International Journal of Electrical and Electronics Engineers
Vol. No. 9, Issue No. 01, January-June 2017
ISSN (O) 2321-2055
ISSN (P) 2321-2045

A REVIEW ON LOW COMPLEXITY HEVC CODING FOR MOBILE VIDEO COMMUNICATION

Ms. Yogita Rajiv Kaniche[1], Mr.Sukeshkumar P. Borate[2]

[1] PG Scholar, [2] Assistant Professor, Department of Electronics and Telecommunication, SVPM's College Of Engineering Malegaon (Bk.),Maharashtra (India)

ABSTRACT

INTRA video coding is important for high quality mobile video communication and video applications ,it enhances video quality and prevents error propagation. The recent high-efficiency video coding (HEVC) standard has advantages of flexible quad-tree-based block structure and complex angular INTRA prediction to improve the coding efficiency, but these technologies increase the coding complexity, and consumes large hardware resources, computational time and power cost. It is an obstacle for real-time video applications. To reduce the coding complexity and save power cost, we propose a fast INTRA coding unit (CU) depth decision method based on statistical modeling and correlation analyses.

We examine the spatial CU depth correlation with help of different textures and present effective strategies to predict the most probable depth range based on correlation among CUs. Sometimes the spatial correlation may fail for image boundary and transitional areas between textural and smooth areas, we present a statistical model-based CU decision approach.In this approch adaptive early termination thresholds are determined and then updated based on the rate-distortion (RD) cost distribution and quantization parameters (QPs).

Keywords: Coding unit (CU), high-efficiency video coding (HEVC), low complexity, power efficient, spatial correlation.

I. INTRODUCTION

With the development of multimedia technologies and computing technologies, the past few decades have seen a great success of the development of various mobile devices and applications, which significantly eases people's life and industrial manufacturing. Mobile devices such as smart phones, personal digital assistant (PDA), and tablet, getting more popular, it booms broadband mobile Internet access, e.g., 3G and 4G. It automatically arises the demand for mobile video applications,like mobile video communications, remote monitoring, mobile3-D, and mobile TV. Owning to an raising demand for high visual quality, high definition (HD) and ultra HD (UHD) videos become popular.It provides more realistic visual enjoyment and more accurate representation to human eyes. However, the HD/UHD video data volume increases as the increase of video resolution such as (up to 4k × 2k, 8k × 4k) and frame rate (e.g., 60 fps,up to 600 fps for industrial high speed video), These requires a powerful encoder to compress them to reduce the service charge, data traffic, and enhance the service quality.Also coding efficiency, video error resilience and coding complexity shall considered in encoder design[1].. In the mobile video and industrial applications factors like network latency, capabilities, and bandwidth are not stable. These parameters fluctuate due to various environments, capacity of devices, and heterogeneous network conditions etc.[3]. Moreover, the wireless network for video transmission is an error prone channel where the packet loss and bit error may easily occur.[2]. These error data degrade the image quality of the error/lost frame and bring about distortions to successive frames due to INTER prediction and motion compensation, which is called error propagation.These transmission errors cannot be recovered by retransmissions or nondeterministic back-offs. To enhance the video quality and prevent the error propagation, INTRA frames, which do not reference to other previous coded frames, are added during encoding.

Intra-frame coding is used in video coding (compression).The intra-frame coding refers to the various lossless and lossy compression techniques are performed relative to information contained only within the current frame in the video sequence. Temporal processing is not performed outside of the current picture or frame. HEVC encoder is very similar to that of a JPEG still image video encoder.

The coding process varies depending on which type of encoder is used (e.g., JPEG or H.264), but the most common steps are : partitioning into macro blocks, transformation (e.g., using a DCT or wavelet), quantization and entropy encoding. INTRA frames are random access point that allow a decoder to start decoding at the location of INTRA frames,useful in video skimming. INTRA frame has much lower complexity than INTER frames, i.e., P and B frames, which is very important to machine vision and industrial high speed video that up to 600 fps. This property is essential to mobile devices having limited resources such as computing capabilities, memory, and battery.

An high-efficiency video coding has been standardized as the latest video coding standard, It doubles the compression efficiency of H.264/MPEG-4 AVC, i.e., half the transmission bit rate or storage space while keeiping the same video quality.[4]. While improving the compression efficiency of INTRA frames, many new coding technologies have been started, sophisticated INTRA prediction modes (up to 35 modes in HEVC), multimode transform, and hierarchical coding block structure. But, they significantly increase the computational complexity and memory access of the encoder and consumes more computing time, power, and battery of the mobile devices.[5].

Intuitively, all 35 intra mode checking is not required when there is some information available about the reference pixels that can be used to predict the mode of the current PU. Briefly, the proposed algorithm takes into account the reference pixels because of their high correlation with the current PU. DC mode is selected if reference pixels are the same, meaning their variance is close to zero. In such case, RMD and RDO phases of HM are skipped. If the variance is not close to zero, then 19 modes out of 35 modes are checked for Hadamard cost.[4]. Then top 2 modes are selected and their neighboring modes are checked for Hadamard cost. Before giving this most promising modes list to RDOQ process, the list is further refined by dropping all the modes that lie in the range $(N - 5)$, if Nth mode is already checked for RD.[6-9]. As modes have a high correlation, thus skipping will save time by introducing a minor increase in BD-Rate. Apart from this, early PU split skipping method is presented, which is based on RD cost.

This paper is organized as follows. Motivation is presented in Section II. Then, fast INTRA CU depth decision algorithms consisting of SC-CUDD and SM-CUET are presented in Section III. Finally, conclusion is drawn in Section IV.

International Journal of Electrical and Electronics Engineers
Vol. No. 9, Issue No. 01, January-June 2017
ISSN (O) 2321-2055
ISSN (P) 2321-2045

II. MOTIVATIONS

Larger resolution and higher frame rate of HD/UHD video increase the data volume for compressing and makes power efficient video coding more challenging and desirable. In a word, a low power and high efficiency INTRA coding is essentially important and highly desired to mobile videos and industrial video applications, like remote monitoring, surveillance, remote control, machine vision, and video camera with high-speed imaging.

Intra video coding enhances video quality, prevents error propagation, and facilitates random access. The recent high-efficiency video coding (HEVC) standard has developed flexible quad-tree-based block structure and complex angular INTRA prediction. It improves the coding efficiency, but increase the coding complexity, which consumes large hardware resources, computing time and power cost, and it creates obstacles for real-time video applications.

III. PRAPOSED SYSTEM

3.1 Introduction

System propose a fast INTRA coding unit (CU) depth decision method based on statistical modeling and correlation analyses.We analyze the spatial CU depth correlation with different textures and present effective strategies to predict the most probable depth range based on the correlation between CUs.[6] Sometimes the spatial correlation may fail for image boundary and transitional areas between textural and smooth areas, then system present a statistical model-based CU decision approach. In this adaptive early termination thresholds are determined and then updated based on the rate-distortion (RD) cost distribution, video content, and quantization parameters (QPs).[10].

3.2 General Block Diagram of Video Coding.

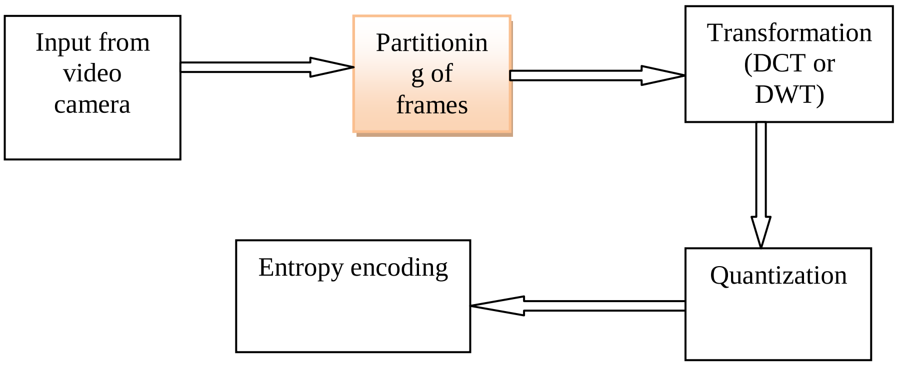

Fig: 3.1 General block diagram of Video Coding

3.3 Operation of the System

System propose an advanced INTRA CU decision algorithm to effectively lower the computational complexity of HEVC by jointly considering the spatial correlation, video texture, and statistical RD cost properties. The proposed algorithm lies in the following two aspects:

1) Sub algorithm spatial correlation-based CU depth decision (SC-CUDD) jointly exploits the CU's texture and spatial correlation, in which the hit rate (HR) and complexity reduction of 7–9 prediction strategies are analyzed in detail to obtain the optimal one.

2) Sub algorithm statistical model-based CU early termination (SM-CUET) is proposed by exploiting the statistical RD properties of CUs, in it early termination thresholds can calculated and updated based on the RD cost, video contents, and quantization parameters (QPs).

Proposed two schemes are combined to effectively reduce the coding complexity, which can minimize the HD video codec design and the related industrial applications.

3.4 Performance Measures

3.4.1. Spatial Correlation-Based CU Depth Decision

The video content is highly spatially correlated, the CU depths of the spatial neighboring CTBs are highly correlated, which could be utilised for the CU decision.The spatial correlation decreases as distance increases, the CU depth range of the above and left CTBs are more correlated to the current CTB.[11].

To analyze this correlation, Let Bup and Bleft are the above and left CTBs, respectively; Bcur denotes the current CTB. Operator D(X) denotes the depth range of CTB X. We analyze the HR of using D (Bup) and D (Bleft) to predict the D (Bcur) over different test sequences.

But the direct prediction from *B*up or *B*left is not so efficient. To tackle this problem, jointly take the texture and spatial correlation into consideration since the INTRA CU depth is usually texture dependent. For example, if the *B*cur has more similar texture with the *B*up when compared with *B*left, it is likely that *D* (*B*cur) is similar with *D* (*B*up). On the other hand, if the texture of the *B*cur is smoother or more complex than the textures of *B*up and *B*left, it shall be treated differently. Motivated by the texture properties of the video content, we divided a frame into three types of regions and proposed corresponding prediction strategies. The three regions are as follows.[12].

1) Normal region is the *B*cur whose texture complexity is in-between those of *B*up and *B*left, i.e., min (*T* (*B*up), *T* (*B*left)) ≤ *T* (*B*cur) ≤ max (*T* (*B*up), *T* (*B*left)).

2) Smooth region is the *B*cur whose texture complexity is smoother than those of *B*up and *B*left, i.e.,*T* (*B*cur) <min (*T* (*B*up), *T* (*B*left)).

3) Complex region is *B*cur whose texture is more complex than those of *B*up and *B*left, i.e.,*T* (*B*cur) >max(*T*(*B*up),*T*(*B*left)).

The operator *T*(*X*) indicates the texture complexity of CTB X, which is calculated by

$$T(X) = \sum_{Iij \in X} |Iij - 1/N_X \sum_{Iij \in X} Iij| \qquad (1)$$

Where *NX* is the number of pixels in the CTB X, and *Iij* is the luminance value of the pixel at position (*i*, *j*).Three kinds of regions will be analyzed individually and the optimal CU depth prediction strategies will be taken correspondingly.

1) Normal Region

We have developed and analyzed seven different CU depth prediction strategies (SN1 to SN7) for the CTB in this normal region, as shown in Table 3.1

Table 3.1 Prediction strategies for the CTB in Normal region

Short name	**Prediction strategies**
SN1	D(Bcur)=D(Bup)∩ D(Bleft)
SN2	D(Bcur)=D(Bup)∪ D(Bleft)
SN3	D(Bcur)=D(Bup)
SN4	D(Bcur)=D(Bleft)
SN5	D(Bcur)=D(Bup) if T(Bup)>T(Bleft), Otherwise D(Bcur)=D(Bleft)
SN6	D(Bcur)=D(Bup) if T(Bup)<T(Bleft), Otherwise D(Bcur)=D(Bleft)
SN7	D(Bcur)=D(Bup),if |T(Bcur)-T(Bup)|<|T(Bcur)-T(Bleft)|,Otherwise D(Bcur)=D(Bleft)

The union operator is the sum of the depth ranges of two blocks and intersection operator describes the common part of the two depth ranges. SN5 to SN7 predict the current CU depth by considering the texture similarity with neighboring CUs. For example, SN7 is *D* (*B*cur) that is predicted from *D* (*B*up) if the complexity difference between *B*cur and *B*up is smaller than that of *B*current *B*left.

2) Complex and Smooth Regions:

For the complex and smooth regions, we developed nine strategies for the CTB depth range prediction, as shown in the first column in Table 3.2.

Table 3.2 Prediction strategies for CTB in complex and smooth region (Unit :%)

Short name (Complex region)	Short name (Smooth region)	Prediction strategies
SC1	SS1	[max (a_0-1,0),max(a1-1),0]
SC2	SS2	[max (a_0-1,0),a_1]
SC3	SS3	[max (a_0-1,0),min(a1+1),3]
SC4	SS4	[a_0, max (a_1-1,0)]
SC5	SS5	[a_0,a_1]
SC6	SS6	[a_0,min(a_1+1),3]
SC7	SS7	[min (a_0+1,3),max(a_1-1),0]
SC8	SS8	[min (a_0+1,3),a_1]
SC9	SS9	[min (a_0+1,3),min(a_1+1),3]

The first column shows the nine different prediction strategies for the *D* (*B*up), where *a*0 and *a*1 are the minimum and maximum CU depth of *D* (*B*up) and *D* (*B*left), $a0 \leq a1$. These prediction strategies are shortened as SC1 to SC9 for complex region andSS1 to SS9 for smooth region. For example, the strategy SC5 is [*a*0, *a*1], which means the predicted depth range is from *a*0 to*a*1 for the complex regions. SC4 is [a0, max (*a*1 − 1, 0)] which indicates predicted depth range that is from *a*0 to *a*1 − 1. Since*a*0 • {1 and *a*1 • } 1 might be out of the valid depth range [0, 3], *max* () and *min* () are operators that clipped them to [0, 3]. These strategies SC*n* for the complex region and strategies SS*n*,*n*∈[1,9], for the smooth region can be executed similarly.[13].

For complex regions, the current CTB has higher possibility of selecting smaller CU (larger CU depth) comparing to its neighboring *B*up and *B*left CUs. Therefore, we shall further check a higher CU depth level, i.e., *a*1 + 1. For the smooth regions, the current CTB is probably select larger CU (smaller CU depth). Thus, we shall

International Journal of Electrical and Electronics Engineers
Vol. No. 9, Issue No. 01, January-June 2017
ISSN (O) 2321-2055
ISSN (P) 2321-2045

further check a lower CU depth level, i.e., $a0 - 1$. Based on the analyses, derive the optimal CU size prediction strategy based on the spatial correlation and video texture as

$D(B_{cur})$
$= [\max(0,a_0\text{-}1),a_1]$, $(T(B_{cur}) < \min(T(B_{up}), T(B_{left}))$ for smooth
$= [a_0,a_1]$, for normal region (2)
$= [a_0,\min(3,a_1+1)]$, $(T(B_{cur}) > \max(T(B_{up}), T(B_{left}))$ for complex

Note that for the cases that one of the above and left neighboring CTBs is unavailable, the CU locates at the image boundary, full range [0, 3] is used in order to maintain the RD performance.[14]. To evaluate the overall HR of the proposed spatial correlation-based CU depth decision , we implemented the proposed algorithm on HM8.0, which encoded 10 test sequences with various resolutions and characteristics and two sets of QPs, {22, 27, 32, 37} and {24, 28, 32, 36} are tested.

The HR of four regions, which are called boundary CTBs, smooth, normal, and complex CTBs. $Pi, I\in$ [1,4], is the probability of the four kinds of regions in each sequence. HRi, $i\in$[1,4], is the HR for the four kinds of regions. The overall HR of a sequence (HRALL) is calculated as

$HR_{ALL} = \sum_{I=1}^{4} HR_i.P_i$ (3)

3.4.2. Statistical Model-Based CU Early Termination

The SC-CUDD approach is efficient for most regions. However, the image boundary and transitional regions between texture and smooth areas this approach may fail due to lack of reference information and low correlation. To tackle this problem and further reduce the coding complexity, we propose the SM-CUET scheme. In HEVC, the CU size varies from the LCU with 64 × 64to the smallest CU (SCU) with 8 × 8. For the SCU INTRA prediction, it will further choose 2N × 2N or N × N as its best PU size. SCU can be further split into four sub 4 × 4 blocks.[15]. Thus, we model the CU depth decision process with four levels of decisions, as shown in Fig. 3.2.

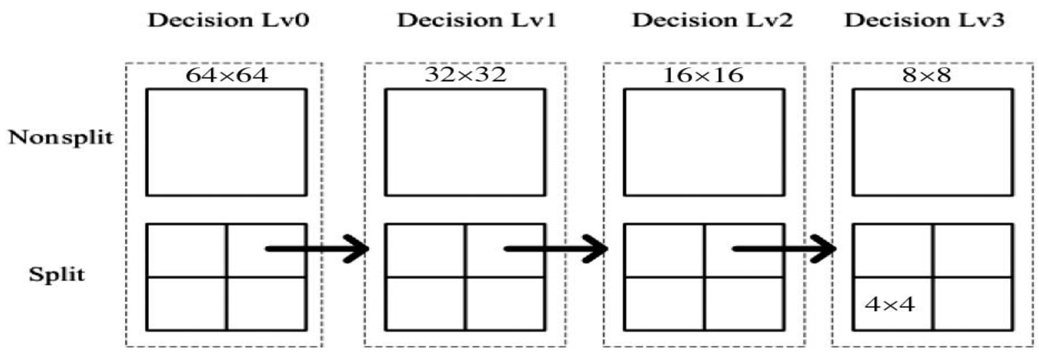

Fig: 3.2 Structure of four level decisions

Each level of decision needs to determine whether to split or non-split. For example, it first checks 64 × 64 and gets its RD cost. Then, it needs to determine whether shall further split the CU or not. If it is predicted as the best CU depth, the CU is not necessary to be split further and this CTB decision process is terminated. Otherwise, the CU shall be further split into four32 × 32 sub CUs and checked. For each of the four sub CUs with 32 × 32, it goes to decision level 1.We will get the RD cost for each of them, and accordingly determine whether they should be split or not.It ends when goes to block size with 4 × 4. We have four levels of decisions and in each level of CU decision we need to decide whether to spit a CU into four sub CUs or not. In the HEVC INTRA coding, the large size CUs are used in the smooth area and the small size CUs are used in the texture area. Thus, when we use large size CU i.e,the smooth area, its RD cost will be smaller than that of using small size CU.[15]. In other words, if the RD cost of using large size CU is small, it is of high probability to be the best CU size. To use this property and verify our assumption, we statistically analyze the average RD cost of each depth (depth 0 to depth 3) and their probability density function (PDF).

3.4.3. Proposed Overall CU Depth Decision Algorithm

It consists of two major parts, where part 1 is the SCCUDD and part 2 is the SM-CUET. These two sub algorithms can be applied jointly. In the part 1 of the flowchart, D (CTB) is the depth range of the current CTB, which is predicted from the spatial neighboring CTBs and stored when checking LCU.The rest of the part 1 is the implementation of (5). Note that the D (Bcur) is updated for every CU. If CU depth is within the D (Bcur), the part 2 is activated for further reduce the CU depth searching. For each CU, the current CU size will be checked first. Then, based on its RD cost and the adaptive threshold T (di), the CU is further split into four sub CUs if necessary and CU depth plus 1 for further checking. Otherwise, the current CU is pruned and goes to encode next CU. Note that for the first frame, threshold T (di) is initially set as 0 and then it will be adaptively determined based on the statistical model and different decision levels.

IV. CONCLUSION

In this paper, we propose a novel fast CU decision algorithm combined ed of two subalgorithms, including SC-CUDD and SM-CUET, to reduce the complexity of INTRA coding for mobile video applications.

1) We examine the spatial CU depth correlation in INTRA coding, and present SC-CUDD to predict the most probable depth range for CUs based on the spatial correlation.

2) We present the SM-CUET algorithm, in which early termination threshold will be adaptively determined and updated based on the RD cost distribution, video content, and coding parameters.

An extensive experiment shows that the proposed overall algorithm can reduce the coding complexity upto 56.76% and 55.61%.

REFERENCES

[1] C. H. Yeh, M. F. Li,M. J. Chen, M. C. Chi, X. X. Huang, and H. W. Chi, “Fast mode decision algorithm through inter-view rate-distortion prediction for multiview video coding system,” *IEEE Trans. Ind. Informat.*, vol. 10, no. 1, pp. 594–603, Feb. 2014.

[2] J. Lei, J. Sun, Z. Pan, S. Kwong, J. Duan, and C. Hou, “Fast mode decision using inter-view and inter-component correlations for multiview depth video coding,” *IEEE Trans. Ind. Informat.*, vol. 11, no. 4, pp. 978–986, Aug. 2015.

[3] L. Xu, S. Kwong, Y. Zhang, and D. Zhao, “Low-complexity encoder framework for window-level rate control optimization,” *IEEE Trans. Ind. Electron.*, vol. 60, no. 5, pp. 1850–1858, May 2013.

[4] G. J. Sullivan, J. R. Ohm, W. J. Han, and T. Wiegand, “Overview of the high efficiency video coding standard,” *IEEE Trans. Circuits Syst. Video Technol.*, vol. 22, no. 12, pp. 1649–1668, May 2012.

[5] L. Shen, Z. Liu, X. Zhang,W. Zhao, and Z. Zhang, “An effective CU size decision method for HEVC encoders,” *IEEE Trans. Multimedia*, vol. 15, no. 2, pp. 465–470, Feb. 2013.

[6] E. Peixoto, T. Shanableh, and E. Izquierdo, "H.264/AVC to HEVC video transcoder based on dynamic thresholding and content modeling," *IEEE Trans. Circuits Syst. Video Technol.*, vol. 24, no. 1, pp. 99–112, Jan. 2014.

[7] X. Shen and L. Yu, "CU splitting early termination based on weighted SVM," *EURASIP J. Image Video Process.*, vol. 2013, no. 4, pp. 1–11, Apr. 2013.

[8] H. Lee, H. J. Shim, Y. Park, and B. Jeon, "Early skip mode decision for HEVC encoder with emphasis on coding quality," *IEEE Trans. Broadcast.*, vol. 61, no. 3, pp. 388–397, Sep. 2015.

[9] X. Li, J. An, and X. Guo, "Adaptive CU depth range," doc. JCTVC-E090, JCTVC of ISO/IEC and ITU-T, Geneva, Switzerland, Apr. 2011.

[10] L. Shen, Z. Zhang, and Z. Liu, "Effective CU size decision for HEVC intracoding," *IEEE Trans. Image Process.*, vol. 23, no. 10, pp. 4232–4241, Oct. 2014.

[11] Y. Wang, X. Fan, L. Zhao, S. Ma, D. Zhao, and W. Gao, "A fast intra coding algorithm for HEVC," in *Proc. IEEE Int. Conf. Image Process. (ICIP'14)*, Oct. 2014, pp. 4117–4121.

[12] M. Zhang, H. Bai, C. Lin, M. Zhang, and Y. Zhao, "Texture characteristics based fast coding unit partition in HEVC intra coding," in *Proc. Data Compress. Conf. (DCC'15)*, Apr. 2015, pp. 477–477.

[13] H. Zhang and M. Zhan, "Fast intra mode decision for high efficiency video coding (HEVC)," *IEEE Trans. Circuits Syst. Video Technol.*, vol. 24, no. 4, pp. 660–668, Apr. 2014.

[14] N. Hu and E. H. Yang, "Fast mode selection for HEVC intra frame coding with entropy coding refinement based on transparent composite model," *IEEE Trans. Circuits Syst. Video Technol.*, vol. 25, no. 9, pp. 1521–1532, Sep. 2015.

[15] M. Jamali, S. Coulombe, and F. Caron, "Fast HEVC intra mode decision based on edge detection and SATD costs classification," in *Proc. Data Compress. Conf. (DCC'15)*, Apr. 2015, pp. 43–52.