IMPROVEMENT OF I-PICTURE CODING USING INTER-PICTURE PROCESSING

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ABSTRACT

An improvement of standard encoder has been saturated recently. However, new coding method does not have a compatibility with conventional standard. To solve this problem, new concept coding method that has a semi-compatibility with standard may be discussed. On the other hand, cyclic Intra-picture coding is used for access and refreshment. However, I-picture spend large amount of bits. An enhancement of I-picture is desired with keeping its refreshment performance. Further, it's a problem that quality change at the border of GOP because of its independency. To respond these, we propose the coding which is applied an inter-frame processing at the border of GOP. Applied method is the reduction of quantization error using the motion compensated inter-picture processing. In this report, we check the improvement of the efficiency and the compatibility of proposed method. As a result of examination, we recognize that the total gain is maximally 1.2dB in PSNR. Generally, the degradation of performance in standard decoding is smaller than its gain. Also the refreshment performance is tested.

Keywords: Compatibility, I-picture coding, Motion compensation, Quantization error reduction

1. INTRODUCTION

Coding efficiency of a standard method can be enhanced by improvement of encoder. However, the improvement has been saturated recently. New coding method, such as H.264, has significant high efficiency. However, it does not have a compatibility with conventional MPEG standard. [1] [2]

To solve these problems, we discuss a new concept coding method that has a semi-compatibility with MPEG standard method. To keep compatibility, we can not modify the main architecture of encoding. We apply new technology to I-picture only. However, bit amount of I-picture is significant and performance of I-picture spreads to the other picture. Further, this can reduce the problem of quality change at the border of GOP because of its filter effect.[3]

Applied method is a reduction of quantization error using a motion compensated inter-frame processing. It has been proposed for the all intra coding. [4] [5] This time, we consider the parameters and the control methods to fit the inter-picture processing. In encoder side, quantization error of a last P-picture is added before usual encoding. The decoder side is similar to a noise reduction. [6 -[8] Motion compensations are applied for the inter-frame processing both in the encoder side and the decoder side.

We apply the proposed method to MPEG-4 main profile. The proposed method is compared to the normal coding. The sequences are ITE standard sequences. To check the compatibility of proposal, PSNR are evaluated in the standard decoding of enhanced bit-stream. Farther, the refreshment performance in the case of bit-stream error, is tested.

2. MOTION PICTURE CODING

2.1. Improvement of I-picture Efficiency

In an inter-picture coding, intra picture should be used twice a second usually. Inter-picture prediction is stopped at this frame and influence of error is also stopped. This matter causes a breath effect which is a cyclic change of reproduced picture. Inter-picture processing at the border of GOP is effective to solve this problem. Furthermore, coding efficiency can be improved also.

Intra-picture is rare in GOP, however, it occupies 30% to 40% at total bit amount. Improvement of intra-picture is effective for the over all performance of an inter-picture coding. Therefore, an improvement of I-picture efficiency using inter-picture processing is important and effective.

2.2. Semi-Compatible Coding

In a standard coding, full-compatible coding and decoding should be required basically. On the other hand, pre-processing and post-processing are not limited to use for a standard CODEC. Data syntax of standard should be kept absolutely.

However, modification of semantics or a picture may allow. In this case, slight drift is caused by mismatch between an encoder and decode. However, if CODEC has self-refreshing mechanism, it is not significant problem. Under these considerations, an enhanced CODEC may be possible and it has semi-compatibility shown in Fig.1.

In Fig.1, Bit-stream which is encoded by enhanced (new) encoder, can be decoded at not only enhanced decoder, but also standard decoder. However, qualities of reconstructed picture are different between enhanced decoder and standard decoder.

In enhanced decoder, picture quality (coding efficiency) is significantly better than the reference. Quality of standard decoding is poor, because of CODEC mismatch. In the case of decoding of standard bit-stream in enhanced decoder, picture quality may be better than standard decoding. However, this item is not important.

In this coding system, if degradation of standard decoding is not significant, smooth shift to enhanced CODEC may be possible.

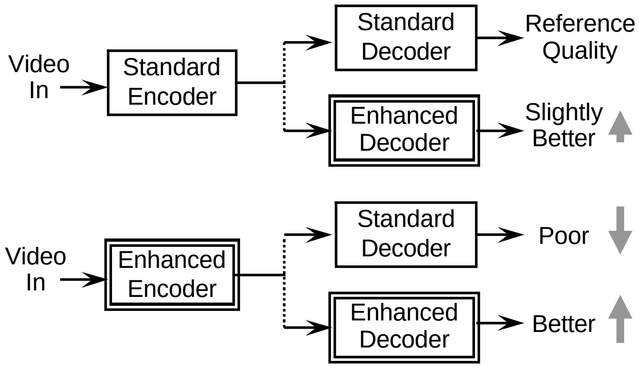

Fig.1 Compatibility of Proposed Coding System

3. PROPOSED CODING

3.1. GOP Structure

Inter-picture processing is added for I-picture. Fig.2 shows relation of inter-pictures processing. The processing of P and B-picture are completely the same as the standard. Inter-picture processing is applied between latest p-picture of last GOP and Intra-picture. As the result, inter-picture processing is used at different position in the prediction and the proposed processing.

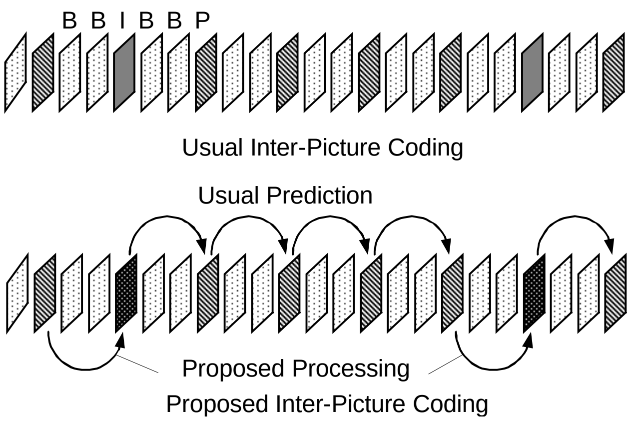

Fig.2 Processing for Inter-picture Coding

3.2. Inter-frame Processing

Fig. 3 shows structure of inter-picture processing. P-and B-picture performs the same inter-frame processing as the usual prediction coding. For I-picture, inversed quantization error of last P picture is added to an I-picture before the encoding. Intra-picture picture processing and all syntax are completely the same as standard.

In the decoder, additional processing is also applied only for I-picture. Decoded last P-picture and I-picture are averaged. Processed I-picture is used for a reference also.

Motion compensation is applied for the inter-frame processing both in an encoder side and a decoder side. However, behaviors of motion compensation are not completely the same.

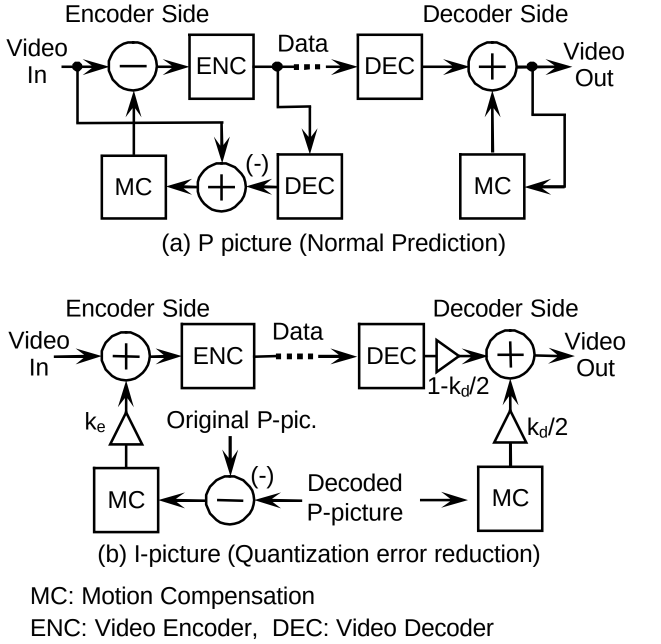

Fig.3: Structure of Inter-Picture Processing

4. DETAILS OF PROCESSING

4.1. Detail of Pre-Processing for Encoder

The detail of inter-frame processing in encoder is shown in Fig.4. Input pixel P_i and quantization error e are added to the encoding pixel P_{i-e} by next equation.

$$P_{i-e}(x,y) = P_i(x,y) + k_e e(x+dx, y+dy) \qquad (1)$$

where

x,y : horizontal, vertical pixel position

dx,dy : components of motion vector

The adding factor k_e(0-1) of quantization error is controlled by inter-frame correlation. Quantization error e is given by original P-picture P_p and local decoded P_{p-d}.

$$e(x,y) = P_p(x,y) - P_{p-d}(x,y) \qquad (2)$$

The quantization error is also compensated by the same motion vector which to calculate k_e. In this, motion is estimation by using the original picture of P-picture. Motion vector is used to move both quantization error and picture to calculate k_e. To prediction of next P-picture, local decoded I-picture is used. Therefore, this processing is not pure pre-processing, but in-loop processing.

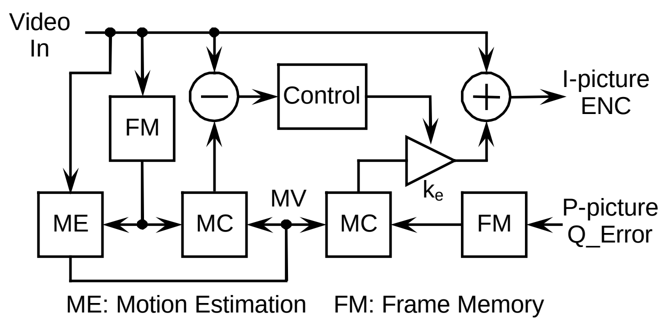

Fig.4: Additional Processing for Encoder

4.2. Detail of Post-Processing for Decoder

The detail of inter-frame processing in decoder is shown in Fig.5. Decoded I-picture $P_{i\text{-}d}$ and decoded P-picture $P_{p\text{-}d}$ are added to output pixel $P_{i\text{-}o}$ by next equation.

$$P_{i-o}(x,y)=(1-\frac{k_d}{2})P_{i-d}(x,y)+\frac{k_d}{2}P_{p-d}(x+dx,y+dy) \qquad (3)$$

In the decoder, motion estimation is based on decoded picture. The motion vector is not the same as the one in encoder completely. Adding factor k_d(0-1) is not the same as k_e also. To prediction of next P-picture, local decoded I-picture is used. The processing cost of decoder is similar to encoder because of motion estimation.

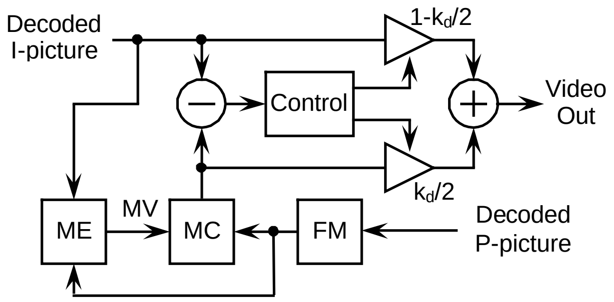

Fig.5: Additional Processing for Decoder

4.3. Control of Adding Factor

Fig.6 shows the control of adding factor k_e/k_d. The k is determined by differences between current picture and motion compensated reference picture. To take smooth control, the spatial low pass filter is applied to absolute differences. If pictures have high correlation (small difference), k_e/k_d is close to 1.0. The quantization error and the picture are added enough, and, the error reduction effect is the maximum.

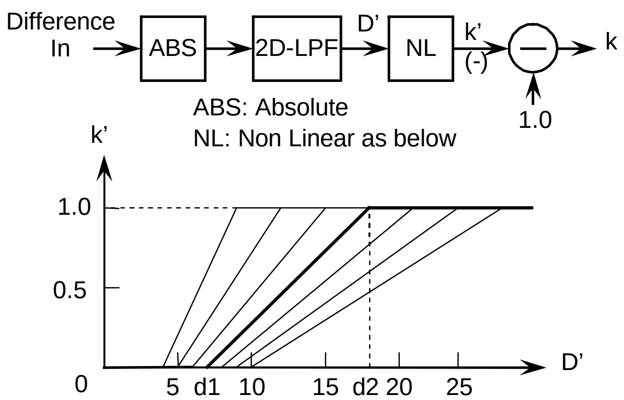

Fig.6: Control of Adding Factor

4.4. Motion Compensation

In case of inter-frame predictive coding, difference of processing between encoder and decoder causes accumulation of error. Therefore, the information of motion compensation should be transmitted. However, in the case of proposed processing, the adding is basically leaky. Mismatch of inter-frame processing is acceptable, and, information need not be transmitted.

If transmission of motion information is required, amount of the information should be considered. Accurate motion compensation enlarges amount of motion information. However, in case of proposed processing, motion information is not transmitted. Improvement of motion compensation gives good performance without disadvantage. This is a good point of the proposed method that normal inter-frame coding does not have.

Accuracy of motion compensation is quarter pixel and block size is 4 by 4. These are the same parameters as motion compensation in H.264. However, in the case of H.264, larger block are use usually, because of rate-distortion optimization.

In motion estimation, we refer the matching value of neighbor blocks to avoid incorrect motion vector. Block size is 4 x 4 pixel, however, 20 x 20 pixel in neighbor blocks are used to determine the motion vector.

4.5. Refreshment Performance

In the proposed coding, the performance of refreshment should be considered because of the inter-picture processing for I-picture. In the adaptive processing, the decoded I-picture and the last P-picture are averaged when they have good matching. If p-picture is not similar to I-picture, p-picture is rejected automatically. On the other hand, inter-picture processing is an averaging, this means that leaky factor of processing is 0.5. Therefore, refreshment performance is expected as good enough.

5. EXAMINATION

5.1. Processing Parameters

Processing parameters of inter-picture processing are shown in Table 1. Value of d1 and d2 depend on Q_scale.
We use MPEG-4 coding with default quantization matrix and fixed quantization scale as a coding. Coding conditions are shown in Table 2.

Table.1 Processing Condition

Item	Parameters
d1 (Fig.6)	= Q_Scale
d2 (Fig.6)	2.0d1 for k'_e / 2.7d1 for k'_d
Search Range	+/-15 pixel (H, V)

Table.2 Coding Condition

Item	Prameter
Coding Method	MPEG-4 (M=3 / N=15)
Quantization	Q_Scale = 5, 7, 10, 14
Picture	720x480 / 30p (16:9)
Number of frame	150 (5 sec.)

Tested sequences are ITE (The Institute of Television Engineering) standard sequences. We select sequences called "Square" and "Market". These sequences have panning and object motion.

5.2. Results of Coding

In the first portion of "Square" and "Market", PSNR change of each coding are shown in Fig. 7 and 8. Results of the standard coding are shown as "std-std", the proposed enhanced coding are shown as "pre-post", standard decoding of enhanced bit-stream are shown as "pre-std". Situation of the transmitting error was also compared. PSNR of the case of lacking last p-picture are shown as "error". However, the constant quantization is used. Therefore, bit-rate is slightly different each other.

In "pre-post", PSNR of I-picture is improved significantly in comparison to "std-std". The all pictures in GOP including previous a couple of B-picture, are improved because of the reference picture improvement.

In "pre-std", degradations of PSNR are start from I-picture. However, they decrease gradually because of the self correction of mismatch.

In "error", the performance of first GOP after P-picture lacking, is the same as "pre-std" because of stopping the additional inter-picture processing. In the next GOP, it is about the same as the "pre-post". It means that the proposed method has an enough refresh performance.

Fig. 9 shows PSNR of full sequence versus bit-rate. In "Square", the PSNR gain of "pre-post" is more than 1.0 dB in all bit-rate. The degradation in "pre-std" is less than the gain, and it depends on bit-rate. In "Market", the gain is less than "Square" because of its motion characteristics.

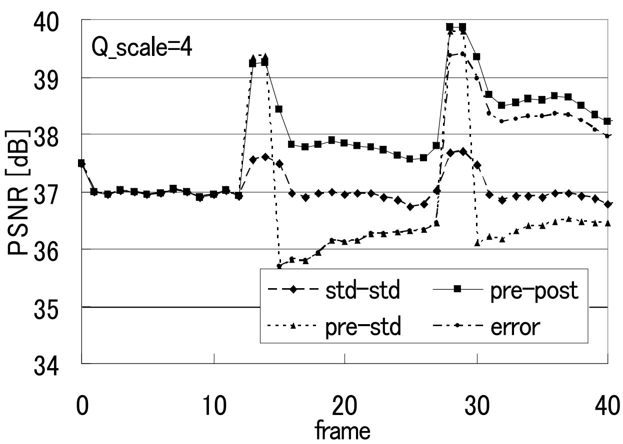

Fig.7 PSNR Change (Square)

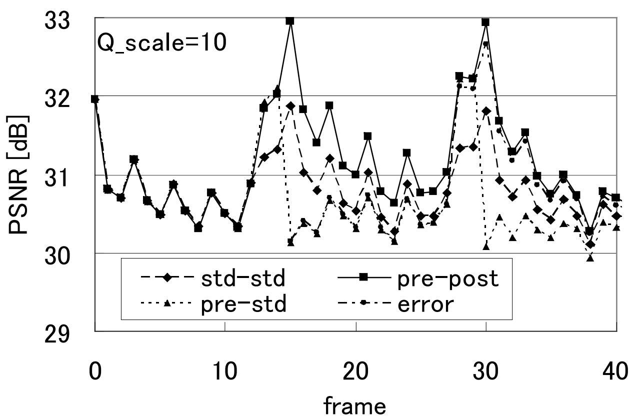

Fig.8 PSNR Change (Market)

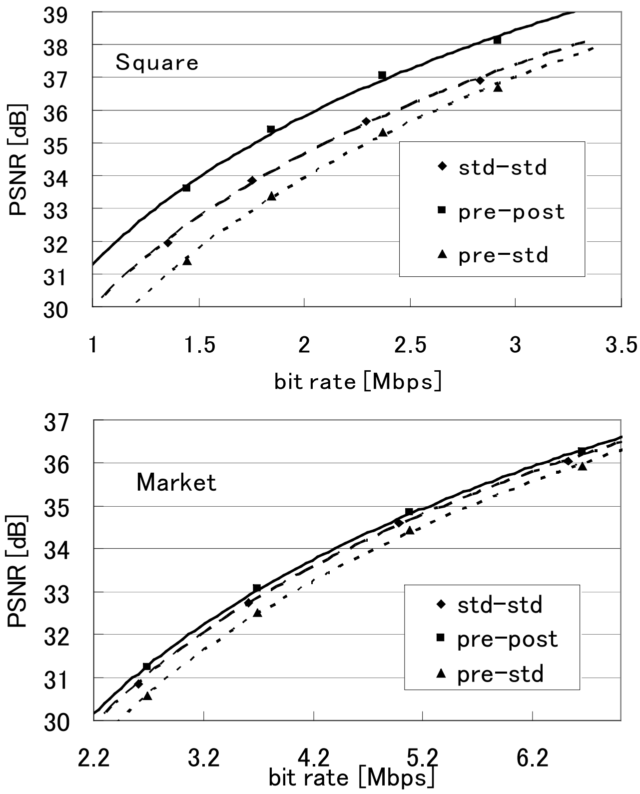

Fig.9 PSNR vs. bit rate

Fig. 10 and 11 show reconstructed picture of first P-picture. We think that comparison of I-picture is unfair, because bit amounts of I-pictures are different. In "pre-post", the proposed decoding has an effect of noise reduction. Therefore, subjective picture qualities are improved rater than the amount of PSNR. We recognized the reduction of breath effect in the motion picture viewing. In "pre-std", degradations of picture quality can be seen because of remaining the quantization error of last GOP. However, there are not significant at motion picture viewing.

pre-post Square (1.5Mbps) pre-std

Fig.10 Reconstructed Pictures (100x100 pixels)

original "std-std"

pre-post Market (2.6Mbps) pre-std

Fig.11 Reconstructed Pictures (100x100 pixels)

6. CONCLUSION

We discussed new concept coding method that has a semi-compatibility with the standard method. We proposed the coding which is applied an inter-frame processing at the border of GOP. Applied technology is the reduction of quantization error using the motion compensated inter-picture processing.

We applied the proposed method to MPEG-4 main profile. To check the compatibility of proposal, PSNR were evaluated in the standard decoding of enhanced bit-stream. Farther, the refreshment performance was tested.

As a result of examination, we recognized that the total gain is maximally 1.2dB in PSNR. And, the reduction of breath effect is recognized. Generally, the degradation of performance in standard decoding is smaller than its gain. Also the refreshment performance is good enough.

Improvement in efficiency of P and B-picture is due to be considered as a future subject.

7. REFERENCES

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