

Document made available under the Patent Cooperation Treaty (PCT)

International application number: PCT/EP2006/012492

International filing date: 22 December 2006 (22.12.2006)

Document type: Certified copy of priority document

Document details: Country/Office: US
Number: 60/766,300
Filing date: 09 January 2006 (09.01.2006)

Date of receipt at the International Bureau: 11 March 2007 (11.03.2007)

Remark: Priority document submitted or transmitted to the International Bureau in compliance with Rule 17.1(a) or (b)



World Intellectual Property Organization (WIPO) - Geneva, Switzerland
Organisation Mondiale de la Propriété Intellectuelle (OMPI) - Genève, Suisse

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FILING DATE UNDER 35 USC 111.**

APPLICATION NUMBER: 60/766,300

FILING DATE: January 09, 2006

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APPLICATION, TO BE USED FOR FILING ABROAD UNDER THE PARIS
CONVENTION, IS US60/766,300**

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T. Wallace
T. WALLACE

Certifying Officer

APPLICATION DATA SHEET

Electronic Version v14

Stylesheet Version v14.1

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Application Information:	
Title of Invention :	Adaptive coding of the prediction error in hybrid video coding
Application Type :	provisional, utility
Attorney Docket Number :	
Botanic Information:	
Publication Information:	
Suggested Figure for Publication -	
Suggested Classification -	
Suggested Technology Center -	
Total Number of Drawing Sheets -	
Representative Information:	
Domestic Priority Information:	
Foreign Priority Information:	
Assignee Information:	

**DECLARATION (37 CFR 1.63) FOR UTILITY OR DESIGN APPLICATION USING AN
APPLICATION DATA SHEET (37 CFR 1.76)**

Electronic Version v11

Stylesheet Version v10

**Title of
Invention**

Adaptive coding of the prediction error in hybrid video coding

As the below named inventors, we declare that:

This declaration is directed to the invention titled: " Adaptive coding of the prediction error in hybrid video coding"

We believe that we are the original and first inventors of the subject matter which is claimed and for which a patent is sought;

We have reviewed and understand the contents of the above-identified application, including the claims, as amended by any amendment specifically referred to above;

We acknowledge the duty to disclose to the United States Patent and Trademark Office all information known to us to be material to patentability as defined in 37 CFR 1.56, including for continuation-in-part applications, material information which became available between the filing date of the prior application and the national or PCT International filing date of the continuation-in-part application.

All statements made herein of own knowledge are true, all statements made herein 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 are punishable by fine or imprisonment, or both, under 18 U.S.C. 1001, and may jeopardize the validity of the application or any patent issuing thereon.

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TRANSMITTAL

Electronic Version v1.1

Stylesheet Version v1.1.0

Title of Invention	Adaptive coding of the prediction error in hybrid video coding
Application Number : Date : First Named Applicant: Mr. Mathias Narroschke Confirmation Number: Attorney Docket Number:	
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Submitted By:	Elec. Sign.
Dr. Joern Ostermann	/Ostermann/

Documents being submitted:	Files
us-declaration	PredErrCod-usdecl.xml us-declaration.dtd us-declaration.xsl
us-fee-sheet	PredErrCod-usfees.xml us-fee-sheet.xsl us-fee-sheet.dtd
us-request	PredErrCod-usrequ.xml us-request.dtd us-request.xsl
application-body	FDSDCoding.xml application-body.dtd Image1.tif Image2.tif Image3.tif Image4.tif Image5.tif Image6.tif isoamsa.ent isoamsb.ent isoamsc.ent isoamsn.ent isoamso.ent isoamsr.ent isobox.ent isocyr1.ent isocyr2.ent isodia.ent isogr1.ent isogr2.ent isogr3.ent isogr4.ent isolat1.ent isolat2.ent isomfrk.ent isomopf.ent isomscr.ent isonum.ent isopub.ent isotech.ent mathml2.dtd mathml2-qname-1.mod mmlalias.ent mmlextra.ent soextblx.dtd us-application-body.xsl wipo.ent
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abstract-pdf	FDSDCoding-abst.pdf
claims-pdf	FDSDCoding-clms.pdf

description-pdf	FDSDCoding-desc.pdf
drawings-pdf	FDSDCoding-draw.pdf
Comments	

ACKNOWLEDGEMENT RECEIPT

Electronic Version 1.1

Stylesheet Version v1.1.1

Title of Invention	Adaptive coding of the prediction error in hybrid video coding																																																																																																						
Submission Type : Provisional Application Application Number: 60/766300  EFS ID: 100951 Server Response: <table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th style="width: 20%;">Confirmation Code</th> <th>Message</th> </tr> </thead> <tbody> <tr> <td>ISVR1</td> <td>Submission was successfully submitted - Even if Informational or Warning Messages appear below, please do not resubmit this application</td> </tr> <tr> <td>ICON1</td> <td>1300</td> </tr> <tr> <td>USPTOEFSNot</td> <td>For assistance with e-filing a patent application, contact the Patent Electronic Business Center: Toll-Free Number:1(866) 217-9197 Website: http://www.uspto.gov/ebc/</td> </tr> </tbody> </table>				Confirmation Code	Message	ISVR1	Submission was successfully submitted - Even if Informational or Warning Messages appear below, please do not resubmit this application	ICON1	1300	USPTOEFSNot	For assistance with e-filing a patent application, contact the Patent Electronic Business Center: Toll-Free Number:1(866) 217-9197 Website: http://www.uspto.gov/ebc/																																																																																												
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application-body	isocyr1.ent	5345	2006-01-09
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application-body	isogr1.ent	4030	2006-01-09
application-body	isogr2.ent	2259	2006-01-09
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application-body	us-application-body.xsl	82504	2006-01-09
application-body	wipo.ent	4956	2006-01-09
application-body-pdf-wrap	FDSDCoding-pdf-wrap.xml	747	2006-01-09
abstract-pdf	FDSDCoding-abst.pdf	14913	2006-01-09
claims-pdf	FDSDCoding-clms.pdf	15941	2006-01-09
description-pdf	FDSDCoding-desc.pdf	40676	2006-01-09
drawings-pdf	FDSDCoding-draw.pdf	149629	2006-01-09
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Total files size		990465	

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Adaptive coding of the prediction error in hybrid video coding

DESCRIPTION

State of the art

[Para 1] Standardized video coding algorithms are based on hybrid coding. The temporal redundancy is reduced by using block based motion compensated prediction. The prediction error signal is transformed into the frequency domain resulting in coefficients. The coefficients are quantized and zigzag scanned starting at the DC-coefficient as shown in Fig. 1 resulting in a 1D array. This 1D array is entropy-coded by a coder, which is optimized for an array of coefficients with decreasing energy. In the latest standard H.264/AVC, Context-Based Adaptive Binary Arithmetic Coding (CABAC) or Context-Adaptive Variable-Length Coding (CAVLC) is used for this purpose.

Adaptive coding of the prediction error in the frequency and in the spatial domain

[Para 2] The coding efficiency of the transform is high if the prediction error samples are correlated. For marginally correlated samples in the spatial domain, the transform is inefficient. Therefore, coding in the spatial domain is proposed as depicted in Fig. 2. Each prediction error block is either coded in the spatial domain or in the frequency domain whereas the domain is determined by the adaptation control. The information about the domain is sent as side information. For the purpose of spatial domain coding, the prediction error samples are quantized. The quantized samples are sent to the entropy coding and to

the inverse quantization. The scan of the quantized samples is derived from the prediction signal by the scan control.

Quantizers for the spatial domain

[Para 3] In H.264/AVC rate distortion optimized quantizers for the coefficients with two different distortion measures are applied. The first measure is the mean squared quantization error, the second one is the subjectively weighted quantization error.

[Para 4] According to the H.264/AVC quantizers for the coefficients, two quantizers for the prediction error samples are developed. Since the distribution of the prediction error is close to a Laplacian distribution, a scalar dead-zone plus uniform threshold quantizer is used in the case of mean squared quantization error optimization. Fig. 3 visualizes the parameters a, b and c of the quantization and inverse quantization. For each quantization parameter QP, an individual quantizer is designed. Table 1 shows the parameters a, b and c exemplarily for commonly used QPs in the H.264/AVC coding scheme. In the case of subjectively weighted quantization error optimization, a non uniform quantizer is proposed with representative levels r_i , $-r_i$ and decision thresholds in the middle of adjacent r_i which are also shown in Table 1. In the case that large errors occur at edges, visual masking at edges is exploited. Consequently, large quantization errors are allowed at edges, small ones if the image signal is flat. In Fig. 5, the measured mean absolute reconstruction error of subjectively weighted quantization in the frequency domain is shown for each absolute value of the prediction error. It also shows the absolute reconstruction error of subjectively weighted quantization in the spatial domain. The representation levels r_i are adjusted such that the mean absolute reconstruction error is the same for quantization in the frequency and spatial domain with respect to the quantization intervals in the spatial domain.

The quantizer design can also exploit other features of the visual system. Furthermore, quantizers can be used that create a quantization error with properties different to those of the H.264/AVC quantizers.

Table 1: Parameters a,b, and c of the quantizer in the case of mean squared error optimization and representative levels r_i of the quantizer in the case of subjectively weighted quantization error optimization

QP	a	B	c	r_1	r_2	r_3	r_4	r_5
23	9.6	1.6	2.7	0	11	28	46	66
26	14.8	1.4	4.8	0	14	36	58	110
29	22.2	1.4	6.9	0	20	54	92	148
32	30.2	1.4	9.3	0	28	76	130	220

Adaptation control

[Para 5] The adaptation control decides if a block is coded in the frequency or in the spatial domain and generates the side information to indicate the domain. For the decision purpose, the rate distortion costs are measured for the coding in the spatial and for coding in the frequency domain. The domain with the lower rate distortion costs is chosen. The rate distortion costs are calculated by the required rate R and the resulting distortion D weighted by a Lagrange parameter L : $L \cdot R + D$. As distortion measure, the mean squared quantization error is used, but also other measures are possible e.g. the mean absolute quantization error. As Lagrange parameter L the commonly used Lagrange parameter for the coder control of H.264/AVC is used $L=0.85 \cdot 2^{((QP-12)/3)}$. Alternative methods for determining the rate distortion costs are possible.

[Para 6] The Adaptation control can alternatively control the coding method e.g. based on the prediction signal or based on the correlation in the prediction error or based on the domain, the prediction error is coded in at a motion compensated position of already transmitted frames.

Entropy coding of the quantized samples in the spatial domain

[Para 7] For the entropy coding in the spatial domain, the same method as for the quantized coefficients in the case of coding in the frequency domain is used. In the case of H.264/AVC, it is CABAC but also CAVLC is possible. Instead of the quantized coefficients, the quantized samples are coded. However the scan is changed. The scan in the spatial domain is controlled by the magnitude of the gradient of the prediction image signal at the same spatial position. The samples to be coded are arranged in an order of decreasing gradients as depicted in Fig. 3. Instead of a scan controlled by the gradient also other scans as e.g. a predefined scan or a scan controlled by the quantized prediction error of already transmitted frames or a scan derived from already transmitted quantized samples of the current block or combinations thereof can be applied. In addition, the method for the scan determination can be signaled for segments of the video sequence, e.g. for each frame or for each slice or for each groups of pictures.

[Para 8] Separate probability models are used for the spatial domain whereas the initialization of these models is derived from the statistic of the quantized samples. The context modeling in the spatial domain is done in the same way as in the frequency domain.

Coding of the side information

[Para 9] The adaptive control generates the information in which domain a block is coded, whereas the block size is 4x4 or 8x8 picture elements according to the size of the transform, but also other block sizes independent of the size of the transform are possible.

[Para 10] The flag **Slice_FD_SD_coding_flag** indicates if all blocks of the current slice are coded in the frequency domain or if at least one block is coded in the spatial domain. This flag is coded by one bit.

[Para 11] If at least one block of the slice is coded in the spatial domain, it is indicated by the flag **MB_FD_SD_coding_flag** for each individual macroblock of the current slice if all blocks of the current macroblock are coded in the frequency domain or if at least one block is coded in the spatial domain. This flag is coded conditioned by the flags of the already coded neighboring blocks to the top and to the left.

[Para 12] If at least one block of a macroblock is coded in the spatial domain, it is indicated by the flag **FD_or_SD_flag** for each block of the macroblock to be coded if the current block is coded in the frequency or in the spatial domain. This flag is coded conditioned by the flags of the already coded neighboring blocks to the top and to the left.

[Para 13] Alternatively, the side information can also be coded conditioned by the prediction signal.

Syntax and Semantics

[Para 14] This section describes exemplary syntax and semantics which allows the incorporation of the invented algorithm into the H.264/AVC coding scheme.

The flag **Slice_FD_SD_coding_flag** is introduced in the *slice_header* as shown in Table 2.

The flag **MB_FD_SD_coding_flag** is send in each *macroblock_layer* as shown in Table 3.

In the *residual_block_cabac* it is signaled by the flag **FD_or_SD_flag** if frequency domain coding or spatial domain coding is applied for the current block (see Table 4).
A similar scheme can be applied in other video coding algorithms for the prediction error coding.

Table 2: Extension of the syntax of the slice_header of H.264/AVC

slice_header(){	C	Descriptor
.		
.		
.		
Slice_FD_SD_coding_flag	2	u(1)
.		
.		
.		

Table 3: Extension of the syntax of the macroblock_layer of H.264/AVC

macroblock_layer(){	C	Descriptor
.		
.		
.		
If (Slice_FD_SD_coding_flag == 1){		
MB_FD_SD_coding_flag	2	u(1)
}		
.		
.		
.		

Table 4: Extension of the syntax of the residual_block_cabac of H.264/AVC

residual_block_cabac{	C	Descriptor
.		
.		
.		
If (Slice_FD_SD_coding_flag==1 && MB_FD_SD_coding_flag==1){		
FD_or_SD_flag	3 4	ae(v)
If (FD_or_SD_flag==1){		
Code_Prediction_error_in_spatial_domain		
}		
else{		
Code_Prediction_error_in_frequency_domain		
}		
}		
.		
.		
.		

Decoder

[Para 15] The decoder is depicted in Fig. 6. Based on the transmitted side information, the decoder decodes each block of the prediction error either in the frequency or in the spatial domain. The scan is derived in the same way as in the encoder.

What is claimed is:

[Claim 1] A technique which encodes and decodes the blocks of the prediction error of a hybrid encoding and decoding system adaptively in the frequency or in the spatial domain.

[Claim 2] Adaptation control which generates the information for each block if the coding in the frequency or in the spatial domain is applied. This is done based on a rate distortion criterion.

[Claim 3] An encoding and decoding technique for the side information which is hierarchically structured and uses entropy coding.

[Claim 4] A scan technique for encoding and decoding the quantized prediction error samples in the spatial domain which is fixed or derived from already transmitted prediction error images or derived from the prediction image for instance from the gradient of the prediction image.

[Claim 5] A technique for encoding and decoding the quantized samples of the prediction error using the CABAC technique.

ABSTRACT

Standardized video coding algorithms are based on hybrid coding using motion compensated prediction and transform coding of the prediction error. The transform is efficient if the samples of the prediction error are correlated. For marginally correlated samples, the transform is inefficient. Therefore, adaptive coding in the frequency and in the spatial domain is applied. In the spatial domain, scalar quantization is applied. The entropy coding of the quantized samples is done in the same way as for the quantized coefficients. For each prediction error block, either standardized transform coding or coding in the spatial domain is applied. The information about the domain is sent as side information.

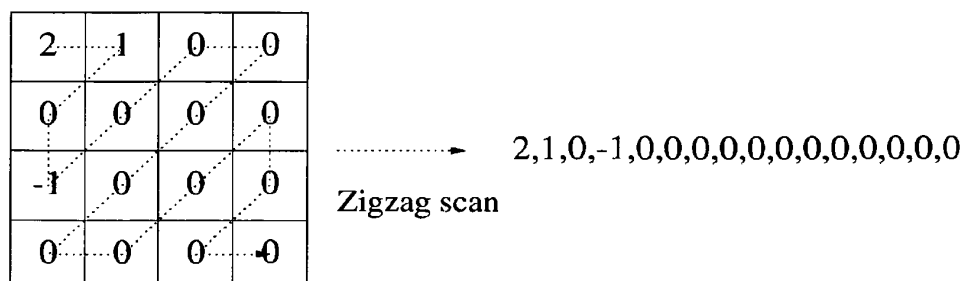


Fig. 1. Scan of quantized coefficients according to the position

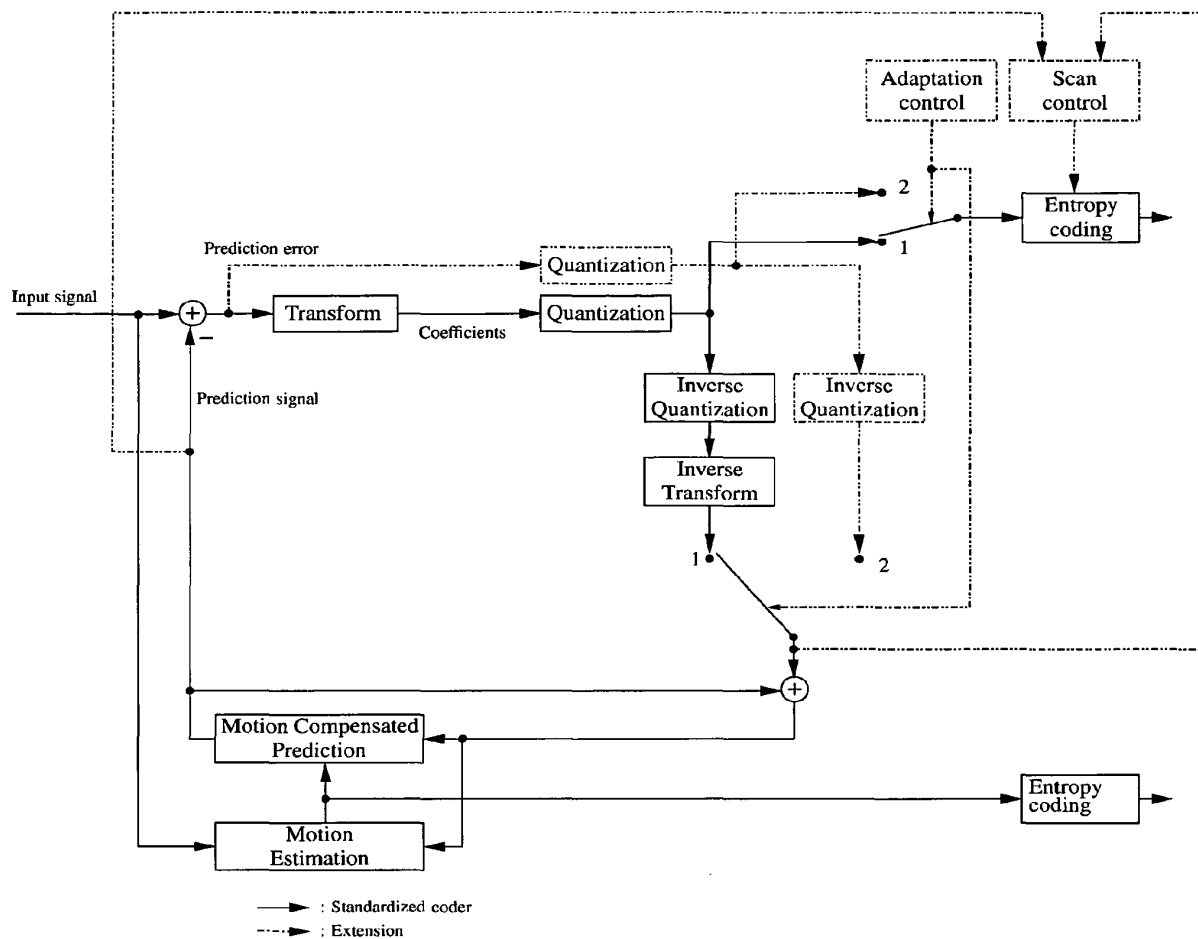


Fig. 2. Block diagram of the adaptive hybrid video encoder

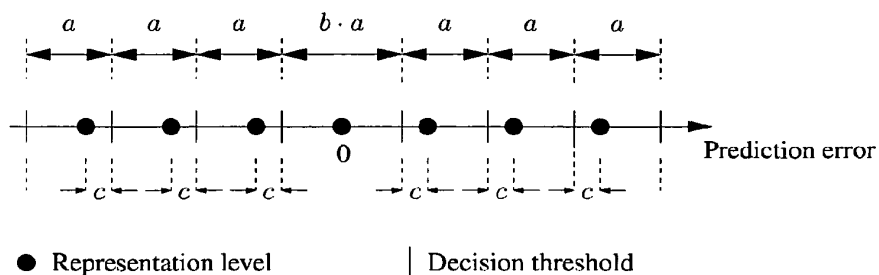


Fig. 3. Quantizer in the case of mean squared quantization error optimization

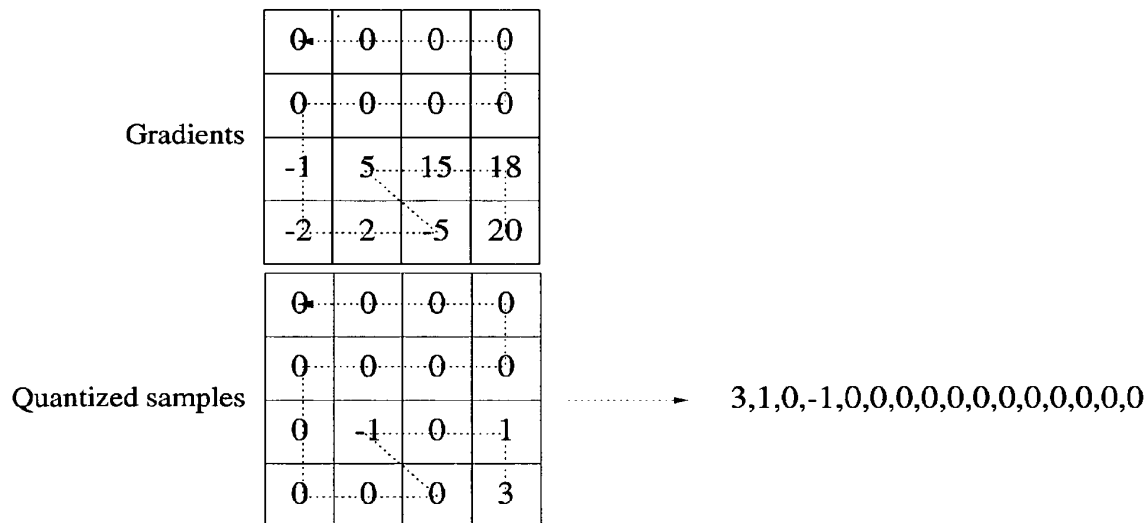


Fig. 4. Scan of quantized samples according to the magnitude of the gradient in the prediction image

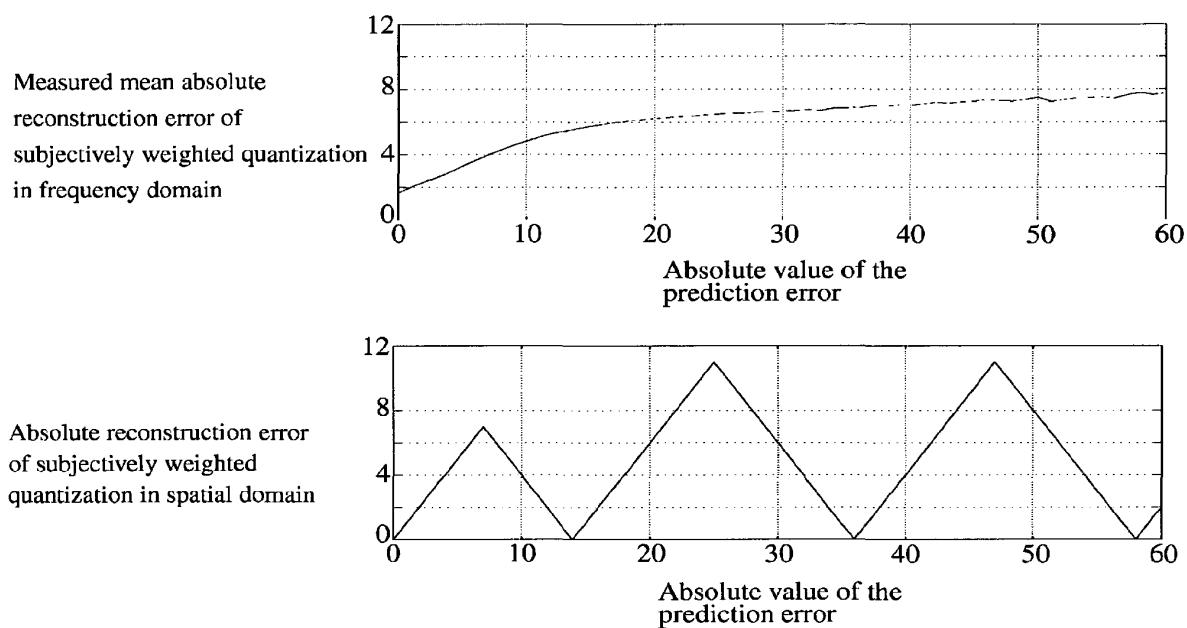


Fig. 5. Measured mean absolute reconstruction error of subjectively weighted quantization in the frequency domain and absolute reconstruction error of subjectively weighted quantization in the spatial domain. QP=26

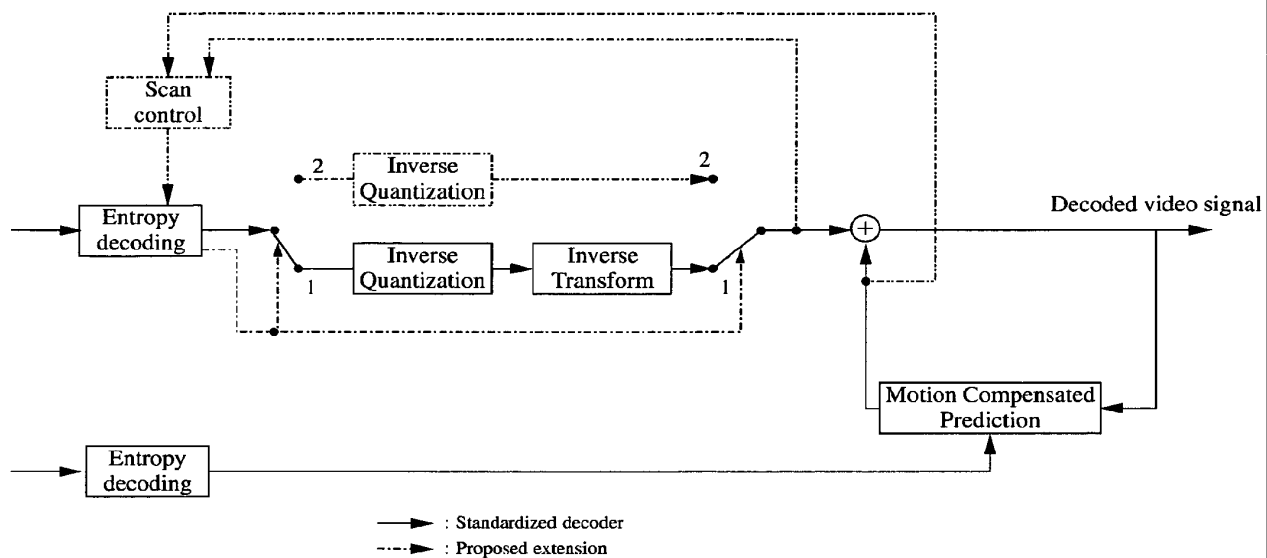


Fig. 6. Block diagram of the adaptive hybrid video decoder