Elsevier J. of Visual Communication & Image Representation (Special issue on Emerging H.264/AVC Video Coding Standard), Vol. 17(2), April 2006

Editorial

Special Issue on 'Emerging H.264/AVC Video Coding Standard'

The growing availability and widespread use of digital multimedia information and personal wireless communication devices have motivated development of several video compression standards over the past two decades. These compression standards have been developed to achieve better picture quality, higher coding efficiency, and more error robustness for various applications. The H.264 / MPEG-4 part 10 is the powerful and state-of-the-art video compression standard recently developed by the ITU-T/ISO/IEC Joint Video Team (JVT) consisting of experts from ITU-T's Video Coding Experts Group (VCEG) and ISO/IEC's Moving Picture Experts Group (MPEG). This new international video coding standard aims at having significant improvements in coding efficiency and error robustness in comparison to the previous standards such as MPEG-2, H.263, and MPEG-4 part 2.

This special issue brings together practitioners and researchers working in all aspects of the H.264/AVC standard based video compression, communication, and networking. We are very pleased with a large number of high quality submissions for this special issue. This issue consists of 17 papers which are organized into the following sections: survey, motion estimation, encoding, rate control, networks and implementation.

This special issue opens with an overview paper about the H.264/AVC standard by Kwon *et al.,* which discusses various important features of the standard and compares the coding scheme with the other standards.

Efficient motion compensation is one of the key reasons for superior performance of the H.264/AVC standard compared to older standards such as MPEG-2/4 and H.263. Unfortunately, the motion estimation is the most computation intensive part of a video encoder. A set of four papers presents techniques for fast motion estimation. The first paper, "Fast Motion Search with Efficient Inter-Prediction Mode Decision for H.264" by Kuo *et al.*, presents a fast inter-prediction mode decision and motion search algorithm by employing a multi-resolution motion estimation scheme and an adaptive rate-distortion model with early termination rules. The next paper, "Fast Motion Estimation and Inter Mode Decision for H.264/MPEG-4 AVC Encoding" by Zhou *et al.* introduces a new concept of 'adaptive diversity search strategy' for fast motion vector (MV) search. The authors investigate three fast motion estimation strategies by MV merging and splitting for variable size block motion estimation, which explores the correlation of MVs of overlapping blocks. The third paper "Fast Integer-Pel and Fractional-Pel Motion Estimation for H.264/AVC" by Chen *et al.* describes a fast motion estimation algorithm for both the fast integer-pel and fractional-pel search. It has almost the same quality performance as that of the full search scheme. The final paper "Fast H.264 Intra-Prediction Mode Selection Using Joint Spatial and Transform Domain

Features” by Kim *et al.* presents a low complexity intra prediction mode selection scheme without significant rate-distortion performance degradation. The proposed scheme uses spatial and transform domain features of the target block to filter out the majority of candidate modes.

Intra-frame mode selection and inter-frame mode selection are new features introduced in the H.264 standard. Intra-frame mode selection dramatically reduces spatial redundancy in I frames, while inter-frame mode selection significantly affects the output quality of P-/B frames by selecting an optimal block size with motion vector(s) or a mode for each macroblock. Unfortunately, this feature requires a myriad amount of encoding time when a full-search method is utilized. The third section consists of four papers on efficient encoding. The first paper “An Extension of Direct Macroblock Coding for Predictive (P) Slices of the H.264 Standard” by Tourapis *et al.*, proposes schemes to enhance motion compensation and improve the coding efficiency. This is achieved by introducing a new DIRECT macroblock type to exploit the MV temporal correlation and an enhancement to the existing SKIP within Predictive (P) slices. The next paper, “Efficient Intra- and Inter-mode Selection Algorithms for H.264/AVC” by Yu *et al.* presents fast mode selection algorithms for both intra-frames and inter-frames. In H.264/AVC, various macroblock types are used for improving the compression efficiency. However, it is not efficient for these macroblock types to be coded by separate syntax elements. Baek *et al.* in “An Improved H.264/AVC Video Encoding Based on a New Syntax Element” propose an efficient coding method based on the new single combined syntax element as well as the effective VLC code. Flexible macroblock ordering (FMO) is an important error resiliency scheme used in H.264. Lambert *et al.* provide an in-depth discussion of FMO and demonstrate its benefits in case of packet loss over IP networks in their paper “Flexible Macroblock Ordering in H.264/AVC”. A quantitative assessment of FMO overhead is presented for a number of scenarios.

The fourth section consists of two papers on rate control. The first paper, “Adaptive Rate Control for H.264” by Li *et al.* presents a rate control scheme by using the concept of basic unit (e.g., an MB, slice or frame) and a linear prediction model. The corresponding quantization parameter is computed by using a quadratic rate distortion model. Both constant bit rate (CBR) and variable bit rate (VBR) cases are studied. The second paper, “Improved H.264 Rate Control by Enhanced MAD-Based Frame Complexity Prediction” by Yi and Ling presents a rate control scheme based on a more accurate frame complexity measure, which has a stronger correlation with optimally allocated bits than that of the predicted MAD.

Real-time transmission of video data in network environments, such as wireless and Internet, requires high compression efficiency and network friendly design. H.264/AVC aims at achieving improved compression performance and a network-friendly video representation for different types of applications, such as conversational, storage, and streaming. The fifth section consists of four papers on error resiliency and network performance. The first paper “Error Resiliency Schemes in H.264/AVC Standard” by Kumar *et al.* introduces various error resiliency schemes employed by H.264/AVC. The related topics such as non-normative error concealment and network environment are also discussed. Hierarchical Quadratic Amplitude Modulation (QAM) is an efficient method that provides the unequal priority control for communication channels without adding any redundancy to the transmitted data.

Scalability is an efficient layering technique that is not entirely supported in the current specification of H.264/AVC. The second paper, “Layered H.264 Video Transmission with Hierarchical QAM” by Ghandi and Ghanbari proposes an SNR scalable scheme. The unequal error protection by hierarchical coding to both scalable and data partitioned bitstreams is also analyzed. The third paper, “Network Performance Analysis of Advanced Video Coding Schemes,” by Lotfallah and Panchanathan presents the network performance analysis of H.264 and PFGS coding schemes. The robustness of these coding schemes to channel losses is evaluated using video sequences containing various motion activity levels. The final paper, “Stitching of H.264 Video Streams for Continuous Presence Multipoint Videoconferencing” by Banerji *et al.* presents a computationally simple video stitching scheme applicable to continuous presence multipoint videoconferencing. The proposed scheme employs a blend of compressed-domain and pixel-domain tools to eliminate the drift that results when a compressed-domain approach is used.

Efficient implementation of compression algorithms is crucial to lower the production cost of a codec. The sixth and final section consists of two papers on efficient implementation. The first paper, “Implementation of H.264 Encoder and Decoder on Personal Computers,” by Chen *et al.* analyzes software implementation of H.264 encoder and decoder on general-purpose processors with media instructions and multi-threading capabilities. Specifically, the paper discusses the optimization on Intel Pentium 4 processors. The second paper, “A Proposed Hardware Reference Model for Spatial Transformation and Quantization in H.264” by Amer *et al.* presents three VLSI prototypes to exploit spatial redundancy in the H.264 standard.

We hope that this special issue would provide useful insights on various aspects of the H.264/AVC standard, its applications and scope for future improvements. We would like to thank the authors for their excellent contributions to this special issue. We are also deeply indebted to the reviewers for their timely and constructive responses. Finally, we would like to thank Professors C.-C. Jay Kuo and Josh Zeevi, Editors-in-Chief, for their encouragement and support.

SUNIL KUMAR
Electrical and Computer Engineering Department
Clarkson University
Potsdam, NY 13699 USA

MRINAL K. MANDAL
Electrical and Computer Engineering Department
University of Alberta
Edmonton, Alberta T6G 2V4 Canada

SETHURAMAN PANCHANATHAN
Computer Science and Engineering Department
Arizona State University
Tempe, AZ 85287 USA