Bandwidth Adaptive Quality Smoothing for Unequal Error Protected Scalable Video Streaming*

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Many scalable video coders partition video data into groups of frames (GOF), and encode each GOF into an independent embedded bitstream. For the robust transmission of embedded bitstream over packet-loss channels, a commonly used approach is FEC-based multiple description coding (FEC-MDC) [1]. FEC-MDC first partitions the bitstream into segments of decreasing importance, then protects these segments using progressively weaker forward error correction (FEC) channel codes, and finally packs them into a fixed number of packets of equal length. The objective of FEC-MDC is to find an optimal FEC redundancy assignment solution that maximizes the expected reconstruction quality under a given channel bit rate constraint.

For a video sequence, if each GOF of it is allocated the same channel bit rate, then different GOFs may have different optimal expected qualities, since each GOF has its own rate-distortion property. This quality fluctuation can be annoying to human eyes. By introducing a startup delay and a receiver buffer, it is possible to allocate different channel bit rate for different GOFs, and achieve near constant or graceful varying optimal expected qualities among various GOFs.

In this paper, we address the problem of inter-GOF bit allocation for FEC-MDC protected scalable video sequences. The objective is to minimize the variation in quality while streaming over packet-loss channels with time-varying bandwidth. We present an online heuristic algorithm to adaptively allocate bits for every GOF. Before transmitting a GOF, we first estimate the current available network bandwidth, and calculate the spare channel bit rate available to be used for current GOF. Then we propose a novel AIMD (Additive Increase / Multiplicative Decrease) quality control mechanism to regulate the changing behavior of target quality: (a) If the spare channel bit rate is greater than a certain value, then we increase the target quality gracefully in a linear mode; (b) Else if it is less than another certain value, then we decrease the target quality aggressively. Finally, once the target quality is determined, we allocate bits for current GOF to meet the target quality requirement by iteratively increasing or decreasing the packet length used by FEC-MDC packetization. Since this procedure is time costly, we propose a fast approximate-approaching based dual-stage iteration technique to accelerate it. Experimental results show that our techniques can achieve near constant or graceful increasing quality in a segment by segment scheme, and the improved algorithm is very efficient and can be used in real-time online computation. Besides, we also analyze the impacts of some algorithm parameters to the quality smoothing results.

The full length version of this paper is available at http://www.jdl.ac.cn/en.

[1] A.E. Mohr, E.A. Riskin, R.E. Ladner, "Graceful Degradation Over Packet Erasure Channels Through Forward Error Correction". Proc. DCC, Snowbird, UT, USA, March 1999.

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