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Guest Editorial

Special issue on resource-aware adaptive video streaming

Modern multimedia applications such as mobile television, IPTV, distributed video conferencing, streaming and gaming over wired and wireless networks have stimulated research for new technologies in the area of multimedia architectures, processing, and networking. Current communications networks exhibit a wide range of capabilities, including various architectures, throughputs, quality of service and protocols; interconnection of different networks provides several advantages, but also poses major technical challenges. On the other hand, users employ heterogeneous terminals with a wide range of computational and display capabilities, energy resources, features, accessibilities, and user preferences. The variety of possible scenarios has generated a need for effective techniques for streaming and adapting compressed videos in such heterogeneous environments.

A streaming video system comprises four major components: (1) the encoder application that compresses video signals, (2) the media server that stores the compressed video streams and transmits them on demand, (3) the transport mechanism that delivers media packets from the server to a client by sharing network resources with other users, and (4) the client device that decompresses and renders the video data. In practice, video streaming over networks is often subject to various constraints of resources across theses components, such as insufficient network bandwidth, time-varying channel condition, limited processing power of media server, limited computing power or battery power of video encoder/decoder. For the best end-to-end performance, an adaptive streaming system that can well adapt to such resource constraints is required.

Considerable amounts of research activities in industry and academia have been devoted to developing the enabling technologies that are needed to make better use of video content across systems and applications of various kinds. The goal of this special issue is to provide an up-to-date picture of state-of-the-art research in the field of video streaming, emphasizing the two key aspects of *adaptation* and *resource-awareness*. Overall, we have, received 41 submissions addressing the differnt aspects of the video processing framework. After a thorough review process, a total of 11 papers were selected, covering the topics of adaptive video streaming algorithms, video adaptation, adaptive video encoding, and real-world applications.

The first three papers cover the topic of bandwidth and resource adaptive video streaming algorithms and their applications. The first paper by Roitzsch and Pohlack, "Video Quality and System Resources: Scheduling two Opponents" analyzes the possible trade-offs between video quality and system resources. The authors develop an online resource usage model for video decoding, which estimates the resources saved when some parts of the video are not fully decoded; they also provide replacement methods for these parts. Moreover, they define a metric that measures user perception of video quality, and show how this metric can be used to maximize video quality under given resource constraints. An application to H.264/AVC is described and evaluated. In the paper "ARMOR—A System for Adjusting Repair and Media Scaling for Video Streaming," Wu et al. proposes a new video quality metric called distorted playable frame rate to capture user perceptual quality considering temporal and quality degradations. User studies were conducted to justify the effectiveness of the proposed quality metric. Based on the metric, the authors present a video streaming system that dynamically adjusts repair and media scaling to maximize the distorted playable frame rate under varying network conditions. The paper "Rateless Scalable Video Coding for Overlay Multisource Streaming in MANETs" by Schierl et al. addresses the problem of delivering video contents across an overlay network built on top of a mobile ad-hoc network. The authors propose a solution that employs two key ingredients. The first is concurrent streaming from multiple sources, while the second is the use of rateless codes. They utilize scalable video coding and forward error correction to guarantee a suitable degree of quality of service. Moreover, they perform distributed rate-distortion optimization among video streams that are competing in the network, thereby achieving a high degree of resilience to network dynamics.

Video streaming over wireless networks is a challenging task because of the changes in the wireless channel conditions that can occur due to interference, fading, and station mobility. The time-varying nature of wireless channels makes rate adaptation and quality adaption very crucial in wireless video transport. Two papers address the problem of adaptive video streaming in wireless networks. The paper "Combining the Rate Adaptation and Quality Adaptation Schemes for Wireless Video Streaming" by Lee and Chung considers the problem of video streaming over wireless networks, and focuses on rate and quality adaptation. A cross-layer framework is proposed, in which the rate adaptation is performed at the physical and data link layers, while the quality adaptation is carried out at the application layer. A sender-oriented rata adaptation scheme is proposed, which uses the received signal strength indicator to estimate the conditions of the wireless channel. These conditions are used to drive the quality adaptation. Simulation results are presented using both constant and variable bitrate traffic. In the paper "Maximum-Throughput Delivery of SVC-based Video over MIMO Systems with Time-Varying Channel Capacity," Song and Chen propose a QoS-guaranteed scalable video transmission scheme over MIMO wireless systems. On top of the

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scalable extension of H.264/AVC codec, the proposed scalable video delivery strategy includes three adaptive operations: power allocation based on water-filling, adaptive channel selection, and data rate maximizing power reallocation. Simulation results demonstrate that the throughput of the proposed SVC-based MIMO system is proportionally increased with the number of antennas compared to SISO system.

Scalable Video Coding (SVC) is a powerful tool of achieving resource-aware video streaming as it can provide various scaling options, such as temporal, spatial and SNR scalability, where adaptation by truncating enhancement layers of different scalability types results in different kinds and/or levels of visual quality depending on the content and bit-rate. Two papers cover the topic of SVC-based video adaptation. The paper "Design Options and Comparison of In-network H.264/SVC Adaptation" by Kuschnig et al. explores mechanisms for in-network bitstream adaptation. It implements and compares approaches based on SVC bitstream extraction and truncation, and respectively MPEG-21 metadata-driven processing. Experiments with prototype systems shows the superiority of the SVC-based techniques in terms of complexity, error resilience and overhead, while the description driven approach however presents the interesting benefit to be independent to the specific video coding format. In the paper "A Rate-Distortion Optimization Model for SVC Inter-layer Encoding and Bitstream Extraction," Peng et al. propose a two-prong approach to achieve rate-distortion (R-D) optimal extraction of SVC bitstreams. A set of adaptation rules are developed for setting the quantization parameters and the inter-layer dependencies among the SVC coding layers. The proposed method addresses the following three design considerations: (1) the combined effect of proper encoder setting coupled with matching bitstream extraction and decoding mechanisms, (2) the computation efficiency of search strategies for R-D optimized extraction paths, and (3) the choice of extraction paths amenable to successive refinement of SVC bitstreams. Simulation results show that, in addition to the improvement in playback picture quality among heterogeneous viewing devices, the proposed method also promises R-D convexity along optimal extraction paths.

Video encoding and playback on a mobile device such as a PDA, pocket-PC, multimedia-enabled mobile phone, or a laptop PC operating in battery mode, is a resource-intensive task considering the limited computing/battery power of the mobile device. Resource adaptive video encoding/decoding is crucial for resource-constrained devices. Two papers address the problems of resource-aware encoding algorithms. In the paper "Adaptive Slice-Level Parallelism for H.264 Encoding Using Pre Macroblock Mode Selection," Jung and Jeon address the parallelization of H.264/AVC encoding algorithms in order to adapt to multicore processing systems. In particular, they achieve slice-level parallelism by a new adaptive slice-size selection technique based on preprocessing that performs fast macroblock mode selection. Simulations results show that effective balancing of the computational load permits to halve the computation time. The paper "Hybrid Layered Video Encoding and Caching for Resource Constrained Environments" by Chattopadhyay and Bhandarkar proposes a novel hybrid layered coding scheme combined with smart caching to dynamically adapt distribution and playback of video to power-constrained devices. The hybrid coder uses a generative sketch based representation for the video combined with a layered texture codec to achieve several video profiles, corresponding to different power consumption requirements at the end device. The caching scheme dynamically tracks statistics on prioritized clients to determine retention values for different content profiles, for low latency power adaptive delivery. The paper includes interesting results that demonstrate the impact of the schemes on video quality evaluation, cache efficiency as well as computational and power requirements at end devices.

Distributed video coding (DVC) based on the Wyner–Ziv theorem has been stimulating many research activities as it offers a number of potential advantages such as flexible partitioning of the complexity between the encoder and decoder and error robustness to channel errors. DVC is also well suited for multiview coding by exploiting correlation between views without requiring communications between the cameras. Two papers address the design issues of distributed video coding. The paper "Advanced Side Information Creation Techniques and Framework for Wyner–Ziv Video Coding" by Ascenso and Pereira deals with distributed video coding, which can be used to adapt the complexity of the coding and decoding stages. In particular, for this application, motion estimation at the decoder is critical to reconstruct the Wyner–Ziv frames. The authors propose a technique to generate high-quality side information through regularization of the motion vector field. They integrate this technique in a transform-based distributed coder, showing significant performance improvements over H.264/AVC intra coding. In the paper "Side Information Estimation and New Symmetric Schemes for Multiview Distributed Video Coding," Maugey and Pesquet–Popescu address the design problem of DVC in the framework of multiview video, which is motivated by multicamera applications and in general by the development of the H.264/MVC extension. The paper provides two contributions. First, it studies the problem of exploiting the multiple side information available in a multicamera system, evaluating the performance improvement achieved with respect to single side information. Second, it proposes a scheme for groups of pictures longer than two, exploiting long-term correlations of the video sequence.

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