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Editorial

Advanced Video Technologies and Applications for H.264/AVC and Beyond

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The recently developed video coding standard, H.264/AVC, significantly outperforms previous standards in terms of coding performance at reasonable implementation complexity. Several application systems, such as high-definition DVD and digital video broadcasting for handheld devices and high-definition television systems, have adopted H.264 or its modified versions as the video coding standard. In addition, the extensions of H.264/AVC to scalable and multiview video coding applications are nearly finalized. Many video services, especially bandwidth-limited wireless video, will benefit from the H.264 coder due to its outstanding features.

The use of variable block sizes for intra- and inter-prediction in combination with different intra-prediction modes and motion compensation using multiple reference frames is one of the main reasons for the improved coding efficiency in H.264/AVC. Together with many other new features, the encoder can select between multitudes of different coding modes.

The determination of the optimal coding mode under the joint rate and distortion consideration, which is called the rate-distortion optimization (RDO), introduces a huge amount of memory access and computational complexity for testing all possible modes in video encoders. Hence, a reduction of the complexity of motion estimation and mode selection in an H.264/AVC encoder becomes an important task for real-time applications. In selecting the quantization parameters at the frame and the block levels, the goal is to design a rate-control method that maximizes the video quality with a constrained bandwidth. Regardless of the superior coding efficiency of the H.264/AVC standard, there still exist many video coding standards. For example, MPEG-2 and H.263 have been adopted by the current television and video telephony systems, respectively. Therefore, an effective transcoding method, which can effectively convert the existing non-H.264 bitstreams to H.264 conforming bitstreams, while maintaining the excellent rate-distortion performance, will greatly smooth the transition in the migration to H.264/AVC.

Compressed video is typically the most demanding component in modern multimedia services. The statistical analysis on H.264/AVC bitstreams will help to precisely characterize the traffic in video communication. Furthermore, the accurate prediction of dynamic bandwidth allocation of video encoders in network utilization is also important to achieve the best quality of service (QoS). Over wireless and Internet communications, transmission rate variations and transmission-error/packet-loss are inevitable during video streaming. To provide seamless services, the switching capabilities provided by the H.264/AVC standard should be intelligently used to adapt to changing channel characteristics. It has been noted that the more the video is compressed, the more the decoder suffers from error propagation and picture degradation in the case of data loss. Identifying the critical bits of an H.264/AVC bitstream and adding in various degrees of protection can provide a more robust video transmission. Various techniques such as unequal error protection, prioritized transmission, and proper slice insertion in the H.264/AVC stream can further enhance its error resilient features.

This EURASIP JASP special issue, entitled "Advanced video technologies and applications for H.264/AVC and beyond," presents eleven recent research papers related to H.264/AVC. They cover a wide spectrum including the following important topics: adaptive backward motion prediction, fast motion estimation and mode selection, fast rate-distortion optimization (RDO), rate control, H.263 to H.264 transcoding, long video tracing, switched streaming, and error protection. These papers can generally be grouped into two main categories based on their contributions: (1) H.264/AVC fast parameter selection and rate-control, and (2) H.264/AVC video bitstream modeling and error protection techniques for video transmission. A summary of the papers in these two categories is given below.

The first five papers address the issues related to fast or optimal parameter selection and rate-control techniques that improve either coding performance or coding speed.

The first paper, "Least-square prediction for backward adaptive video coding," by Li discusses a least-square prediction technique using the duality between the edge contour in images and the motion trajectory in video to achieve a better prediction than the 4×4, full-search, quarter-pel block matching algorithm without transmitting any overhead. This better prediction will improve the coding efficiency.

The paper, "Fast motion estimation and intermode selection for H.264," by Choi et al. presents a multi-frame/multi-resolution motion estimation method using the Hexagon search. For fast inter-mode selection, a bottom-up merge strategy is suggested.

In "Scalable fast rate-distortion optimization for H.264/AVC," Pan et al. design a scalable fast RDO algorithm to effectively choose the best coding mode by initially searching the most probable modes.

The paper, "Rate control for H.264 with two-step quantization parameter determination but single-pass encoding," by Yang et al. proposes an efficient rate-control strategy for H.264, which maximizes the video quality by determining the quantization parameter (QP) for each macroblock. With a preanalysis coarse QP, the refinement of the QP is further enhanced by using the information of motion-compensated residues.

By adopting motion estimation and rate control mechanism, the paper "Efficient video transcoding from H.263 to H.264/AVC standard with enhanced rate control," by Nguyen and Tan devises an H.263 to H.264 transcoding system based on a motion vector reestimation scheme and a fast intra-prediction mode selection. An enhanced rate-control method based on a quadratic model for selecting quantization parameters is also suggested.

The next six papers discuss video bitstream modeling and error protection techniques for effectively transmitting the H.264/AVC bitstreams.

In "H.264/AVC video compressed traces: multifractal and fractal analysis," Reljin et al. examine the H.264/AVC video by fractal and multifractal spectra, which can precisely characterize both local and global features such that a more accurate modeling of the compressed video traffic can be achieved.

Dealing with the bandwidth variation issue, the paper, "Optimized H.264-based bit stream switching for mobile video streaming," by Stockhammer et al. exploits the H.264/AVC SP/SI pictures to optimize the encoders by introducing a framework for dynamic switching and frame scheduling. The achievable performance gains over the constant bit-rate encoding are demonstrated for wireless video streaming over enhanced GPRS.

Zhang and Zeng in "Seamless bit-stream switching in multirate-based video streaming systems" propose an efficient switching method by using an independent or a joint processing in the wavelet domain and an SPIHT coding scheme to achieve an improved coding quality on the H.264/AVC SP/SI pictures.

The paper, "H.264 layered coded video over wireless networks: channel coding and modulation constraints," by Ghandi et al. presents the prioritized transmission of H.264 layered coded video over wireless channels by using prioritized forward error correction coding or hierarchical quadrature amplitude modulation to achieve the layered transmission of data-partitioned and SNR-scalable coded video.

In "Robust transmission of H.264/AVC streams using adaptive group slicing and unequal error protection," Thomos et al. present an error resilient scheme for transmission of H.264/AVC video streams over lossy packet networks using Reed-Solomon codes, adaptive classification of macroblocks, and channel rate allocation.

By using an error-resilient unequal error protection method, the paper, "Error-resilient unequal error protection of fine granularity scalable video bitstreams," by Cai et al. proposes a packet loss protection method for streaming the fine granularity scalable video to guarantee the successful decoding of all received bits resulting in strong error-resilience and high robustness video transmission.

The guest editors would like to thank all the authors for their contributions. We would also like to express our deep appreciation to the reviewers for their conscientious efforts in evaluating all the submitted manuscripts and improving readability of the accepted papers. We hope that this special issue will inspire further research work on improving the coding performance of H.264/AVC coders as well as all the practical issues related to the transmission of H.264/AVC coded streams.

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