A Transcoding Method for Improving the Subjective Picture Quality

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Summary
We propose a new transcoding method to control the picture quality dependently on the view focus. In the proposed method, the quantization step-size obtained by the homogeneous or heterogeneous approach is reassigned to improve the subjective picture quality. The smaller value of quantization step-size is assigned to more important position from view point but the larger value of quantization step-size is assigned to less important position. From the simulation, we show that the proposed method can make better subjective picture quality relatively in parts of center of displayed picture, more important position of view point.

Key words:
Transcoding, Subjective picture quality, View foucs, Quantization step-size

1. Introduction

Homogeneous bitstream transcoding method that converts the bitrates, picture rates and resolutions with keeping the same coding standard or syntax is widely used for various applications in the inter-network communications.
For the homogeneous transcoding, the bitrate reduction may be needed when a final user cannot accept the bitrate of the originally compressed or/and stored bitstream. The bitrate reduction algorithm converts from high bitrate bitstream to lower rate bitstream. There are two types of bitrate reductions[1-4]. The first one is full decoding and re-encoding. This method accomplishes a re-ordering of the reconstructed pictures and a re-estimation of motion vectors for the motion compensated coding, thus the delay time and the implementation complexity for the transcoding are increased. The second one is to achieve the target bitrate only with the re-quantization process in DCT (Discrete Cosine Transform) domain. The bitstream is partially decoded only by both the inverse VLC (Variable Length Code) and inverse quantization. That is, the DCT coefficients are obtained from an inverse quantization with each quantization step-size. For reducing the video bitrate, the DCT coefficients are re-quantized with a larger quantization step-size. Finally, the coefficients generated by the re-quantization are converted into a new bitstream with a lower bitrate after the VLC encoding process. This bitstream transcoding operation does not include the re-ordering and re-estimation for the motion compensation. Therefore, the bitstream transcoding by re-quantization process requires lower complexity and a little more processing time. Fig. 1 shows a transcoding system by the re-quantization between H.264 coded bitstreams[5-8].

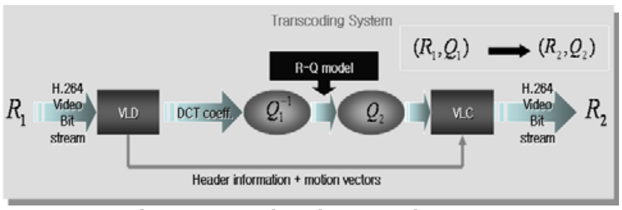

Fig. 1 Transcoding system, where bitstream (bitrate R_1, quantization step-size Q_1) is transcoded to another bitstream (bitrate R_2, quantization step-size Q_2).

For the bitstream transcoding, the several methods[9-13] have been proposed. All of methods concerns with proper allocation of bitrate or quantization step-size in order to satisfy good picture quality or high PSNR (Peak Signal to Noise Ratio).
However, the conventional methods did not deal with subjective picture quality dependently on the view concern within the displayed picture. When we watch the video, we would focus on the center position of the picture if all of pictures has the same priority. That is, it can be differently important of subjective picture quality dependently on the position of monitor which video plays, center and corner parts.
We propose a new transcoding method that makes better video quality relatively in parts of center of monitor which can emphasize importance of visual quality relatively.
The organization of this paper is as follows. Section 2 provides the conventional transcoding methods. In Section 3, the proposed transcoding method is described for improving the subjective picture quality by properly allocating the quantization parameters dependently on the view position. Section 4 shows the simulation results of the proposed method about quantization parameter

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compared with the conventional one. In Section 5, we summarize the main results.

2. Conventional transcoding method

For the bitrate reduction of transcoding, the optimal schemes [9,10] have been proposed in order to solve the Lagrangian optimization based on each rate-distortion formulation. The critical drawback of the optimization is the heavy complexity required to measure the rate-distortion data on all possible quantization settings. In [11] and [12], accurate rate control methods for transcoding are presented based on the linear relationship between the number of bits generated from the quantized DCT coefficients and the number of non-zero DCT coefficients.

For simple implementation, the transcoding method has been proposed in [1]. This method shows the relationship between bitrate and quantization step-size for transcoding, a linear relative formula as a logarithmic function between bitrate (*R*) and quantization step-size (*Qstep*),

$$\log Qstep = b + a \cdot \log R \tag{1}$$

where, *b* and *a* are dependent on the video characteristics. Also a transcoding algorithm is presented which updates the model parameters given for the previous picture or slice using an approximated relationship between bitrate and quantization step-size according to the coded picture-type. That is, if a target bitrate in bits per second, $BR_t(bps)$ is given in the case of already an encoded bitrate $BR_1(bps)$ in bits per second, then target quantization step-size $Qstep_t$ is obtained from following equation.

$$Qstep_t = Qstep_1 \cdot \left(\frac{BR_t}{BR_1}\right)^a \tag{2}$$

where, the value of *a* is approximated by the previous coded results.

3. Proposed transcoding method for Improving subjective picture quality

A transcoding method is proposed to control the picture quality dependently on the view concern within displayed picture.

Therefore, it is required to assign the value of quantization step-size differently according to the location of slice of picture as shown at following equation.

$$\hat{Q}_s(i_s) = \alpha(i_s - \frac{N_s+1}{2})^2 + \beta, \quad 1 \le i_s \le N_s \tag{3}$$

where, i_s is an index of slice within a picture and it increases downward. $\hat{Q}_s(i_s)$ is a reassigned quantization step-size for the i_s. N_s is the total number of slice within a picture. α, β are the constants for control of the subjective picture quality. By the value of α, we can control the picture quality differently on the slice position. As the value of α is large, the difference of quantization step-sizes between the center slice and the top or bottom slice can be increased. Fig. 2 shows the reassigned quantization step-size for the different α.

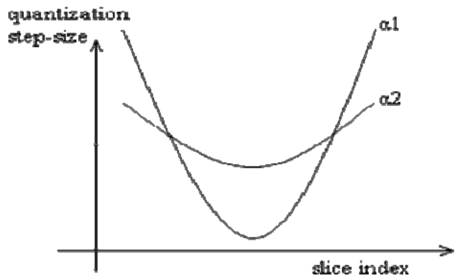

Fig. 2 Quantization step-size assigned dependently on the slice position according to Eq. (3), $\alpha_1 > \alpha_2$.

Assume that the average values of the quantization step-sizes before and after the picture quality control are same.

$$\sum_{i_s=1}^{N_s} \hat{Q}_s(i_s) = \sum_{i_s=1}^{N_s} Q_s(i_s) \equiv \overline{Q}_s \cdot N_s \tag{4}$$

where $\overline{Q}_s$ is an average value of all of the quantization step-sizes of a picture. By using Eq. (3) and (4), we can find the value of β in the condition of the given α as follows.

$$\sum_{i_s=1}^{N_s}\left(\alpha(i_s - \frac{N_s+1}{2})^2 + \beta\right) = \overline{Q}_s \cdot N_s \tag{5}$$

$$\alpha \sum_{i_s=1}^{N_s}\left(i_s - \frac{N_s+1}{2}\right)^2 + \beta \cdot N_s = \overline{Q}_s \cdot N_s \tag{6}$$

$$\alpha\left(\sum_{i_s=1}^{N_s} i_s^2 - (N_s+1)\sum_{i_s=1}^{N_s} i_s + \frac{N_s(N_s+1)^2}{4}\right) + \beta \cdot N_s = \overline{Q}_s \cdot N_s \tag{7}$$

By using $\sum_{i_s=1}^{N_s} i_s^2 = N_s(N_s+1)(2N_s+1)/6$ and $\sum_{i_s=1}^{N_s} i_s = N_s(N_s+1)/2$, we can find as follows.

$$\beta = \overline{Q}_s - \alpha \frac{N_s^2 - 1}{12} \tag{8}$$

From substitution Eq. (8) into Eq. (3), we can find following formula with just only constant α,

$$\hat{Q}_s(i_s) = \alpha(i_s - \frac{N_s+1}{2})^2 + \overline{Q}_s - \alpha\frac{N_s^2-1}{12}, \quad 1 \le i_s \le N_s \tag{9}$$

The final above equation is applied to control the subjective picture quality dependently on the slice position after finding the quantization step-size by the re-quantization processing such as Eq. (2) in the case of the homogeneous approach.

4. Simulation Results

For the simulation, JM 9.5[14] of H.264 was used, and four test sequences, ‘Flower’, ‘Bus’, ‘Foreman’, and ‘Waterfall’, have the same resolution of horizontal 352 pixels and vertical 288 pixels. The sequences were coded by the H.264 baseline profile, I-picture was repeated by a 15-picture interval within 30 pictures, and each picture contains 18 slices of the same size.

Fig. 3 shows the simulation results for ‘Flower’ sequence in the case where a bitstream, coded with the bitrate of 1.5Mbps, is transcoded to the bitrate of 0.4Mbps. The quantization parameter obtained by the proposed transcoding method (denoted as Qp3) is compared with the conventional method (denoted as Qp2) which is described in Section 2[1]. The quantization parameter of the conventional method varies independently with the slice position within each picture, composed with 18 slices. However, the quantization parameter of the proposed method keeps the smallest value in the center slice of the picture but largest value in the corner slice. We can see that the proposed method can control the subjective picture quality because the subjective picture quality is directly related with the quantization parameter.

Fig. 4, Fig. 5, and Fig. 6 shows the simulation results for ‘Bus’, ‘Foreman’, and ‘Waterfall’ sequences, respectively. Similarly, the proposed method has the smallest value of the quantization parameter in the center slice of the picture but largest value in the corner slice.

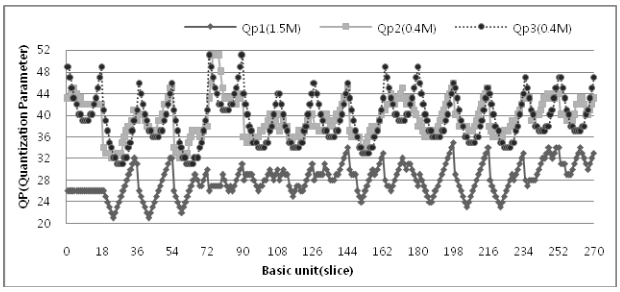

Fig. 3 Quantization parameters before and after transcoding for ‘Flower’ test sequence, where 1.5Mbps bitstream (QP1) is transcoded to 0.4Mbps bitstream. The proposed method is denoted as Qp3(0.4M) and the conventional method is denoted as QP2(0.4M).

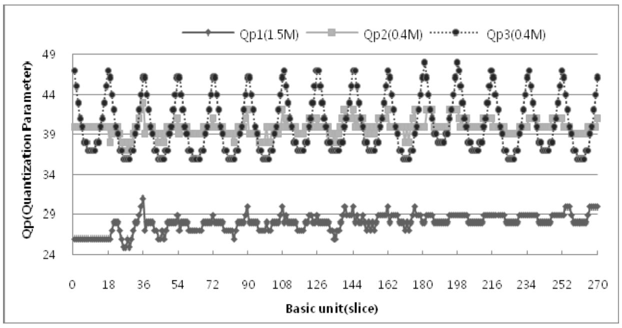

Fig. 4 Quantization parameters before and after transcoding for ‘Bus’ test sequence, where 1.5Mbps bitstream (QP1) is transcoded to 0.4Mbps bitstream. The proposed method is denoted as Qp3(0.4M) and the conventional method is denoted as QP2(0.4M).

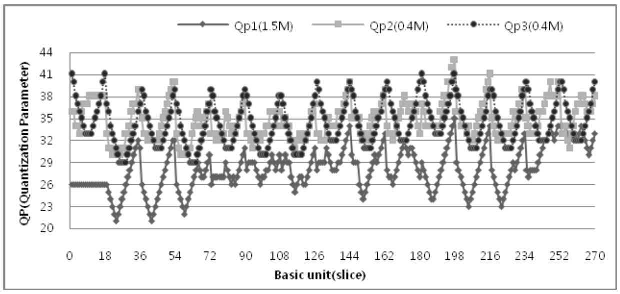

Fig. 5 Quantization parameters before and after transcoding for ‘Foreman’ test sequence, where 1.5Mbps bitstream (QP1) is transcoded to 0.4Mbps bitstream. The proposed method is denoted as Qp3(0.4M) and the conventional method is denoted as QP2(0.4M).

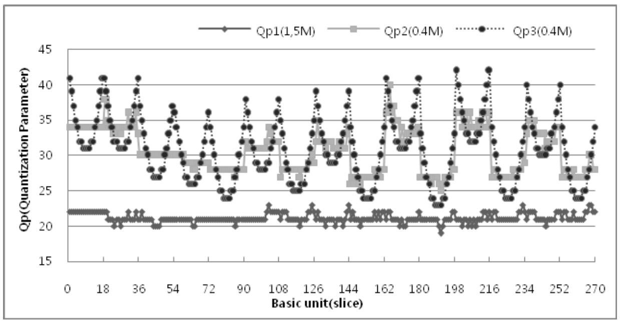

Fig. 6 Quantization parameters before and after transcoding for ‘Waterfall’ test sequence, where 1.5Mbps bitstream (QP1) is transcoded to 0.4Mbps bitstream. The proposed method is denoted as Qp3(0.4M) and the conventional method is denoted as QP2(0.4M).

5. Conclusion

This paper proposes a new transcoding method that makes better video quality relatively in parts of center of monitor which can emphasize importance of visual quality relatively. In order to control the picture quality dependently on the view focus, the smaller value of quantization step-size is assigned to more important position of view concern but the larger value of quantization step-size is assigned to less important position. From the simulation, this paper illustrates that the target lower bitrate is obtained by the re-quantization process after finding the proper quantization step-size to control the picture quality. The proposed method can be applied to the heterogeneous transcoding as well as the homogeneous transcoding.

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