Introduction to the Special Section on the HEVC Standard

Video compression, as typified by international video coding standards such as H.261, MPEG-1, H.262/MPEG-2 Part 2, H.263, MPEG-4 Part 2, and H.264/MPEG-4 AVC, has grown steadily more prominent and powerful since its infancy. Reducing the bit rate required for a given subjective reproduction quality remains one of the most challenging tasks in signal processing. The task keeps on evolving by the steady increase of picture resolution and frame rate of the video signal. Moreover, video applications have expanded over the last decade from television to notebooks, smartphones, tablets, and beyond—even expanding from 2-D into stereoscopic 3-D, with autostereoscopic 3-D starting to emerge from research laboratories worldwide. Video-based applications have experienced a relentless expansion of use, along with increased quality demands—with a progression from standard definition into high definition (HD), ultra-high definition, and beyond.

This special section presents a new technology developed to respond to this daunting challenge. High Efficiency Video Coding (HEVC) is the next generation of compression standard. It was developed by the ITU-T | ISO/IEC Joint Collaborative Team on Video Coding (JCT-VC), which consists of experts from the ITU-T's Visual Coding Experts Group (VCEG) and ISO/IEC's Moving Picture Experts Group (MPEG). Its design represents the standardization community's new best algorithms for video coding.

As was the case with the H.264/MPEG-4 AVC standard that preceded it and went on to become the worldwide dominant technology for video applications, the compelling value proposition for HEVC is its compression capability. We estimate that HEVC can compress a video to about half the bit rate of H.264/MPEG-4 AVC without sacrificing its picture quality. This advance repeats the achievement that H.264/MPEG-4 AVC itself showed relative to its predecessors.

To achieve this, algorithmic features have been included in HEVC that are substantial advances over those in previous standards. In particular, this includes features that help in the compression of video with increased picture resolution, such as HD and beyond. At the time when previous standards were developed, some encoding technologies had been too complex to use, and research with high picture resolutions was much more difficult than it is today.

For those considering the use of HEVC in real-world products and applications, three questions are of fundamental importance.

1) What are its key technical design elements and how do they work?
2) How good is its compression capability?
3) How hard is it to implement?

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We have constructed this special section with one paper to answer each of these three questions.

The paper "Overview of the High Efficiency Video Coding Standard (HEVC)" by Sullivan, Ohm, Han, and Wiegand provides a concise description of the standard to familiarize readers with the HEVC technical design.

The paper "Comparison of the Coding Efficiency of Video Coding Standards—Including High Efficiency Video Coding (HEVC)" by Ohm, Sullivan, Schwarz, Tan, and Wiegand contains a report of rigorous tests done to measure the standard's compression capabilities. In this paper, significant quality gains are shown relative to prior designs for a very broad range of applications.

The paper "HEVC Complexity and Implementation Analysis" by Bossen, Bross, Sühring, and Flynn gives an assessment of the HEVC implementation requirements, considering both the overall architecture demands and those of particular tools within the design.

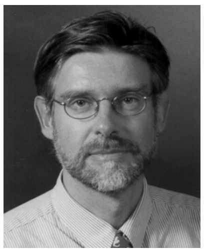
The standard will be finalized in January 2013—just after this special section is published, and the current design (draft 9) is now stable and ready for implementation work to commence toward the transition from a specification document into today's world of diverse products and applications. We believe that this special section gives a useful perspective on the core coding tools used in HEVC and its overall architecture in a timely fashion, while providing the community with a good balance of enlightening information and a sufficiently complete portrait of the concepts and content of the standard. For background information and more detail on particular design elements, the interested reader may refer to other papers in the special issue on emerging research and standards in next generation video coding, which is published together with this special section, and also to the papers in the prior special section of the IEEE TRANSACTIONS ON CIRCUITS AND SYSTEMS FOR VIDEO TECHNOLOGY on the joint call for proposals on high efficiency video coding (HEVC) standardization, which appeared in December 2010 describing some contributions to the call for proposals that launched the joint HEVC development project.

This is the next major milestone in the history of video coding and its standardization. We are proud of the accomplishment of the JCT-VC committee (and its ITU-T and ISO/IEC parents) in developing this great new standard, and the credit for the work is entirely due to the great contributions by the participants.

The imminent release of the HEVC standard marks just the beginning. We believe that for years to come, major work will be accomplished in the community to take advantage of the new standard, to further test its capabilities, and to optimize its implementations. You will soon see a growing body of research work written about its many applications and systemenvironment optimizations, implementation architectures and analysis, fast encoding strategies, robustness to network difficulties, and more. You will even begin to see works that will try to surpass its capabilities, although we believe it has substantially raised the bar and represents about the best that is reasonably possible today.

Above all, the HEVC project has demonstrated that the predictions of the demise of video compression innovations, which may have been in some heads after the finalization of previous standards projects, were a little premature. We are also sure that after HEVC is born, video coding research will continue to flourish vigorously. The standardization committees are already working on expanding the capabilities of HEVC with research on professional scenarios, enhanced-precision usage, scalable extensions, and 3-D extensions. We are confident that even more is just around the corner.

We would also like to thank the Editor-in-Chief Hamid Gharavi for his support in putting together this special section. We are also deeply indebted to the paper reviewers for their quick and constructive responses on the manuscripts.



Jens-Rainer Ohm (M'92) received the Dipl.-Ing., Dr.-Ing., and Habil. degrees from the Technical University of Berlin (TUB), Berlin, Germany, in 1985, 1990, and 1997, respectively.

From 1985 to 1995, he was a Research Associate with TUB, where he was also a Lecturer from 1992 to 2000. From 1996 to 2000, he was a Project Coordinator with the Heinrich Hertz Institute (HHI), Berlin. In 2000, he became a Full Professor and since then has been the Chair of the Institute of Communication Engineering, RWTH Aachen University, Aachen, Germany. He has authored textbooks on multimedia signal processing, analysis, coding, communication engineering, and signal transmission. He has written numerous papers in the aforementioned fields. His current research interests and teaching activities include image, video, and audio signal processing, coding, transmission and content description, and fundamental topics of signal processing and digital communication systems.

Dr. Ohm has been participating in the work of the Moving Picture Experts Group (MPEG) since 1998. He has been Chair and Co-Chair of various standardization activities in video coding, namely, the MPEG Video Subgroup since 2002, the Joint Video Team of MPEG and ITU-T SG 16 VCEG from 2005 to 2009, and, currently, the Joint Collaborative Team on Video Coding and the Joint Collaborative Team on 3-D Video Coding Extensions. He served as an Associate Editor for the IEEE TRANSACTIONS ON CIRCUITS AND SYSTEMS FOR VIDEO TECHNOLOGY from 2001 to 2005. He is a member of various professional organizations, including VDE/ITG, EURASIP, and AES.

Gary J. Sullivan (S'83–M'91–SM'01–F'06) received the B.S. and M.E. degrees in electrical engineering from the University of Louisville, Louisville, KY, in 1982 and 1983, respectively, and the Ph.D. and Engineer's degrees in electrical engineering from the University of California, Los Angeles, in 1991.

He has been the long-standing Chairman or Co-Chairman of various video and image coding standardization activities in the ITU-T Video Coding Experts Group (VCEG) and ISO/IEC MPEG. He is best known for leading the development of the ITU-T H.264 | ISO/IEC 14496-10 MPEG-4 Advanced Video Coding (AVC) standard and its Scalable Video Coding and 3-D/Stereo/Multiview Video Coding extensions. He is a Video/Image Technology Architect with the Windows Division, Microsoft Corporation, Redmond, WA. With Microsoft Corporation, he has been the Originator and Lead Designer with the DirectX video acceleration video decoding feature of the Microsoft Windows operating system. His current research interests and areas of publication include image and video compression, rate-distortion optimization, motion estimation and compensation, scalar and vector quantization, and loss resilient video coding.

Dr. Sullivan has received the IEEE Masaru Ibuka Consumer Electronics Award, the IEEE Consumer Electronics Engineering Excellence Award, the INCITS Technical Excellence Award, the IMTC Leadership Award, and the University of Louisville J. B. Speed Professional Award in Engineering. The team efforts that he has led have been recognized by the ATAS Primetime Emmy Engineering Award and by a pair of NATAS Technology and Engineering Emmy Awards. He is a fellow of the SPIE. He has been a Guest Editor for two special issues and a prior special section for the IEEE TRANSACTIONS ON CIRCUITS AND SYSTEMS FOR VIDEO TECHNOLOGY.

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Dr. Wiegand was the Co-Chair of the JVT in December 2001. He was an editor of the H.264/MPEG-4 AVC video coding standard and its extensions in February 2002. From 2005 to 2009, he was the Co-Chair of the MPEG video. He has received the IEEE Masaru Ibuka Consumer Electronics Award, the Karl Heinz Beckurts Award, the Eduard Rhein Technology Award, the EURASIP Group Technical Achievement Award, the Innovations Award of the Vodafone Foundation, the Fraunhofer Award, and several Best Paper Awards. The projects that he co-chaired for development of the H.264/MPEG-4 AVC standard have been recognized by the ATAS Primetime Emmy Engineering Award and by a pair of NATAS Technology and Engineering Emmy Awards. He was an Associate Editor for the IEEE TRANSACTIONS ON CIRCUITS AND SYSTEMS FOR VIDEO TECHNOLOGY from 2006 to 2010, and was a Guest Editor for two of its special issues and a prior special section.