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Non-uniform quantization method considering HEVC entropy coding

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Non-fixed Quantization Considering Entropy Encoding in HEVC

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summary

ITU-T VCEG and ISO/IEC MPEG jointly formed JCT-VC (Joint Collaborative Team on Video Coding) to develop next-generation video coding. Standardization of HEVC (High Efficiency Video Coding) is in progress. Quantization and inverse quantization used in HEVC are Quantization and inverse quantization of the same size are performed on transformation coefficients at all positions within the TU (Transform Unit). Transformation coefficients within TU are distributed equally. Therefore, it is inefficient to perform quantization and inverse quantization of the same size on the transform coefficients at all positions. Also, in the order of injection, The quantized coefficients on the side may be inefficient due to the entropy encoding method. In this paper, considering the efficiency of entropy coding, We present an algorithm that improves performance by performing quantization of different sizes depending on the location of the transform coefficient within the TU. The principle of this algorithm is quantum Quantization and inverse quantization of different sizes are performed according to the scanning order of the TU according to the statistical characteristics of the sized coefficient distribution. This algorithm is The average Y BD-rate showed an improvement in compression rate of 0.34%.

Abstract

MPEG and VCEG have constituted a collaboration team called JCT-VC(Joint Collaborative Team on Video Coding) and have been developing HEVC(High Efficiency Video Coding) standard. All transform coefficients in a TU(Transform Unit) have been equally quantized according to the quantization and inverse quantization method which is used in HEVC standard. Such an equal quantization is not efficient because the transformed coefficients in the TU are not eqully distributed. Furthermore, the quantized coefficients which is positioned in later scanning order cannot be efficient due to the entropy scanning method. We suggest an algorithm that transform coefficients are quantized at different values according to the position in TU considering a scanning order of entropy encoding to improve the coding efficiency. The principle of this algorithm is that quantization and inverse quantization are carried out according to the scanning order which is in accordance with the statistical characteristic of distribution of quantized transform coefficients. The proposed algorithm shows on the average of 0.34% Y BD-rate compression rate improvement.

Keyword : High Efficiency Video Coding, Non-fixed quantization, Scanning order, Entropy encoding

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ÿ. Introduction

Recently, ITU-T VCEG and ISO/IEC MPEG jointly JCT-VC(Joint Collaborative Team on Video Coding)ÿ ÿ It was successful. JCT-VC developed HEVC[1] , the next-generation video standard.

Many coding technologies are being developed and adopted to increase compression efficiency.

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It has been done. Compared to existing compression standards, HEVC provides up to 64x64 block size, expanded orientation in intra-screen prediction mode Angular Intra Prediction (AIP) [2] with improved performance motion vector prediction method[3][4], 8-bit video within the codec IBDI (Internal Bit-Depth Increase)[5][6][7], motion vector merging[4], RDOQ[8], ALF[9], and Cbf Fast Mode[10] technologies, which are coded by increasing 10 bits, are adopted. and standardization is in progress with the goal of a compression efficiency more than twice that of H.264 /MPEG-4 AVC .

HEVC encoding is performed in units of LCU (Largest Coding Unit) of size 64x64 . Each LCU has a hierarchical quadtree structure It is written as . One LCU is split into four CUs Each split CU is further split into four CUs . all. The depth of the quadtree is 4 and it is divided into CUs of at least 8x8 size . It can happen. The encoding of each LCU is centered on each role. Rate-distortion optimization is performed in units of CU (Coding Unit), PU (Prediction Unit), and TU (Transform Unit) . Among these, TU is a unit that performs transformation and quantization and is a hierarchical quadtree It consists of a shape. The size of the TU is at least 4x4, and at most It is 32x32. TU has a depth of 3 if the size of the CU is 2Nx2N. It can be split into sizes of 2Nx2N, NxN, and (1/2)Nx(1/2)N . Quantization basically converts the remaining error value after prediction. Transformation within the quantization TU to reduce the size of one transformation coefficient Divide the coefficients into tables. HEVC's quantization is performed at the TU level. Quantization is performed on the luminance component and chrominance component respectively. All positions in the table and inverse quantization table have the same values. It is based solely on the QP (Quantization Parameter) value. It only changes. graph. 1 shows the Q value and IQ value for each QP%6 all. The Q value and IQ value are used in the formula used when quantizing, and the Q value As this increases, quantization becomes smaller, and the Q value increases by 6. Tickets every time . Quantize the Q value of 1 by dividing it by 2. HEVC RDOQ (Rate-distortion optimized quantiza-tion)[8] was adopted as the quantization technology . RDOQ quantizes one coefficient within a TU. When doing this , the error value and entropy coding are performed using multiple coefficient candidates. Calculate the number of bits considered and select the coefficient with the lowest rate distortion value. It's a way of writing. When RDOQ was adopted, the performance showed an average of about -4.7% of Y BD-rate , but the computational complexity of the encoder was reduced. It increased by about 31% on average . In this paper, quantization within TU Quantization table according to the scanning method of the coefficients and the location of the coefficients By using different inverse quantization tables, the time is the same but the We propose a non-uniform quantization method that improves performance.

Chapter 2 describes the current HEVC quantization and inverse quantization methods and The injection method is explained, and in Chapter 3, the proposed uneven One quantization method will be described. Chapter 3 proposes It also explains how the quantization method performs. do. In Chapter 4, HM4.0 [11], the reference software for HEVC. Based on HEVC's quantization and dequantization methods and the proposed We present the results of performance comparison with the method. In Chapter 4, RDOQ and The experimental results of the proposed method and the differences in performance and encoding time are We explain and conclude in Chapter 5.

Table 1. Q value and IQ value according to QP value

Table 1. Q and IQ according to QP value

QP%6 0		1	2	3	4	5
Q	26214 23302	20560 18396	16384 14564			
IQ	40	45	51	57	64	72

ÿ. HEVC quantization and scanning method

1. Quantization and dequantization in HEVC

Quantization is dividing a continuous quantity into certain intervals and is considered to be the same amount. conventional encoding According to the method, after completing prediction within or between screens, By converting the remaining residual blocks using a method such as DCT (Digital Cosine Transform), the energy is transferred to DC. Creates a concentrated conversion coefficient block. Quantization is a conversion coefficient Quantization table to efficiently reduce block energy It means dividing by . Quantization is the most lossy It is the fundamental cause. The degree of loss is determined by the number in the quantization table. It may vary depending on the size. A typical encoding method is this quantum The values of the quantization table can be adjusted using the quantization parameter (QP : Quantization Parameter) . QP value If this is high, the transformation coefficient is quantized to be large, and if it is low, it is quantized to be small.

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I'm angry.

Currently, HEVC encoders use intra- or inter-screen prediction and

After performing the conversion, the encoder converts using equation (1) below.

Quantize the ring coefficient, and the resulting quantized coefficient is

entropy encoding is performed while generating a reference image.

In order to do this , use the inverse quantization formula in Equation (2) below to inverse

It is quantized [13].

$$level = \frac{Coeff\ Q\ offset_{QP\%6} +}{6\ 2^{21 + - \frac{QP}{\log_2 N}}} \qquad (1)$$

$$CoeffQ = \frac{level\ IQ_{\%6}\ 6\ 2^{\frac{QP}{}}}{2^{\log_2 QPN-1}} \qquad (2)$$

In the above equation, level, Coeff, and CoeffQ mean quantized coefficients,

transform coefficients, and inverse quantized transform coefficients, respectively. Also , N is

It means the length of one side of TU . offset is in the quantization process.

Errors due to rounding and the size of the dead zone

It is a deciding factor.

Q and IQ above mean Q value and IQ value, respectively . Q value and IQ

The value is the remainder of QP divided by 6 (QP%6) as shown in Table 1.

It depends on whether the location of the coefficient in the TU is DC or AC .

Maintain the same Q and IQ values. This is in the quantization table

All values are the same. Same size for coefficients at all positions within TU

This means performing quantization and inverse quantization. But change

The energy of the ring coefficient is concentrated toward the DC coefficient and

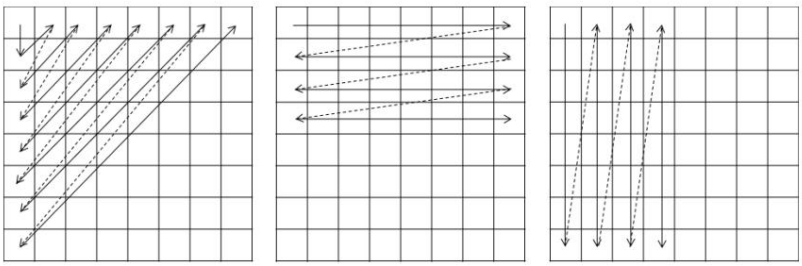
Since the importance of image quality is also high, it may vary depending on the location.

It is necessary to perform quantization of the size.

1. HEVC scanning method

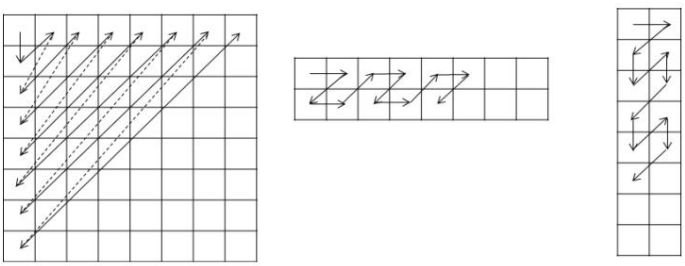
According to a typical encoding method, entropy encoding can be performed

After quantizing the transform coefficients, quantization is performed.



(a) Scanning method when predicting within the screen

(a) Scanning order for Intra prediction



(b) Scanning method when predicting between screens

(b) Scanning order for Inter prediction

Figure 1. HEVC scanning method

Fig. 1. Scanning order in HEVC

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Scan the calculated coefficients and arrange them in a row. entropy sign

In order to produce a lower bit rate as a result of processing, the

The quantized coefficients are placed at the front in the scanning order.

It is

advantageous. Figure 1 shows the efficient HEVC scanning method. screen

In my prediction mode, the quantized coefficients within the TU are displayed on the screen.

Considering efficiency according to prediction mode information, a total of three methods are

used: diagonal scanning, horizontal scanning, and vertical scanning.

Inject. In-screen prediction has 35 modes depending on the prediction direction.

there is. Among them , the predicted value from the pixels at the top of the TU is

When the prediction mode is selected, the residual signal is displayed vertically.

Since there is a high possibility of high correlation in each direction, quantization

It is highly likely that the calculated coefficients are concentrated upward. At this time

Horizontal direction, scanning the quantized coefficients at the top first

Using the scanning method is efficient in terms of entropy coding.

It's the enemy. On the other hand, predicted values from pixels to the left of the TU

If the prediction mode that brings is selected, the residual signal is

Since there is a high possibility of high correlation in the horizontal direction,

There is a high possibility that the magnetized coefficient is concentrated to the left. this

When scanning vertically, the quantized coefficient on the left is scanned first.

In terms of entropy coding, using the directional scanning method is

It is efficient [14]. Inter-

screen prediction uses coding units in a rectangular shape when making predictions.

It is predicted by dividing into prediction units (PU) of

It is also predicted by dividing it into PU . Unlike H.264/AVC

HEVC uses 2Nx(1/2)N conversion technology. rectangular

When predictions are made in prediction units of type, this rectangular shape

Convert to When performing square transformation and quantization

A diagonal scanning method is used, and non-square conversion is used.

And when performing quantization, zigzag scanning is used [3][13].

ÿ. Proposed non-uniform quantization method

In this paper, in order to increase compression efficiency,

Accordingly, the transform domain is divided into two regions and the quantization size is

Suggest a different way to do it. For all conversion coefficients of TU

If quantized to the same size, 0 is placed at the back in the scanning order.

Quantized coefficients with small absolute values may appear. injection

If the transformation coefficients at the back in order are greatly quantized, DC

Quantized coefficients that are important in terms of subjective image quality, such as coefficients

While maintaining the same value, entropy encoding method is used to

When encoding, efficient encoding becomes possible. quantized

The size was controlled by changing the Q value in equation (1), and the equation below

As in (3) , the Q value is adjusted to create Q' and quantized.

$$Q'_{L\,QP\%6} = Q_{QP\%6} R'_{L}$$
$$Q'_{CH\,QP\%6} = Q_{QP\%6} R'_{CH} \qquad (3)$$

QQP%6 is the table. Adjusting the size of the quantization shown in 1

This is the value used in quantization equation (1) . Also, Q'L, QP%6 and

Q'CH, QP%6 enlarges the quantized coefficients at the back in scanning order.

In order to do this, the values to be used instead of the QQP%6 value in equation (1) are

Q'L, QP%6 are the values to be used for the quantized coefficients of luminance TU.

Q'CH,QP%6 are the values to be used for the quantized coefficients of color difference TU .

R refers to the ratio between Q and Q'. If R is given as less than 1, quantization can be made

larger than before according to equation (1) . RL and

RCH refers to the R value of the luminance component and chrominance component, respectively . Quantization

The degree to which the converted conversion coefficients are concentrated toward DC is greater than that of the luminance component.

Because the difference component is stronger, regarding luminance TU and chrominance TU

Different sizes were applied. Therefore, the Q' value is QP divided by 6.

It varies depending on the value of the rest of the eye, and is the luminance component or the chrominance component.

It varies depending on the size and the R value.

Accordingly, when inverse quantization is performed, inverse quantization is performed according to the proposed quantization.

It must be quantized. To do this, the relationship between Q value and IQ value

Knowing that, create an IQ value according to the relation and inverse quantize it.

When, the IQ' value is placed at the same position as the quantized position with the Q' value in the TU.

It must be inverse quantized using equation (2) . Equation (4) is

This is an expression that expresses the relationship between Q value and IQ value. Using

this formula, once the Q value is determined , the IQ value can be created accordingly .

$$IQ'_{L\,QP\%6} Q'_{L\,QP\%6} = 2^{20}$$
$$IQ'_{CH\,QP\%6} Q'_{CHQP\%6} = 2^{20} \qquad (4)$$

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According to the above equation, IQ'L, QP%6 and IQ'CH, QP%6 are the IQQP%6 values of equation (2) used when dequantizing the quantized coefficients behind in scanning order within the TU. As the IQ' value to be entered instead, IQ'L, QP%6 are used for luminance TU , and IQ'CH, QP%6 are used for chrominance TU . When dequantizing, in order to restore a conversion coefficient that is close to the original conversion coefficient before quantization, the product of the Q value and the IQ value must be 220 . This can be known based on equation (1) used for quantization and equation (2) used for inverse quantization.

Figure 2 shows the shape of quantization using the proposed method, taking square-shaped 8x8 TU, non-square 8x2, and 2x8- shaped TU as examples. According to Figure 2, different types of quantization are performed according to the diagonal scanning method, horizontal scanning method, vertical scanning method, and zigzag scanning method.

all. In the TU shape shown in Figure 2 , the white part is the area where quantization is performed using the Q value, and the gray part is the area where quantization is performed using the Q' value multiplied by the R value . The standard for dividing the quantized area into two parts is the part separated by the sum of the horizontal and vertical lengths of the TU in the scanning order. For example , if the size of the TU is NxM, the parts that are N+M apart in the scanning order are quantized to the same size as before, and from the next order onwards, they are quantized larger than before with the proposed Q' value applied. Accordingly, inverse quantization also dequantizes the region quantized with the Q value within the TU to the IQ value, and the region quantized with the Q' value is

inverse quantized with the IQ' value. Figure 3 shows that the proposed method is efficient in terms of entropy encoding. As shown in (a), it is located at the back in the scan

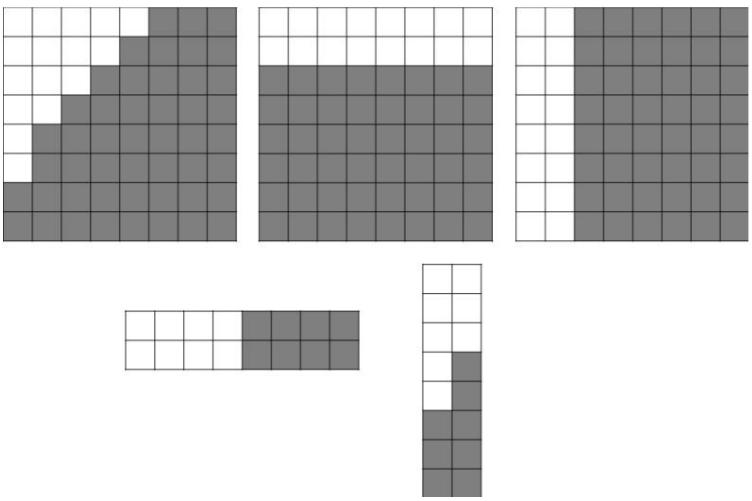

Figure 2. Proposed quantization method in 8x8 TU and non-square TU . 2. Proposed Quantization in 8x8 TU and non-square TU

-10-1011001-4-1100000000-1-10000000000000-100...

(a) Original Quantized Coefficient

-10-1011001-4-1100000000 0 00000000000000 000...

(b) Proposed Quantized Coefficient

Figure 3. Quantized coefficients on the scanning oath of 8x8 TU . 3. Quantized Coefficient according to scanning order of 8x8 TU

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Quantized coefficients are not as important information as other coefficients when expressing subjective image quality in the high-frequency region. However, when entropy encoding, it actually takes a lot of bits to express coefficients in the low-importance high-frequency region. In the case of adaptive variable length coding (CAVLC) based on entropy coding of HEVC , the position of the last non-zero coefficient in the scanning order within the block is sent to the decoder, and the position of the non-zero coefficient between non-zero coefficients is sent to the decoder. The number of 0s is sent to the decoder. In that case, even if the coefficients of the high frequency series are very small, the bit rate may increase if the number of zeros between non-zero coefficients is large. To prevent this from happening, it is necessary to increase quantization of the coefficients corresponding to the high frequency region located later in the scanning order.

Therefore, the proposed algorithm reduces the number of bits required to express the number of zeros between non-zero coefficients in the high-frequency region while leaving the coefficients in the low-frequency region, such as the DC coefficient, as is. However, the bit rate can be reduced, enabling efficient coding.

ÿ. Experiment result

1. Experimental conditions

The proposed non-uniform quantization method considering the performance of entropy coding was implemented in the HEVC reference software HM4.0 [11] version , and the experimental conditions were the same as the common experimental conditions of HEVC [15] . Table 2 is a table of coding technologies used in High Efficiency and Low Complexity . The entropy coding technology adopts context-based adaptive arithmetic coding (CABAC: Context-based Adaptive Variable Coding) in High Efficiency , and coding-based adaptive variable length coding (CAVLC: Context-based Adaptive Variable Coding) in low complexity.

Table 2. Test Conditions of High Efficiency and Low Complexity

High Efficiency	Low Complexity
Coding Unit 8x8 up to 64x64 in tree structure	
Prediction Units Asymmetric Motion Partition	
Transform unit tree(3 level max) Transform block size 4x4 to 32x32 samples Mode-dependent Transform for 4x4 block (DST) Non-square Quad-tree Transform Rate Distortion Optimized Quantization	
Angular Intra Prediction (Max. 34 directions and Planar mode) Adaptive Intra Smoothing Intra Chroma Prediction using Luma samples	
Luma: 8-tap separable DCT-based interpolation filter (1/4-sample) Chroma: 4-tap separable DCT-based interpolation filter with (1/8-sample)	
Coding Unit based Skip & Prediction Unit based merging Advanced motion vector prediction	
CABAC entropy coding	CAVLC
Internal bit-depth increase (2 bits)	x
Deblocking filter Sample Adaptibe Offset	
Adaptive loop filter	x

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Length Coding) is adopted. The experimental video is shown in Table 3.

HEVC experimental video was used. Performance evaluation of technology in HEVC

There are three recommended coding structures: Intra Only, Random Access, and Low

Delay . Intra Only Structure

is a structure in which every frame has an I picture, and inter-screen prediction is

This structure is not used. Therefore, the proposed method in Figure 2

Medium, diagonal scanning method, vertical scanning method, horizontal scanning method

Use the method applied to the injection method of fragrance. The random access structure

is hierarchical with a GOP (Group of pictures) size of 8.

(hierarchical) B picture (IBBBBBBBP) and I picture every second

It is a structure that includes (IDR, Instaneous Decoder Refresh) , and the low delay

structure has an IPPPPPPPP... structure in which only the first sheet has an I picture.

all. Here, P picture is GPB (Generalized P and B picture).

all. Random access structure and low delay structure predict between screens

Since , all of the proposed methods in Figure 2 are used. graph

The images in 3 are used to produce the same results as in Table 4.

Set the QP (Quantization Parameter) values to 22, 27, 32, 37.

It was rough. As a result of the experiment, when the RDOQ was excluded,

Performance improvement was highest when RL=0.9 RCH=0.7 , and RDOQ was

Performance when RL=0.95 and RCH=0.7 when tested without exclusion

The improvement was the highest.

2. Experimental results

Tables 4 and 5 show HM4.0 and HM4.0, in which the proposed method is implemented.

This is the result of performance comparison with HM4.0 . RDOQ off in Tables 4 and 5

The proposed method and HM4.0 excluding the RDOQ encoder option

is the performance difference, and RDOQ off vs RDOQ on is RDOQ encoder

Table 3. Experimental videos

Table 3. Test Sequences

class	video name	resolution	frames per second
A	Traffic	2560x1600	30fps
A	PeopleOnStreet	2560x1600	30fps
A	Nebuta Festival	2560x1600	60fps
A	SteamLocomotiveTrain	2560x1600	60fps
B	Kimono	1920x1080	24fps
B	ParkScene	1920x1080	24fps
B	Cactus	1920x1080	50fps
B	BasketballDrive	1920x1080	50fps
B	BQTerrace	1920x1080	60fps
C	BasketballDrill	832x480	50fps
C	BQMall	832x480	60fps
C	PartyScene	832x480	50fps
C	RaceHorses	832x480	30fps
D	BasketballPass	416x240	50fps
D	BQSquare	416x240	60fps
D	BlowingBubbles	416x240	50fps
D	RaceHorses	416x240	30fps
AND	Vidyo1	1280x720	60fps
AND	Video3	1280x720	60fps
AND	Vidyo4	1280x720	60fps

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Table 4. Experimental results at High Efficiency

Table 4. Experimental results in High Efficiency

ÿ		RDOQ off			RDOQ off vs RDOQ on			RDOQ on		
		Y BD-rate	U BD-rate	V BD-rate	Y BD-rate	U BD-rate	V BD-rate	Y BD-rate	U BD-rate	V BD-rate
Intra Only	A	-0.6%	-1.3%	1.3%	-5.3%	0.8%	2.5%	-0.12%	0.46%	1.21%
	B	-0.6%	-2.1%	-2.4%	-6.5%	-0.4%	-0.4%	0.01%	0.31%	0.31%
	C	-0.6%	-0.6%	-1.5%	-5.0%	0.4%	-0.5%	-0.08%	0.67%	0.22%
	D	-0.4%	-1.5%	-1.4%	-4.9%	1.9%	0.8%	-0.02%	0.18%	0.18%
	AND	-0.1%	-3.2%	-3.0%	-4.8%	-0.3%	-0.9%	0.06%	-0.50%	-0.41%
	average	-0.5%	-1.7%	-1.4%	-5.4%	0.5%	0.3%	-0.03%	0.26%	0.34%
random Access	A	-0.7%	1.5%	3.9%	-5.0%	-4.3%	-4.5%	-0.12%	2.30%	4.17%
	B	-0.3%	0.0%	0.0%	-5.3%	-6.4%	-5.8%	-0.02%	0.94%	0.93%
	C	0.1%	0.4%	0.2%	-5.0%	-7.1%	-7.2%	0.05%	1.35%	0.95%
	D	0.1%	0.2%	-0.1%	-4.8%	-5.4%	-5.6%	0.07%	0.84%	0.29%
	average	-0.2%	0.5%	0.9%	-5.1%	-5.8%	-5.8%	-0.01%	1.33%	1.55%
Low Delay	B	-0.4%	-0.9%	-1.3%	-4.1%	-5.5%	-4.8%	-0.02%	0.83%	-0.17%
	C	-0.1%	-0.2%	-0.5%	-3.6%	-5.4%	-5.4%	-0.03%	0.67%	0.25%
	D	0.0%	-0.7%	-1.1%	-3.6%	-5.9%	-5.7%	-0.04%	0.41%	0.41%
	AND	0.0%	-2.1%	-1.5%	-1.8%	-3.4%	-1.9%	0.11%	-1.32%	-0.10%
	average	-0.1%	-0.9%	-1.1%	-3.4%	-5.2%	-4.6%	0.00%	0.28%	0.09%

Table 5. Experimental results at low complexity

Table 5. Experimental results in Low Complexity

ÿ		RDOQ off			RDOQ off vs RDOQ on			RDOQ on		
		Y BD-rate	U BD-rate	V BD-rate	Y BD-rate	U BD-rate	V BD-rate	Y BD-rate	U BD-rate	V BD-rate
Intra Only	A	-0.6%	-2.2%	-1.1%	-5.4%	-4.5%	-4.3%	-0.05%	-0.20%	0.21%
	B	-1.0%	-2.8%	-2.9%	-7.6%	-6.9%	-7.3%	0.02%	0.12%	0.10%
	C	-0.7%	-0.9%	-1.6%	-5.3%	-4.1%	-5.0%	-0.06%	0.57%	0.37%
	D	-0.5%	-1.6%	-1.2%	-5.0%	-3.0%	-3.9%	-0.04%	0.29%	0.54%
	AND	-0.4%	-3.5%	-3.2%	-5.2%	-10.0%	-9.9%	0.00%	-0.42%	-0.37%
	average	-0.7%	-2.1%	-2.0%	-5.8%	-5.6%	-6.0%	-0.02%	0.10%	0.19%
Rando m Access	A	-0.5%	1.4%	2.4%	-4.0%	-8.8%	-9.8%	-0.13%	1.47%	2.53%
	B	-0.4%	-0.6%	-0.5%	-5.0%	-11.7%	-11.9%	-0.03%	0.80%	0.69%
	C	0.0%	0.2%	0.0%	-4.8%	-11.1%	-11.3%	-0.01%	1.06%	0.75%
	D	0.0%	-0.2%	0.3%	-4.9%	-11.1%	-11.3%	-0.03%	0.76%	0.99%
	average	-0.2%	0.2%	0.5%	-4.7%	-10.7%	-11.1%	-0.05%	1.01%	1.20%
Low Delay	B	-0.5%	-0.9%	-1.5%	-3.4%	-10.7%	-11.8%	-0.09%	0.86%	0.61%
	C	-0.3%	-0.3%	-0.8%	-3.4%	-9.6%	-9.6%	-0.11%	1.02%	0.29%
	D	-0.2%	-1.1%	-0.7%	-3.4%	-11.7%	-11.6%	-0.09%	0.43%	0.38%
	AND	-0.2%	-2.4%	-1.1%	-2.0%	-11.2%	-8.1%	-0.02%	-0.53%	0.24%
	average	-0.3%	-1.1%	-1.0%	-3.2%	-10.8%	-10.5%	-0.08%	0.53%	0.40%

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When the option is excluded and when the RDOQ is not excluded

This is the performance difference of HM4.0 . Based on RDOQ algorithm

The proposed method can be applied. Therefore, in Tables 4 and 5

RDOQ on is HM4.0 that applies the method proposed to RDOQ

This is the performance difference of HM4.0 . The BD-rate shown in Table 4 is

Defined in VCEG-M33[16] , on the rate-distortion curve

Indicates the average bit rate increase. Therefore, BD-rate is negative

It can be evaluated that the compression ratio has improved. Additionally, Table 4 shows

These are the experimental results in the High Efficiency structure , and Table 5 shows the

experimental results in the Low Complexity structure .

As a result of the RDOQ off experiment , the best performance was achieved in the Intra Only structure.

It came out high, and at this time, Y BD-rate was at High Efficiency.

-0.5% came out, and -0.7% came out in Low Complexity . also

In an Intra Only structure, the color difference component is -1.4% to -2.1%.

BD-rates up to . Looking at the experimental results, except for the Random Access

structure, energy is generally used rather than luminance component.

The compression ratio is higher in chrominance components with low frequencies and many low-frequency regions.

improved. In addition, high-resolution video, Class A and Class B,

You can see that the performance is the highest.

According to the RDOQ on experimental results, even if the proposed method is applied,

There is no difference in performance. As mentioned earlier, RDOQ is a

When quantizing one coefficient , there are multiple coefficient candidates and the error value is

Rate distortion by calculating the number of bits considering hyperentropy coding

This method uses the coefficient with the lowest value. As can be seen in RDOQ off vs

RDOQ on , RDOQ has good performance, but

Complexity increases significantly. When encoding increased by RDOQ

The liver can be confirmed in Table 5. That is, all quantized data in the TU are

Since the coefficients are optimized for rate distortion, it is suitable for the already proposed method.

The minimum number of bits is used compared to the intended PSNR.

There is no difference in compression rate even if the method proposed here is applied .

C. Table 6 and Table 7 suggest the encoding time and decoding time, respectively.

This is a table comparing the method with the reference software HM4.0 . ÿT is true

When encoding or decoding between the Joe software and the proposed method

Table 6. Encoding time ÿT

Table 6. Encoding Time ÿT

ÿT(%)	RDOQ off		RDOQ off vs RDOQ on		RDOQ on	
	High Efficiency	Low Complexity	High Efficiency	Low Complexity	High Efficiency	Low Complexity
Intra Only	100%	101%	117%	119%	101%	101%
Random Access	100%	100%	125%	142%	99%	102%
Low Delay	101%	100%	153%	128%	99%	100%
Average	100%	100%	132%	130%	100%	101%

Table 7. Decryption time ÿT

Table 7. Decoding Time ÿT

ÿT(%)	RDOQ off		RDOQ on	
	High Efficiency	Low Complexity	High Efficiency	Low Complexity
Intra Only	101%	101%	102%	102%
Random Access	100%	100%	101%	101%
Low Delay	100%	100%	101%	101%
Average	100%	100%	101%	101%

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It is the ratio between the two and can be expressed in equation (5) below . also

Since RDOQ is an encoder option, the dequantization method uses RDOQ

As it is the same as excluding the decoding time, the RDOQ is also

It's the same as excluding it. Results of RDOQ off vs RDOQ on in Table 6

Looking at the results, RDOQ requires a lot of coding time to achieve the same

performance as the experimental results of RDOQ off vs. RDOQ on in Tables 4 and 5.

It can be seen that this increases. RDOQ encodes about 31% on average

Increase time. On the other hand, the proposed method in Tables 6 and 7

Encoding time and decoding time are both RDOQ off and RDOQ on .

You can see that it is similar to the reference software. Therefore, the suggestion

The algorithm used increases the overall encoding or decoding time.

Encoding while reducing the overall BD-rate without

Performance has been improved.

$$D \mp \frac{T_{proposed}}{T_{referenced}} \times 100(\%) \qquad (5)$$

ÿ. conclusion

The proposed quantization method considering entropy encoding is

By performing greater quantization on the quantized coefficients that are later in the order,

Entropy by removing coefficients with small energy

Increases coding efficiency. When applying the proposed method to HM4.0

When turned on , the maximum BD-rate in the luminance component is approximately -0.7%.

BD-rate performance has been improved by up to -2.1% in the chrominance

component , and the encoding and decoding times are maintained at 100% .

Therefore, the proposed method has good compression performance and low complexity.

It can be useful in applications that require luxury.

It is expected that

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