

# High Efficiency Video Coding

**Ochoa Dominguez, Humberto,Rao, Kamisetty R.**

**High Efficiency Video Coding and Other Emerging Standards** K.R. Rao,J.J. Hwang,D. N. Kim,2017-07-21 High Efficiency Video Coding and Other Emerging Standards provides an overview of high efficiency video coding (HEVC) and all its extensions and profiles. There are nearly 300 projects and problems included, and about 400 references related to HEVC alone. Next generation video coding (NGVC) beyond HEVC is also described. Other video coding standards such as AVS2, DAALA, THOR, VP9 (Google), DIRAC, VC1, and AV1 are addressed, and image coding standards such as JPEG, JPEG-LS, JPEG2000, JPEG XR, JPEG XS, JPEG XT and JPEG-Pleno are also listed. Understanding of these standards and their implementation is facilitated by overview papers, standards documents, reference software, software manuals, test sequences, source codes, tutorials, keynote speakers, panel discussions, reflector and ftp/web sites - all in the public domain. Access to these categories is also provided.

High Efficiency Video Coding (HEVC) Vivienne Sze,Madhukar Budagavi,Gary J. Sullivan,2014-08-23 This book provides developers, engineers, researchers and students with detailed knowledge about the High Efficiency Video Coding (HEVC) standard. HEVC is the successor to the widely successful H.264/AVC video compression standard, and it provides around twice as much compression as H.264/AVC for the same level of quality. The applications for HEVC will not only cover the space of the well-known current uses and capabilities of digital video - they will also include the deployment of new services and the delivery of enhanced video quality, such as ultra-high-definition television (UHDTV) and video with higher dynamic range, wider range of representable color, and greater representation precision than what is typically found today. HEVC is the next major generation of video coding design - a flexible, reliable and robust solution that will support the next decade of video applications and ease the burden of video on world-wide network traffic. This book provides a detailed explanation of the various parts of the standard, insight into how it was developed, and in-depth discussion of algorithms and architectures for its implementation.

**High Efficiency Video Coding** Mathias Wien,2014-09-29 The video coding standard High Efficiency Video Coding (HEVC) targets at improved compression performance for video resolutions of HD and beyond, providing Ultra HD video at similar compressed bit rates as for HD video encoded with the well-established video coding standard H.264/AVC. Based on known concepts, new coding structures and improved coding tools have been developed and specified in HEVC. The standard

is expected to be taken up easily by established industry as well as new endeavors, answering the needs of today's connected and ever-evolving online world. This book presents the High Efficiency Video Coding standard and explains it in a clear and coherent language. It provides a comprehensive and consistently written description, all of a piece. The book targets at both, newbies to video coding as well as experts in the field. While providing sections with introductory text for the beginner, it suits as a well-arranged reference book for the expert. The book provides a comprehensive reference for the technical details of the employed coding tools; it further outlines the algorithmic advances compared to H.264/AVC. In addition to the technical aspects, the book provides insight to the general concepts of standardization, how specification text is written, and how these concepts apply to the HEVC specification.

Coding Video Iain E. Richardson, 2024-08-28 A fully up-to-date guide to transformative consumer technologies Video compression – or video coding – has been at the centre of a revolution in the way video is produced, delivered, and consumed. It has made the switch from analogue to digital video possible and has enabled fundamental shifts in the way we now watch video. New video compression standards, together with adaptive streaming protocols, are used to deliver high-quality video to homes and workplaces around the world. Coding Video provides a practical and comprehensive guide to the new landscape of video coding and video streaming. This book explains the core technologies with a wealth of practical examples and illustrations, covers key standards such as H.265/HEVC and includes an introduction to the new H.266/VVC standard. Coding Video will appeal to engineers, application developers, product designers and digital video professionals, as well as to graduate students and researchers in Engineering, Computer Science and related subjects.

High Efficiency Video Coding and Other Emerging Standards K.R. Rao, J.J. Hwang, D.N. Kim, 2022-09-01 High Efficiency Video Coding and Other Emerging Standards provides an overview of high efficiency video coding (HEVC) and all its extensions and profiles. There are nearly 300 projects and problems included, and about 400 references related to HEVC alone. Next generation video coding (NGVC) beyond HEVC is also described. Other video coding standards such as AVS2, DAALA, THOR, VP9 (Google), DIRAC, VC1, and AV1 are addressed, and image coding standards such as JPEG, JPEG-LS, JPEG2000, JPEG XR, JPEG XS, JPEG XT and JPEG-Pleno are also listed. Understanding of these standards and their implementation is facilitated by overview papers, standards documents, reference software, software manuals, test sequences, source codes, tutorials, keynote speakers, panel discussions, reflector and ftp/web sites – all in the public domain. Access to these categories is also provided.

**Complexity-Aware High Efficiency Video Coding** Guilherme Corrêa, Pedro Assunção, Luciano Agostini, Luis A. da Silva Cruz, 2015-12-29 This book discusses computational complexity of High Efficiency Video Coding (HEVC) encoders with coverage extending from the analysis of HEVC compression efficiency and computational complexity to the reduction and scaling of its encoding complexity. After an introduction to the topic and a review of the state-of-the-art research in the field,

the authors provide a detailed analysis of the HEVC encoding tools compression efficiency and computational complexity. Readers will benefit from a set of algorithms for scaling the computational complexity of HEVC encoders, all of which take advantage from the flexibility of the frame partitioning structures allowed by the standard. The authors also provide a set of early termination methods based on data mining and machine learning techniques, which are able to reduce the computational complexity required to find the best frame partitioning structures. The applicability of the proposed methods is finally exemplified with an encoding time control system that employs the best complexity reduction and scaling methods presented throughout the book. The methods presented in this book are especially useful in power-constrained, portable multimedia devices to reduce energy consumption and to extend battery life. They can also be applied to portable and non-portable multimedia devices operating in real time with limited computational resources.

**Versatile Video Coding: Latest Advances in Video Coding Standards** Ochoa Dominguez, Humberto, Rao, Kamisetty R., 2019-03-08 Video is the main driver of bandwidth use, accounting for over 80 per cent of consumer Internet traffic. Video compression is a critical component of many of the available multimedia applications, it is necessary for storage or transmission of digital video over today's band-limited networks. The majority of this video is coded using international standards developed in collaboration with ITU-T Study Group and MPEG. The MPEG family of video coding standards begun on the early 1990s with MPEG-1, developed for video and audio storage on CD-ROMs, with support for progressive video. MPEG-2 was standardized in 1995 for applications of video on DVD, standard and high definition television, with support for interlaced and progressive video. MPEG-4 part 2, also known as MPEG-2 video, was standardized in 1999 for applications of low-bit rate multimedia on mobile platforms and the Internet, with the support of object-based or content based coding by modeling the scene as background and foreground. Since MPEG-1, the main video coding standards were based on the so-called macroblocks. However, research groups continued the work beyond the traditional video coding architectures and found that macroblocks could limit the performance of the compression when using high-resolution video. Therefore, in 2013 the high efficiency video coding (HEVC) also known as H.265, was released, with a structure similar to H.264/AVC but using coding units with more flexible partitions than the traditional macroblocks. HEVC has greater flexibility in prediction modes and transform block sizes, also it has a more sophisticated interpolation and deblocking filters. In 2006 the VC-1 was released. VC-1 is a video codec implemented by Microsoft and the Microsoft Windows Media Video (WMV) 9 and standardized by the Society of Motion Picture and Television Engineers (SMPTE). In 2017 the Joint Video Experts Team (JVET) released a call for proposals for a new video coding standard initially called Beyond the HEVC, Future Video Coding (FVC) or known as Versatile Video Coding (VVC). VVC is being built on top of HEVC for application on Standard Dynamic Range (SDR), High Dynamic Range (HDR) and 360° Video. The VVC is planned to be finalized by 2020. This book presents the new VVC, and updates on the HEVC. The book discusses the advances in lossless coding and covers the topic of screen

content coding. Technical topics discussed include: Beyond the High Efficiency Video CodingHigh Efficiency Video Coding encoderScreen contentLossless and visually lossless coding algorithmsFast coding algorithmsVisual quality assessmentOther screen content coding algorithmsOverview of JPEG Series

High Efficiency Video Coding (HEVC) Based Screen Content Coding Hong Zhang,2013

High Efficiency Video Coding (HEVC) Tools for Next Generation Video Content Yanxiang Wang,2016

Next-Generation Video Coding and Streaming Benny Bing,2015-08-28 Reviews the new High Efficiency Video Coding (HEVC) standard and advancements in adaptive streaming technologies for use in broadband networks and the Internet This book describes next-generation video coding and streaming technologies with a comparative assessment of the strengths and weaknesses. Specific emphasis is placed on the H.265/HEVC video coding standard and adaptive bit rate video streaming. In addition to evaluating the impact of different types of video content and powerful feature sets on HEVC coding efficiency, the text provides an in-depth study on the practical performance of popular adaptive streaming platforms and useful tips for streaming optimization. Readers will learn of new over-the-top (OTT) online TV advancements, the direction of the broadband telecommunications industry, and the latest developments that will help keep implementation costs down and maximize return on infrastructure investment. Reviews the emerging High Efficiency Video Coding (HEVC) standard and compares its coding performance with the MPEG-4 Advanced Video Coding (AVC) and MPEG-2 standards Provides invaluable insights into the intra and inter coding efficiencies of HEVC, such as the impact of hierarchical block partitioning and new prediction modes Evaluates the performance of the Apple and Microsoft adaptive streaming platforms and presents innovative techniques related to aggregate stream bandwidth prediction, duplicate chunk Includes end-of-chapter homework problems and access to instructor slides Next-Generation Video Coding and Streaming is written for students, researchers, and industry professionals working in the field of video communications. Benny Bing has worked in academia for over 20 years. He has published over 80 research papers and 12 books, and has 6 video patents licensed to industry. He has served as a technical editor for several IEEE journals and an IEEE Communications Society Distinguished lecturer. He also received the National Association of Broadcasters (NAB) Technology Innovation Award for demonstrations of advanced media technologies.

**Video coding standards** K.R. Rao,Do Nyeon Kim,Jae Jeong Hwang,2013-10-07 The requirements for multimedia (especially video and audio) communications increase rapidly in the last two decades in broad areas such as television, entertainment, interactive services, telecommunications, conference, medicine, security, business, traffic, defense and banking. Video and audio coding standards play most important roles in multimedia communications. In order to meet these requirements, series of video and audio coding standards have been developed such as MPEG-2, MPEG-4, MPEG-21 for audio and video by ISO/IEC, H.26x for video and G.72x for audio by ITU-T, Video Coder 1 (VC-1) for video by the Society of Motion

Picture and Television Engineers (SMPTE) and RealVideo (RV) 9 for video by Real Networks. AVS China is the abbreviation for Audio Video Coding Standard of China. This new standard includes four main technical areas, which are systems, video, audio and digital copyright management (DRM), and some supporting documents such as consistency verification. The second part of the standard known as AVS1-P2 (Video - Jizhun) was approved as the national standard of China in 2006, and several final drafts of the standard have been completed, including AVS1-P1 (System - Broadcast), AVS1-P2 (Video - Zengqiang), AVS1-P3 (Audio - Double track), AVS1-P3 (Audio - 5.1), AVS1-P7 (Mobile Video), AVS-S-P2 (Video) and AVS-S-P3 (Audio). AVS China provides a technical solution for many applications such as digital broadcasting (SDTV and HDTV), high-density storage media, Internet streaming media, and will be used in the domestic IPTV, satellite and possibly the cable TV market. Comparing with other coding standards such as H.264 AVC, the advantages of AVS video standard include similar performance, lower complexity, lower implementation cost and licensing fees. This standard has attracted great deal of attention from industries related to television, multimedia communications and even chip manufacturing from around the world. Also many well known companies have joined the AVS Group to be Full Members or Observing Members. The 163 members of AVS Group include Texas Instruments (TI) Co., Agilent Technologies Co. Ltd., Envivio Inc., NDS, Philips Research East Asia, Aisino Corporation, LG, Alcatel Shanghai Bell Co. Ltd., Nokia (China) Investment (NCIC) Co. Ltd., Sony (China) Ltd., and Toshiba (China) Co. Ltd. as well as some high level universities in China. Thus there is a pressing need from the instructors, students, and engineers for a book dealing with the topic of AVS China and its performance comparisons with similar standards such as H.264, VC-1 and RV-9.

*Circuit Implementations for High-efficiency Video Coding Tools* Mehul Deepak Tikekar, Massachusetts Institute of Technology. Department of Electrical Engineering and Computer Science, 2012 High-Efficiency Video Coding (HEVC) is planned to be the successor video standard to the popular Advanced Video Coding (H.264/AVC) with a targeted 2x improvement in compression at the same quality. This improvement comes at the cost of increased complexity through the addition of new coding tools and increased computation in existing tools. The ever-increasing demand for higher resolution video further adds to the computation cost. In this work, digital circuits for two HEVC tools - inverse transform and deblocking filter are implemented to support Quad-Full HD (4K x 2K) video decoding at 30fps. Techniques to reduce power and area cost are investigated and synthesis results in 40nm CMOS technology and Virtex-6 FPGA platform are presented.

*High Efficiency Video Coding Processor with Residue Number System* Niras Cheeckottu Vayalil, 2017 The recent demand for high density video, such as ultra high definition (UHD) as well as its distribution over wired and wireless networks, led to the proposal of the latest video encoding standard, high efficiency video coding (HEVC/H.265), by the joint collaborative team on video coding (JCT-VC). HEVC/H.265 achieves a significantly better compression than its predecessor, advanced video coding (AVC/H.264), by roughly 50% for an equivalent visual reproduction quality. However, the improved

compression efficiency comes with a drawback, the computational complexity. Since HEVC/H.265 encoding involves enormous computations, a hardware implementation of the encoder is necessary for real-time encoding, in particular for UHD video. The most computationally intensive task in video encoding is motion estimation, which comprises up to 80% of the total time for video encoding. There have been several suggestions for motion-estimation algorithms for reducing the complexity, but many proposed for AVC/H.264 are no longer suitable for HEVC/H.265 due to the underlying coding changes and other complications. Hence, this re- search offers different algorithms and architectures for motion estimation, providing a trade-off between implementation cost and performance. Hardware design is proposed for a full-search motion-estimation algorithm which always comes up with the best results. The memory requirement is reduced to a large extent together with the data bandwidth demand. Another important aspect of real-time video compression, including motion estimation, is the delay of the arithmetic computations. Residue number systems have been used for decades for improving arithmetical operations performance. However, the non-positional nature of an RNS makes it difficult to do some mathematical operations such as sign detection, but it is a vital component for designing motion estimation and other elements of a video processor. The dissertation presents a fast algorithm and its architecture for sign detection, which decreases the area-delay product by 24% compared to designs in the literature. Since the full-search algorithm searches every possible location in a search area, the algorithm involves much computation, therefore fast-search methods are preferred for low-cost solutions. The test zone (TZ) search is a fast-search algorithm and is widely used for HEVC/H.265 as it provides near optimal performance. In this dissertation, a TZ-search hardware architecture is presented, which shows 51% less gate count than existing proposals in the literature and considerably fewer memory requirements than most. Further improvement is achieved by developing a fast-search algorithm appropriate for hardware designs, providing an area-efficient, real-time UHD video-encoding-capable design without degradation in quality from the TZ search in HEVC reference software. An angle-restricted test zone (ARTZ) search motion estimation is also proposed for software applications exploiting directional probabilities of the search, saving about 17% to 55% of time for motion estimation compared to the TZ search. The discrete cosine transform (DCT) is a standard method in several previous codecs and it is also a key factor for compression techniques in HEVC/H.265. A variable-length two-dimensional design is proposed for HEVC/H.265, where the architecture is optimised for the most likely block sizes in UHD video, thus eliminating unnecessary complexities found in many designs, and accomplishing more than 60% savings in hardware.

*Evaluation of Coding Tools for Screen Content in High Efficiency Video Coding* Shwetha Chandrakant Kodpadi, 2016 High Efficiency Video Coding (HEVC) [1] is the latest Video Coding Standard. It challenges the state-of-the-art H.264/AVC [3] Video Coding standard which is in current use in the industry by being able to reduce the bit rate by 50% and retaining the same video quality. It came into existence in the early 2013 although Joint Collaborative Team on Video Coding (JCT-VC) was

formed in January 2001 to carry out developments on HEVC, and ever since then a huge range of developments has been going on. On 13 April 2013 [11], HEVC standard also called H.265 was approved by ITU-T, Joint Collaborative Team on Video Coding (JCTVC), a group of video coding experts from ITU-T Study Group (VCEG) and ISO/IEC JTC 1/SC 29/WG 11 (MPEG). Coding of screen content video is becoming important because of applications such as wireless displays, graphics, remote desktop, remote gaming, automotive infotainment, cloud computing, distance education etc. Video in these applications often has mixed content consisting of natural video, text and graphics in the same picture. Coding of screen content, very high bit-rate and lossless coding, coding of auxiliary pictures (e.g., alpha transparency planes), and direct coding of RGB source content were included in HEVC Range Extensions (RExt) [20] and focused in HEVC SCC Extension. As part of this thesis, SCM test model 5 is used as the latest Screen content model. Different coding tools and non-normative algorithms for screen content coding in HEVC Version1, HEVC-RExt and HEVC-SCC are explained in detail. Coding efficiency of the main Screen content coding tools, Intra block Copy (IBC), Palette mode (PM), Adaptive Colour Transform (ACT) are evaluated using SCM5.2. Further, the coding efficiency of HEVC16.6+SCM5.2 is evaluated against HEVC16.4+RExt and state of the art H.264/AVC. SCM with IBC gives bitrate savings from 5%-45%, SCM with PM gives 14-67 % and SCM with ACT gives 0.001% to 0.0038 % compared to SCM without IBC, without PM and without ACT, respectively. Also, SCM is evaluated against JM19.0 and HEVC-RExt. It can be seen that SCM gives bitrate saving of about 45% - 83% compared to HEVC+RExt under lossless condition and 23%-87% compared to JM19.0 (AVC) under lossless condition. Under lossy condition, SCM gives 57%-81% BD-bitrate savings compared to HEVC+RExt and 62%-88% BD-bitrate savings compared to JM19.0.

### **Rate Control Algorithm for High Efficiency Video Coding (HEVC) Lin Sun,2012**

*Homogeneous Transcoding of HEVC* Ninad Gorey,2017 Video transcoding is an essential tool to promote inter-operability between different video communication systems. This thesis presents a cascaded architecture for homogeneous transcoding of High Efficiency Video Coding. Cascaded Transcoding model decodes the input video sequence and follows the procedure of reference encoder, with the difference being a higher QP value. The encoder will code the sequence with the goal of achieving highest coding performance, and since the encoder is not restricted by any means, it is reasonable to assume that the coding performance is the best possible transcoding performance. H.265 is the latest video coding standard which supports encoding videos with wide range of resolutions, starting from low resolution to beyond High Definition i.e. 4k or 8k. H.265 also known as HEVC was preceded by H.264/AVC which is a very well established and widely used standard in industry and finds its applications in broadcast and multimedia telephony. HEVC achieves high coding efficiency at the cost of increased complexity and not all devices have complex hardware capable enough to process the HEVC bit stream. So, to enable HEVC content playing capabilities on heterogeneous device platforms homogeneous transcoding of HEVC is necessary. Different transcoding architectures are investigated and architecture with optimum performance is implemented

and studied as part of this research. The architecture is implemented using existing reference software of H.265. Different quality metrics (PSNR, Bitrate, Bitrate Ratio, Transcoding time) are measured for the proposed scheme using different test sequences and conclusions are drawn based on these results.

**A Memory-Efficient I-Frame Decoder for High Efficiency Video Coding (H.265/HEVC)** Chen-Yi Lee, Chia-Lin Liu, 2013

Fast Mode Decision Algorithms for High Efficiency Video Coding (HEVC) and Image Matting Yongfang Shi, 2013

*Video Over Wireless* Benny Bing, 2015-12-03 Publisher's Note: Products purchased from Third Party sellers are not guaranteed by the publisher for quality, authenticity, or access to any online entitlements included with the product. State-of-the-art wireless video standards, techniques, and best practices This fully illustrated guide teaches the latest methods for effectively delivering and consuming high-quality mobile Internet video content on cross-platform personal devices. Video Over Wireless features clear and concise explanations of next-generation technologies, including over-the-top TV, wireless broadband, and video streaming and aggregation. Experienced educator and author Benny Bing offers expert insights on emerging standards as well as invaluable tips for maximizing coding efficiency and enhancing error resiliency. Video Over Wireless covers: Pay, digital, and online TV Internet-based mobile video Media clouds and cloud support for mobile apps Non-real-time TV delivery 802.11ac and 4G/5G LTE standards Wi-Fi deployments and applications Key issues in wireless transmission Single-antenna design for handheld devices Mobile digital TV and ATSC 2.0/3.0 Video traffic smoothing and multiplexing Apple and Microsoft adaptive bit rate streaming Spatial and temporal error concealment WebM, H.264/MPEG-4 AVC, and H.265/HEVC Video coding enhancements and the impact of different content types

*Digital Video Processing* A. Murat Tekalp, 2015-06-06 Over the years, thousands of engineering students and professionals relied on Digital Video Processing as the definitive, in-depth guide to digital image and video processing technology. Now, Dr. A. Murat Tekalp has completely revamped the first edition to reflect today's technologies, techniques, algorithms, and trends. Digital Video Processing, Second Edition, reflects important advances in image processing, computer vision, and video compression, including new applications such as digital cinema, ultra-high-resolution video, and 3D video. This edition offers rigorous, comprehensive, balanced, and quantitative coverage of image filtering, motion estimation, tracking, segmentation, video filtering, and compression. Now organized and presented as a true tutorial, it contains updated problem sets and new MATLAB projects in every chapter. Coverage includes Multi-dimensional signals/systems: transforms, sampling, and lattice conversion Digital images and video: human vision, analog/digital video, and video quality Image filtering: gradient estimation, edge detection, scaling, multi-resolution representations, enhancement, de-noising, and restoration Motion estimation: image formation; motion models; differential, matching, optimization, and transform-domain methods; and 3D motion and shape estimation Video segmentation: color and motion segmentation, change detection, shot

boundary detection, video matting, video tracking, and performance evaluation Multi-frame filtering: motion-compensated filtering, multi-frame standards conversion, multi-frame noise filtering, restoration, and super-resolution Image compression: lossless compression, JPEG, wavelets, and JPEG2000 Video compression: early standards, ITU-T H.264/MPEG-4 AVC, HEVC, Scalable Video Compression, and stereo/multi-view approaches

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### High Efficiency Video Coding Introduction

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