Integrated Circuits and Systems

Vivienne Sze
Madhukar Budagavi
Gary J. Sullivan *Editors*

High Efficiency Video Coding (HEVC)

Algorithms and Architectures

Springer

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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 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 **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 and 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 de blocking filters In 2006 the VC 1 was released VC 1 is a video codec implemented by Microsoft and the Microsoft Windows Media Video VMW 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 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 How ever 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 pro viding 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 consider ably 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 **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 todays 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

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 Algorithms, Architectures and Circuits for Low Power HEVC Codecs Chiraag Juvekar,Massachusetts Institute of Technology. Department of Electrical Engineering and Computer Science,2014 In order to satisfy the demand for high quality video streaming aggressive compression is necessary High Efficiency Video Coding HEVC is a new standard that has been designed with the goal of satisfying this need in the coming decade For a given quality of video HEVC offers 2x better compression than existing standards However this compression comes at the cost of a commensurate increase in complexity Our work aims to control this complexity in the context of real time hardware video codecs Our work focused on two specific areas Motion Compensation Bandwidth and Intra Estimation HEVC uses larger filters for motion compensation leading to a significant increase in decoder bandwidth We present a novel motion compensation cache that reduces external memory bandwidth by 67% and power by 40% The use of large variable sized coding units and new prediction modes results in a dramatic increase in the search space of a video encoder We present novel intra estimation algorithms that substantially reduce encoder complexity with a modest 6% increase in BD rate These algorithms are co designed with the hardware architecture allowing us to implement them within reasonable hardware constraints **Rate Control Algorithm for High Efficiency Video Coding (HEVC)** Lin Sun,2012 *Fast Intra/ Inter Mode Decision Algorithms for High Efficiency Video Coding (HEVC)* Junaid Tariq,2016 Advanced Video Coding for Next-Generation Multimedia Services Yo-Sung Ho,2013-01-09 This book aims to bring together recent advances and applications of video coding All chapters can be useful for researchers engineers graduate and postgraduate students experts in this area and hopefully also for people who are generally interested in video coding The book includes nine carefully selected chapters The chapters deal with advanced compression techniques for multimedia applications concerning recent video coding standards high efficiency video coding HEVC multiple description coding region of interest ROI coding shape compensation error resilient algorithms for H 264 AVC wavelet based coding facial video coding and hardware implementations This book provides several useful ideas for your own research and helps to bridge the gap between the basic video coding techniques and practical multimedia applications We hope this book is enjoyable to read and will further contribute to video coding **Algorithms and Hardware Co-design of HEVC Intra Encoders** Yuanzhi Zhang,2019 Digital video is becoming extremely important nowadays and its importance has greatly

increased in the last two decades Due to the rapid development of information and communication technologies the demand for Ultra High Definition UHD video applications is becoming stronger However the most prevalent video compression standard H 264 AVC released in 2003 is inefficient when it comes to UHD videos The increasing desire for superior compression efficiency to H 264 AVC leads to the standardization of High Efficiency Video Coding HEVC Compared with the H 264 AVC standard HEVC offers a double compression ratio at the same level of video quality or substantial improvement of video quality at the same video bitrate Yet HE VC H 265 possesses superior compression efficiency its complexity is several times more than H 264 AVC impeding its high throughput implementation Currently most of the researchers have focused merely on algorithm level adaptations of HEVC H 265 standard to reduce computational intensity without considering the hardware feasibility What s more the exploration of efficient hardware architecture design is not exhaustive Only a few research works have been conducted to explore efficient hardware architectures of HEVC H 265 standard In this dissertation we investigate efficient algorithm adaptations and hardware architecture design of HEVC intra encoders We also explore the deep learning approach in mode prediction From the algorithm point of view we propose three efficient hardware oriented algorithm adaptations including mode reduction fast coding unit CU cost estimation and group based CABAC context adaptive binary arithmetic coding rate estimation Mode reduction aims to reduce mode candidates of each prediction unit PU in the rate distortion optimization RDO process which is both computation intensive and time consuming Fast CU cost estimation is applied to reduce the complexity in rate distortion RD calculation of each CU Group based CABAC rate estimation is proposed to parallelize syntax elements processing to greatly improve rate estimation throughput From the hardware design perspective a fully parallel hardware architecture of HEVC intra encoder is developed to sustain UHD video compression at 4K 30fps The fully parallel architecture introduces four prediction engines PE and each PE performs the full cycle of mode prediction transform quantization inverse quantization inverse transform reconstruction rate distortion estimation independently PU blocks with different PU sizes will be processed by the different prediction engines PE simultaneously Also an efficient hardware implementation of a group based CABAC rate estimator is incorporated into the proposed HEVC intra encoder for accurate and high throughput rate estimation To take advantage of the deep learning approach we also propose a fully connected layer based neural network FCLNN mode preselection scheme to reduce the number of RDO modes of luma prediction blocks All angular prediction modes are classified into 7 prediction groups Each group contains 3 5 prediction modes that exhibit a similar prediction angle A rough angle detection algorithm is designed to determine the prediction direction of the current block then a small scale FCLNN is exploited to refine the mode prediction

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

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 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 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 3D Video Coding for Embedded Devices Bruno Zatt,Muhammad Shafique,Sergio Bampi,Jörg Henkel,2014-07-08 This book shows readers how to develop energy efficient algorithms and hardware architectures to enable high definition 3D video coding on resource constrained embedded devices Users of the Multiview Video Coding MVC standard face the challenge of exploiting its 3D video specific coding tools for increasing compression efficiency at the cost of increasing computational complexity and consequently the energy consumption This book enables readers to reduce the multiview video coding energy consumption through jointly considering the algorithmic and architectural levels Coverage includes an introduction to 3D videos and an extensive discussion of the current state of the art of 3D video coding as well as energy efficient algorithms for

3D video coding and energy efficient hardware architecture for 3D video coding **Reducing the Compexity of Inter-prediction Mode Decision for High Effeciency Video Codec** Kushal Shah,ProQuest Dissertations and Theses (Electronic resource collection),2014 The High Efficiency Video Coding HEVC standard is the latest joint video project of the International Telecommunication Unit ITU T Video Coding Experts Group VCEG and the ISO IEC Moving Picture Experts Group MPEG standardization organizations working together in a partnership known as the Joint Collaborative Team on Video Coding JCT VC While the HEVC is based on the same architecture of the widely used H 264 AVC Advance Video Coding standard 8 it includes many new coding tools and almost all the encoder blocks are optimized with respect to their counterparts in the H 264 AVC standard This allows the new standard to achieve up to 50% bitrate reduction compared to its predecessor with the same visual quality at the cost of increased complexity 1 Like H 264 AVC mode decisions with Motion Estimation ME remain among the most time consuming computations in HEVC In an inter prediction mode decision a fullsearch algorithm searches for every possible block size and refines the results from integer pel to quarter pel resolution Thus a full search algorithm guarantees the highest level of compression performance However the considerable computational complexity for a mode decision decreases the encoding speed In this thesis a fast adaptive termination 20 algorithm is proposed that terminates early the mode decision in inter prediction for HEVC Based on Rate Distortion RD cost all the inter prediction modes are classified as skip or non skip modes and to select the best mode minimum RD cost of these two modes are predicted For skip mode the mode decision is predicted in early stage while in non skip mode different stages are proposed to speed up the mode decision Experimental results based on several video test sequences suggest a decrease of about 25% 40% in encoding time is achieved with implementation of the Fast Adaptive Termination algorithm for interprediction mode decision with negligible degradation in peak signal to noise ratio PSNR Metrics such as BD bitrate Bj ntegaard Delta bitrate BD PSNR Bj ntegaard Delta Peak Signal to Noise Ratio SSIM Structural Similarity and computational complexity are also used **Coding Video, Enhanced Edition** Iain E. Richardson,2019-07-19 As new codec technologies emerge opportunities and challenges are created More powerful codecs such as the new High Efficiency Video Coding HEVC format have the potential to enable the delivery of faster better quality and richer media to our homes and handsets At the same time the task of implementing and optimising video coding products increases in complexity The challenge for designers and implementers is further complicated by issues such as interoperability and patent licensing Coding Video will provide a practical and up to date guide to this complex and rapidly changing landscape It will give the reader the necessary context to understand the field and in addition to the technical fundamentals it will cover historical background interoperability and transport and commercial issues such as patents and licensing 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 effieciency 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

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