Channel-Aware Rate-Control for Real-Time Video Transmission for H.264/AVC

Sanghyun Park[1]

[1] Sunchon National University, Sunchon, Korea
shark@scnu.ac.kr

Abstract. The growing demand for advanced mobile multimedia let the wireless mobile internet access be developed rapidly. The current mobile network is capable of providing flexible quality of service mechanisms including exact estimation of network bandwidth. In this paper, we propose a new GOP level rate control algorithm which can accurately estimate an initial QP according to the estimated network bandwidth. In the proposed algorithm, we observe the relation between the initial QP and the number of bits of I frame in a GOP. Based on the observation, we propose a new method to estimate the optimal initial QP which maximizes the PSNR of a GOP. It is shown by experimental results that the proposed algorithm predicts the optimal initial QP accurately and thus achieves better PSNR performance than that of the existing algorithm.

Keywords: H.264/AVC, Initial QP, Rate control, Video compression

1 Introduction

One of the main trends in the mobile communications sector is the connected everywhere, anytime, anyhow philosophy. This philosophy is also denominated Always Best Connected (ABC) philosophy [1]. It is based on the facts that several Radio Access Technologies (RATs) can co-exist and each technology provides different capabilities. Therefore, to provide best service, a mobile station (MS) always has to analyze the current situation and select a proper RAT which can provide the best service [2,3,4]. In addition, there have been many researches on how to estimate network capabilities, so an MS can accurately estimate the bandwidth of the new network when it changes an RAT.

Rate control aims to achieve good perceptual quality given the transmission bit rate constraint. Usually, rate control regulates the coded bit stream by adjusting quantization parameter (QP) while optimizing the video presentation quality. In this Paper, an adaptive initial QP determination algorithm is proposed when an MS changes networks. The algorithm is capable of accurately estimating the QP of I-

frame according to the bandwidth of the new network. Experimental results show that the proposed algorithm outperforms the existing method for H.264/AVC rate control.

The rest of this paper is organized as follows. The development of the proposed method of the adaptive initial QP determination is discussed in Section 2. Section 3 demonstrates the experimental results for performance comparison. Finally, a conclusion is drawn in Section 4.

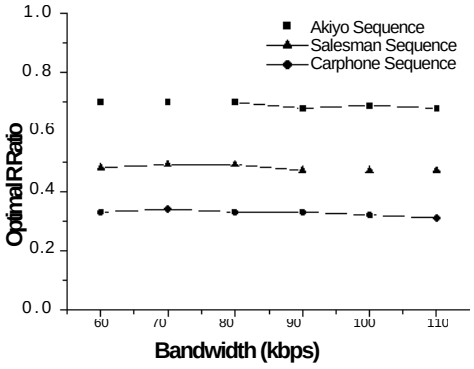

Fig. 1. Optimal R Ratio comparison versus network bandwidth for Akiyo, Carphone, and Salesman sequences.

2 Proposed GOP Level Rate Control

This paper focuses on the initial QP determination of the GOP level rate control which can be applicable to the real-time application. Thus, it is assumed that the frame structure is “IPPP..." without B frame.

In JVT rate control scheme, the QP for an I-frame depends on the average QP of P-frames in the previous GOP. This initialization scheme is simple, but it is roughly adaptive to the available channel. Therefore the initial QP's of QCIF video sequences are always 40 when the bandwidth is less than about 114kbps.

Efficient rate control scheme has to find the optimal value more quickly. In addition, it has to take into consideration the properties of each video sequences such as frame complexities and motion characteristics. However, the algorithm becomes more complex as the number of parameters is increased, and the complicated algorithm cannot be used for real-time applications.

We observe the characteristics of R Ratio according to the network bandwidth using various test sequences. Experimental results show that the optimal R Ratio is similar regardless of the network bandwidth. Thus, we investigate the optimal R Ratio

according to the network bandwidth. Let $_{Rop}$ denote the optimal R Ratio. Fig. 1 shows that $_{Rop}$'s of each sequence is similar regardless of the network bandwidth.

The proposed rate control algorithm uses the property that $_{Rop}$ of a video sequence maintains similar values as the target bandwidth varies. When the MS changes the network, details of the proposed rate control algorithms is as follows:

Step 1: Determining

In the proposed scheme, the first GOP of a sequence is encoded by the existing method. That is, the first initial QP is set to 40 and the initial QP is adapted gradually to the optimal value. To find $_{Rop}$, the MS updates $_{Rop}$ with the new R Ratio if the PSNR of the GOP is greater than the maximum PSNR value after encoding a GOP.

Step 2: Estimating the bandwidth of new network

We assume that an MS can estimate the bandwidth of the new network. There are many methods for an MS to estimate the bandwidth. For instance, QoS-aware scheduling algorithms for LTE OFDMA was proposed to deliver real-time video, where an MS negotiates the bandwidth with the network [2,3,5]. That is, an MS knows the bandwidth before establishing a new connection.

Step 3: Calculating the optimal initial QP

In this step, we have to calculate the QP which is used to encode the I-frame and generate the number of bits corresponding to the $_{Rop}$. There are several methods for H.264/AVC which estimate the number of bits given the QP value. To calculate the optimal initial QP, we use Kamaci's method [6]. Kamaci's method uses two parameters. To determine parameters, we first encode the I-frame with the QP of 10 and then determine model parameters and calculate the optimal initial QP.

3 Experimental results

Numerous experiments have been conducted to evaluate the performance of the proposed rate control algorithm, which has been implemented with the latest version of the JVT reference software, JM18.3 using baseline profile. The results achieved here are compared with those achieved using JVT-W057 rate control algorithm adopted by JM18.3. The simulation was conducted with the first 150 frames of four QCIF test sequences of Akiyo, Carphone, Foreman, Salesman. In order to ensure the equivalence of the rate control parameters, the sizes of the basic units for the basic unit-level rate control are fixed at 1 macroblock. The network bandwidth varies at the second GOP from 60kbps to 110kbps and from 110kbps to 60kbps.

Since the major issue for video coding is the quality of the video at the given target bit rate, the average PSNR value of each QOP is calculated and listed in Table 1 in order to provide an objective evaluation of the video quality. The proposed scheme uses JVT algorithm for the first GOP, so the PSNR results of the first GOP's are not included in Table 1. The proposed scheme shows better video quality than the rate control of JVT algorithm in terms of the average PSNR value.

Table 1. PSNR comparison with video sequences of Akiyo, Carphone, Foreman, and Slaesman.

Video sequence	Bandwidth (kbps)	JVT[7]			Proposed		
		2nd	3rd	4th	2nd	3rd	4th
Akiyo	60 −∗110	40.09	40.71	40.09	45.36	43.63	43.18
	110−∗ 60	36.78	37.24	37.02	42.05	40.73	40.05
Carphone	60 −∗110	35.64	36.74	36.16	36.56	37.85	36.83
	110−∗ 60	32.79	34.02	33.31	34.01	34.96	33.82
Foreman	60 −∗110	34.41	34.42	33.58	35.71	35.22	34.28
	110−∗ 60	31.86	31.87	31.02	33.11	32.67	31.27
Salesman	60 −∗110	33.93	35.17	36.02	37.25	38.41	38.42
	110−∗ 60	30.92	31.99	32.76	33.46	34.34	34.85

4 Conclusion

In this paper, an adaptive initial QP determination algorithm for H.264/AVC is proposed. The proposed algorithm uses the property that the optimal R Ratio's of each sequence maintain similar values regardless of the network bandwidth. The proposed algorithm also takes the characteristics of each video sequence into consideration. Thus it can precisely estimate the optimal initial QP compared with the existing method. Experimental results show that the proposed scheme achieves better video quality than that of JVT-W057. In case of Akiyo sequence, the proposed algorithm improves the average PSNR of GOPs more than 3dB.

References

1. M. Tsagkaropoulous, I. Politis, T. Dagiuklas, and S. Kotsopoulos, Enhanced vertical handover based on 802.21 framework for real-time video streaming, Proceedings of ProMobiMedia '09, (2009) pp. 62-67; London, United Kingdom
2. J.Y. Pyun, D.Y. Choi, S.K. Noh, and G.R. Kwon, OFDMA Channel Aware Error-Resilient Mobile Streaming Video Service over Mobile WiMAX, IEEE Trans. on Comsumer Electron., no. 1, vol. 57 (2011)
3. A.A. Lenskiy and S. Seol, The Analysis of R/S Estimation Algorithm with Applications to WiMAX Network Traffic, International Journal of Multimedia and Ubiquitous Engineering, no. 3, vol. 7 (2012)
4. J. Choi, S. Lee, I. Kim, and Y. Woo, Live-Video Service using Multicast in Wireless Network, International Journal of Multimedia and Ubiquitous Engineering, no. 4, vol. 7 (2013)
5. H. Luo, S. Ci, D. Wu, J. Wu, and H. Tang, Quality-Driven Cross-Layer Optimized Video Delivery over LTE, IEEE Comm. Mag., no. 2, vol. 48 (2010)
6. N. Kamaci, Y. Altunbasak, and R.M. Mersereau, Frame bit allocation for the H.264/AVC video coder via Cauchy-density-based rate and distortin models, IEEE Trans. Circuits Syst. Video Technol., no. 8, vol. 15 (2005)
7. Z. Li, F. Pan, and K. Lim, Text Description of Joint Model Reference Encoding Methods and Decoding Concealment Methods, JVT-W057, 23rd Meeting, (2007); San Jose, USA