet to be encoded may be estimated from the actual coding complexity of the most recently coded frames of the same picture type. Since I frames occur infrequently, only the most recently coded I frame is used as the complexity estimate (X[I]). As a compromise between stability and response speed, four most recently coded frames of the same picture type are used to generate the complexity estimate for P and B

frames. It should be appreciated that averaging more frames provides a more stable complexity estimate but a slower response time. Likewise, averaging fewer frames provides a less stable complexity estimate but a faster response time.

The rate control algorithm maintains a queue to store the complexity values of the four most recently coded P frames, and a queue to store the complexity values of the four most recently coded B frames. The complexity estimate for P (or B) frame, X[P] (or X[B]), is then calculated as the average of the four complexity values stored in the P (or B) complexity queue.

The complexity estimates for I, P and B frames are used to calculate the target quantizer scale value and the bit budget for upcoming frames to be encoded. Details are described in the following sections.

Since the complexity estimates are computed from statistics generated from encoding the past frames, special handling is required at start up, scene change, or fade to reset the complexity estimate when the coding complexity from the past is not available or is not reliable.

At startup, the I complexity estimate and the P and B complexity queues are initialized to a set of default startup complexity values (StartupX[I/P/B]). If the current frame to be encoded is the first I or P frame after fade-in from black or scene change, the I complexity estimate and the values stored in the P and B complexity queues are conditionally replaced by the default startup value. Every stored value in the P and B complexity queue and the I complexity, are compared

with the startup complexity. The stored complexity is replaced by the startup complexity if the stored complexity is smaller.

If multiple scene changes occur within proximity to each other (e.g. flashes, special effects, or a bad edit), the complexity estimates are reset only once at the first scene change. This is achieved by skipping the reset if the complexity adjustment occurred in the previous P frame.

The default startup complexities are moderate complexity values calculated based on the assumption that an I frame consumes approximately 4 times as many bits as a P frame, and B frames consume approximately 20% fewer bits than P frames. This ratio of 4.0:1.0:0.8 is obtained from empirical observations. Other values of I:P:B ratios are possible. Furthermore, the startup complexities assume a provisional average quantizer scale value (StartupQuant) which varies linearly between 20 to 28 for bit rate values between 10 Mbps to 26 Mbps. This provisional average quantizer value is clamped at 20 for bit rate values lower than 10 Mbps, and at 28 for bit rate values higher than 26 Mbps.

The startup complexity values for I, P, and B frames are calculated as follows:

```
StartupX [I] = 4.0 * StartupQuant * N * (BitRate /
FrameRate) / (4.0 + 1.0*Np + 0.8*Nb)

StartupX [P] = 1.0 * StartupQuant * N * (BitRate /
FrameRate) / (4.0 + 1.0*Np + 0.8*Nb)
```

```
StartupX [B] = 0.8 * StartupQuant * N * (BitRate /
FrameRate) / (4.0 + 1.0*Np + 0.8*Nb)
```

To accelerate the convergence of the P and B complexity estimate to the new scene, a state machine is implemented to handle the complexity update for the P and B frames following the complexity reset.

1. For the initial I or P frame after scene change (or fade-in from black), the complexity estimates are set to the reset value before the frame is encoded. After encoding the initial frame, the complexity estimates are updated using the new encoding complexity (AvgQuant * SumPanelBitCount). If the initial frame is an I frame, the I complexity estimate is updated. If the initial frame is a P frame, the entire P complexity queue is replaced by the new encoding complexity. The P encoding complexity is used to estimate the B encoding complexity, so the entire B complexity queue is replaced by the encoding complexity of the P frame multiplied by the value 0.8, which value is the estimated ratio of B complexity to P complexity. Other reasonable values can, of course, be used.

2. Because of reordering, the first group of B frames following the initial I or P frame may belong to the old scene. Therefore, if there is only one B frame in the group (M=2), the encoding complexity after encoding that B frame is discarded so that the B complexity queue stays at the reset value after that B frame is encoded. If there is more than one B frame in the first group of B frames (M=3), the encoding

complexity of the first B frame is used as the complexity estimate for the next B frames in the group. Therefore, the B complexity queue is updated normally except for the last B frame in the group. After encoding the last B frame in the group, the B complexity queue is set to the reset value so that statistics possibly from the old scene will not contaminate the complexity estimates of the new scene.

3. If the initial frame is an I frame, after encoding the first P frame that follows the initial frame, the entire P complexity queue is replaced by the new encoding complexity. The B complexity queue is replaced by the encoding complexity of the P frame multiplied by a value such as 0.8, i.e., an estimated ratio of B complexity to P complexity. If the initial frame is a P frame, the complexity queue is updated normally after encoding the first P frame following the initial frame.

4. After encoding the first B frame in the second group of B frames following the initial frame, the entire B complexity queue is replaced by the new encoding complexity (AvgQuant * SumPanelBitCount) of the B frame.

5. The complexity queues are updated normally (by replacing the oldest entry by a new value) for every frame thereafter. For example, consider a scene change that occurs at frame I0 in the following sequence of frames (in encoding order): I0, B1, B2, P3, B4, B5, P6, ... Before encoding I0, the complexity estimates are forced to reset. The I complexity estimate is updated after encoding I0. The B

complexity queue is set to the new encoding complexity after encoding B1. This new complexity estimate is used for encoding B2. After encoding B2, the B complexity queue is set to the reset value. After encoding P3, the entire P complexity queue is replaced by the encoding complexity of P3, and the entire B complexity queue is replaced by the same value multiplied by, e.g., 0.8. After encoding B4, the entire B complexity queue is replaced by the encoding complexity of B4. From B5 and P6 onward, the complexity queues are updated normally.

Consider a case where a fade-in from black happens at frame P0 in the following sequence of frames (in encoding order): P0, B1, B2, P3, B4, B5, P4, ... Before encoding P0, the complexity estimates (including I complexity) are forced to reset. After encoding P0, the P complexity queue is replaced by the encoding complexity of P0, and the B complexity queue is set to the same value multiplied by, e.g., 0.8. The B complexity queue is set to the new encoding complexity after encoding B1. This new complexity estimate is used for encoding B2. After encoding B2, the B complexity queue is set to the reset value. After encoding P3, both P and B complexity queues are updated in the same way as after encoding P0. After encoding B4, the entire B complexity queue is replaced by the encoding complexity of B4. From B5 and P6 onward, the complexity queues are updated normally.

A fade-out to black increases the complexity for P and B frames but decreases the complexity of I frames.

Therefore, on the first frame when a fade-out is detected, a constant factor larger than one is multiplied with every entry of the B and P complexity queues to increase the complexity estimate. For example, the multiplier 1.25 can be used for P complexity and the multiplier 1.5 can be used for B complexity. The I complexity estimate is reduced by multiplying a constant factor less than one for every frame where fade-out is detected. The multiplier 0.975 can, for example, be applied on I complexity for every frame during a fade-out to black.

B) Update The Encoder's Buffer Status

Since the data transfer rate of the compressed data from the panel compressors' local buffers to the video FIFO via the PCI bus is much faster than the data output rate from the video FIFO, we can consider the combined video FIFO and the panel compressor's local buffers together as a single entity for the encoder's buffer level considerations. The level of the video FIFO is latched at Field Sync and is read by the MCC via the PCI bus interface.

First the total number of bits generated from the previous frame is calculated as follows:

FrameBitCount = SumPanelBitCount + HeaderBitCount

Then, the total encoder buffer level is computed as:

EncoderBufferLevel = VideoBufferLevel + FrameBitCount

A new GOP is set up if the current frame is an I frame. Before encoding an I frame, the MCC rate control algorithm calculates the bit budget for the new GOP, assuming a nominal number of frames for the GOP (N). The MCC rate control algorithm tries to bring the video buffer to a constant low level (TargetBufferLevel) at the start of every GOP. The TargetBufferLevel is set to be a fraction (one-eighth) of the usable buffer space in the encoder and decoder combined.

TargetBufferLevel = (BufferDelay * BitRate)/ 8

where BufferDelay is the total buffer delay which is detailed in section D below.

First, the MCC estimates the time duration of the upcoming GOP (GopDuration) based on the film mode status. The GOP is divided into two parts, namely, (i) the frames already preprocessed and waiting in the encoder's pipeline, and (ii) the future frames that have not yet entered the encoder's pipeline. For the frames that are already in the pipeline, the exact duration of the frames can be calculated from the number of frames in the pipeline (PipelineSize) and the number of frames that have a repeat field (PipelineRepeatFields). For the future frames that have not yet entered the pipeline, it is assumed that those frames have the same film mode classification as the most recently preprocessed frame, and the three-two pulldown pattern is continued if they are classified as film.

The current I frame is not included in the calculation of the PipelineSize and PipelineRepeatFields. However, the exact duration of the current frame (PictureDuration) is known from the repeat field status. If the current frame to be encoded has repeat first field, the PictureDuration equals (1.5/FrameRate), otherwise, PictureDuration equals (1.0/FrameRate). This process can be implemented using the following code:

```
if ( most recently preprocessed frame is film ) {
    if ( (N – 1 – PipelineSize) is even ) {
        GopInputFrames = PipelineSize + ( 0.5 * PipelineRepeatFields ) + 1.25 * ( N – 1 – PipelineSize )
    } else {
        if ( most recently preprocessed frame has repeat first field ) {
            GopInputFrames = 1.0 + PipelineSize + ( 0.5 * PipelineRepeatFields ) + 1.25 * (N – 2 – PipelineSize)
        } else {
            GopInputFrames = 1.5 + PipelineSize + ( 0.5 * PipelineRepeatFields ) + 1.25 * (N – 2 – PipelineSize)
        }
    }
}
GopDuration = PictureDuration + (GopInputFrames / InputFrameRate )
```

The target bit rate of the new GOP is the average number of bits transmitted during the GOP plus the surplus or deficit carried over from the previous GOP. This carry over is reflected by the deviation of the

current buffer level from the target buffer level. In particular:

GOP_target = (GopDuration * BitRate) + β * (TargetBufferLevel - EncoderBufferLevel)

where β is an adaptive feedback control factor, such that β=1.0 when there are surplus bits carried over from the previous GOP (EncoderBufferLevel < TargetBufferLevel) and β = 0.75 when there is a deficit (EncoderBufferLevel > TargetBufferLevel). This arrangement allows the rate control algorithm to respond quickly to make use of the unused bit (if any) left over from the previous GOP, yet avoids starving the new GOP if the previous GOP consumes more bits than the budget. Thus, any negative feedback is absorbed by the buffer and spread over future GOPs to avoid sudden degradation in the video quality. The GopTarget may be adjusted later during the GOP if the GOP size is extended to align the next I frame with a scene change, or if the film mode status changes.

C) Adjust the GopTarget

Within a GOP, the GOP target is adjusted every frame for the following:

i) If a scene change is detected, the encoder may lengthen the GOP to align the next I frame with the scene change. In this case, the GopTarget is increased accordingly to provide the bits needs for coding the extra bits. This adjustment is only done on P frames, since extra B frames must be accompanied by P frames.

If the current frame is film, the increment is (1.25 * M * BitRate/FrameRate), otherwise the increment is (M * BitRate / FrameRate). The constant M is the distance (in frames) between two consecutive P frames.

ii) When the initial target bit budget is calculated at the beginning of the GOP, it is assumed that the entire GOP will operate in film mode if the last preprocessed frame is film, or in regular video mode if the last preprocessed frame is non-film. However, the film mode status may change in the middle of a GOP.

If the most recently preprocessed frame belongs to the current GOP and switches from non-film to film, the GopTarget is increased accordingly to account for the expected increase in the expected duration of the GOP. The increase in GopTarget is calculated as:

0.25 * (BitRate / FrameRate) * (Number of unprocessed frames remaining in the GOP),

where the number of unprocessed frames is calculated as:

N - (Number of frames already encoded in the GOP) - PipelineSize - 1.

On the other hand, if the input switches from film to normal video, the GopTarget is decreased by the same amount to account for the expected decrease in the duration of the GOP. The film to video (or video to film) adjustment is skipped if the number of frames

encoded so far in the GOP exceeds (N - PipelineSize - 1).

D) Buffer Protection

The end-to-end buffer delay is set by the packet processor and is defined as the time elapsed from the time the first bit of the picture enters the encoder FIFO to the time the picture is pulled out from the decoder FIFO (Decoder Time Stamp (DTS) of the picture). The MCC rate control algorithm uses the delay value to calculate the maximum allowable number of bits in the picture that does not overflow the encoder buffer or underflow the decoder buffer. For high bit rates, the system stores as many bits as the decoder buffer allows to maximally utilize the buffers. For low bit rates, however, an upper bound of, e.g., one-half second delay is set to ensure a reasonable channel acquisition delay. For compliance with the ATSC standard, it is assumed that the decoder uses a 488*1024*16 = 7995392 bit buffer. The buffer delay is calculated from the following equation:

BufferDelay = Min (7995392 bits / BitRate , 0.5 second)

The delay is fixed at, e.g., 0.5 second for bit rates below 16 Mbps, and decreases linearly for bit rates above 16 Mbps, e.g. 0.2 second at 40Mbps.

To prevent the decoder buffer from underflowing, all the bits currently in the encoder buffer plus the bits

to be generated for the current frame have to be transported to the decoder before the decode time of the current frame. Since the PCI bandwidth is much higher than the output bit rate, we can assume that the transfer of data from the panel compressors to the video FIFO is instantaneous. The worst case decode time of the current frame is (BufferDelay-MaxJitter) time units after current picture is transferred to the video FIFO, which happens one picture processing time later.

If the encoder's current buffer level is higher than the nominal number of bits (BitRate * PictureDuration) to be transmitted from the encoder buffer to the decoder buffer during the current frame time, a constant output bit rate (BitRate) will be maintained. Otherwise, the packet processor will generate null packets to fill up the gap in the transport bandwidth, which effectively reduces the video bit rate. Therefore, the projected video FIFO level one frame time later when the current picture enters the video FIFO is:

```
max ( EncoderBufferLevel - (BitRate * PictureDuration ),  0 )
```

From the time the current frame enters the video FIFO to the decode time of the frame, worst case (BufferDelay-MaxJitter) * BitRate bits will be transported to the decoder FIFO so that the number of bits available for the current frame is:

```
FrameMaxDecoder = (BufferDelay -MaxJitter)*BitRate - Max
(EncoderBufferLevel - (BitRate * PictureDuration), 0)
```

To prevent the encoder's video FIFO from overflow, the size of the current frame plus the level of the FIFO when the current frame is transferred to the video FIFO should not exceed the size of the video FIFO (VideoFifoSize), i.e.:

```
FrameMaxEncoder = VideoFifoSize - Max EncoderBufferLevel -
(BitRate * PictureDuration),  0)
```

In an example implementation, the size of the video FIFO is 12582912 bits, although any other suitable FIFO size can be used as will be appreciated by those skilled in the art.

The maximum allowable bitstream size of the current frame is then calculated as the smaller of FrameMaxEncoder and FrameMaxDecoder. An offset of two transport packets' worth of video data (2*8*184 = 2944 bits) is included to provide a safety margin. Thus:

```
FrameMaxBits = MIN (FrameMaxEncoder, FrameMaxDecoder) - 2944
```

Since the packet processor inserts null packets to effectively reduce the video bandwidth when there is not enough data in the video FIFO, it is not necessary to set a lower bound on the frame size to protect the encoder or decoder buffer.

E) Calculate bit budget for the frame

For every picture to be encoded, the MCC rate control algorithm calculates a target for the number of bits to be generated for the frame (FrameTargetBits). The

basic idea is to distribute the available bits to the I, P, and B frames in proportion to the complexity estimates adjusted by a set of constant weighting factors (K[I], K[P], K[B]). The weighting factors (K[]) account for the different perceptual and statistical characteristics of I, P and B frames. As an example, the weighting factors (0.75, 1.0, 0.75) can be used, although other weighting factors are equally applicable. A portion of the deviation of the actual bits used from the target is fed back to adjust the target for the future frames.

For an I frame:

```
FrameTargetBits = GopTarget * K[I] * X[I] /
(K[I]*X[I] + Np*K[P]*X[P] + Nb*K[B]*X[B])
```

The smaller of FrameTargetBits value of the I frame and the actual number of bits generated by the I frame is then deducted from the GopTarget before allocating the remaining bits to the P and B frames. Note that if the actual number of bits generated exceeds the target, the target is deducted from the GopTarget instead of the actual bits because the I frame consumes bits at a much higher rate than P and B frames. Deviation of the I frame's bit consumption from the target may deplete the bit budget of the remaining P and B frames. By decoupling the actual I frame bits from the B and P bit allocation, the feedback is deferred to the next GOP.

For B and P frames, an allocation ratio is first calculated as follows:

AllocationFactor[P] = (N-1) / (Np + Nb* Max (1/2 , Min (3,(K[B]*X[B] / K[P]*X[P]))))

AllocationFactor[B] = (N-1) / (Nb + Np* Max (1/3 , Min (2,(K[P]*X[P] / K[B]*X[B]))))

The ratio of the weighting complexity (K*X) of P to B frames are bounded by ½ and 3 to avoid extreme allocation caused by an inaccurate complexity estimate. An initial frame target is then computed by applying the allocation factor to the average number of bits available to the P and B frames, as follows:

InitialFrameTargetBits = AllocationFactor * GopTarget / (GopLength-1)

Note that GopLength is the current length of the GOP, which may be larger than NominalGopLength because the GOP is extended to align the next I frame with the scene change. If the current frame count with respect to the start of the GOP is less than the nominal GOP length (N), GopLength is set to the same value as N. If the current frame count exceeds N, GopLength is increased by M frames for every time a P frame is encountered. Feedback is then added to the InitialFrameTargetBits to compensate the deviation of the actual bit consumption from the target. The feedback is computed as:

PictureFeedback = α * (AccumulatedFrameTargetBits - GopBitCount)

AccumulatedFrameTargetBits is the accumulation of the FrameTargetBits since the beginning of the GOP. The PictureFeedback portion of the FrameTargetBits is excluded in the accumulation in every P and B frame. GopBitCount is the number of bits generated by the current GOP up to and including the last coded frame.

After encoding each frame, the GopBitCount is increased by the effective number of bits generated by the frame. Since the null packet is inserted to sustain the transport bit rate when the video FIFO level is lower than that required to produce one transport packet, the effective number of bits produced for the last coded frame is lower bounded by the number of bits that are required to sustain a constant output bit rate during the upcoming frame time minus the number of bits that are already in the video FIFO. The effective number of bits generated is:

Max (FrameBitCount, (PictureDuration*BitRate - VideoBufferLevel))

The constant α controls the response of the system. If α is too big, the system becomes unstable; if α is too small, the response is slow. In an example embodiment, α can be set to 1/N, although other values can be substituted.

To avoid exceesive negative feedback that may deplete the bit budget of the current frame, the magnitude of PictureFeedback is bounded to not exceed one-third of the InitialFrameTargetBits if the feedback is negative.

FrameTargetBits = InitialFrameTargetBits + PictureFeedback

Finally, the FrameTargetBits is bounded both from above and below. It is necessary that the FrameTargetBits does not lie in the proximity of the maximum allowable number of bits that applies for buffer protection. Otherwise, panic mode may be invoked too early and the picture quality will be excessively degraded. Although it is not necessary to set a minimum picture size to protect the buffer, it is desirable that the encoded frame is big enough such that bandwidth would not be wasted by sending null packets. Therefore, a minimum value for the FrameTargetBits is calculated as the worst case number of bits required to prevent the encoder video FIFO from emptying.

FrameMinTarget = (1.5 * BitRate / FrameRate) - Max (EncoderBufferLevel - (BitRate * PictureDuration), 0)

To avoid extreme values that may result from inaccurate complexity estimates, hard limits are provided so that the FrameTargetBits will not exceed the upper limit or fall below this limit.

FrameTargetBits = Min (FrameTargetBits, 0.8 * FrameMaxBits, MaxTarget)

FrameTargetBits = Max (FrameTargetBits, FrameMinTarget, MinTarget)

The value of MaxTarget and MinTarget are defined as:

MaxTarget [I frame] = GopTarget - (N-1) * (Number of Macroblocks per frame) * 8

MaxTarget [P or B frame] = GopTarget / N

MinTarget [I frame] = GopTarget / N

MinTarget [P or B frame] = (Number of Macroblocks per frame) * 8

F) Determine the target quantizer scale for the frame.

The target quantizer scale is calculated from the target frame bit rate and the complexity estimate, lower bounded to prevent incorrect complexity estimates from driving the quantizer scale too low. The quantizer scale is also upper bounded by the maximum MPEG nonlinear quantizer scale value.

FrameQuant = Max (MinFrameQuant, X[picture_type] / FrameTargetBits)

The value MinFrameQuant is set to 2.

To improve stability in case of inaccurate complexity estimates, especially in complex still images, the algorithm sets a lower bound for the target quantizer value of P and B frames if it drops suddenly from a relatively higher value. The following adjustments are made to FrameQuant if FrameQuant is smaller than the last AvgQuant value of the same picture type and smaller than 24:

FrameQuant = Min (StartupQuant, (FrameQuant + Max (LastFrameQuant, LastAvgQuant)) / 2

where LastFrameQuant is the target quantizer (FrameQuant) value of the most recently coded frame of the same picture type, and LastAvgQuant is the actual average quantizer (AvgQuant) value of the most recently coded frame of the same picture type.

The target quantizer scale (FrameQuant) value calculated on the MCC is then clamped by a maximum value and delivered to the panel compressors to be used initially to code the panels. Details for setting the upper bound and the quantization strategy on the panel compressors are provided hereinafter. The quantizer scale values are adjusted periodically at RC sync interrupts by a feedback process to drive the actual number of bits generated in the picture towards the target.

G) Delay start of a new GOP if buffer level is too high

Before a new GOP may be started, the algorithm makes sure that there is enough room in the buffer to accommodate the surge of bits to be generated by the upcoming I frame. Since the rate control task is carried out after the decision of picture coding type, the buffer is inspected to determine the feasibility of starting a new GOP at the next frame. If there is not enough space in the buffer, the rate control task sends a signal to prevent the next frame from starting a new GOP. The next frame is allowed to start a new GOP if:

EncoderBufferLevel + FrameTargetBits - (PictureDuration * BitRate)

is below a threshold which is precomputed as:

Min (0.5 * BufferDelay * BitRate, TargetBufferLevel + (0.333 * N * BitRate / FrameRate))

5. MCC RC sync interrupt

Ideally, the frame target quantizer scale (FrameQuant) should be used throughout the picture to produce a uniform quality over the entire picture. However, the rate control model based on the frame complexity estimate is not always accurate. Thus, adjustments to FrameQuant are necessary to control the bit rate. A feedback mechanism is used such that the accumulated bit count of the frame is compared to the target bit rate of the frame, scaled by the portion of macroblocks coded.

At RC Sync interrupt, the MCC reads two parameters from every panel compressor. These parameters are (i) the number of macroblocks currently encoded, and (ii) the number of bits generated so far. The MCC sums up these statistics for all eight panels (SumPanelBitCount and SumPanelMbCount). The MCC then computes a partial target and a partial maximum for the number of bits generated.

PartialFrameTargetBits = FrameTargetBits * SumPanelMbCount / (Number of macroblocks per frame)

PartialFrameMaxBits = FrameMaxBits * SumPanelMbCount / (Number of macroblocks per frame)

The adjustment of the quantizer scale is based on the ratios of the SumPanelBitCount to PartialFrameTargetBits and to PartialFrameMaxBits. If the bit count (SumPanelBitCount) exceeds 0.9 of PartialFrameMaxBits, the quantizer scale is adjusted as:

CurrentQuant = CurrentQuant * 0.9 * SumPanelBitCount / PartialFrameMaxBits

where CurrentQuant is the current quantizer scale being used, which is initialized to the value FrameQuant at the start of encoding the frame. Otherwise the adjustment is based on the ratio of SumPanelBitCount to PartialFrameTargetBits using the following piecewise linear model:

ratio < 1.5 :	CurrentQuant = FrameQuant
2.0 ≥ ratio > 1.5 :	CurrentQuant = (1+0.5*(ratio-1.5))* Max(FrameQuant, CurrentQuant)
ratio ≥ 2.0 :	CurrentQuant = 1.25 + (ratio - 2.0) * Max (FrameQuant, CurrentQuant)

Assuming that the bit count at the end of each frame is close to the target bit rate, the final quantizer scale value of the panel would be close to the initial value which is FrameQuant. Such arrangement avoids visible seams at panel boundaries that can be caused by abrupt changes in the quantizer scale.

To improve stability, the value of CurrentQuant calculated in the current RC sync is then averaged with the value of CurrentQuant calculated in the previous RC sync.

The value of CurrentQuant is then capped to the same upper bound as that used to cap FrameQuant (detailed hereinafter), and averaged with the previous CurrentQuant value. Before sending the final value of quantizer scale to the panel compressors, CurrentQuant is further adjusted to increase the quantizer scale value to protect the buffers if the SumPanelBitCount is approaching the limit of FrameMaxBits:

```
if (SumPanelBitCount > 0.975 * FrameMaxBits)
    CurrentQuant = 512
else if (SumPanelBitCount > 0.95*FrameMaxBits) AND
(SumPanelMbCount < 0.8*MacroblocksPerFrame) )
    CurrentQuant = 4 * CurrentQuant
else if (SumPanelBitCount > 0.9*FrameMaxBits) AND
(SumPanelMbCount < 0.7*MacroblocksPerFrame) )
    CurrentQuant = 2 * CurrentQuant
```

Finally, the value of CurrentQuant is capped again by the same upper bound as that used to cap FrameQuant. A lower bound of 2 also applies to CurrentQuant.

6. Quantization Strategy

The panel compressors perform quantization by multiplying the DCT coefficients with precomputed sets of reciprocal values of the quantizers. There are 32

precomputed sets of multipliers on the panel compressors. The first 31 tables correspond to the MPEG quantizer scale index of 1 to 31, which are mapped to the quantizer scale value of 1 to 112 according to the MPEG nonlinear quantizer mapping table. The 32nd table is reserved for a panic mode in which all multipliers are set to zero, except for the intra DC, so that the DCT coefficients may be discarded to minimize the number of bits generated. This panic mode should be invoked only as an emergency measure to protect the buffers. The DC value of the non-intra panic multiplier table (PanicNonIntraDCMul) may be written by the MCC to determine whether to normally quantize the non-intra DC by the maximum MPEG quantizer scale (112), or set it to a fraction of the normally quantized value. If the panel compressor receives from the MCC a quantizer scale value (PanelQuant) between 1 to 112, the normal tables are selected. For any PanelQuant value above 112, the panic table will be selected.

The quantization scale value calculated by the MCC (FrameQuant or CurrentQuant) spans a range of 1 to 512. This value is converted to an 8-bit value from 1 to 255 (PanelQuant) to be sent to the panel compressor to select the multiplier table, and is also used to determine the non-intra DC multiplier of the panel compressor's panic table:

1 <= CurrentQuant <= 112:	PanelQuant = round currentQuant to the nearest integer by truncation. PanicNonIntraDCMul = MaxQuantNonIntraDCMul
112 < CurrentQuant <= MaxRcQuant:	PanelQuant = 112; PanicNonIntraDCMul = MaxQuantNonIntraDCMul

MaxRcQuant < CurrentQuant < 512: PanelQuant = 255;
PanicNonIntraDCMul = MaxQuantNonIntraDCMul

CurrentQuant = 512: PanelQuant = 255;
PanicNonIntraDCMul = 0.3 * MaxQuantNonIntraDCMul

where MaxQuantNonIntraDCMul is the non-intra DC entry of the multiplier table for the maximum MPEG quantizer scale (112). MaxRcQuant is a constant value current set to 144.

Normally, the FrameQuant value should not be allowed to exceed MaxRcQuant above which the panel compressor may invoke panic mode that severely degrade the picture quality. However, if the encoder buffer is at the verge of overflowing, or if the decoder buffer is at the verge of undeflowing, the panel compressors should be allowed to go into panic mode at the onset of encoding the frame. Therefore, the following adaptive algorithm is used to set the upper bound of FrameQuant base on the value of FrameMaxBits. If FrameMaxBits is big enough to support the worst case number of bits generated by normal MPEG quantization (FrameMaxBits exceeds a thresholdPanicThreshold1), FrameQuant is capped by MaxRcQuant to avoid going into panic mode.

Once FrameMaxBits goes below PanicThreshold1, the upper bound is changed, e.g., to 176, which enables panic mode on the panel compressors but preserves the non-intra DC coefficient at panic. If the FrameMaxBits further drops below a second threshold PanicThreshold2, the upper bound is set to 512 so that the quantized value of the non-intra DC coefficient can be reduced beyond that of normal quantization. A hysteresis mechanism is provided so that

once the upper bound is raised above MaxRcQuant, it will not return to MaxRcQuant until FrameMaxBits exceeds a third threshold (PanicThreshold3). The thresholds {PanicThreshold1, PanicThreshold2, PanicThreshold3} can be set, for example, to the values {750000, 500000, 1500000} for P and B frames, and {1500000, 1000000, 3000000} for I frames.

7. Panel Compressors

Each panel compressor receives the PanelQuant value from the MCC at every RC Sync and at picture start. The panel compressors then perform the following routine on a macroblock by macroblock basis:

A) Update the encoding statistics.

Accumulate the macroblock count, PanelSumQuant (sum of actual quantizer scale used), and PanelBitCount (number of bits generated so far in the panel). These statistics are reset to zero at the beginning of the frame.

B) Check fullness of local buffer; ramp up the quantizer scale if the local buffer level is approaching full.

```
if ( LocalBufferLevel < (112/128) * LocalBufferSize )
      PanelQuant unchanged
else if  (LocalBufferLevel < (120/128) * LocalBufferSize)
      PanelQuant = 4 * PanelQuant
else if (LocalBufferLevel < (124/128) * LocalBufferSize )
      PanelQuant = 16 * PanelQuant
else
```

PanelQuant = 255

C) Modulate PanelQuant by adaptive quantization the same way as in MPEG Test Model 5.

D) Apply the final quantizer scale to perform quantization.

8. Packet Processor

Whenever the video FIFO has at least one transport packet payload's worth of data (184 bytes), the packet processor retrieves the data from the primary video FIFO at an average data rate equal to the video bit rate (bit_rate) as specified by the user. Whenever the FIFO level falls below 184 bytes, the packet processor will stop retrieving data from the FIFO to protect the FIFO from underflow. Null packets will then be substituted for video packets to maintain a constant transport bit rate.

It should now be appreciated that the present invention provides a rate control algorithm for optimizing the performance of a video encoder that utilizes multiple parallel compression engines. The invention has application to both HDTV and SDTV encoders.

Although the invention has been described in connection with various preferred embodiments, it should be appreciated that numerous adaptations and modifications thereof can be provided without departing from the scope of the invention as set forth in the claims.

What is claimed is:

1. A method for controlling the quantization in a digital video encoder that comprises a plurality of parallel compression engines, comprising the steps of:

determining a target quantization level for a video frame;

applying said target quantization level to the first slice of every video image panel of a plurality of panels representing said video frame and being processed in parallel by said video encoder; and

driving the quantization level at the last slice of each of said image panels toward said target quantization level.

2. A method in accordance with claim 1 wherein said driving step uses piecewise linear feedback to drive the quantization level of the last slice of each of said image panels toward said target quantization level.

3. A method in accordance with claim 2 wherein said feedback compensates for variations in the quantization level between the first and last slice of each of said image panels.

4. A method in accordance with claim 1 wherein a group of pictures (GOP) target bit rate is adjusted based on a number of film pictures and non-film pictures currently in a processing pipeline of at least one of said compression engines.

5. A method in accordance with claim 4 wherein a higher target bit rate is provided for non-film pictures.

6. A method in accordance with claim 1 wherein a buffer level of said video encoder is used to control the start of a new group of pictures (GOP).

7. A method in accordance with claim 1 wherein:

every input picture is partitioned into a fixed number of horizontal panels; and

each of said panels is compressed by a separate compression engine.

8. A method in accordance with claim 7 wherein said panels are simultaneously compressed during a frame time.

9. A method in accordance with claim 8 wherein the compressed panel data are stored locally at the compression engines for subsequent transfer to a video buffer of the video encoder within a next frame time.

10. A method in accordance with claim 9 wherein data are retrieved from said buffer, to form a transport packet, at an average rate equal to a specified video bit rate whenever the buffer has at least one transport packet payload's worth of data.

11. A method in accordance with claim 10 wherein null packets are substituted for video packets to maintain a constant transport bit rate whenever said buffer level falls below one transport packet payload's worth of data.

12. A method in accordance with claim 7 wherein a reference quantizer scale is calculated for each of said compression engines.

13. A method in accordance with claim 12 wherein the reference quantizer scale for a compression engine is calculated based on:

an accumulation of quantizer scale values for that compression engine (sum_quant),

an accumulation of the number of bits generated on that compression engine (bitcount);

an accumulation of the number of macroblocks processed on that compression engine (MBcount); and

a fullness level of a video buffer of the video encoder (buffer_level).

14. A method in accordance with claim 13 wherein the compression engine modifies its reference quantizer scale based on a local buffer fullness to generate a final quantizer scale value for use in quantization.

15. A method in accordance with claim 14 wherein a panic mode is initiated by the compression engine if the final quantizer scale value is higher than a predetermined maximum value, said panic mode maintaining the quantization at or below said predetermined maximum value.

16. A method for controlling the rate at which data is processed by a digital video encoder using a plurality of parallel compression engines to compress successive macroblocks of video data, comprising the steps of:

providing frame level rate control on successive video frames in accordance with a picture start interrupt service routine once per coded picture; and

providing macroblock level rate control in accordance with a rate control interrupt service routine a plurality of times per coded picture.

17. A method in accordance with claim 16 wherein said picture start interrupt routine updates frame level statistical variables by processing data collected from a prior coded frame.

18. A method in accordance with claim 16 comprising the further step of calculating a target bit rate for a new group of pictures (GOP) if a new frame to be processed comprises an intra-coded (I) frame.

19. A method in accordance with claim 16 comprising the further steps of:

calculating upper and lower limits on the number of bits that a new frame is allowed to generate for every frame to be encoded; and

computing a target number of bits to be generated for each frame and for each of a plurality of panels into which each frame is divided.

20. A method in accordance with claim 19 wherein said target number of bits is computed by distributing the bits in proportion to relative complexity values of the video frames being processed.

21. A method in accordance with claim 19 comprising the further step of calculating a frame target quantizer scale from the target number of bits computed for a frame.

22. A method in accordance with claim 21 wherein said frame target quantizer scale is provided to each of said plurality of compression engines as an initial reference quantizer scale for use in commencing coding of the video frame.

23. A method in accordance with claim 22 wherein said macroblocks comprise DCT coefficients, said method comprising the further step of:

enabling said compression engines to force some of said DCT coefficients to zero if said reference quantizer scale is too high to maintain the number of bits that the new frame is allowed to generate within said upper limit.

24. A method in accordance with claim 19 wherein said rate control interrupt service routine provides interrupts which initiate a modulation of a frame target quantizer scale, said modulation being based on feedback to attempt to bring the actual number of bits for each of said panels to the corresponding target number of bits for the panel.

25. Apparatus for controlling the quantization in a digital video encoder that comprises a plurality of parallel compression engines, comprising:

means for determining a target quantization level for a video frame;

means for applying said target quantization level to the first slice of every video image panel of a plurality of panels representing said video frame and being processed in parallel by said video encoder; and

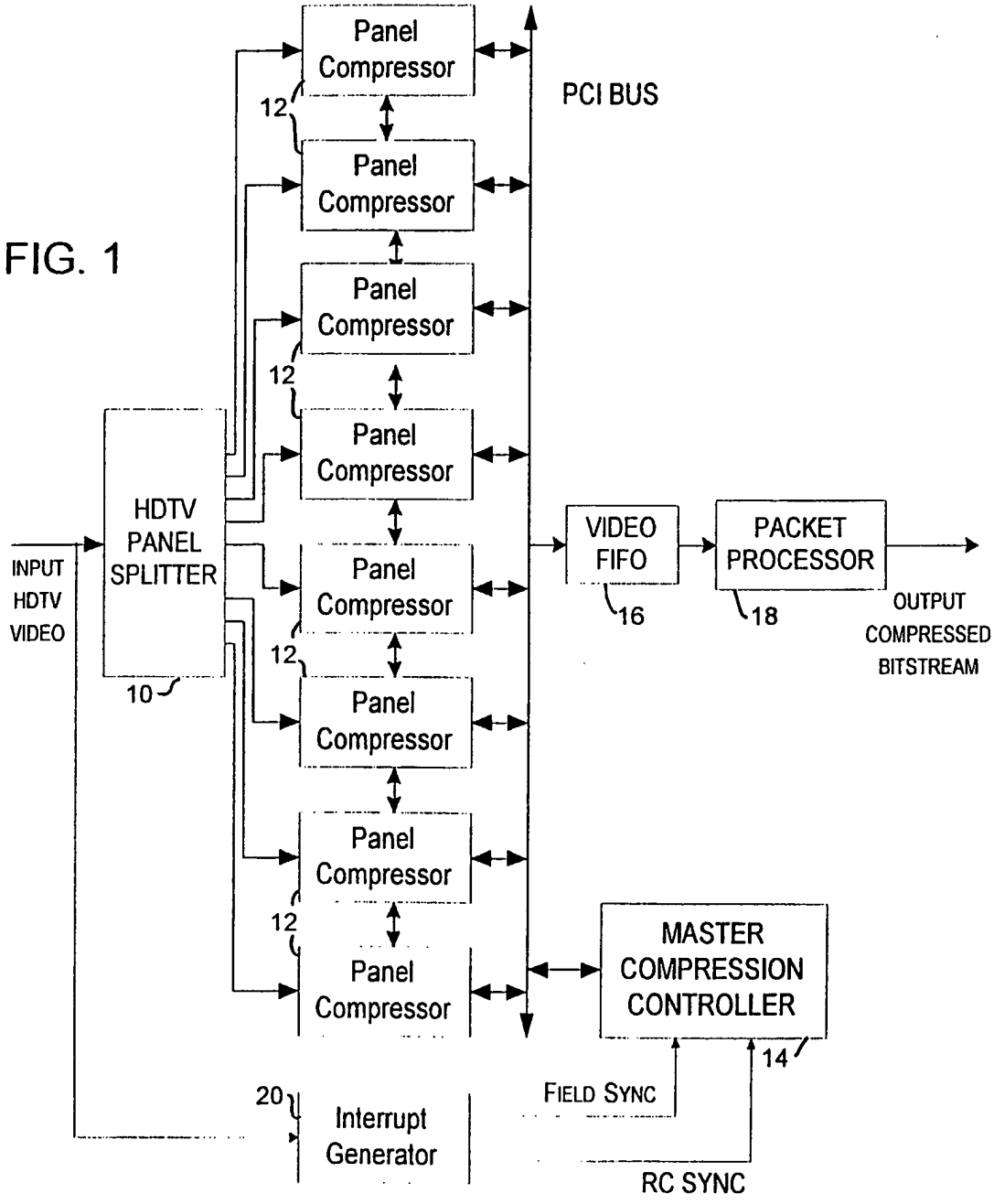
means for driving the quantization level at the last slice of each of said image panels toward said target quantization level.

26. Apparatus for controlling the rate at which data is processed by a digital video encoder using a plurality of parallel compression engines to compress successive macroblocks of video data, comprising:

means for providing frame level rate control on successive video frames in accordance with a picture start interrupt service routine once per coded picture; and

means for providing macroblock level rate control in accordance with a rate control interrupt service routine a plurality of times per coded picture.

FIG. 1


Panel Compressor
12
PCI BUS
HDTV PANEL SPLITTER
INPUT HDTV VIDEO
10
VIDEO FIFO
16
PACKET PROCESSOR
18
OUTPUT COMPRESSED BITSTREAM
MASTER COMPRESSION CONTROLLER
14
FIELD SYNC
RC SYNC
20
Interrupt Generator

INTERNATIONAL SEARCH REPORT

Inter ıal Application No
PCT/US 99/22663

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 H04N7/50 H04N7/26

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)
IPC 7 H04N

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)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 5 701 160 A (KIMURA JUNICHI ET AL) 23 December 1997 (1997-12-23) column 7, line 17 -column 9, line 6 figures 11,12,15A,44	1-3,6-9, 12
Y		10,11, 13-15, 22,23
A		16-19

X	US 5 650 860 A (UZ K METIN) 22 July 1997 (1997-07-22) the whole document	16-21, 24,26
Y		10,11, 13-15, 22,23
A		1,4,5, 7-9,12, 25

	-/--	

[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in 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
27 January 2000	08/02/2000

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL – 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Fassnacht, C

Form PCT/ISA/210 (second sheet) (July 1992)

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication,where appropriate, of the relevant passages	Relevant to claim No.
A	EP 0 851 656 A (HUGHES AIRCRAFT CO) 1 July 1998 (1998-07-01) the whole document	1-26
A	BAGNI D ET AL: "Efficient intra-frame encoding and improved rate control in H.263 compatible format" 10 September 1997 (1997-09-10) , NTG FACHBERICHTE, PAGE(S) 767-774 XP002095679 ISSN: 0341-0196 * section "3.1 Rate Control with local modeling" *	1-26
A	KEESMAN G ET AL: "BIT-RATE CONTROL FOR MPEG ENCODERS" SIGNAL PROCESSING. IMAGE COMMUNICATION,NL,ELSEVIER SCIENCE PUBLISHERS, AMSTERDAM, vol. 6, no. 6, 1 February 1995 (1995-02-01), page 545-560 XP000491860 ISSN: 0923-5965 the whole document	1-26
P,X	US 5 949 490 A (BORGWARDT PETER A ET AL) 7 September 1999 (1999-09-07) the whole document	1-3,6-9, 12-16, 25,26
A	US 5 694 170 A (TIWARI PRASOON ET AL) 2 December 1997 (1997-12-02)	

INTERNATIONAL SEARCH REPORT

information on patent family members

Inte. ·nal Application No
PCT/US 99/22663

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 5701160 A	23-12-1997	JP 8037662 A CN 1119386 A	06-02-1996 27-03-1996
US 5650860 A	22-07-1997	NONE	
EP 0851656 A	01-07-1998	NONE	
US 5949490 A	07-09-1999	NONE	
US 5694170 A	02-12-1997	JP 8294130 A US 6008848 A	05-11-1996 28-12-1999

Form PCT/ISA/210 (patent family annex) (July 1992)

OPAP IAP4 MAR 01 2011 PATENT & TRADEMARK OFFICE

IFW

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Re: Application of: Jani Lainema

Attorney Docket: 944-001.107-2

Serial No.: 11/881,367

Group Art Unit: 2621

Filed: July 26, 2007

Examiner: Gims S. Philippe

For: METHOD AND DEVICE FOR INDICATING QUANTIZER PARAMETERS IN A VIDEO CODING SYSTEM

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

SUPPLEMENTAL INFORMATION DISCLOSURE STATEMENT

Sir:

Applicant submits herewith references of which they are aware, which they believe may be material to the examination of this application and in respect of which they may have a duty to disclose in accordance with 37 C.F.R. 1.56.

This Supplemental Information Disclosure Statement is timely since it is certified by the undersigned that each item of information contained in the Supplemental Information Disclosure Statement was first cited in any communication from a foreign patent office (copy enclosed) in a counterpart foreign application not more than three months prior to the filing of this Supplemental Information Disclosure Statement per 37 C.F.R. 1.97(c) and 37 C.F.R. 1.97 (e)(1), therefore, the undersigned respectfully submits that no fee is due. The Commissioner is hereby authorized to charge to Deposit Account 23-0442 any fee deficiency required to submit this Supplemental Information Disclosure Statement.

I hereby certify that this correspondence is being deposited today with the United States Postal Service as first class mail in an envelope addressed to Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450

Marie E. Forte — February 25, 2011

Marie E. Forte — Date

The references are listed in the enclosed foreign search report dated February 11, 2011.

A PTO 1449 listing the cited references is also enclosed.

Respectfully submitted,

Kenneth Q. Lao
Registration No. 40,061

Date: February 23, 2011

WARE, FRESSOLA, VAN DER SLUYS
& ADOLPHSON LLP
Bradford Green, Building 5
755 Main Street, PO Box 224
Monroe, CT 06468
(203) 261-1234

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	PATENT NUMBER	GROUP ART UNIT	FILE WRAPPER LOCATION
11/881,367		2482	

OC000000046474035

Correspondence Address/Fee Address Change

The following fields have been set to Customer Number 10945 on 11/22/2010

- **Correspondence Address**
- **Maintenance Fee Address**
- **Power of Attorney Address**

The address of record for Customer Number 10945 is:

10945
NOKIA CORPORATION
c/o Ware, Fressola, Van Der Sluys & Adolphson LLP
Building Five, Bradford Green
755 Main Street, PO Box 224
Monroe, CT 06468

Application Number	Application/Control No.	Applicant(s)/Patent under Reexamination	
	11/881,367	LAINEMA, JANI	

Document Code - DISQ	Internal Document – DO NOT MAIL

TERMINAL DISCLAIMER	☒ APPROVED	☐ DISAPPROVED
Date Filed : 02/28/11	This patent is subject to a Terminal Disclaimer	

Approved/Disapproved by:
Angie Walker

U.S. Patent and Trademark Office

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NOTICE OF ALLOWANCE AND FEE(S) DUE

10945 7590 01/03/2012

NOKIA CORPORATION
c/o Ware, Fressola, Van Der Sluys & Adolphson LLP
Building Five, Bradford Green
755 Main Street, PO Box 224
Monroe, CT 06468

EXAMINER
PHILIPPE, GIMS S

ART UNIT	PAPER NUMBER
2485	

DATE MAILED: 01/03/2012

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
11/881,367	07/26/2007	Jani Lainema	944-001.107-2	1389

TITLE OF INVENTION: METHOD AND DEVICE FOR INDICATING QUANTIZER PARAMETERS IN A VIDEO CODING SYSTEM

APPLN. TYPE	SMALL ENTITY	ISSUE FEE DUE	PUBLICATION FEE DUE	PREV. PAID ISSUE FEE	TOTAL FEE(S) DUE	DATE DUE
nonprovisional	NO	$1740	$300	$0	$2040	04/03/2012

THE APPLICATION IDENTIFIED ABOVE HAS BEEN EXAMINED AND IS ALLOWED FOR ISSUANCE AS A PATENT. PROSECUTION ON THE MERITS IS CLOSED. THIS NOTICE OF ALLOWANCE IS NOT A GRANT OF PATENT RIGHTS. THIS APPLICATION IS SUBJECT TO WITHDRAWAL FROM ISSUE AT THE INITIATIVE OF THE OFFICE OR UPON PETITION BY THE APPLICANT. SEE 37 CFR 1.313 AND MPEP 1308.

THE ISSUE FEE AND PUBLICATION FEE (IF REQUIRED) MUST BE PAID WITHIN THREE MONTHS FROM THE MAILING DATE OF THIS NOTICE OR THIS APPLICATION SHALL BE REGARDED AS ABANDONED. THIS STATUTORY PERIOD CANNOT BE EXTENDED. SEE 35 U.S.C. 151. THE ISSUE FEE DUE INDICATED ABOVE DOES NOT REFLECT A CREDIT FOR ANY PREVIOUSLY PAID ISSUE FEE IN THIS APPLICATION. IF AN ISSUE FEE HAS PREVIOUSLY BEEN PAID IN THIS APPLICATION (AS SHOWN ABOVE), THE RETURN OF PART B OF THIS FORM WILL BE CONSIDERED A REQUEST TO REAPPLY THE PREVIOUSLY PAID ISSUE FEE TOWARD THE ISSUE FEE NOW DUE.

HOW TO REPLY TO THIS NOTICE:

I. Review the SMALL ENTITY status shown above.

If the SMALL ENTITY is shown as YES, verify your current SMALL ENTITY status:

A. If the status is the same, pay the TOTAL FEE(S) DUE shown above.

B. If the status above is to be removed, check box 5b on Part B - Fee(s) Transmittal and pay the PUBLICATION FEE (if required) and twice the amount of the ISSUE FEE shown above, or

If the SMALL ENTITY is shown as NO:

A. Pay TOTAL FEE(S) DUE shown above, or

B. If applicant claimed SMALL ENTITY status before, or is now claiming SMALL ENTITY status, check box 5a on Part B - Fee(s) Transmittal and pay the PUBLICATION FEE (if required) and 1/2 the ISSUE FEE shown above.

II. PART B - FEE(S) TRANSMITTAL, or its equivalent, must be completed and returned to the United States Patent and Trademark Office (USPTO) with your ISSUE FEE and PUBLICATION FEE (if required). If you are charging the fee(s) to your deposit account, section "4b" of Part B - Fee(s) Transmittal should be completed and an extra copy of the form should be submitted. If an equivalent of Part B is filed, a request to reapply a previously paid issue fee must be clearly made, and delays in processing may occur due to the difficulty in recognizing the paper as an equivalent of Part B.

III. All communications regarding this application must give the application number. Please direct all communications prior to issuance to Mail Stop ISSUE FEE unless advised to the contrary.

IMPORTANT REMINDER: Utility patents issuing on applications filed on or after Dec. 12, 1980 may require payment of maintenance fees. It is patentee's responsibility to ensure timely payment of maintenance fees when due.

PART B - FEE(S) TRANSMITTAL

Complete and send this form, together with applicable fee(s), to: Mail **Mail Stop ISSUE FEE**
Commissioner for Patents
P.O. Box 1450
Alexandria, Virginia 22313-1450
or Fax (571)-273-2885

INSTRUCTIONS: This form should be used for transmitting the ISSUE FEE and PUBLICATION FEE (if required). Blocks 1 through 5 should be completed where appropriate. All further correspondence including the Patent, advance orders and notification of maintenance fees will be mailed to the current correspondence address as indicated unless corrected below or directed otherwise in Block 1, by (a) specifying a new correspondence address; and/or (b) indicating a separate "FEE ADDRESS" for maintenance fee notifications.

CURRENT CORRESPONDENCE ADDRESS (Note: Use Block 1 for any change of address)

10945 7590 01/03/2012

NOKIA CORPORATION
c/o Ware, Fressola, Van Der Sluys & Adolphson LLP
Building Five, Bradford Green
755 Main Street, PO Box 224
Monroe, CT 06468

Note: A certificate of mailing can only be used for domestic mailings of the Fee(s) Transmittal. This certificate cannot be used for any other accompanying papers. Each additional paper, such as an assignment or formal drawing, must have its own certificate of mailing or transmission.

Certificate of Mailing or Transmission

I hereby certify that this Fee(s) Transmittal is being deposited with the United States Postal Service with sufficient postage for first class mail in an envelope addressed to the Mail Stop ISSUE FEE address above, or being facsimile transmitted to the USPTO (571) 273-2885, on the date indicated below.

(Depositor's name)
(Signature)
(Date)

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
11/881,367	07/26/2007	Jani Lainema	944-001.107-2	1389

TITLE OF INVENTION: METHOD AND DEVICE FOR INDICATING QUANTIZER PARAMETERS IN A VIDEO CODING SYSTEM

APPLN. TYPE	SMALL ENTITY	ISSUE FEE DUE	PUBLICATION FEE DUE	PREV. PAID ISSUE FEE	TOTAL FEE(S) DUE	DATE DUE
nonprovisional	NO	$1740	$300	$0	$2040	04/03/2012

EXAMINER	ART UNIT	CLASS-SUBCLASS
PHILIPPE, GIMS S	2485	375-240030

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.

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.

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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
11/881,367	07/26/2007	Jani Lainema	944-001.107-2	1389

10945 7590 01/03/2012

NOKIA CORPORATION
c/o Ware, Fressola, Van Der Sluys & Adolphson LLP
Building Five, Bradford Green
755 Main Street, PO Box 224
Monroe, CT 06468

EXAMINER	
PHILIPPE, GIMS S	

ART UNIT	PAPER NUMBER
2485	

DATE MAILED: 01/03/2012

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 788 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 788 day(s).

If a Continued Prosecution Application (CPA) was filed in the above-identified application, the filing date that determines Patent Term Adjustment is the filing date of the most recent CPA.

Applicant will be able to obtain more detailed information by accessing the Patent Application Information Retrieval (PAIR) WEB site (http://pair.uspto.gov).

Any questions regarding the Patent Term Extension or Adjustment determination should be directed to the Office of Patent Legal Administration at (571)-272-7702. Questions relating to issue and publication fee payments should be directed to the Customer Service Center of the Office of Patent Publication at 1-(888)-786-0101 or (571)-272-4200.

Privacy Act Statement

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

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

1. The information on this form will be treated confidentially to the extent allowed under the Freedom of Information Act (5 U.S.C. 552) and the Privacy Act (5 U.S.C 552a). Records from this system of records may be disclosed to the Department of Justice to determine whether disclosure of these records is required by the Freedom of Information Act.
2. A record from this system of records may be disclosed, as a routine use, in the course of presenting evidence to a court, magistrate, or administrative tribunal, including disclosures to opposing counsel in the course of settlement negotiations.
3. A record in this system of records may be disclosed, as a routine use, to a Member of Congress submitting a request involving an individual, to whom the record pertains, when the individual has requested assistance from the Member with respect to the subject matter of the record.
4. A record in this system of records may be disclosed, as a routine use, to a contractor of the Agency having need for the information in order to perform a contract. Recipients of information shall be required to comply with the requirements of the Privacy Act of 1974, as amended, pursuant to 5 U.S.C. 552a(m).
5. A record related to an International Application filed under the Patent Cooperation Treaty in this system of records may be disclosed, as a routine use, to the International Bureau of the World Intellectual Property Organization, pursuant to the Patent Cooperation Treaty.
6. A record in this system of records may be disclosed, as a routine use, to another federal agency for purposes of National Security review (35 U.S.C. 181) and for review pursuant to the Atomic Energy Act (42 U.S.C. 218(c)).
7. A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (i.e., GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.
8. A record from this system of records may be disclosed, as a routine use, to the public after either publication of the application pursuant to 35 U.S.C. 122(b) or issuance of a patent pursuant to 35 U.S.C. 151. Further, a record may be disclosed, subject to the limitations of 37 CFR 1.14, as a routine use, to the public if the record was filed in an application which became abandoned or in which the proceedings were terminated and which application is referenced by either a published application, an application open to public inspection or an issued patent.
9. A record from this system of records may be disclosed, as a routine use, to a Federal, State, or local law enforcement agency, if the USPTO becomes aware of a violation or potential violation of law or regulation.

Notice of Allowability	Application No.	Applicant(s)	
	11/881,367	LAINEMA, JANI	
	Examiner	Art Unit	
	GIMS PHILIPPE	2485	

-- 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 *applicant's response received on February 28, 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 *4-14,17-27 and 37*.

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 03/01/11, 7/26/07
4. ☐ Examiner's Comment Regarding Requirement for Deposit of Biological Material
5. ☐ Notice of Informal Patent Application
6. ☐ Interview Summary (PTO-413), Paper No./Mail Date _____ .
7. ☐ Examiner's Amendment/Comment
8. ☐ Examiner's Statement of Reasons for Allowance
9. ☒ Other *eDAN Amended Specification attachment*.

/Gims S Philippe/
Primary Examiner, Art Unit 2485

Search Notes	Application/Control No.	Applicant(s)/Patent Under Reexamination
	11881367	LAINEMA, JANI
	Examiner	Art Unit
	Gims S Philippe	2482

SEARCHED

Class	Subclass	Date	Examiner
375	240.04, 240.16	11/20/10	GP
341	107	11/20/10	GP

SEARCH NOTES

Search Notes	Date	Examiner
Keyword searched; Inventor's name searched	11/20/10	GP
Updated previously searched areas	12/14/11	GP

INTERFERENCE SEARCH

Class	Subclass	Date	Examiner
	General Interference search of claims (US PG PUB, US PAT)	12/13/11	GP

In the Specification

Please amend the paragraph beginning on page 1, line 4 as follows:

This application is a divisional application of and claims priority to a co-pending U.S. patent application Serial No. 10/421,629, filed April 23, 2003, which is based on and claims priority to U.S. provisional application No. 60/374,667, filed April 23, 2002.

/GP/

Please amend the paragraph beginning on page 6, line 7 as follows:

The quantized DCT coefficients for each block are passed from the quantizer 106 to the video multiplex coder 170, as indicated by line 125 in Figure 1. The video multiplex coder 170 orders the quantized transform coefficients for each block using a zigzag scanning procedure, thereby converting the two-dimensional array of quantized transform coefficient values into a one-dimensional array. [[.]] Typically, the video multiplex coder 170 next represents each non-zero quantized coefficient in the one-dimensional array by a pair of values, referred to as *level* and *run*, *level* being the value of the quantized coefficient and *run* being the number of consecutive zero-valued coefficients preceding the coefficient in question. The *run* and *level* values are further compressed using entropy coding. For example, a method such as variable length coding (VLC) may be used to produce a set of variable length codewords representative of each (*run*, *level*) pair.

Please amend the paragraph beginning on page 15, line 29 as follows:

Preferably, an indication of the default level of quantization to be used throughout encoding of the digital video sequence is provided. Even more preferably, an indication of the default level of quantization is provided in the encoded bit-stream representative of the digital video sequence, ~~Advantaegously~~ advantageously, the encoded bit-stream, including the indication of the default level of quantization to be used throughout encoding of the digital video sequence, is transmitted to a video decoding device.

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PATENT AND TRADEMARK OFFICE

INFORMATION DISCLOSURE CITATION FORM FOR PATENT APPLICATION (FORM PTO-1449) (Substitute)	Docket No.: 944-001.107-2	Serial No.: 11/881,367
	Applicant(s): Jani Lainema	
	Filing Date: July 26, 2007	Group: 2621

U.S. PATENTS

Initials	Patent Number	Issue Date	Name	Class	Sub-class	Filing date
/GP/	US 5,907,362	5-25-1999	Yamamoto	348	405	

U.S. PATENT PUBLICATIONS

Initials	Publication No.	Pub. Date	Name	Class	Sub-class	Filing Date

FOREIGN PATENT DOCUMENTS

Initial	Document Number	Date	Country	Name	Translation? Yes/No/n/a
/GP/	WO 2000 21302 A1	4-13-00	International	Gen Instrument Corp.	English

OTHER DOCUMENTS (Title, Author, Date, Pages, Etc., if known)

/GP/	Single-pass constant-and variable-bit-rate MPEG-2 video compression, N. Mohsenian, R. Rajagopalan, C.A. Gonzales, July 4, 1999, XP-002216512
/GP/	A Video Compression Algorithm With Adaptive Bit Allocation and Quantization, Eric Viscito and Cesar Gonzales, November 11, 1991, Visual Communications and Image Processing '91: Visual Communication, Boston – SPIE Vol. 1605

Examiner's Signature: /Gims Philippe/	Date Considered: 12/13/2011

Initial if reference was considered, whether or not citation is in conformance with MPEP. Mark through citation if not considered. Include a copy of this citation form with your next correspondence to the Applicant(s).

Customer No.: 4955

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Re: Application of: Jani Lainema

Attorney Docket: 944-001.107-2

Serial No.: to be assigned 11/881,367

Group Art Unit: to be assigned

Filed: herewith

Examiner: to be assigned

For: **METHOD AND DEVICE FOR INDICATING QUANTIZER PARAMETERS IN A VIDEO CODING SYSTEM**

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

INFORMATION DISCLOSURE STATEMENT

Sir:

Applicant submits herewith references of which they are aware, which they believe may be material to the examination of this application and in respect of which they may have a duty to disclose in accordance with 37 CFR 1.56.

While this Information Disclosure Statement may be "material" pursuant to 37 CFR 1.56, it is not intended to constitute an admission that any document referred to herein is "prior art" for this invention unless specifically designated as such.

In accordance with 37 CFR 1.97(g), the filing of this Information Disclosure Statement shall not be construed to mean that a search has been made or that no other material information as defined under 37 CFR 1.56(a) exists.

I hereby certify that this correspondence is being deposited with the United States Postal Service "Express Mail Post Office to Addressee" service under 37 C.F.R. 1.10, Express Mail Label No. EV914764379US, on the date indicated below and is addressed to Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.

Cathy Sturmer — 7.25.07
Date

A PTO-1449 with cited reference is also enclosed.

This IDS is being submitted prior to receipt of a first Official Action in this matter; therefore, the undersigned respectfully submits that no fee is due for filing this IDS. Should any fees be due of which the undersigned is unaware, the Commissioner is hereby authorized to charge deposit account 23-0442 any fee deficiency required to submit this IDS.

Respectfully submitted,

Kenneth Q. Lao
Registration No. 40,061

Date: July 25, 2007

WARE, FRESSOLA, VAN DER SLUYS
& ADOLPHSON LLP
Bradford Green, Building 5
755 Main Street, PO Box 224
Monroe, CT 06468
(203) 261-1234

FORM PTO-1449 INFORMATION DISCLOSURE STATEMENT	ATTY DOCKET NO. 944-001.107-2	SERIAL NO. 11/881,367 To be assigned
	APPLICANTS: Jani Lainema	
	FILING DATE: herewith	ART UNIT: to be assigned

UNITED STATES PATENT DOCUMENTS

EXAM. INITIAL		DOCUMENT NUMBER	DATE	INVENTOR/ASSIGNEE	CLASS	SUBCLASS	FILING DATE IF APPROPRIATE
/GP/		U.S. 5,231,484	July 27, 2991	Gonzales et al.	358	133	
		U.S. 5,751,358	May 12, 1998	Suzuki et al.	348	405	
		U.S. 5,054,103	Oct. 1, 1991	Yasuda et al.	382	56	
		U.S. 5,144,426	Sept. 1, 1992	Tanaka et al.	358	133	
		U.S. 5,715,009	Feb. 3, 1998	Tahara et al.	348	423	
		U.S. 6,256,349	July 3, 2001	Suzuki et al.	375	240.18	
		U.S. 5,237,410	Aug. 17, 1993	Inoue	358	136	
		U.S. 2003/152146	Aug. 14, 2003	Lin et al.	375	240.16	
/GP/		U.S. 6,677,868	Jan. 13, 2004	Kerofsky et al.	341	107	

FOREIGN PATENT DOCUMENTS

		DOCUMENT NUMBER	DATE	COUNTRY	CLASS	SUBCLASS	TRANSLATION YES/NO

OTHER DOCUMENTS (INCLUDING AUTHOR, TITLE, DATE, PERTINENT PAGES, ETC.)

/GP/		"Joint Model Number 1 (JM-1)", Doc. JVT-A003, Appendix B; Joint Video Team (JVT) of ISO/IEC MPEG and ITU-T VCEG; January 2002; pp. 1-79.

Examiner (To be assigned) /Gims Philippe/	Date: 12/27/2011

Issue Classification	Application/Control No.	Applicant(s)/Patent Under Reexamination
	11881367	LAINEMA, JANI
	Examiner	**Art Unit**
	GIMS PHILIPPE	2485

ORIGINAL		INTERNATIONAL CLASSIFICATION														
CLASS	SUBCLASS	CLAIMED					NON-CLAIMED									
375	240.03	H	0	4	N	7 / 12 (2006.01.01)										

CROSS REFERENCE(S)					
CLASS	SUBCLASS (ONE SUBCLASS PER BLOCK)				
375	240.16				

☐ 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
-	1	12	17	-	33										
-	2	13	18	-	34										
-	3	14	19	-	35										
1	4	15	20	-	36										
2	5	16	21	23	37										
3	6	19	22												
4	7	20	23												
5	8	21	24												
6	9	22	25												
7	10	17	26												
8	11	18	27												
9	12	-	28												
10	13	-	29												
11	14	-	30												
-	15	-	31												
-	16	-	32												

NONE (Assistant Examiner) (Date)	**Total Claims Allowed:** 23	
/GIMS PHILIPPE/ Primary Examiner.Art Unit 2485 12/13/2011 (Primary Examiner) (Date)	O.G. Print Claim(s) 1	O.G. Print Figure 5

EAST Search History

EAST Search History (Prior Art)

Ref #	Hits	Search Query	DBs	Default Operator	Plurals	Time Stamp
L1	5	((encod$3 same (motion with compensat$ with prediction)) same (default with quantization))	US-PGPUB; USPAT; EPO; JPO; DERWENT	OR	ON	2011/12/13 23:58
L2	3	((encod$3 same (motion with compensat$ with prediction)) same (default with quantization)).clm.	US-PGPUB; USPAT; EPO; JPO; DERWENT	OR	ON	2011/12/13 23:59

12/14/11 12:00:27 AM
C:\Documents and Settings\gphilippe\My Documents\EAST\Workspaces\13056773.nf.wsp

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)

10945 7590 01/03/2012

NOKIA CORPORATION
c/o Ware, Fressola, Van Der Sluys & Adolphson LLP
Building Five, Bradford Green
755 Main Street, PO Box 224
Monroe, CT 06468

Note: A certificate of mailing can only be used for domestic mailings of the Fee(s) Transmittal. This certificate cannot be used for any other accompanying papers. Each additional paper, such as an assignment or formal drawing, must have its own certificate of mailing or transmission.

Certificate of Mailing or Transmission
I hereby certify that this Fee(s) Transmittal is being deposited with the United States Postal Service with sufficient postage for first class mail in an envelope addressed to the Mail Stop ISSUE FEE address above, or being facsimile transmitted to the USPTO (571) 273-2885, on the date indicated below.

(Depositor's name)
(Signature)
(Date)

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
11/881,367	07/26/2007	Jani Lainema	944-001.107-2	1389

TITLE OF INVENTION: METHOD AND DEVICE FOR INDICATING QUANTIZER PARAMETERS IN A VIDEO CODING SYSTEM

APPLN. TYPE	SMALL ENTITY	ISSUE FEE DUE	PUBLICATION FEE DUE	PREV. PAID ISSUE FEE	TOTAL FEE(S) DUE	DATE DUE
nonprovisional	NO	$1740	$300	$0	$2040	04/03/2012

EXAMINER	ART UNIT	CLASS-SUBCLASS
PHILIPPE, GIMS S	2485	375-240030

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: NOKIA CORPORATION
(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

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 23-0442 (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 /Kenneth Q. Lao/ Date April 2, 2012

Typed or printed name Kenneth Q. Lao Registration No. 40,061

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.

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.

Electronic Patent Application Fee Transmittal

Application Number:	11881367
Filing Date:	26-Jul-2007
Title of Invention:	METHOD AND DEVICE FOR INDICATING QUANTIZER PARAMETERS IN A VIDEO CODING SYSTEM
First Named Inventor/Applicant Name:	Jani Lainema
Filer:	Kenneth Q. Lao/Lorraine Kniffin
Attorney Docket Number:	944-001.107-2

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($)
Extension-of-Time:				
Miscellaneous:				
			Total in USD ($)	**2040**

Electronic Acknowledgement Receipt

EFS ID:	12445092
Application Number:	11881367
International Application Number:	
Confirmation Number:	1389
Title of Invention:	METHOD AND DEVICE FOR INDICATING QUANTIZER PARAMETERS IN A VIDEO CODING SYSTEM
First Named Inventor/Applicant Name:	Jani Lainema
Customer Number:	10945
Filer:	Kenneth Q. Lao/Lorraine Kniffin
Filer Authorized By:	Kenneth Q. Lao
Attorney Docket Number:	944-001.107-2
Receipt Date:	02-APR-2012
Filing Date:	26-JUL-2007
Time Stamp:	12:13:10
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	yes
Payment Type	Deposit Account
Payment was successfully received in RAM	$2040
RAM confirmation Number	11307
Deposit Account	230442
Authorized User	

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)	PTOL_85_Issue_fee_Transmittal.pdf	725986 d25309fb9b373c42f9c09cf51082ca78a6255eda	no	1
Warnings:					
The page size in the PDF is too large. The pages should be 8.5 x 11 or A4. If this PDF is submitted, the pages will be resized upon entry into the Image File Wrapper and may affect subsequent processing					
Information:					
2	Fee Worksheet (SB06)	fee-info.pdf	32222 61516e64effc89b0d66d679ba0dbbdb761f8a729	no	2
Warnings:					
Information:					
			Total Files Size (in bytes):	758208	

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.

FORM PTO-1449 INFORMATION DISCLOSURE STATEMENT	ATTY DOCKET NO. 944-001.107-2	SERIAL NO. 11/881,367 To be assigned
	APPLICANTS: Jani Lainema	
	FILING DATE: herewith	ART UNIT: to be assigned

UNITED STATES PATENT DOCUMENTS

EXAM. INITIAL		DOCUMENT NUMBER	DATE	INVENTOR/ASSIGNEE	CLASS	SUBCLASS	FILING DATE IF APPROPRIATE
/GP/ Change(s) applied to document. /S.R.R./ 2/16/2012		U.S. 5,231,484	July 27, ~~2991~~ 1993	Gonzales et al.	358	133	
		U.S. 5,751,358	May 12, 1998	Suzuki et al.	348	405	
		U.S. 5,054,103	Oct. 1, 1991	Yasuda et al.	382	56	
		U.S. 5,144,426	Sept. 1, 1992	Tanaka et al.	358	133	
		U.S. 5,715,009	Feb. 3, 1998	Tahara et al.	348	423	
		U.S. 6,256,349	July 3, 2001	Suzuki et al.	375	240.18	
		U.S. 5,237,410	Aug. 17, 1993	Inoue	358	136	
		U.S. 2003/152146	Aug. 14, 2003	Lin et al.	375	240.16	
/GP/		U.S. 6,677,868	Jan. 13, 2004	Kerofsky et al.	341	107	

FOREIGN PATENT DOCUMENTS

		DOCUMENT NUMBER	DATE	COUNTRY	CLASS	SUBCLASS	TRANSLATION YES/NO

OTHER DOCUMENTS (INCLUDING AUTHOR, TITLE, DATE, PERTINENT PAGES, ETC.)

/GP/		"Joint Model Number 1 (JM-1)", Doc. JVT-A003, Appendix B; Joint Video Team (JVT) of ISO/IEC MPEG and ITU-T VCEG; January 2002; pp. 1-79.

Examiner (To be assigned) /Gims Philippe/	Date: 12/27/2011

PATENT

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Commissioner for Patents
PO 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 each of the United States patent applications identified in Schedule A attached hereto, and appoints the practitioners associated with the Customer Number provided below to prosecute the noted applications 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

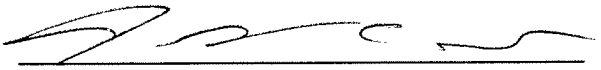
NOKIA CORPORATION, the assignee of record, hereby elects under 37 C.F.R. § 3.71 to prosecute these patent applications and certifies that it is the assignee of the entire right, title, and interest in each United States patent application noted in Schedule A by virtue of an assignment from the inventor(s) to Nokia Corporation.

As required by 37 CFR 3.73(b)(1)(ii), the documentary evidence of the chain of title from the original owner to the assignee was submitted for recordation pursuant to 37 CFR 3.11, and the reel and frame numbers confirming recordation in the US Patent Office are provided in Schedule A.

The undersigned (whose title is supplied below) is empowered to sign this certificate on behalf of the Assignee.

Assignee of Record:

NOKIA CORPORATION

By: 

Print Name: Thomas Arria

Title: Senior IPR Specialist

Date: 4/11/12

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

LEGAL01/13180529v2

SCHEDULE A
Revocation of Power of Attorney and New Power of Attorney
By Assignee Nokia Corporation

Nokia Ref.	Attorney Docket No.	Appl. No.	Filing Date	Conf. No.	Assignment Reel/Frame
17604-US-DIV	042933/417395	11/881,367	7/26/2007	1389	014385/0356-*(Recorded in parent Appl. No. 10/421,629)*
17623-US-CNT	042933/417396	11/408,908	4/21/2006	9810	013204/0473-*(Recorded in parent Appl. No. 10/171,467)*
17623-US-DIV	042933/417397	11/901,667	9/17/2007	6699	014507/0298-*(Recorded in parent Appl. No. 10/459,126)*
18786-US-CNT	042933/417398	12/862,240	8/24/2010	3651	016120/0739-*(Recorded in parent Appl. No. 10/496,601)*
19129-US-CNT	042933/417399	12/899,701	10/7/2010	6341	015290/0912-*(Recorded in parent Appl. No. 10/763,805)*
19460-US-PCT	042933/417400	10/516,887	7/25/2005	6812	017174/0670
19770-US-PCT	042933/417402	10/548,741	6/19/2006	4726	018021/0729
31695-US-PCT	042933/417403	12/086,730	10/23/2008	2649	021303/0633
32135-US-PCT	042933/417404	10/516,870	8/25/2005	2379	016058/0188
32154-US-PCT	042933/417405	10/530,952	12/15/2005	2243	016313/0610
32546-US-CNT[2]	042933/417406	11/453,791	6/14/2006	6786	012487/0487-*(Recorded in parent Appl. No. 09/777,521)* 018906/0442
33008-US-NP	042933/417407	10/187,393	6/27/2002	3451	013373/0858
33867-US-PCT	042933/417408	10/584,381	4/11/2007	1277	019242/0147
35592-US-CNT	042933/417409	10/781,325	2/17/2004	9454	012934/0016-*(Recorded in parent Appl. No. 10/115,268)*
35910-US-CIP	042933/417410	10/291,192	11/8/2002	2503	015179/0217
35949-US-NP	042933/417411	10/621,259	7/15/2003	9729	014503/0102
36003-US-NP	042933/417412	10/255,560	9/25/2002	1646	013711/0626
36416-US-CNT	042933/417413	12/803,098	6/17/2010	6026	015157/0543 016214/0041
36457-US-NP	042933/417414	10/782,372	2/18/2004	3558	015574/0165
36516-US-NP	042933/417415	10/854,765	5/26/2004	5937	015932/0380
36531-US-NP	042933/417416	10/602,540	6/23/2003	1200	014793/0040
36561-US-NP	042933/417417	10/656,886	9/4/2003	1554	014947/0715
36762-US-REI	042933/417418	13/411,189	3/2/2012	1400	015308/0324-*(Recorded in parent Appl. No. 10/705,077)*
37097-US-NP	042933/417419	10/746,843	12/24/2003	9210	015339/0994
37250-US-NP	042933/417422	11/015,755	12/16/2004	4222	015700/0477
37293-US-NP	042933/417423	10/692,290	10/23/2003	7122	014970/0234
37298-US-CNT	042933/417424	12/150,307	4/25/2008	5670	014970/0221-*(Recorded in parent Appl. No. 10/692,291)*
37298-US-NP	042933/417425	10/692,291	10/23/2003	4222	015700/0477
37379-US-NP	042933/417427	11/049,638	2/1/2005	7063	016664/0093
37692-US-NP	042933/417428	12/084,677	5/5/2008	1655	020946/0937

Signature: _____
Thomas Arria
Date: 4/11/12

SCHEDULE A
Revocation of Power of Attorney and New Power of Attorney
By Assignee Nokia Corporation

Nokia Ref.	Attorney Docket No.	Appl. No.	Filing Date	Conf. No.	Assignment Reel/Frame
41039-US-CNT	042933/417429	12/804,803	7/28/2010	1349	016173/0026-*(Recorded in parent Appl. No. 11/039,058)*
41627-US-PCT	042933/417430	12/227,313	2/18/2009	6491	022136/0839
42325-US-PCT	042933/417431	11/922,647	12/20/2007	7744	021015/0428
42722-US-PCT	042933/417432	10/560,675	2/23/2007	2319	020187/0821
43008-US-NP	042933/417433	10/782,399	2/18/2004	4342	014772/0120
43056-US-NP	042933/417434	10/668,105	9/22/2003	7632	014876/0767
43143-US-PCT	042933/417435	10/582,833	6/14/2006	6761	018002/0366
43315-US-NP	042933/417436	10/805,678	3/18/2004	8566	015663/0499
43496-US-CNT	042933/417437	12/459,138	6/25/2009	3296	014928/0896
43672-US-NP	042933/417438	11/129,655	5/13/2005	9878	016880/0279
43683-US-NP	042933/417439	10/875,079	6/23/2004	7893	015103/0979
43884-US-NP	042933/417440	11/063,664	2/22/2005	6687	016574/0554
43930-US-CNT	042933/417441	12/433,326	4/30/2009	8856	015104/0019-*(Recorded in parent Appl. No. 10/841,888)*
43930-US-NP	042933/417442	10/841,888	5/7/2004	2211	015104/0019
44032-US-CNT	042933/417444	13/240,499	9/22/2011	6174	020099/0269-*(Recorded in parent Appl. No. 11/597,003)*
44138-US-PCT	042933/417445	12/083,576	2/5/2009	1272	021413/0001
44156-US-NP	042933/417446	11/057,118	2/11/2005	2509	016215/0204
44183-US-CNT	042933/417448	12/924,456	9/27/2010	9678	016568/0609-*(Recorded in parent Appl. No. 11/057,065)*
44311-US-NP	042933/417449	11/107,334	4/15/2005	4541	016775/0074
44367-US-NP	042933/417450	10/806,023	3/22/2004	9971	014865/0148
44521-US-PCT	042933/417451	11/665,971	2/12/2008	2568	020157/0126
44723-US-NP	042933/417452	10/985,725	11/10/2004	4767	015700/0701
44842-US-PCT	042933/417453	11/988,184	5/22/2009	3458	022720/0669
44895-US-PCT	042933/417454	11/631,235	12/28/2006	1773	018752/0973
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47657-US-DIV	042933/417458	13/373,304	11/9/2011	5069	018287/0484-*(Recorded in parent Appl. No. 11/453,268)*
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48371-US-NP	042933/417464	10/958,671	10/4/2004	9747	015581/0976
48710-US-NP	042933/417466	11/331,433	1/11/2006	7226	017673/0016

Signature: _____
Thomas Arria

Date: 4/12/12

SCHEDULE A
Revocation of Power of Attorney and New Power of Attorney
By Assignee Nokia Corporation

Nokia Ref.	Attorney Docket No.	Appl. No.	Filing Date	Conf. No.	Assignment Reel/Frame
48785-US-NP	042933/417467	11/292,752	12/1/2005	3505	017304/0484
48785-US-PCT	042933/417468	11/720,973	8/26/2009	5247	023147/0996
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49044-US-NP	042933/417470	11/177,250	7/8/2005	3584	017029/0571
49054-US-PCT	042933/417471	11/992,242	4/27/2009	6693	022639/0259
49481-US-NP	042933/417472	11/391,723	3/27/2006	4295	018051/0632
49486-US-NP	042933/417473	11/404,106	4/13/2006	8328	018111/0692
49784-US-PCT	042933/417474	11/921,533	6/22/2009	6581	022855/0520
49786-US-NP	042933/417475	11/181,690	7/13/2005	2855	017096/0050
49937-US-PCT	042933/417476	12/223,245	1/21/2011	6651	021445/0489
49952-US-PCT	042933/417477	12/086,667	4/5/2010	9174	024186/0809
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51739-US-NP	042933/417488	11/824,598	6/29/2007	2516	019724/0843
51932-US-NP	042933/417489	11/431,144	5/9/2006	5476	018068/0475
52483-US-NP	042933/417490	11/515,499	9/1/2006	5402	018600/0264
52612-US-CNT	042933/417491	12/930,669	1/11/2011	6002	018206/0174
45534-US-CNT	042933/417455	13/406,866	2/28/2012	5828	020977/0334-*(Recorded in parent Appl. No. 11/918,690)*
52713-US-PCT	042933/417492	12/311,303	11/3/2009	9037	022517/0636
52800-US-PCT[2]	042933/417493	12/227,730	9/25/2009	6218	023310/0961
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52897-US-NP	042933/417496	11/453,568	6/14/2006	5299	018195/0814
53047-US-NP	042933/417497	11/436,202	5/16/2006	6336	018237/0891
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53115-US-NP	042933/417499	11/486,856	7/14/2006	5380	018203/0800
53474-US-NP	042933/417500	11/523,140	9/19/2006	3973	018435/0142
55179-US-NP	042933/417501	11/978,207	10/26/2007	4846	020390/0651

Signature: _____
Thomas Arria
Date: 4/11/12

SCHEDULE A
Revocation of Power of Attorney and New Power of Attorney
By Assignee Nokia Corporation

Nokia Ref.	Attorney Docket No.	Appl. No.	Filing Date	Conf. No.	Assignment Reel/Frame
55879-US-NP	042933/417502	11/725,169	3/15/2007	3685	019426/0787
56029-US-CNT[2]	042933/417503	11/505,539	8/16/2006		009222/0221-*(Recorded in parent Appl. No. 09/087,253)* 012875/0306-*(Recorded in parent Appl. No. 09/087,253)* 018367/0245-*(Recorded in parent Appl. No. 09/087,253)* 019206/0370
56622-US-NP	042933/417504	12/008,703	1/10/2008	1734	020725/0704
57397-US-PCT	042933/417505	12/665,403	4/21/2010	1843	024224/0773
61143-US-NP	042933/417506	12/005,038	12/20/2007	2188	020628/0637
62320-US-NP	042933/417507	12/164,587	6/30/2008	1578	021589/0617
62513-US-NP	042933/417508	12/069,447	2/7/2008	6814	020885/0589
62700-US-NP	042933/417509	12/074,545	3/3/2008	7792	021093/0904
62893-US-NP	042933/417510	12/080,790	4/4/2008	5470	021065/0802
63627-US-NP	042933/417511	12/157,674	6/12/2008	8454	021144/0503
63751-US-NP	042933/417512	12/157,169	6/5/2008	6157	021256/0795
64173-US-NP	042933/417513	12/202,262	8/30/2008	1982	021826/0113
64305-US-PCT	042933/417514	12/736,515	10/13/2010	3344	025151/0453
64314-US-PCT	042933/417515	12/988,644	10/20/2010	3119	025199/0702
64427-US-NP	042933/417516	12/381,152	3/6/2009	1152	022651/0225
64674-US-NP	042933/417517	12/321,011	1/13/2009	5341	022480/0035
65129-US-NP	042933/417518	12/317,070	12/18/2008	9047	022424/0484
65148-US-CIP	042933/417519	12/586,995	9/29/2009	7159	024295/0480
65148-US-NP	042933/417520	12/319,933	1/13/2009	8750	022178/0424
65199-US-NP	042933/417521	12/319,968	1/13/2009	9683	022176/0254
65440-US-NP	042933/417522	12/321,371	1/15/2009	5608	022544/0784
66100-US-NP	042933/417523	12/339,386	12/19/2008	7112	022356/0080
66252-US-NP	042933/417524	12/470,855	5/22/2009	4689	023028/0764
66436-US-NP	042933/417525	12/339,526	12/19/2008	7382	022123/0964
66461-US-NP	042933/417526	12/459,086	6/25/2009	3014	022929/0709
66548-US-NP	042933/417527	12/387,313	4/29/2009	4729	023021/0950
66647-US-NP	042933/417528	12/339,351	12/19/2008	7051	022363/0880
67421-US-NP	042933/417529	12/386,472	4/16/2009	5746	022665/0750
69421-US-NP	042933/417530	12/459,022	6/24/2009	3022	023225/0445
71570-US-NP	042933/417531	12/806,672	8/17/2010	4424	025139/0227
71802-US-NP	042933/417533	12/858,905	8/18/2010	6863	025096/0652

Signature: _____
Thomas Arria

Date: 4/11/12

NOKIA

LIMITED POWER OF ATTORNEY

that we, the undersigned, under the authority granted to each of us to sign jointly on behalf of

NOKIA CORPORATION
Keilalahdentie 4
02150 Espoo
Finland

hereby authorize the following person

Thomas Arria
Nokia Corporation
5 Wayside Road
01803 Burlington
U.S.A.

Nokia Corporation
P.O.Box 226,
FI-00045 NOKIA GROUP, Finland
(Keilalahdentie 4, 02150 ESPOO)

Tel. +358 7180 08000
Fax +358 7180 38226

Business Identity Code
0112038-9, Helsinki

in his capacity as Senior IP Specialist, Patenting, to sign alone in the name of Nokia Corporation all the documents that relate to the filing, prosecution and registration of patent applications, as well as post-grant operations relating to patents granted based on such patent applications. Such documents may include without limitation case-specific Powers of Attorney, Assignment Deeds for assigning the ownership of an invention to Nokia, Novelty Declarations and Inventorship Declarations.

The rights granted under this Power of Attorney may not be transferred further, other than as specified above.

The authority granted by this Power of Attorney shall expire six (6) months from the date of execution.

Notwithstanding the foregoing, the authority granted by this Power of Attorney shall expire when the authorized person's employment with Nokia ends.

This Power of Attorney is duly signed on this day of January 1, 2012.

NOKIA CORPORATION

By:
Name: Harri Honkasalo
Title: Director,
Legal and Intellectual Property

By:
Name: Paul Melin
Title: Vice President,
Legal and Intellectual Property

Electronic Acknowledgement Receipt

EFS ID:	12517004
Application Number:	11881367
International Application Number:	
Confirmation Number:	1389
Title of Invention:	METHOD AND DEVICE FOR INDICATING QUANTIZER PARAMETERS IN A VIDEO CODING SYSTEM
First Named Inventor/Applicant Name:	Jani Lainema
Customer Number:	10945
Filer:	Robert Flynt Strean/LARIEKO WELCH
Filer Authorized By:	Robert Flynt Strean
Attorney Docket Number:	944-001.107-2
Receipt Date:	11-APR-2012
Filing Date:	26-JUL-2007
Time Stamp:	14:13:28
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	Nokia_POA_April2012.pdf	912347 2faa289734d017f35a573a71b911364829cbaaa2	no	7

Warnings:	
Information:	

Total Files Size (in bytes):	912347

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 NO.	ISSUE DATE	PATENT NO.	ATTORNEY DOCKET NO.	CONFIRMATION NO.
11/881,367	05/08/2012	8175148	944-001.107-2	1389

10945 7590 04/18/2012

NOKIA CORPORATION
c/o Ware, Fressola, Van Der Sluys & Adolphson LLP
Building Five, Bradford Green
755 Main Street, PO Box 224
Monroe, CT 06468

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 1320 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, Irving, TX;

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
11/881,367	07/26/2007	Jani Lainema	042933/417395

CONFIRMATION NO. 1389

POA ACCEPTANCE LETTER

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

OC000000056935212

Date Mailed: 10/09/2012

NOTICE OF ACCEPTANCE OF POWER OF ATTORNEY

This is in response to the Power of Attorney filed 04/11/2012.

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.

/snguyen/

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

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www.uspto.gov

APPLICATION NUMBER	FILING OR 371(C) DATE	FIRST NAMED APPLICANT	ATTY. DOCKET NO./TITLE
11/881,367	07/26/2007	Jani Lainema	944-001.107-2

CONFIRMATION NO. 1389

POWER OF ATTORNEY NOTICE

10945
NOKIA CORPORATION
c/o Ware, Fressola, Van Der Sluys & Adolphson LLP
Building Five, Bradford Green
755 Main Street, PO Box 224
Monroe, CT 06468

OC000000056935175

Date Mailed: 10/09/2012

NOTICE REGARDING CHANGE OF POWER OF ATTORNEY

This is in response to the Power of Attorney filed 04/11/2012.

- 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).

/snguyen/

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

Alston & Bird LLP

Bank of America Plaza
101 South Tryon Street, Suite 4000
Charlotte, NC 28280-4000
(704) 444-1000
Fax (704) 444-1111

February 6, 2013

Certificate of Correction Branch
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Re: United States Patent for *Method And Device for Indicating Quantizer Parameters In A Video Coding System*
Application No. 11/881,367; Filed July 26, 2007
Patent No. 8,175,148; Issued May 8, 2012
Our File 042933/417395

Sir:

It is respectfully requested that a Certificate of Correction be issued for the above-identified patent, in accordance with 37 C.F.R. §1.322. This request is made in order to correct the mistakes incurred through the fault of the United States Patent and Trademark Office ("USPTO").

The mistakes appearing in the patent are set forth on the Certificate of Correction e-filed herewith.

Respectfully submitted,

Guy R. Gosnell
Registration No. 34,610

GRG:mhf
Enclosure
LEGAL02/33912580v1

UNITED STATES PATENT AND TRADEMARK OFFICE
CERTIFICATE OF CORRECTION

PATENT NO. : 8,175,148 B2 Page 1 of 1

APPLICATION NO. : 11/881,367

ISSUE DATE : May 8, 2012

INVENTOR(S) : Lainema

It is certified that an error appears or errors appear in the above-identified patent and that said Letters Patent is hereby corrected as shown below:

Drawings,
Sheets 5 and 6 should be deleted to be substitued with the attached sheets 5 and 6, as shown on the attached pages.

MAILING ADDRESS OF SENDER

ALSTON & BIRD LLP
Bank of America Plaza
101 South Tryon Street, Suite 4000
Charlotte, NC 28280-4000
Tel Charlotte Office (704) 444-1000

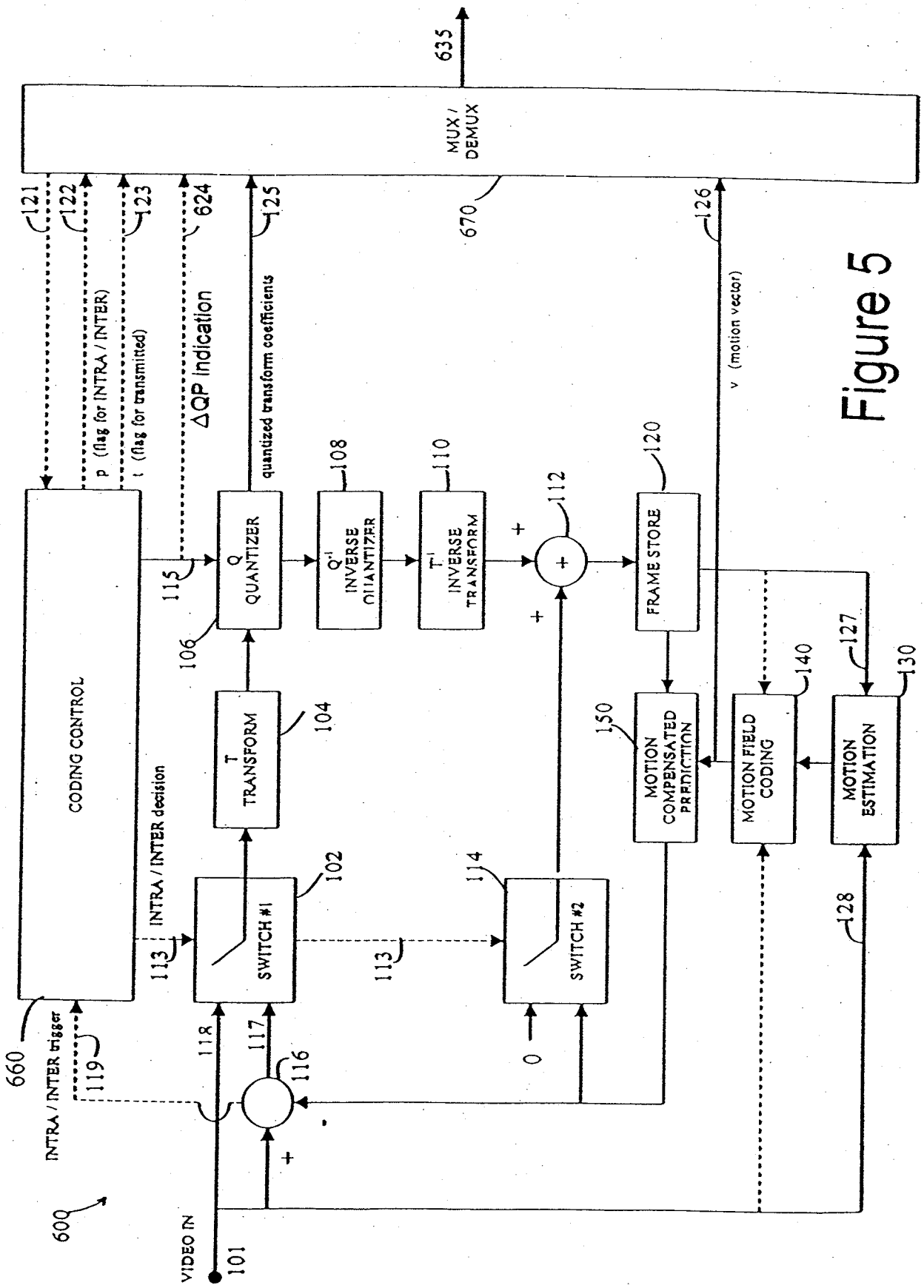

635
MUX / DEMUX
670
121
122
123
624
125
126
p (flag for INTRA / INTER)
t (flag for transmitted)
ΔQP indication
quantized transform coefficients
v (motion vector)
CODING CONTROL
Q QUANTIZER
Q⁻¹ INVERSE QUANTIZER
T⁻¹ INVERSE TRANSFORM
FRAME STORE
T TRANSFORM
MOTION COMPENSATED PREDICTION
MOTION FIELD CODING
MOTION ESTIMATION
SWITCH #1
SWITCH #2
INTRA / INTER decision
INTRA / INTER trigger
VIDEO IN
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Figure 5

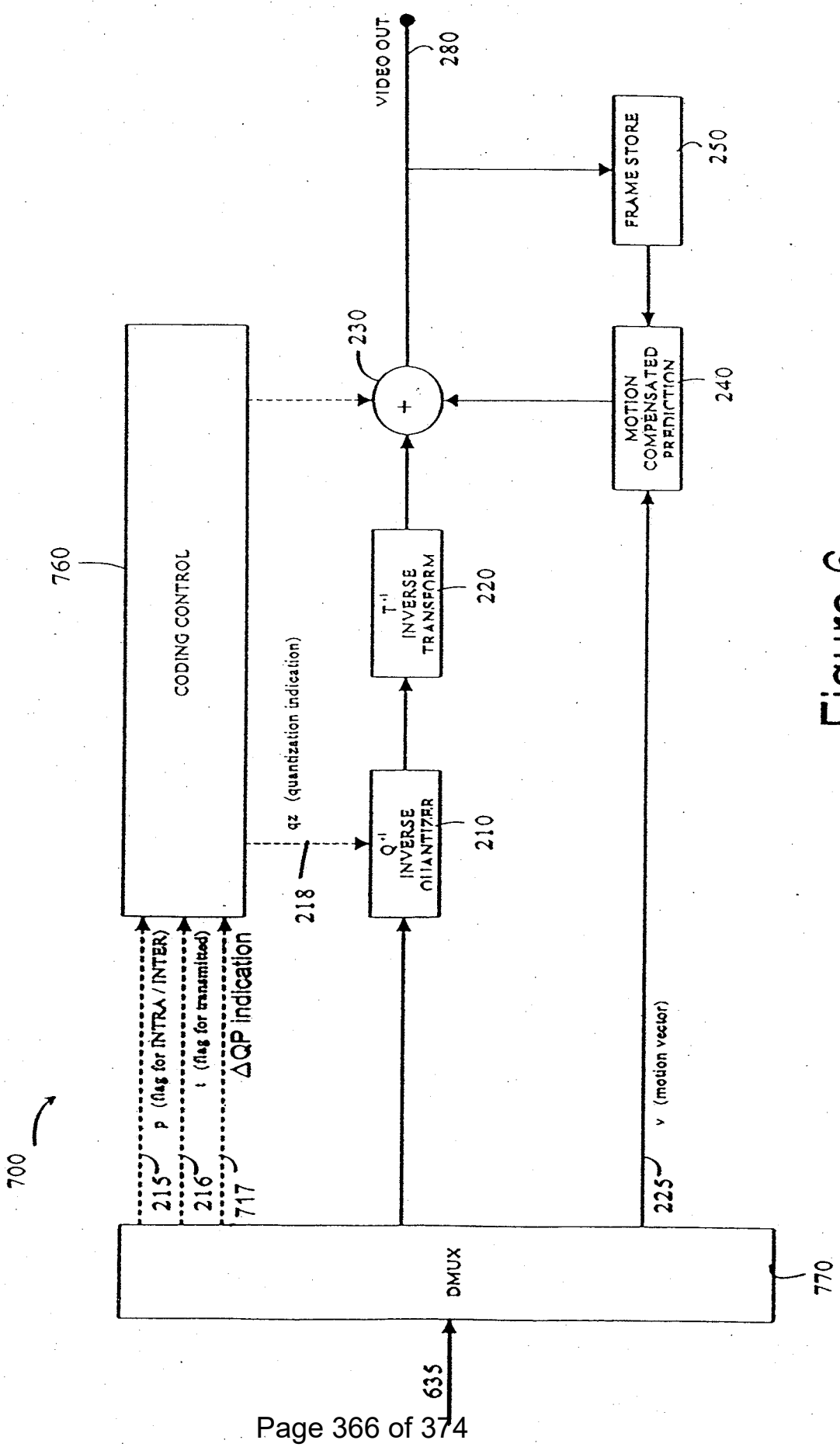

700
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DMUX
770
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p (flag for INTRA / INTER)
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t (flag for transmitted)
717
ΔQP indication
760
CODING CONTROL
218
qz (quantization indication)
Q⁻¹
INVERSE QUANTIZER
210
T⁻¹
INVERSE TRANSFORM
220
230
+
VIDEO OUT
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FRAME STORE
250
MOTION COMPENSATED PREDICTION
240
225
v (motion vector)

Figure 6

Electronic Acknowledgement Receipt

EFS ID:	14887751
Application Number:	11881367
International Application Number:	
Confirmation Number:	1389
Title of Invention:	METHOD AND DEVICE FOR INDICATING QUANTIZER PARAMETERS IN A VIDEO CODING SYSTEM
First Named Inventor/Applicant Name:	Jani Lainema
Customer Number:	10949
Filer:	Jonathan Abbott Thomas/Marigrace Faulkner
Filer Authorized By:	Jonathan Abbott Thomas
Attorney Docket Number:	042933/417395
Receipt Date:	06-FEB-2013
Filing Date:	26-JUL-2007
Time Stamp:	12:01:18
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	Request for Certificate of Correction	coc417395.PDF	97073 e50504ae891826b1e8caf8399972c8b8362 8c118	no	4

Warnings:	
Information:	

Total Files Size (in bytes):	97073

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SPE RESPONSE FOR CERTIFICATE OF CORRECTION

Paper No.: _____

DATE : 2-13-13

TO SPE OF : ART UNIT 2485

SUBJECT : Request for Certificate of Correction for Appl. No.: 11/881,367 Patent No.: 8175148

COCIN mailroom date: 2-6-13

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Please review the requested changes/corrections as shown in the **COCIN** document(s) in the IFW application image. No new matter should be introduced nor should the scope or meaning of the claims be changed.

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In particular note: _____

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703-756-1814

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- ☐ **Approved** — **All** changes apply.
- ☐ **Approved in Part** — Specify below which changes **do not** apply.
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Comments: _____

_____

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SPE Art Unit

SPE RESPONSE FOR CERTIFICATE OF CORRECTION

ePaper No.: _____

DATE : Feb. 27- 2014

TO SPE OF : ART UNIT 2489

SUBJECT : Request for Certificate of Correction for Appl. No.: 11881,367 Patent No.: 8,175,148

COCIN mailroom date 2-6-2013

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In particular note:

Ennis Young
Certificates of Correction Branch
571-272-3435 (FAX) 571-270-9946

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x	**Approved**	**All** changes apply.
☐	**Approved in Part**	Specify below which changes **do not** apply.
☐	**Denied**	State the reasons for denial below.

Comments: The request for Certificate of Correction has been approved by the Examiner. /G.P/

_____

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_____ _____

SPE Art Unit

UNITED STATES PATENT AND TRADEMARK OFFICE

CERTIFICATE OF CORRECTION

PATENT NO. : 8,175,148 B2
APPLICATION NO. : 11/881367
DATED : May 8, 2012
INVENTOR(S) : Lainema

It is certified that error appears in the above-identified patent and that said Letters Patent is hereby corrected as shown below:

Delete the title page and substitute therefore with the attached title page consisting of corrected illustrative figure.

Drawings,
Sheets 5 and 6 should be deleted to be substituted with the attached sheets 5 and 6, as shown on the attached pages.

Signed and Sealed this
Thirtieth Day of September, 2014

Michelle K. Lee

Michelle K. Lee
Deputy Director of the United States Patent and Trademark Office

(12) **United States Patent**
Lainema

(10) **Patent No.: US 8,175,148 B2**
(45) **Date of Patent: *May 8, 2012**

(54) **METHOD AND DEVICE FOR INDICATING QUANTIZER PARAMETERS IN A VIDEO CODING SYSTEM**

(75) Inventor: **Jani Lainema**, Irving, TX (US)

(73) Assignee: **Nokia Corporation**, Espoo (FI)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 1320 days.

This patent is subject to a terminal disclaimer.

(21) Appl. No.: **11/881,367**

(22) Filed: **Jul. 26, 2007**

(65) **Prior Publication Data**

US 2007/0291849 A1 Dec. 20, 2007

Related U.S. Application Data

(62) Division of application No. 10/421,629, filed on Apr. 23, 2003, now Pat. No. 7,263,125.

(60) Provisional application No. 60/374,667, filed on Apr. 23, 2002.

(51) **Int. Cl.**
H04N 7/12 (2006.01)

(52) **U.S. Cl.** **375/240.03**; 375/240.16

(58) **Field of Classification Search** 375/240.04, 375/240.16; 341/107

See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

5,054,103	A	10/1991	Yasuda et al.	382/56
5,144,426	A	9/1992	Tanaka et al.	358/133
5,231,484	A	7/1993	Gonzales et al.	358/133
5,237,410	A	8/1993	Inoue	358/136
5,715,009	A	2/1998	Tahara et al.	348/423
5,751,358	A	5/1998	Suzuki et al.	348/405
5,835,030	A	11/1998	Tsutsui et al.	341/51
5,907,362	A	5/1999	Yamamoto	348/405
6,256,349	B1	7/2001	Suzuki et al.	375/240.18
6,263,022	B1	7/2001	Chen et al.	375/240
6,677,868	B2 *	1/2004	Kerofsky et al.	341/107
6,879,632	B1	4/2005	Yokoyama	375/240
7,263,125	B2 *	8/2007	Lainema	375/240.04
7,367,041	B2	4/2008	Morishita et al.	725/37
2003/0152146	A1 *	8/2003	Lin et al.	375/240.16

FOREIGN PATENT DOCUMENTS

JP	06-121171		4/1994
JP	11-004449		1/1999
WO	WO 00 21302	A1	4/2000
WO	WO 01/26381	A1	4/2001

OTHER PUBLICATIONS

Single-pass constant-and variable-bit-rate MPEG-2 video compression, N. Mohsenian, R. Rajagopalan, C.A. Gonzales, Jul. 4, 1999, XP-002216512.

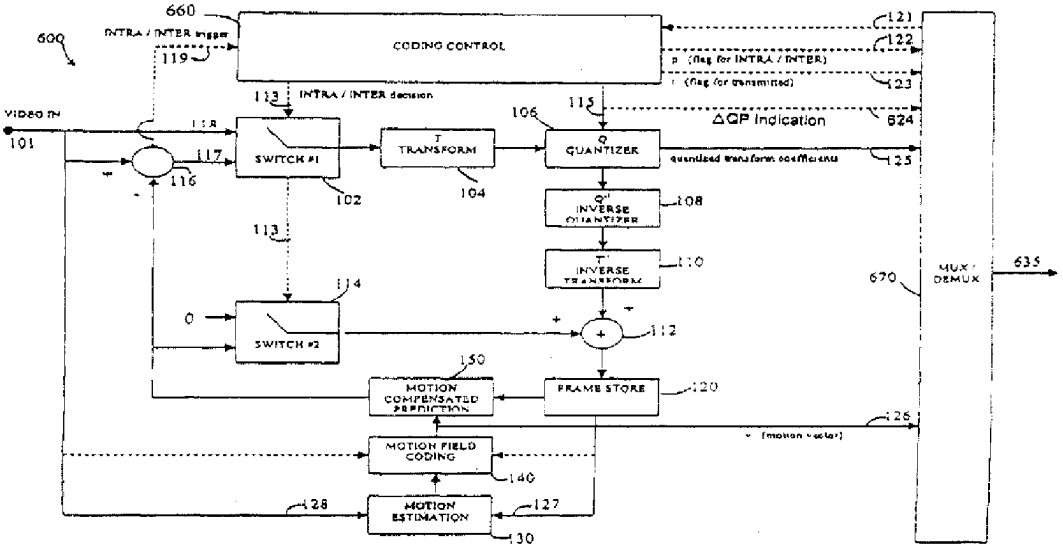
(Continued)

Primary Examiner — Gims Philippe

(57) **ABSTRACT**

A method and device for coding of digital video sequence, wherein an indication of quantization parameter (QP) is provided in the encoded bit-stream for decoding purposes. The QP related information is indicated by introducing a sequence level quantization parameter value SQP. More specifically, instead of coding the absolute values of picture/slice QPs, an indication of the difference ΔQP between the sequence level quantization parameter SQP and the picture/slice QP is provided. This eliminates the need to transmit a full QP for every picture/slice, and enables a statistically smaller difference value to be transmitted, thus providing a reduction in transmission bit-rate. The difference value is subsequently used in a corresponding decoder to reconstruct the picture/slice QP.

23 Claims, 8 Drawing Sheets



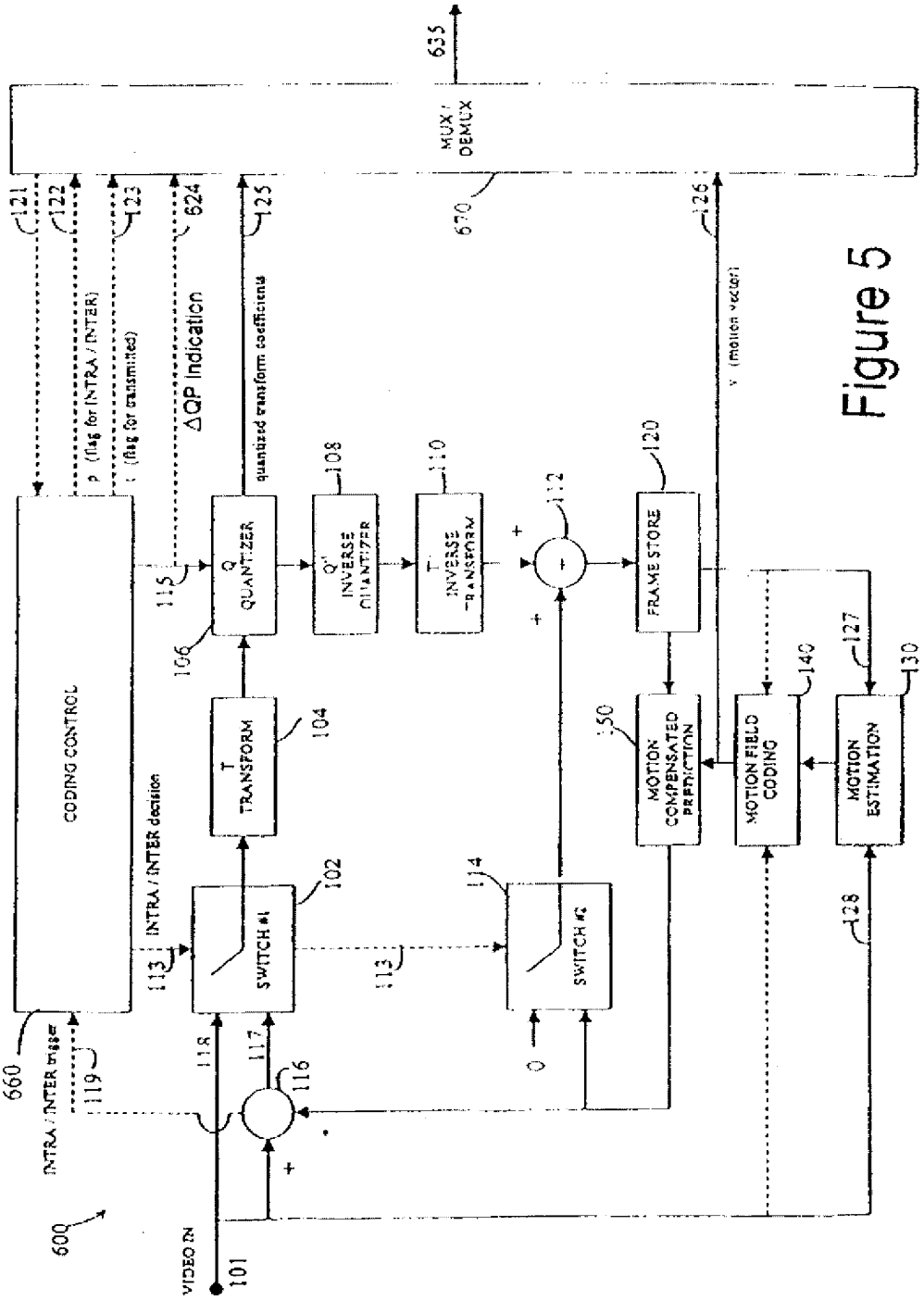

635
MUX / DEMUX
670
121
122
123
624
125
126
ΔQP indication
quantized transform coefficients
CODING CONTROL
INTRA / INTER decision
INTRA / INTER trigger
660
119
600
VIDEO IN
101
SWITCH #1
102
SWITCH #2
114
113
T TRANSFORM
104
Q QUANTIZER
106
115
Q⁻¹ INVERSE QUANTIZER
108
T⁻¹ INVERSE TRANSFORM
110
112
FRAME STORE
120
MOTION COMPENSATED PREDICTION
150
MOTION FIELD CODING
140
MOTION ESTIMATION
127
130
128
116
117
118

Figure 5

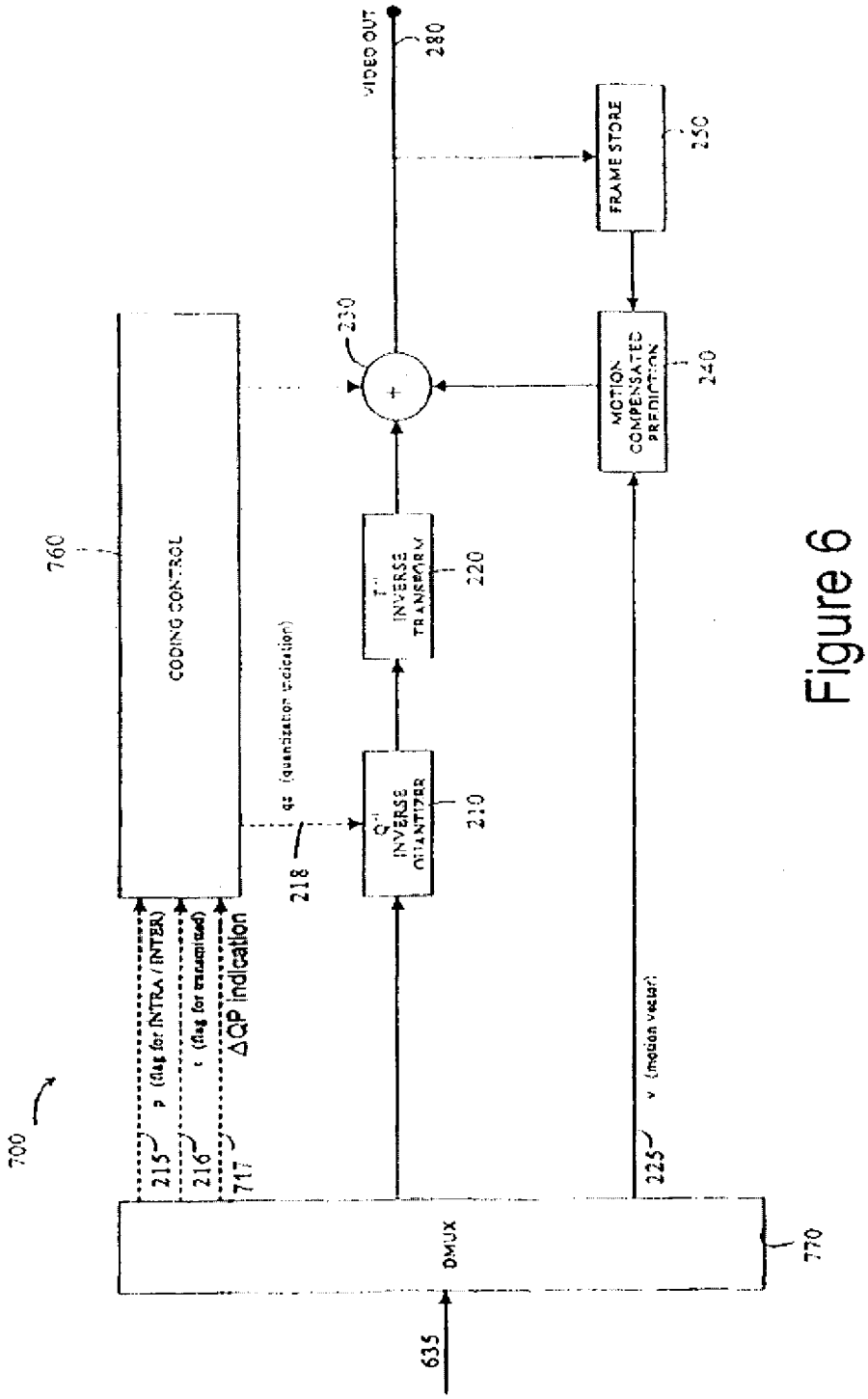

700
760
CODING CONTROL
215
216
717
ΔQP indication
218
Q⁻¹ INVERSE QUANTIZER
210
T⁻¹ INVERSE TRANSFORM
220
230
VIDEO OUT
280
FRAME STORE
250
MOTION COMPENSATED PREDICTION
240
225
DMUX
770
635

Figure 6