End-to-End Modeling of Temporal Scalable Video Transmission over Lossy Channels

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Scalable bitstreams allow decoding at different bit rates and quality levels, depending upon the available bandwidth and computational power of a receiver. "Good" received video quality requires efficient allocation of the available bit-budget among the different layers, and between the source and the channel coders. It is necessary to have a theoretical model using which optimal bit allocation can be achieved. Such a model will also facilitate an understanding of the complex interplay between encoder, channel, and decoder parameters in a scalable transmission scenario.

In the scalable coding arena, [2] presents an estimation-theoretic approach to obtain an optimal scalable video coder using a Markov-source model. Rate-distortion relations for various temporal scalable video coding schemes have been derived in [5]. An optimal and computationally efficient solution to the problem of unequal error protection for scalable image bitstreams was recently presented in [3]. These schemes do not consider intra updates which are used to stop the propagation of residual transmission errors at the decoder. The intra update rate exchanges decoder error resilience with source coding efficiency [1,4], and is an additional important consideration in the end-to-end optimization of video transmission systems. End-to-end analysis and optimization of single-layer video transmission system was made in [1]. To the best of our knowledge, a theoretical end-to-end analysis, encompassing the encoder, the error control channel, and the decoder error propagation, has not been made for scalable video transmission systems.

In an earlier work [7], we derived a theoretical model of a 2-layer temporal scalable data transmission system using a 1-d Gauss Markov source. Our goal is to investigate the applicability of this model for the case of real video signals. We will evaluate Markov-process modeling for video signals, within the DCT domain. Specifically, we will study the effectiveness of the model for DCT coefficients, which have a Laplacian, instead of a Gaussian, distribution [6], and modify the model if necessary. We will also investigate the sensitivity of the model to the accuracy of motion compensation, which affects the correlation between successive samples of the Markov source. We will compare the system performance predicted by the model equations with that obtained from simulations involving real video data using the H.26L codec. It is expected that the model, suitably modified as indicated above, will accurately model a temporal scalable video transmission system.

References

[1] Klaus Stuhlmuller, Modeling and Optimization of Video Transmission Systems, Ph.D. Thesis, University Erlangen-Nuremberg, 2000

[2] Shankar Regunathan and Kenneth Rose, Toward Optimality in Scalable Predictive Coding, IEEE Trans. Image Processing, Vol. 10, No.7, July 2001

[3] Sorina Dumitrescu, Xiaolin Wu, Zhe Wang, Globally Optimal Uneven Error-Protected Packetization of Scalable Code Streams, Proceedings of the DCC 2002

[4] Niko Farber, Feedback based Error Control for Robust Video Transmission, Ph.D. Thesis, University Erlangen-Nuremberg, 2000

[5] Sheila S. Hemami, Distortion Analyses for Temporal Scalability Coding Techniques

[6] R. C. Reininger and J. D. Gibson, "Distributions of the two-dimensional DCT coefficients for images". IEEE Trans. Communications, Vol.31, No.6, June 1983

[7] Shantanu Rane, End-to-End Modeling of 1-D Temporal Scalable Data Transmission over Lossy Channels, EE390 project, Winter 2002, Stanford University.