IRA-International Journal of Technology & Engineering ISSN 2455-4480
Proceedings of the
International Conference on Science & Engineering for Sustainable Development (2017)
Pg. no.352-357
Published by: Institute of Research Advances
https://research-advances.org/index.php/IRAJTE

Review of Fast Mode Decision Algorithms for Intra Prediction in High Efficiency Video Coding Standard

Umesh W. Kaware[*1], Sanjay M. Gulhane[2]

[1,2] Department of Electronics & Telecommunication Engineering
Jawaharlal Darda Institute of Engg. & Technology, Yavatmal (India)
E-mail : umeshkaw@rediffmail.com, E-mail : smgulhane67@rediffmail.com

Type of Review: Peer Reviewed under the responsibility of the Scientific Committee of the Conference and The Institution of Engineers (India).
DOI: http://dx.doi.org/10.21013/jte.ICSESD201733

How to cite this paper:
Kaware, U., Gulhane, S. (2017). Review of Fast Mode Decision Algorithms for Intra Prediction in High Efficiency Video Coding Standard. *Proceedings of the International Conference on Science & Engineering for Sustainable Development (2017)*, 352-357. doi: http://dx.doi.org/10.21013/jte.ICSESD201733

ABSTRACT

The emerging High Efficiency Video Coding (HEVC) standard is a new improved next generation video coding standard. HEVC aims to provide improved compression performance as compared to all other video coding standards. To improve the coding efficiency a number of new techniques have been used. The higher compression efficiency is obtained at the cost of an increase in the computational load. In HEVC 35 modes are provided for intra prediction to improve the compression efficiency. The best mode is selected by Rate Distortion Optimization (RDO) process. It achieves significant improvement in coding efficiency compared with previous standards. However, this causes high encoding complexity. This paper discuss the various fast mode decision algorithms for intra prediction in HEVC.

Keywords: Video Coding, HEVC, Intra Prediction, Mode Decision

INTRODUCTION

V ideo encoding reduces the amount of data required to represent a digital video signal. Digital video takes a large amount of storage or transmission capacity, so video encoding is essential for any application in which storage capacity or transmission bandwidth is constrained. Lossy compression gives higher compression than lossless coding technique. [1].

For digital video compression several international standards have been developed. ITU-T introduced the video compression standard H.261 [2] in 1990 for for videoconferencing and videotelephony applications. Meanwhile, the researchers in ISO/IEC have introduced the first version of the video compression format, MPEG1 in 1992 [3] for multimedia CD-ROM applications with target bit-rate of about 1.5 Mbps In 1994, both ITU-T and ISO/IEC jointly developed MPEG-2 [4] for coding high-quality video at 4 –15 Mb/s for Video On Demand, Digital Broadcast Television and Digital Storage Media. With the advancement in video coding, the ITU-T released H.263 standard in 1995 for very low bit-rate applications such as videoconferencing and video telephony [5]. It provides better picture quality at low bit rates with little additional complexity. In 1998, ISO/IEC developed MPEG-4 standard [6]. Initially, MPEG-4 was aimed primarily at low bit-rate video communications; however, its scope as a multimedia coding standard was later expanded. In 2003, the ITU-T and ISO established a Joint Video Team to develop a new video compression standard. They proposed the H.264 standard , which has also been incorporated into MPEG-4 under the name of Advanced Video Coding (AVC) [7]. The main goals was to double the coding efficiency in comparison to any other existing video coding standards.

Upon these developments Joint Collaborative Team on Video Coding (JCT-VC) developed High Efficiency Video Coding (HEVC). The HEVC standard is designed to focus on two key issues: increased video resolution and increased use of parallel processing architectures.HEVC standard achieves multiple goals, including coding efficiency, ease of transport system integration and data loss resilience, as well as implementability using parallel processing architecture [8]. The HEVC standard improve compression performance relative to existing standards in the range of 50% bit rate reduction for equal perceptual video quality. The key contributor for this improvement is the new intra prediction method that supports a large number of prediction directions.

There are two types of prediction: intra prediction and inter prediction. In Intra Prediction there exists high similarity among neighboring blocks in a video frame. Consequently, a block can be predicted from its neighboring pixels of already coded and reconstructed blocks. It exploits the spatial correlation between the adjacent blocks to reduce spatial redundancies within a picture. The improvement in coding efficiency of HEVC comes from the newly introduced recursive

quad-tree based coding unit split from 64*64 to 8*8. There are 35 prediction modes in HEVC, one planer mode, one DC mode and 33 angular modes [9]. The increased number of spatial intra prediction modes leads to much higher compression efficiency, while requiring tremendous computational power using the expensive rate distortion optimization (RDO) to search best mode. The various researchers addressed the issue of reducing the computational complexity and proposed various fast mode decision algorithms for intra prediction. Improvement in coding complexity is being achieved at the cost of degradation in PSNR and increase in bitrate. Therefore, the development of fast mode decision algorithm for intra prediction is one of the most challenging theme.

LITERATURE REVIEW

HEVC standard has shown better coding performance than the existing video coding standards. It supports a wide range of prediction options for intra prediction. The RDO technique for maximizing coding quality and minimizing the bit rate is employed in HEVC to achieve the best coding result but it exhibits extremely high computational complexity. To reduce the computation of the mode decision for intra prediction various authors have made efforts to reduce down the computational complexity with a relative loss of coding efficiency.
The algorithms proposed in references [10] utilize the edge or directional information. Authors, Thaisa L.da Silva et. al. in [e] proposed a fast mode decision algorithm for HEVC intra prediction based on edge direction information. This algorithm reduces the number of modes that have to be evaluated in intra predictionn and makes the HEVC intra prediction decision mode computationally more efficient. This algorithm evaluates the edges direction present in the prediction unit to be predicted, categorizing these edges in five types; four directional, horizontal, vertical and two diagonals and one non-directional edge. This mode decision scheme decreases intra prediction processing time of up to 32.08% with little increase in bitrate. H.Lei et. al. in [11] proposed algorithm which calculates firstly the texture complexity of coding unit and set the rational threshold to select the size of coding unit fast; then a modified search process is used to decrease the number of candidate modes of prediction and finally early termination for rate distortion optimized quantization is used for intra prediction. The proposed algorithm reduces 40.9% encoding time while suffering from negligible on bit rate performance and negligible average PSNR loss.

Reference [12] presented a fast intra mode decision algorithm consists of both micro and macro level schemes. At the micro-level, the Hadamard costbased progressive rough mode search (pRMS) is proposed to selectively check the potential modes instead of traversing all candidates (i.e., up to 35 in HEVC). Fewer effective candidates will be chosen by the pRMS for the subsequent rate-distortion optimized quantization (RDOQ) to derive the rate-distortion (R-D) optimal mode. An early RDOQ skip method is also introduced to further the complexity reduction. At the macrolevel, the early coding unit (CU) split termination is introduced if the estimated R-D cost [through aggregated R-D costs of (partial) sub-CUs] is already larger than the R-D cost of the current CU. On average, the proposed fast intra mode decision provides about 2.5× speedup with just a 1.0% Bjontegaard delta rate (BD-rate) increase using the HEVC common test condition. M. R. Fini et. al. in [13] proposed a method to reduce the number of modes that have to be tested in intra prediction process. This algorithm includes two phases. Phase I uses only 19 modes in Rough Mode Decision (RMD) step instead of 35 modes. Phase II reduces the number of selected modes in the previous stage based on angular directions.This approach reduces 14.2% encoding time. In reference [14] authors proposed a fast intra prediction mode decision algorithm based on the probability statistics of the best prediction mode and relevance of the neighboring blocks. The proposed algorithm reduces the encoding time by 30.18% with neglible loss of PSNR and 1.97% increase in bit rate. Reference [15] proposed a

fast intra prediction mode decision algorithm to reduce the intra encoding complexity. According to different size of prediction unit, based on statistical data, the algorithm uses threshold method to exclude the intra prediction modes of small possibility, then reduce the number of intra prediction modes for the rate distortion cost (RD Cost) calculation and cut down the encoding complexity. The proposed algorithm achieves a reduction of 24.27% in average in intra prediction coding time, with a negligible average PSNR loss and average bit rate increment.

In reference [16], authors exploit the spatial correlation to adopt edge detection method which establish an edge map and adaptively select the candidate modes using the edge map for a block. The number of the candidate modes is determined through trade-off between computational complexity and coding efficiency. The proposed method reduced the encoding time by 56.8% at the cost of 2.5% BD-BR increase on average compared to full modes at the HEVC reference software. In [17], W. Xiang et. al. proposed a novel fast intra mode decision algorithm by using the texture characteristics of the current prediction unit and the similarity between neighboring PUs. The proposed rough and refine decision schemes are utilized to reduce the number of candidate prediction modes required for checking to save computational copmplexity. The proposed algorithm reduces 25% computational complexity with negligible loss of coding efficiency. Reference [18] presents a fast intra-encoding algorithm for HEVC, which is composed of the four techniques. Firstly, an early termination technique for coding unit (CU) depth decision is proposed based on the depth of neighboring CUs and the comparison results of rate distortion (RD) costs between the parent CU and part of its child CUs. Secondly, the correlation of intra-prediction modes between neighboring PUs is exploited to accelerate the intra-prediction mode decision for HEVC intra-coding and. Thirdly, the TU depth range is restricted based on the probability of each TU depth and one redundant process is removed in the TU depth selection process based on the analysis of the HEVC reference software. Finally, the probability of each case for the intra-transform skip mode is studied to accelerate the intra-transform skip mode decision. Experimental results show that the proposed algorithm can provide about 50% time savings with only 0.5% BD-rate loss on average when compared to HM 11.0 for the Main profile all-intra-configuration.
K. Lim et. al. in [19] proposed a fast PU skip and split termination algorithm. The proposed method consists of three algorithms: early skip, PU skip and PU split termination. The proposed algorithm achieves a saving of 53.52% encoding time. L. Gao et. al.in [20] proposed two fast intra prediction algorithms to reduce the number of candidate modes for rate distortion optimization by obtaining an optimal adjacent modes (OAM) list consisting of dominant directions through the analysis of costs of several general direction modes.Further the most probable mode algorithm is improved to make full use of the spatial correlation between neighbor prediction blocks instead of merging the prediction modes of neighbor prediction blocks into the candidate list. The proposed approach reduce about 27.3% of the encoding time with decrease of coding quality.

LIMITATIONS AND SCOPE

The improvement in coding efficiency of HEVC comes from the newly introduced recursive quad-tree based coding unit split from 64*64 to 8*8. There are 35 prediction modes in HEVC. The increased number of spatial intra prediction modes leads to much higher compression efficiency, while requiring tremendous computational power using the expensive rate distortion optimization (RDO) to search best mode. The researchers in literature proposed various fast mode decision algorithms both for intra prediction in order to reduce down the computational load.

The algorithms proposed in the literature have limitations in coding performance and time consumption. The existing algorithms show the trade-off between the encoding time and the coding performance.

CONCLUSION

In this paper we have discussed various fast mode decision algorithms for intra prediction in HEVC. The improvement in coding complexity is being achieved at the cost of degradation in PSNR and increase in bitrate. The efforts can be made further for improving the intra prediction mode decision algorithm for high efficiency video coding that provides better trade-off between various performance parameters.

REFERENCES

[1] Iain E. Richardson, " The H.264 Advanced Video Compression Standard", *John Wiley and Sons Ltd.*, 2010.

[2] CCITT, "Video Codec for Audiovisual services at p × 64 kbit/s", *CCITT Recommendation H.261*, 1990.

[3] ISO/IEC, "MPEG-1: Information Technology - Coding of Moving Pictures and Associated Audio for Digital Storage Media at up to about 1.5 Mbit/s", *Video*, Geneva, 1993.

[4] ISO/IEC JTC1 and ITU-T, "MPEG-2/H.262: Generic Coding of Moving Pictures and Associated Audio Information - Part 2", *Video*, November 1994.

[5] ITU-T. Video Coding for Low Bit-rate Communication, ITU-T Recommendation H.263, March 1996.

[6] ISO/IEC JTC1/SC29/WG11. MPEG-4 Video Verification Model: Version 18.0,WG11 Document N3908, Pisa, January 2001.

[7] ITU-T and ISO/IEC JTC1. Advanced Video Coding for Generic Audiovisual Services, ITU-T Recommendation H.264 ISO/IEC 14496-10 AVC, 2003.

[8] Gary J. Sullivan, J. R. Ohm, W. J. Han and T. Wiegand, "Overview of the High Efficiency Video Coding (HEVC) Standard", IEEE Transactions on Circuits and Systems for Video Technology, Vol. 22, No. 12, pp. 1649-1667, December 2012.

[9] J. Lainema, F. Bossen, W. J. Han, J. Min and K. Ugur, "Intra Coding of HEVC Standard", IEEE Transactions on Circuits and Systems for Video Technology, Vol. 22, No. 12, pp. 1792-1801, December 2012.

[10] T. L. da Silva, L. V. Agostini and L. A. da Silva, "Fast HEVC Intra Prediction Mode Decision Based on Edge Direction Information", 20th European Signal Processing Conference (EUSIPCO 2012), Bucharest, Romania, August 27-31, 2012, pp. 1214-1218.

[11] H. Lei and Z. Yang, "Fast Intra Prediction Mode Decision for High Efficiency Video Coding", 2nd International Symposium on Computer, Communication, Control and Automation (3CA 2013).

[12] H. Zhang and Z. Ma, "Fast Intra Mode Decision for High Efficiency Video Coding", IEEE

Transactions on Circuits and Systems for Video Technology, Vol. 24, No. 4, pp. 660-668, April 2014 .

[13] M. Fini and F. Z. Asl, "A Fast Intra Mode Decision Method Based on Reduction of the Number of Modes in HEVC Standard", 7th International Symposium on Telecommunications (IST 2014), pp. 839-843.

[14] S. Zhu and D. Zhao, " Fast intra prediction mode decision algorithm for high efficiency video coding", IEEE 9th Conference on Industrial Electronics and Applications (ICIEA 2014), pp. 936-939.

[15] L. Wei, W. Rangding, W. Jiaji, X. Dawen and Xu Jian,"A fast Mode Decision Algorithm for Intra Prediction in HEVC", International Conference on Computer Science and Service System (CSSS 2014), pp. 587-590

[16] S. Na, W. Lee, and K. Yoo, " Edge-Based Fast Mode Decision Algorithm for Intra Prediction in HEVC", IEEE International Conference on Consumer Electronics (ICCE 2014), pp. 11-14.

[17] W. Xiang, C. Cai, Z. Wang, H. Zeng and J. Chen, " Fast Intra Mode Decision for HEVC", 10th International Conference on Signal-Image Technology & Internet-Based Systems, 2014, pp. 283287.

[18] L.Zhao, X. fan, S. Ma and D. Zhao," Fast intra-encoding algorithm for High Efficiency Video Coding",Signal Processing: Image Communication 29 (2014), Elsevier, pp. 935-944.

[19] K. Lim, J. Lee, S. Kim and S. Lee, "Fast PU Skip and Split Termination Algorithm for HEVC Intra Prediction", IEEE Transactions on Circuits and Systems for Video Technology, Vol. 25, No. 8, pp. 1335-1346, August 2015.

[20] L. Gao, S. Dong, W. Wang, R. Wang and W. Gao," Fast Intra Mode Decision Algorithm Based on Refinement in HEVC", IEEE 2017 International Conference, pp. 517-520.