Advanced Telecommunications and Signal Processing

RLE Group
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Academic and Research Staff
Prof. Jae S. Lim

Research Affiliate
Carlos Kennedy

Visiting Scientist
Prof. Chang Dong Yoo

Graduate Students
Brian Heng
Fatih Kamisli

Support Staff
Cindy LeBlanc

Introduction

The present television system was designed nearly 50 years ago. Since then, there have been significant developments in technology, which are highly relevant to the television industries. For example, advances in the very large scale integration (VLSI) technology and signal processing theories make it feasible to incorporate frame-store memory and sophisticated signal processing capabilities in a television receiver at a reasonable cost. To exploit this new technology in developing future television systems, the research areas of the program focused on a number of issues related to digital television design. As a result of this effort, significant advances have already been made and these advances have been included in the U.S. digital television standard. Specifically, the ATSP group represented MIT in MIT's participation in the Grand Alliance, which consisted of MIT, AT&T, Zenith Electronics Corporation, General Instrument Corporation, David Sarnoff Research Center, Philips Laboratories, and Thomson Consumer Electronics. The Grand Alliance digital television system served as the basis for the U.S. Digital Television (DTV) standard, which was formally adopted by the U.S. Federal Communications Commission in December 1996. The standard imposes substantial constraints on the way the digital television signal is transmitted and received. The standard also leaves considerable room for future improvements through technological advances. Current research focuses on making these future improvements.

In addition to research on issues related to the design of digital television system, the research program also includes research on signal processing for telecommunications applications.

Adaptive Multiple Description Mode Selection for Error Resilient Video Communications

Sponsor: Advanced Telecommunications Research Program

Project Staff: Brian Heng

The transmission of video information over error prone channels poses a number of interesting challenges. One would like to compress video data as much as possible in order to transmit it in a timely manner and/or store it within a limited amount of space, yet compressing a video sequence tends to make it more susceptible to errors and transmission losses. Streaming video applications must be able to withstand the potentially harsh conditions present on best-effort networks like the Internet, including variations in available bandwidth, packet losses, and delay. Those which are unable to adapt to these conditions can suffer severe performance degradations each time the network becomes congested.

Multiple description (MD) video coding is one approach that can be used to reduce the detrimental effects caused by packet loss on best-effort networks. In a multiple description system, a video sequence is coded into two or more complementary streams in such a way that each stream is independently decodable. The quality of the received video improves with each received description, but the loss of any one of these descriptions does not cause complete failure. If one of the streams is lost or delivered late, the video playback can continue with only a slight reduction in overall quality.

There have been a number of proposals for MD video coding, each providing their own tradeoff between compression efficiency and error resilience. Previous MD coding approaches applied a single MD technique to an entire sequence. However, the optimal MD coding method will depend on many factors including the amount of motion in the scene, the amount of spatial detail, desired bit rates, error recovery capabilities of each technique, current network conditions, etc. This research examines the adaptive use of multiple MD coding modes within a single sequence. Specifically, this work proposes an adaptive MD coder which selects among MD coding modes in an end-to-end rate-distortion (R-D) optimized manner as a function of local video characteristics and network conditions. This approach makes optimized decisions using a model of expected end-to-end distortion allowing the encoder to minimize the expected end-to-end distortion of the system. Simulation results have shown how one such system based on H.264 is able to adapt to local characteristics of the video and to network conditions on multiple paths and have shown the potential for this adaptive approach to significantly improve video quality. These simulations demonstrate how this system accounts for the characteristics of the video source, e.g. using more redundant modes in regions particularly susceptible to losses, and how it adapts to conditions on the network, e.g. switching from more efficient methods to more resilient methods as the loss rate increases. The results with this approach appear quite promising, and we believe that adaptive MD mode selection can be a useful tool for reliable delivery of video streams over lossy packet networks.

Publications

Journal Articles, Submitted for Publication

B. Heng, J. Apostolopoulos, and J. Lim, “Rate-Distortion Optimized MD Mode Selection for Adaptive Multiple Description Video Coding,” to appear in the special issue of the *EURASIP Journal on Applied Signal Processing* on “Video Analysis and Coding for Robust Transmission”, 1st Quarter 2006.

Conference Proceedings, Published

B. Heng, J. Apostolopoulos, and J. Lim, “End-to-End Rate-Distortion Optimized Mode Selection for Multiple Description Video Coding,” *Proceedings of the IEEE International Conference on Acoustics, Speech, and Signal Processing*, vol. 5, pp. 905-908, March 2005.

B. Heng and J. Lim, "Multiple Description Video Coding Through Adaptive Segmentation," *Proceedings of the SPIE - Applications of Digital Image Processing XXVII*, vol. 5558, pp. 105-115, August 2004.

Reduction of Blocking Artifacts

Sponsor: Advanced Telecommunications Research Program, Higher Education Council of Turkey

Project Staff: Fatih Kamisli

Block-based video compression methods are used extensively in practice. For example, digital television standards in the United States utilize block-based video compression methods. When used in low bit-rate applications, however, they suffer from annoying artifacts known as blocking artifacts. A number of different approaches were proposed in the past to reduce the blocking artifacts. In this research, we have reviewed the advantages and disadvantages of these existing methods and we are currently developing new approaches to solve the blocking artifact problem.