USC University of Southern California

USC Viterbi School of Engineering

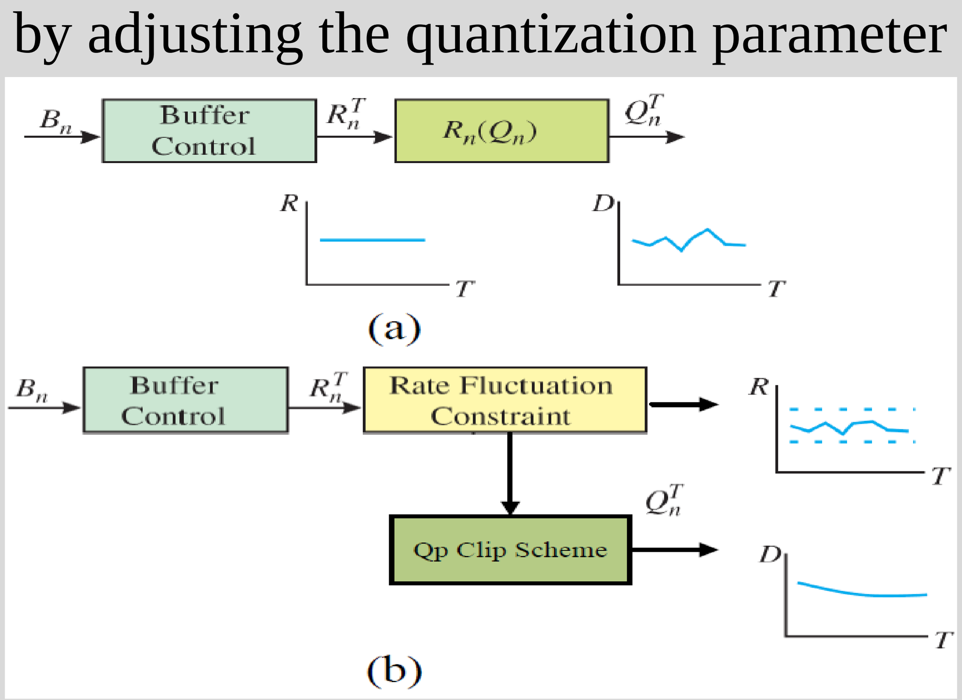
Ming Hsieh Department of Electrical Engineering

Adaptive Quantization-Parameter Clip Scheme for Smooth Quality in H.264/AVC

Sudeng Hu, Multimedia Communication Lab

1 Smooth Quality and Smooth Bitrate

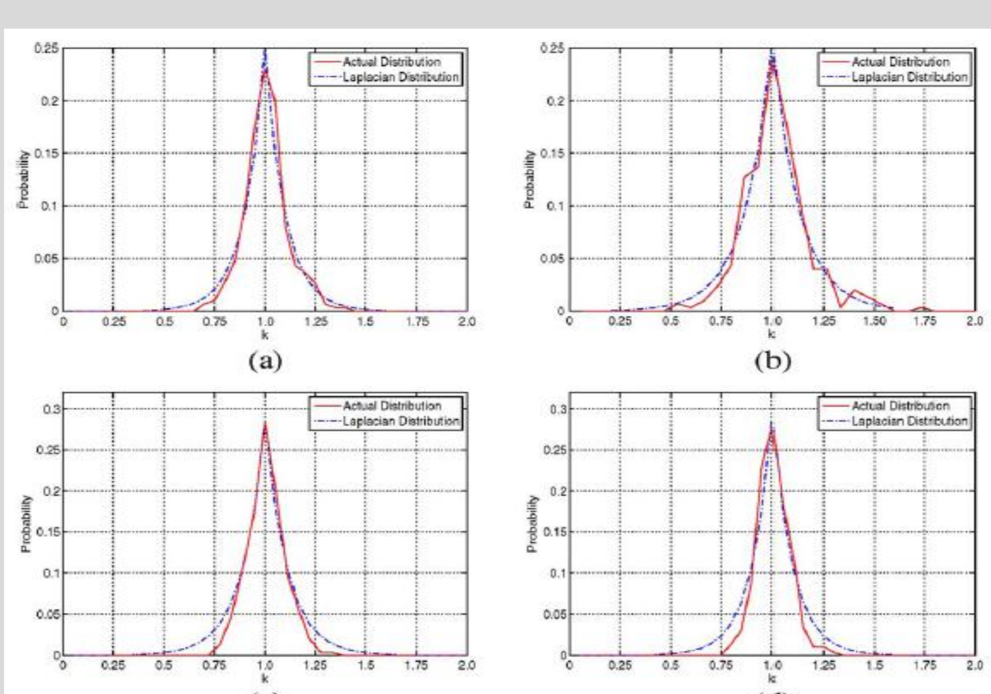
The video sequence usually has varying complexity, which results to fluctuation in the output bitrate if all the frames are coded with the same quality. In order to prevent buffer overflow, the most of rate control algorithms [1] in past were targeting at smooth bitrate by adjusting the quantization parameter (Qp).



However, smooth bitrate leads to quality fluctuation and large quality variation will cause severe temporal artifacts like quality flicker and motion jerkiness. Therefore a good rate control algorithm should smooth the video quality as much as possible within the buffer constraint.

2 Complexity Variation Investigation

To investigate the complexity variation, we define the complexity ratio of nearby frames as k and the distribution of complexity ratio (k) is investigated by carrying out a large number of test in various video sequences.



$$p(k) \approx \frac{\alpha}{2} \cdot e^{-\alpha|k-1|}$$

Sequence	QCIF	CIF	Sequence	QCIF	CIF
Foreman	0.957	0.949	Coastguard	0.969	0.971
Silent	0.963	0.967	Container	0.933	0.905
Akiyo	0.903	0.944	Table	0.990	0.996
Paris	0.935	0.952	Soccer	0.982	0.978
Stefan	0.987	0.994	Mobile	0.980	0.985

We can see that the histogram of k has peak around 1 and decreases sharply at two sides. The pdf of k can be approximated as laplacian distribution and the goodness of the fit is presented .

3 The Proposed Qp Clip Scheme

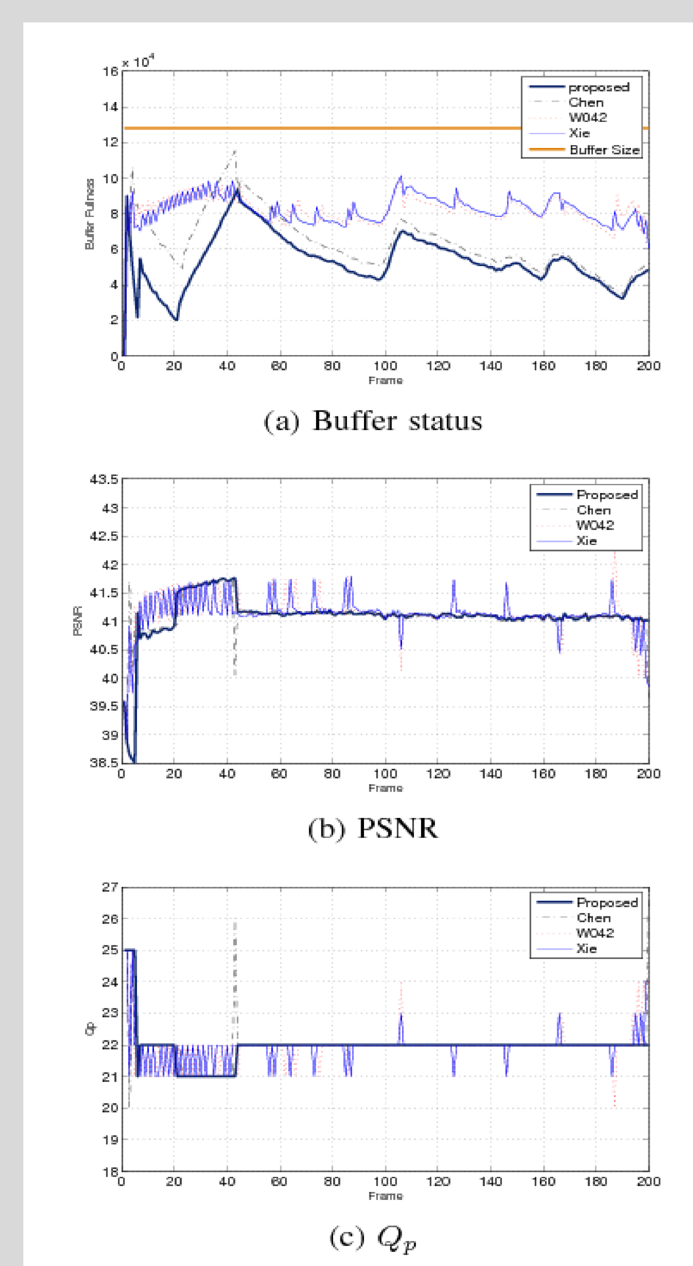
Due to the more choice in Qp, the wider Qp clip range is more likely to prevent buffer overflow or underflow. Therefore in term of buffer control, we hope to set a large Qp clip range for rate control scheme, however large clip range will cause quality variation. In order to narrow down the clip range while keeping the probability of overflow or underflow within a small value, we design an adaptive Qp clip scheme. Based on the complexity ratio distribution and current buffer status, we derived a tightest clip range with safe buffer status as follows.

$$B_o = \frac{1}{\beta}\ln\left(\frac{R(n-1)}{R_{max}(n)}\right) + \frac{1}{\beta}\ln\left(1-\frac{\ln(2-2\phi_1)}{\alpha}\right)$$

To verify the model accuracy, we use the proposed clip scheme to predict the complexity ratio range. As shown in figure that most actual complexity falls in the predicted range which will guarantee safe buffer status.

4 Experimental Results and Discussion

The proposed rate control framework is implemented in H.264/AVC reference software. The performance of three other benchmark rate control algorithms [2-4] are compared. The fluctuation of buffer status, PSNR and Qp are plotted in the figure. It can be observed that although the proposed rate control algorithm results in more fluctuation in buffer occupancy, it is still contained in the buffer. As far as the video quality is concerned, the quality of the proposed algorithm is smoother than others. As for the Qp value, we can see that the proposed algorithm rarely adjust the Qp value.



(a) Buffer status

(b) PSNR

(c) Q_p

5 Reference

[1] T. Chiang and Y.-Q. Zhang, "A new rate control scheme using quadratic rate distortion model," *IEEE Trans. Circuits Syst. Video Technol*. Vol. 7, no. 1, pp 246-250, Feb. 1997

[2] Z. Chen and K. N. Ngan, "Distortion variation minimization in realtime video coding," *Signal Process: Image Commu.*, vol 21, no. 4, pp. 273-279, Apr. 2006.

[3] A. Leontaris and A. M. Tourapis, "Rate control reorganization in the joint model reference software," D.c JVT-W042, California, Apr. 2007.

[4] B. Xie and W. Zeng, "A sequence-based rate control framework for consistent quality real-time video," IEEE Trans. Circuits Syst. Video Technol., vol. 11, no. 1, pp.56-71, Jan. 2006.

Sudeng Hu is with Department of Electrical Engineering, University of Southern California, CA. (email: sudenghu@usc.edu)

Ming Hsieh Institute
Ming Hsieh Department of Electrical Engineering