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Balanced bitrate control of multiple videos in transcoding for multi-view service

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Abstract

In this paper, a balanced bitrate control in transcoding process based on video complexity measure for multi-view system which simultaneously shows multiple channels or video contents in single screen, is proposed. In order to consider the total quality of multiple video streams, the proposed algorithm reduces the complexity of multiple video stream and video quality differences at the same time by controlling bitrates of each stream by weighting when they are stitched for single screen. For the measure of complexity and quality differences between video streams, two different data: histogram of macroblock type and bitrate for each stream are used. The experimental result indicates that proposed algorithm decreases fluctuation of quality difference between videos in the multi-view system.

Keywords: *balanced bitrate control, Multi-view rate control, macroblock type complexity.*

1. INTRODUCTION

Along with the development of network transmission technology, the IPTV(internet protocol television) and web based VOD(video on demand) streaming markets are growing in fast pace[1]. This increasing market provokes many kinds of services that increase UI(user interface) and UX(user experience)[2]. As long as services become abundant, ISP(internet service provider)s competitions are getting intense. In order to stand out among them, ISPs must gain recognition from customers for their services. The multi-view service is most recently introduced[3][4]. It allows service providers to display four channels in single screen all at once. For example, professional baseball games and home shopping channels can be shown in one screen. Though multi-view service improves user experience, it could make users feel uncomfortable if quality of videos vary from each other. This mismatching problem can be solved by rate control of each video stream in multi-view screen. This rate control process goes under transcoding stage where H.264/AVC videos are transcoded into suitable video streams for the multi-view system. However, up to date, not much researches have been done to minimize the quality difference of those videos in multi-view services, but several researches on rate control for only single video stream have been conducted so as to provide constant quality of video. Chiang et all, proposed R-MAD algorithm in which Mean Absolute Difference (MAD) represents the residual signal was used as a measure of image complexity to model relationship between video

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complexity and bitrate[5]. This model allocates a number of bits based on frame complexity, and if complexity of the frame is higher, more bits are allocated; In this way, it reduces fluctuation of video quality difference and improves average video quality. This model has been commonly applied to the rate control. Frame measure, the peak signal-to-noise ratio (PSNR) is sometimes used instead of MAD[6], while a scheme to obtain the ratio of frame MAD for frame complexity prediction is proposed for rate control of H.264/AVC[7]. Although the rate control for multi-view service must consider all video bitrates and their complexities, these conventional algorithms consider only one target video stream. Therefore, in this paper, the proposed method calculates the complexity of each video stream and controls the bitrates of each video stream accordingly in the transcoding stage, and to measure the complexity of each video in multi-view screen, R-MAD and histogram of macroblock type are used.

The rest of the paper is organized as follows: Section II introduces our rate control scheme for multi-view service; Section III demonstrates the experimental results; and Section IV concludes this paper.

2. RATE CONTROLLER BASED WEIGHTED COMPLEXITY

Generally, rate control is working for re-encoding data into lower or higher bitrate without changing video formats; this allows one to fit into given limited network bandwidth or limited storage space. In order to leverage multi-view service, in transcoding stage, input video streams must be transcoded into suitable bitstream. In transcoding process, each video stream's bitrate is re-allocated minimizing quality difference between input videos. The block diagram of proposed rate control scheme in transcoding stage is shown in Figure 1.

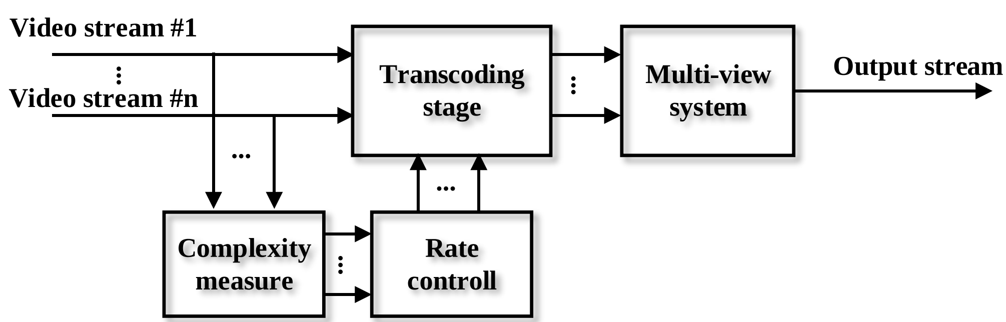

Figure 1. Block diagram of proposed rate control.

The video streams in a video server are transmitted to the multi-view service upon user request. Before the transmission process, the video streams must be transcoded in the video server depending on the condition selected by the user. The transcoding stage, measures the video complexity of each video streams, allocates the target bitrate for the each video, and re-encodes videos accordingly. The complexity weight for each video stream in multi-view system is calculated with Equation 1.

$$W_n = \overline{C}/C_n \tag{1}$$

, where $\overline{C}$ is the average complexity of videos and n is the number of videos in multi-view system. If the complexity weight value is high, then the video becomes more complex than the average complexity. In this model, two different complexity measures including histogram of macroblock type and bitrate are used. If histogram of macroblock type is used for complexity measure, then W_n is equal to MbC_n , and if bitrate is used, W_n is equal to Rb_n which calculated by MAD model[5]. Once the complexity weight is calculated for each video, the target bitrate is calculated with Equation 2.

$$T_n = W_n \times B_n \quad (2)$$

, where B_n represents current bitrate of each bitstream in multi-view system. The target bitrate T_n is obtained by Equation 2 which is used for transcoding process for reducing quality difference from the complexity of videos. If the target video stream is more complex than others, then the target bitrate is fixed by larger value and less complex then it is fixed by smaller bitrate.

2.1 MACROBLOCK TYPE BASED COMPLEXITY MEASURE

H.264/AVC standard is widely applied in various types of services and systems for video compression. H.264/AVC has several types of block sizes ranging from 16x16 to 4x4 enabling precise segmentation of motion representation[8]. In addition, the variable block sizes of motion estimation depend on the frame complexity.

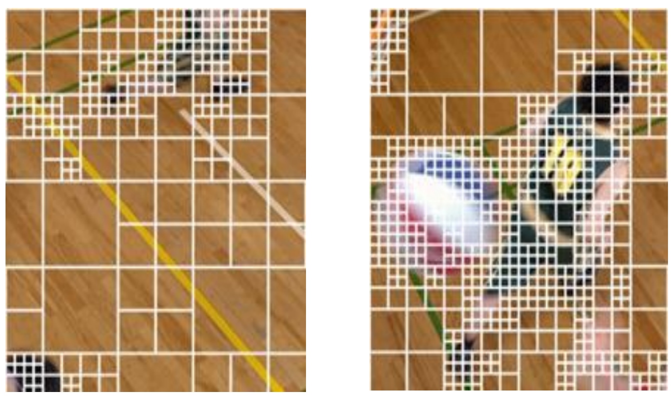

Figure 2. (a). Less complex frame, (b). More complex frame

Figure 2 shows the two different frames of the video stream. Figure 1(b) illustrates the frame that has many motions which is complex frame, and the frame in Figure 1(a) has less motion along with less complexity. Complex frame that has many motions is encoded into small macroblock size background, or less motion frame is encoded into large macroblock size. Besides, in order to measure complexity of each frame, this model employs the sum of weighted macroblock type. This is compared to higher weight in small sized macroblocks, as shown in Equation 3.

$$MbC_{nm} = \alpha \times mb_{16\times16} + \beta \times mb_{16\times8} + \gamma \times mb_{8\times8} + \delta \times mb_{8\times4} + \varepsilon \times mb_{4\times4} \quad (3)$$

, where n is the number of video stream, m is frame number. The weight of each macroblock sizes are defined Table 1.

Table 1. Weight value

Weight	Value
$\boldsymbol{\alpha}$	1
$\boldsymbol{\beta}$	2
$\boldsymbol{\gamma}$	1
$\boldsymbol{\delta}$	2
$\boldsymbol{\varepsilon}$	4

3. RESULTS AND DISCUSSION

In order to prove the effectiveness of the proposed multiple video bitstreams based on rate allocation scheme, JM 17.2 was implemented. For the experimental propose, two different video streams that separated four different scenes of Full-HD resolution with IPPP frame structure were taken. For showing visual difference first encode constant target bitrate of each video. The re-allocated video qualities were compared with constant target bitrate video quality. Consequently, for showing visual difference, we use PSNR (peak signal to noise ratio) measure, the PSNR is defined as Equation 4.

$$MSE = \frac{\sum_{i=1}^{M}\sum_{j=1}^{N}[O(i,j)-E(i,j)]^2}{M \times N}$$
$$PSNR = 10\log_{10}\left(\frac{MAX^2}{MSE}\right) \quad (4)$$

, where MAX is the maximum possible pixel value of the video frame. When test videos pixels are represented as 8 bits per pixel, the MAX is 255. Fig 3 shows the PSNR value for the 5mb same target bitrates.

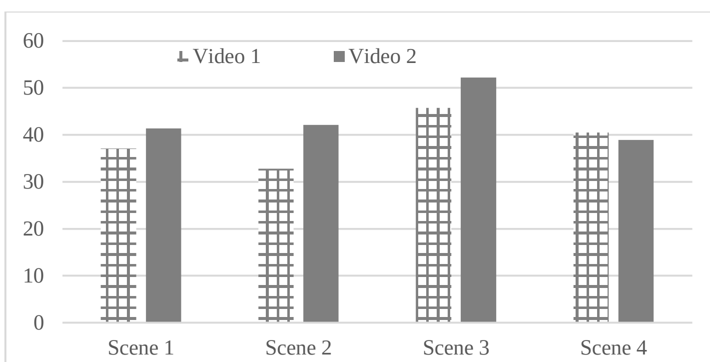

Figure 3. PSNR value of same bitrate

According to Figure 3, the average PSNR difference between video one and two is 5.4dB. Furthermore, in multi-view system when user watching these test videos user feel uncomfortable. In Table 2 and Table 3, the proposed bitrate and histogram of macroblock type methods indicate the significant PSNR difference reduction against the constant target bit rate method. The average PSNR difference of method one and two are 1.5dB and 1.6dB, respectively. Hence, this result shows the necessity of the proposed rate control scheme for multi-view system.

Table 2. Complexity measurement with bitrate

Scene	**Scene #1**		**Scene #2**		**Scene #3**		**Scene #4**	
Video	#1	#2	#1	#2	#1	#2	#1	#2
Bitrate	6.2	3.8	8.2	1.8	8.0	2.0	4.5	5.5
PSNR(dB)	38.0	40.2	35.2	37.4	47.6	48.3	40.1	39.1
Difference of PSNR (dB)	2.2		2.2		0.7		1.0	

Table 3. Complexity measurement with histogram of macroblock type method

Scene	**Scene #1**		**Scene #2**		**Scene #3**		**Scene #4**	
Video	#1	#2	#1	#2	#1	#2	#1	#2
Bitrate	5.5	4.5	7.5	2.5	8.5	1.5	3.9	6.1
PSNR (dB)	37.7	40.5	34.9	37.9	47.8	48.1	39.3	39.7
Difference of PSNR (dB)	2.8		3.0		0.3		0.4	

4. CONCLUSION

The balanced bitrate control in transcoding process based on the complexity measure for multi-view system is proposed. The complexity measurement uses histogram of macroblock type and allocates bitrate of current frame as implemented in H.264/AVC video standard. As a result, the proposed method reduces quality difference of video streams in multi-view system significantly. Furthermore, this result proves the need of the proposed rate control scheme in transcoding for multi-view system.

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