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Rate control based on linear regression for H.264/MPEG-4 AVC

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Abstract

An efficient rate control algorithm is required to transmit coded video sequences without abrupt changes in quality due to the limited channel bandwidth. Thus, in this paper, an efficient rate control method is proposed for the H.264/MPEG (Moving Picture Experts Group)-4 Advanced Video Coding (AVC) baseline profile that meets the above constraint by using a ρ-domain source model. Firstly, a simple target bits determination method that considers the ideal buffer level is proposed, and secondly, a method of adequately determining the Quantization Parameter (QP) is presented using two kinds of linear regression. The experimental results show that the proposed rate control algorithm using the above two methods performs better than other rate control algorithms for H.264/MPEG-4 AVC in terms of the rate estimation error and the standard deviation of the Peak Signal-to- Noise Ratio (PSNR), which provides a measure of the constancy of the video quality throughout the whole video sequence.

Keywords: Bit allocation; H.264/MPEG-4 AVC; Linear regression; Rate control; Video coding

1. Introduction

H.264/MPEG-4 Advanced Video Coding (AVC) was developed through the collaborative efforts of two leading standard bodies, ITU (International Telecommunication Union)-T and ISO (International Organization for Standardization)/IEC (International Electrotechnical Commission) MPEG, in order to provide improved compression efficiency [14]. While H.264/MPEG-4 AVC outperforms previous coding standards and has many outstanding features, such as various intra/inter prediction modes, 4×4 integer transform, rate-distortion optimization, and improved entropy coding, these normative tools do not consider the issue of maintaining a Constant BitRate (CBR) through the network channel. Hence, it is necessary to implement a rate control algorithm in the video encoder in order to transmit the coded video sequence without any abrupt variations of the bitrate over time under conditions of limited channel bandwidth.

The rate control algorithms used for both the previous video coding standards [1,7,10,12] and H.264/MPEG-4 AVC [2,8] are based on the Quadratic R (Rate)-D (Distortion) model, which represents the bitrate and distortion as functions of the quantizer. However, these algorithms produce large errors in the bitrate estimation due to their

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inaccurate source models, especially when there exist many scene changes in the video sequences [3]. On the other hand, those rate control algorithms which make use of the ρ (the percentage of zeros among the quantized transform coefficients)-domain source model [4] are well-known for their accurate estimation of the characteristics of the video, and show better performances in the existing video standards [6]. Many rate control algorithms were developed to attain the practicability of the ρ-domain source model-based rate control for H.264/MPEG-4 AVC [5,9,13]. He and Chen proposed a rate control algorithm for H.264/MPEG-4 AVC using linear rate model also known as ρ-domain source model [5]. They suggested a two-loop encoding method caused by the recursive nature in H.264/MPEG-4 AVC. Although the accurate rate estimation due to the collection of global statistics in the first loop can be obtained, this method is not suitable to real-time application owing to its two-loop encoding characteristic. And another two-loop rate control algorithm using the ρ-domain source model is proposed by Shin et al. [13]. The algorithm models the separate rate model for intra-coded frame according to the different characteristic between the intra-coded frame and the inter-coded frame. With well approximated rate model and the Quantization Parameter (QP) replacement constraint, the algorithm maintained the constant video quality over the scene changes. But, the algorithm has the same problem as the preceding two-loop encoding algorithm. In [9], the authors used a generalized Gaussian parametric model that can be used for estimating the histogram of 4×4 integer transformed coefficients in H.264/MPEG-4 AVC and proposed a simple MB (MacroBlock)-level rate control algorithm implemented with low computational complexity. We incorporated a low rate estimation error, which is the characteristic of the ρ-domain source model, into the proposed rate control algorithm, and propose a rate control method that determines a simple target bitrate by considering the ideal buffer level and determines the optimum value of the QP using two kinds of linear regression for the H.264/MPEG-4 AVC baseline profile.

This paper is organized as follows. In Section 2, the linear relation between the bitrate, R, and ρ is described. A simple target bits determination method that considers the ideal buffer level is presented in Section 3. Methods that determine the QP in the P (Predictive)-frame using the new R–ρ–E_ρ–E_{QP}–QP model and that determine the QP in the I (Intra)-frame using the linear relation of the QP–PSNR are described in Section 4. The proposed rate control algorithm is described in Section 5. A comparison of the experimental results obtained with the proposed rate control algorithm and those used in JM 9.3 [2,9] are given in Section 6. Finally, concluding remarks are given in Section 7.

2. ρ-domain source model

There is a linear relation between the bitrate, R, and ρ which is the percentage of zeros among the quantized transform coefficients in a frame [4]. With this relation, ρ is derived from the designated value

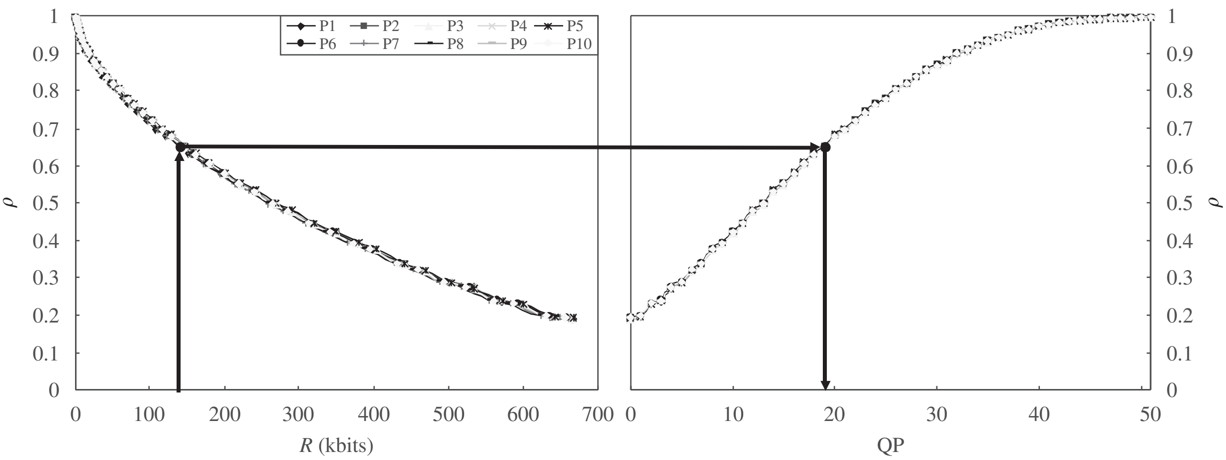

Fig. 1. R–ρ–QP relation plot in "Foreman" sequence (QCIF).