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Editorial
Video Analysis and Coding for Robust Transmission

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Increasing heterogeneity of networks and diversity of user capabilities have determined and sustained a strong interest in robust coding of visual content and flexible adaptation of the bitstreams to network and user conditions. As a result, several methods for robust coding and transmission have been proposed that include multiple description coding, motion-compensated subband video coding, joint source-channel coding, integrated compression and error control, and adaptation/transcoding solutions. These typically increase transmission robustness and network and user awareness by using scalability, error resilience, and adaptivity at little or sometimes no extra cost in coding efficiency.

However, the performance of these methods is affected by the diversity of, and complex interactions within, the visual content. Analysis methods can improve the performance of robust methods for coding and transmission by providing solutions to account for vastly different characteristics of the visual content and complex interactions among data components, to achieve optimal or near-optimal robust solutions. Among several benefits, the application of visual analysis methods within robust coding and transmission frameworks such as those mentioned earlier yields content-aware error resilient solutions and improves prioritization of the visual content for coding and transmission.

This special issue focuses on the seamless integration of visual analysis methods in, or joint design with, robust compression and transmission solutions. The special issue consists of three sections that address robust video coding architectures and configurations, robust entropy coding methods, and quality issues related to robust coding, respectively:

(a) robust video coding paradigms (multiple description coding, motion-compensated subband coding, distributed coding, and cross-layer designs),
(b) robust entropy coding by variable length codes, and
(c) quality issues in robust coding (error resilience, error concealment, and quality evaluation).

In the first set of nine papers, the first three address *multiple description coding* methods. The paper "End-to-end rate-distortion optimized MD mode selection for multiple description video coding" by B. A. Heng et al. discusses an adaptive approach to multiple description coding by a rate-distortion optimized selection of the most appropriate multiple description mode, depending on the network conditions and video features. The proposed method is an H.264-compatible video streaming solution over bursty channels and is based on an encoder-side estimation of the end-to-end distortion. The paper "Multiple description wavelet coding of layered video using optimal redundancy allocation" by N. V. Boulgouris et al. presents a wavelet-based, predictive, multiple description scheme with drift-free reconstruction. In this work, the redundancy allocation problem is tackled as a maximization of the average quality under a total target bitrate constraint. The paper "Unbalanced quantized multi-state video coding" by S. E. Flierl et al. discusses a multiple description coding method that uses multistate video coding (or subsequence splitting). Unbalanced quantized descriptions are designed in this work using a rate-distortion optimization model based on network and video characteristics.

Within the same section of robust video coding paradigms, the fourth and fifth papers address *motion-compensated subband techniques*. The paper "Temporal scalability through adaptive M-band filter banks for robust H.264/MPEG-4 AVC video coding" by C. Bergeron et al. proposes several temporal scalability schemes obtained by frame shuffling that increase robustness in an H.264-compatible framework. This work discusses open-loop and closed-loop architectures in an adaptive M-band hierarchical filter bank framework, and analyzes the sender-side error propagation.

The paper "Motion estimation and signaling techniques for 2D+t scalable video coding" by M. Tagliasacchi et al. presents a 2D + t (in-band) video coding method with fast motion estimation in the wavelet domain and an adaptive in-band version of the update lifting step.

The *distributed source coding* paradigm is the focus of the sixth and seventh papers on robust video coding architectures and paradigms. The paper "Distributed coding of highly correlated image sequences with motion-compensated temporal wavelets" by M. Flierl and P. Vandergheynst makes use of motion-compensated temporal filtering subband codecs in a multiple camera distributed video coding system. The paper investigates the relationship between multiview side information and temporal decorrelation, and proposes an optimal motion-compensated spatiotemporal transform at high bitrates. The work in "A framework for adaptive scalable video coding using Wyner-Ziv techniques" by H. Wang et al. presents a practical, low-complexity distributed coding framework, which exploits a multilayer Wyner-Ziv prediction "link" that connects the same bitplane level between successive planes. Such a link is created by exploiting the high quality reconstruction of the previous frame in the enhancement layer coding of the current frame, and provides improved temporal prediction as compared to MPEG-4 FGS, while maintaining a reasonable complexity on the encoder side.

The eighth and ninth papers of the robust video coding paradigms provide useful guidelines for the *cross-layer design* of wireless video systems. The paper "Robust system and cross-layer design for H.264/AVC-based wireless video applications" by T. Stockhammer focuses on the feature selection for an H.264 codec, and the transport and network parameters for real-time applications. The paper "Source-adaptation-based wireless video transport: A cross-layer approach" by Q. Qu et al. proposes a forward error correction/unequal error protection method, which adapts the H.264 source coding to the motion information. This solution allows the system to better cope with bursty packet losses in real-time transmission over wireless networks.

The second set of papers tackles *robust data representation* by progressive and robust variable-length coding. The paper "Progressive and error-resilient transmission strategies for VLC encoded signals over noisy channels" by H. Jegou and C. Guillemot performs a statistical analysis in order to select the most appropriate binarization code. The paper also discusses soft-input-soft-output and turbo decoding methods, with possible applications to EBCOT and CABAC.

The third set of four papers in this special issue addresses quality issues in robust video coding systems: error resilience, error concealment, and video quality evaluation. In the first two works on *error resilience*, the paper "RD optimized, adaptive, error-resilient transmission of MJPEG2000 coded video over multiple time-varying channels" by S. Bezan and S. Shirani proposes a data partitioning technique across multiple channels. This method makes use of rate-distortion optimized channel protection by RCPC codes and adaptive error correction that depends on the bandwidth and error characteristics of the channels. A different point of view is introduced in the paper "Adaptive UEP and packet size assignment for scalable video transmission over burst error channels" by C.-W. Lee et al., which focuses on achieving error resilience by prioritization for coding and transmission over limited-bandwidth bursty channels. This work presents the design of an MPEG-4 FGS streaming system using an analytic model for the evaluation of video quality. The model takes into account the bit-error rate and packet-error rate, which can face varying channel conditions due to an unequal error protection scheme combined with adaptive packet sizes.

In the same set, the third paper "Classification-based spatial error concealment for visual communications" by M. Chen et al. proposes an adaptive selection of the *error concealment* algorithm by classification. This joint sender-receiver system design is discussed in three scenarios: a receiver-side classification, a sender-based classification, and a sender-side that embeds the classification side information.

The fourth and final paper of this section, "A framework for advanced video traces: Evaluating visual quality for video transmission over lossy networks" by O. A. Lotfallah et al., makes use of video traces for *quality evaluation*. This work addresses the problem of video quality evaluation in lossy transport schemes without accessing the video content. The proposed solution exploits video content descriptors and perceptual quality metrics in order to predict the quality of the reconstructed video accurately.

For this special issue to come to life, significant effort from the contributing authors and reviewers was required. We express our thanks to all. It is our hope that the papers included in this special issue will help researchers and practitioners alike by providing focus and clear understanding of the status and challenges in the area of robust analysis and coding for video transmission.

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Beatrice Pesquet-Popescu received the Engineering degree in telecommunications from the "Politehnica" Institute in Bucharest in 1995, and the Ph.D. from the Ecole Normale Supérieure de Cachan in 1998. In 1998, she was a Research and Teaching Assistant at Université Paris XI, and in 1999, she joined Philips Research, France, where she worked for two years as a Research Scientist, then a Project Leader in scalable video coding. Since October 2000, she is an Associate Professor in multimedia at the Ecole Nationale Supérieure des Télécommunications (ENST). Her current research interests are in scalable and robust video coding, adaptive wavelets, and multimedia applications. EURASIP gave her a "Best Student Paper Award" in the IEEE Signal Processing Workshop on Higher-Order Statistics in 1997, and in 1998, she received a "Young Investigator Award" granted by the French Physical Society. She holds 20 patents in wavelet-based video coding and has authored more than 80 book chapters, journal, and conference papers in the field.

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