A Method for Reducing DMB Video Blocking Effect

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Abstract

In the Digital Multimedia Broadcasting, the bandwidth of the video service is relatively low. H.264, the DMB video encoding standard, is based on the block of encoding systems. In a low bit rate environment, H.264 has blocking effect which affected the playing quality. Based on analyzing the blocking effect generation mechanism and optimization quantization method of DCT coefficients, adjusting the quantization process, reducing the blocking effect of encoding video, improving the video quality of subjective and objective.

Keywords

DMB; blocking effect; video coding; video quality.

1. Introduction

At present, DMB has gradually been applied as the core of the information technology in the university in the past two years [1]. DMB is a digital broadcast system. It can broadcast audio, video, pictures and text. A DMB system can be used to meet all the equipments for campus information tips. DMB standard provides that its channel bandwidth is 1.54MHz [2]. But the available bit rate for the main business channel is 1.152Mbps. And DMB standard video resolution is 320*240. However, today's video terminal (mobile phone, TV, etc.) needs a higher resolution screen. For the resolution of QVGA640*480 on the DMB receiving terminal of LCD TV and other large screen, the rate that DMB allocated to video service can only be up to 512Kbps because of the limitations of existing DMB decoder chip. Therefore, it can only provide one channel to video business.

H.264 which DMB takes as the video encoding standard demonstrates blocking effect in low bit rate. It has an adverse effect on subjective quality of DMB video. The image pixel is divided into non-overlapping blocks in H.264 standard. And then using DCT (discrete cosine transform) to convert these data blocks from spatial domain to frequency domain. The resulting DCT coefficients are quantized and entropy encoded. The cause of blocking effect is the image sub-block processing. The correlation between adjacent blocks is low, and leading to the discontinuity of block boundaries. There are many ways to reduce blocking effect in order to improve the quality of the video. In the literature [3], the block filter is used to smooth the block effect region. But it is certainly to cause the loss of high frequency details and smearing of the image without taking into account the local characteristics of the image. The literatures [4-6] reduce the distortion caused by blocking effect through the methods of improving encoding algorithm. But some of these algorithms reduce the efficiency of encoding, or need to transfer a lot of additional information, or add noise to the image. The results are unsatisfactory.

Generation of blocking effect is caused by the independent of each block’s encoding process, distribution characteristics and errors. Based on analyzing the blocking effect generation mechanism and optimization quantization method of DCT coefficients, adjusting the quantization process, reducing the blocking effect of encoding video, improving the video quality of subjective and objective.

2. Generation of blocking effect

Blocking effect is a discontinuous phenomenon at the block boundary which the human eye perceives in the video. The cause of blocking effect is the image sub-block processing. H.264 encoding uses a transformation similar to DCT based on a 4x4 pixel block. But the transformation is a space transformation based on integer.

4x4 DCT and inverse DCT (IDCT) respectively as

$$P(u,v)=\frac{C(u)C(v)}{2}\sum_{x=0}^{3}\sum_{y=0}^{3}I(x,y)\cos\frac{(2x+1)u\pi}{8}\cos\frac{(2y+1)v\pi}{8} \tag{1}$$

$$I(x,y)=\frac{1}{2}\sum_{u=0}^{3}\sum_{v=0}^{3}C(u)C(v)P(u,v)\cos\frac{(2x+1)u\pi}{8}\cos\frac{(2y+1)v\pi}{8} \tag{2}$$

Among them:

$$C(u),C(v)=\begin{cases}\frac{1}{\sqrt{2}} & u,v=0\\ 1 & others\end{cases} \tag{3}$$

Where $P(u,v)$ is DCT transform coefficient, and $I(x,y)$ is the pixel value of the original image or the residual image block.

This transformation can remove the spatial redundancy between adjacent pixels in blocks. Combined with quantization, it can effectively achieve data compression. Generally speaking, DCT is a kind of encoding way which error could be controlled. If the whole image frame could be transformed, blocking effect will not appear. But H.264 is based on the block. The image frame is divided into 4x4 pixel blocks, and each block is made of DCT to get sixteen DCT transform coefficients. Because of this block transformation, the correlation between blocks are ignored. The DCT transform coefficients of each block are also independent of each other, so that the quantization error between adjacent blocks becomes larger. It can lead to distortion of image.

Suppose that quantization step is $Q(u,v)$. Then the quantized coefficient matrix

$$P_Q(u,v)=round(\frac{P(u,v)}{Q(u,v)}) \tag{4}$$

Where round is rounding operation. And the operation is lossy.

The DCT transform coefficient of inverse quantization reconstruction

$$P^{'}(u,v)=P_Q(u,v)Q(u,v) \tag{5}$$

Then quantization error of DCT transform coefficient can be written as

$$e_P(u,v)=P(u,v)-P_Q(u,v) \tag{6}$$

Seen from the above equations, quantization error $e(u,v)$ is distributed in each reconstruction block of the image domain. There is no correlation between error distribution of adjacent blocks. And block boundaries will appear discontinuity. The discontinuous adjacent block boundary quantization error will make the original smooth place has a larger blocking effect. For example, assume quantization step size is fixed to 10. Then from Eq.(4), quantization and inverse quantization formula for DCT DC component are

$$P_Q(0,0)=round(\frac{P_M(0,0)}{10}) \tag{7}$$

$$P^{'}(u,v)=P_Q(0,0)\times 10 \tag{8}$$

Suppose DCT DC components of block *X1* and block *X2* which are adjacent

$$P_{X_1,M}(0,0)=14,\ P_{X_2,M}(0,0)=15$$

From Eq.(6), (7) and (8), we can obtain that

$$P_{X_1,Q}(0,0) = round(\frac{14}{10}) = 1 \text{ , } P_{X_2,Q}(0,0) = round(\frac{15}{10}) = 2$$

$$P'_{X_1}(0,0) = 1\times 10 = 10 \text{ , } P'_{X_2}(0,0) = 2\times 10 = 20$$

$$e_{X_1,P}(0,0) = 14 - 10 = 4 \text{ , } e_{X_2,P}(0,0) = 15 - 20 = -5$$

DC component is the average of the pixels in each block. It contains key parts of image feature. From Eq.(2), IDCT DC component

$$I(0,0) = \frac{1}{2}\times C(0)\times C(0)\times P(0,0) = \frac{1}{2}\times\frac{1}{\sqrt{2}}\times\frac{1}{\sqrt{2}}\times P(0,0) = 0.25P(0,0)$$

According to the quantization error, the error which caused by DC coefficient in the block *X1* and *X2* respectively as

$$e_{X_1,I}(0,0) = 0.25\times 4 = 1 \text{ , } e_{X_2,I}(0,0) = 0.25\times(-5) = -1.25$$

Then error at the boundary of the block *X1* and *X2* is $1-(-1.25)=2.25$. Two approximate DCT DC coefficients are quantized into different two values. A jump is generated between the two reconstruction blocks. It will generate a visual blocking effect. If the quantized value of the DCT DC component of the block *X2* is adjusted to

$$P_{X_2,Q}(0,0) = 1$$

Then

$$P'_{X_2}(0,0) = 10$$

$$e_{X_2,P}(0,0) = 5$$

$$e_{X_2,I}(0,0) = 0.25\times 5 = 1.25$$

We can obtain that the boundary error of the block *X1* and *X2* will be reduced to

$$1 - 1.25 = -0.25$$

3. Method for reducing blocking effect

From the above example, the adjustment of the quantized DCT DC component can reduce the error between blocks. So Eq.(4) can be improved as

$$\begin{cases} P_{Q,\min}(u,v) = \min\text{int}(\frac{P(u,v)}{Q(u,v)}) \\ P_{Q,\max}(u,v) = \max\text{int}(\frac{P(u,v)}{Q(u,v)}) \end{cases} \quad (9)$$

Where $\min\text{int}(x)$ is the maximum integer not greater than x, $\max\text{int}(x)$ is minimum integer not less than x.

Then, each DCT transform coefficient has two quantized values. For 4x4 DCT coefficient matrix, 2^{16} different quantized coefficient matrices can be generated. They are reconstructed to obtain the reconstructed pixel value *Xr*. Finally, the total boundary error between the 4 edges of *Xr* and the original pixel value *Xo* can be calculated. The quantized matrix of the minimum absolute value in the total boundary errors can be chosen to be the final quantized value of the DCT transform coefficient.

In addition, both DCT and IDCT have linear additivity. IDCT does not need to be repeated for different quantized coefficient matrix when refactoring. From Eq.(9), there is

$$|P_{Q,\min}(u,v) - P_{Q,\max}(u,v)| = 1$$

When $P_Q(u,v)$ is changed from $P_{Q,\min}(u,v)$ to $P_{Q,\max}(u,v)$, the reconstructed formula for a pixel value can be written as follows:

$$IDCT[Q^{-1}(P_{Q,\max}(u,v))] = IDCT[Q^{-1}(P_{Q,\min}(u,v))] + 0.25Q(u,v)$$

Where *IDCT* is inverse DCT, Q^{-1} is inverse quantization.

4. Experimental results and analysis

The code for H.264 quantized process is modified in the original DMB video encoder. Test video named Talk TED which resolution is 854*480 and format is mp4. The encoded video will have 640*480 resolution, 25fps frame rate and 300kbps bit rate. Comparing PSNR of 30 video frames from original encoder and modified encoder. PSNR (Peak Signal to Noise Ratio) is a method that evaluating image quality objectively [7]. The greater PSNR, the less distortion.

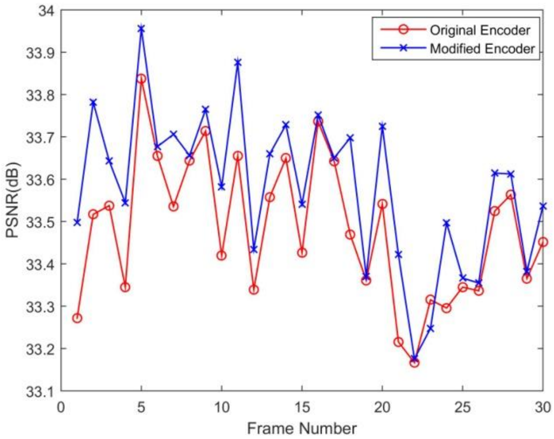
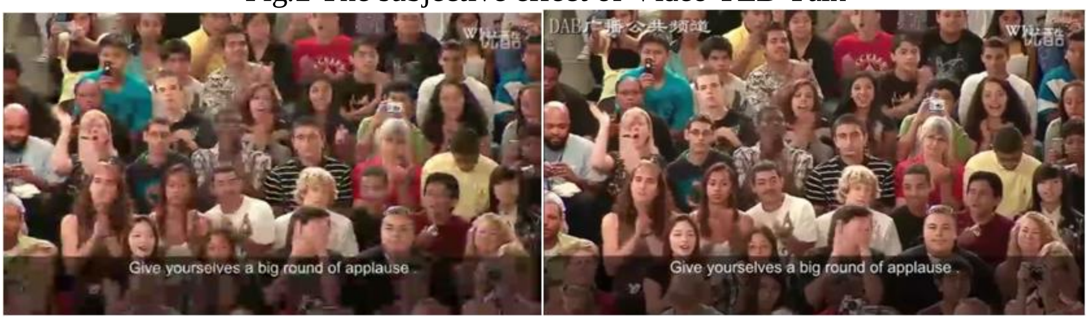


Fig.1 Comparison of PSNR

In Fig.1, the abscissa represents frame number, the ordinate represents PSNR, red line represents the original encoder, the blue line represents the modified encoder. Compared to the original DMB video encoder, PSNR has improved significantly after modifying the quantized process. The performance of this method is more obviously.

(a) The original encoder (b) The modified encoder

Fig.2 The subjective effect of Video TED Talk



(a) The original encoder (b) The modified encoder

Fig.3 The subjective effect of Video Speech

The final effect of video quality is mainly determined by the subjective. Fig.2 and Fig.3 show the subjective effect of video after encoding by two encoders. It can be seen that the video quality encoded by modified encoder is significantly better than original encoder. PSNR is consistent with the subjective effect. Blocking effect and video quality is obviously improved. And For other videos to do the same tests, the results are the same.

5. Conclusions

Based on analyzing the blocking effect generation mechanism, a method for improving video quality is proposed. The method doesn't require any modifications to the decoder. It can improve PSNR, reduce blocking effect, and ameliorate the subjective effect of video. It has good practicability in DMB video service.

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