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H.265/HEVC Based Intra-Prediction Coding for Portable Devices

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ABSTRACT

This paper presents a method to reduce the computational complexity of the intra-prediction coding used in High-Efficiency Video Coding (HEVC) standard targeted for real time video application over portable devices such as smartphones and tablets. Unlike 9 Intra prediction modes in H.264/AVC, 35 Intra Prediction Modes (IPMs) are defined in HEVC/H.265. The increased number of Intra-Prediction modes improve the coding efficiency but it also significantly increases the computational complexity. However, handheld devices or embedded systems have limited processing power that limits the use of HEVC in real time application over these devices/systems. In this work, a fast intra-mode decision algorithm is proposed that restricts the use of vast number of modes according to the computational resources available in the device. The results show that the proposed method significantly reduces the complexity in intra-prediction coding when the number of modes are restricted to five with approximately 5-6 dB drop in PSNR. This marginal decrease in quality is the cost to be paid that enable the use of intra-prediction coding of HEVC in portable devices.

Keywords: *Intra-prediction modes, H.265/HEVC, Video coding, Handheld Devices, Computational complexity*

1. INTRODUCTION

Recently new video coding standard High-Efficiency Video Coding (HEVC) has been developed, promising the significant reduction in bit-rate, without jeopardizing the image quality [1]. The H.265/HEVC [2] is accounted for the accomplishment of gain in compression efficiency up to 50% in contrast with its forerunner H.264/AVC, especially when operating on high-resolution video contents. However, the increased compression efficiency of HEVC is achieved at the cost of increased complexity. HEVC is almost 300% more complex as compared to the currently most used video encoder H.264/AVC [3]. This is because of the use of highly flexible Coding Tree Units (CTU) structure, increased size of reference frames for Motion Estimation, and vast number of Intra-Prediction modes, etc. [3].

The computational complexity of H.265/HEVC is a big challenge that puts a constraint on its use in real-time applications over low processing power devices such as smart-phones, tablets, and laptops. The video encoding and decoding are time delay constrained process. For example, telecast of any live sequence at 30 frames/sec requires the encoding time of a frame to be less than 1/30 = 33.33 millisecond. To minimize the encoding delay in such situation, HEVC requires devices with high processing capabilities. Moreover, as high processing is used, the power required to process the video also increases. On the other hand, hand-held devices have limited resources such as processing power and battery backup that further limits the use of HEVC on the low battery backup devices. Therefore, the computational complexity of H.265/HEVC needs to be reduced such that it can practically be used for real-time video communication over portable devices.

Different solutions to reduce the complexity of the video encoding have been proposed in the literature. In order to optimize the HEVC Inter-Prediction mode decision scheme Vanne et al. [4] proposes a scheme based on rate-distortion-complexity characteristics in terms of various block partition structure. This scheme achieves 31%-51% reduction in HEVC complexity at the cost of 0.2%-1.3% increase in bit-rate. Naccari et al. [5] introduced a scheme by analyzing the HM reference software to reduce the computational cost of HEVC. This proposed study optimizes the Multiple Early Termination for motion estimation, Adaptive Reference Frame Selection, and Adaptive Partition Selection for motion compensation. It achieves 11.5% encoder speed-ups at the cost of 3.1% increase in bit-rate. Correa et al. [6] proposes a scheme that controls the complexity of HM test model so that the execution time can be controlled in power-constrained applications, this controlling on execution time first checks the battery status and runs the encoding process on a specific complexity and then makes the decision: best rate-distortion results at higher complexity and at higher energy consumption, or worst rate distortion results at lower complexity and at lower energy consumption. To reduce the encoding time, Leng et al. [7] proposes an algorithm based on the fast coding unit decision for fame-level or Coding Unit (CU)-level. Information of previous coding frames and results of neighboring CU-coding are utilized to skip some of the CU evaluations that result in a reduction in encoding time. To remove the intrinsic drawbacks of transmitting the redundant set of motion parameters in quad-tree based block partitioning, Shukla et al. [8] proposes a method based on block merging, which is based on a scheme proposed in [9]. Xiong et al. [10] efficiently utilizes the CU selection algorithm based on the fast pyramid motion divergence (PMD). Optical flow of down-sampled frames is used for the extraction of PMD features.

Alternately, the complexity of the HEVC encoding can also be reduced by exploiting the intra-prediction techniques. A couple of scheme has been proposed in the literature to reduce the computational complexity of HEVC Intra-coding. For example, Da Silva et al. [1] and Jiang et al. [2] proposed a fast Intra-mode decision by utilizing the edge information of current Prediction Unit (PU) and the gradient mode histogram respectively, to choose a reduced set of candidate prediction direction. The calculation of gradient information or texture complexity requires huge time. Sun et al. [3] employed a low complexity cost model to implement the level filtering process

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for different CU sizes, which reduces the number of PU levels from five to two, requiring fine processing. Three speedups have already included in HM reference encoder, referred as Early CU termination (ECT), Coded Flag Mode (CFM) and Early Skip Detection (ESD) [11]. The combination of these speedups provides 46% encoding speedup at 1.1% efficiency loss [12]. Zhao et al. [13] utilize the directional information of the spatially adjacent CUs to speed up the Intra mode decision. In the interim, to early terminate the procedure of Intra-mode decision, the block size of current depth transform units [14] and the Intra-mode of corresponding previous depth prediction unit (PU) are used. Tian et al [15] utilized the PU size information of encoded neighboring blocks to skip small prediction unit candidate for the current block. Zhang et al. [16] gave a three-step solution to speed up the HEVC Intra-coding. Followed by a gradual progressive mode search, the original Hadamard transform is replaced by a 2:1 down-sampled Hadamard transform to derive the cost for evaluation. Meanwhile, to reduce the number of modes for subsequent rate-distortion optimized quantization an early termination method is also incorporated. It gives an average 38% reduction in encoding time with 2.9% Bjontegaard [17] delta rate loss of the Luma component on HM6.0 using test sequences of JCT-VC. In [18], PU size is estimated depending upon the correlation of the collected blocks. The authors suggest that PU sizes for the previous frame along with a parsing algorithm are needed to be stored. Hence, additional memory, time, energy is required. Because of the diverse nature of the HEVC angular prediction modes and CTU structures, other approaches [19]–[21] for H.264/AVC Intra-coding may not be efficiently applicable to HEVC.

In this paper, we proposed a fast and efficient intra-prediction technique to reduce the computational complexity of the HEVC encoder. The Intra-prediction in HEVC has two major differences from H.264/AVC as shown in TABLE I. Firstly, the number of prediction block types in HEVC vary from 64x64 to 4x4, whereas, the corresponding number for H.264 is only three (from 16x16 to 4x4). Secondly, 35 Intra prediction modes are introduced in HEVC, significantly higher as compared to the only 9 in H.264/AVC. The TABLE I shows that the number of intra-mode decision in HEVC is 2.65 times more than in H.264/AVC [22]. The number of Intra-mode decision, m, is given by the equation (1)

$$m = \sum_{i=0}^{\log_2 M-2} 2^{2i} N_i \qquad (1)$$

where, N_i is the number of available modes for the i^{th} Prediction Unit (PU) size and M represents the size of Prediction Block (PB).

In order to reduce the unrelenting complexity of HEVC intra-coding, a fast and low computationally complex, preprocessing and learning based scheme is proposed that works on statistical optimization of Intra-Prediction modes (IPMs). Based on its learning, IPMs filtering scheme reduces the number of modes being invoked and thus the complexity, such that the loss in coding efficiency is negligible. Therefore, complexity reduction may make the HEVC codec to be used in low-processing devices with small battery backup. The proposed work is based on the frame context based study carried out in [23] to investigate the complexity behavior of the HEVC intra-prediction modes.

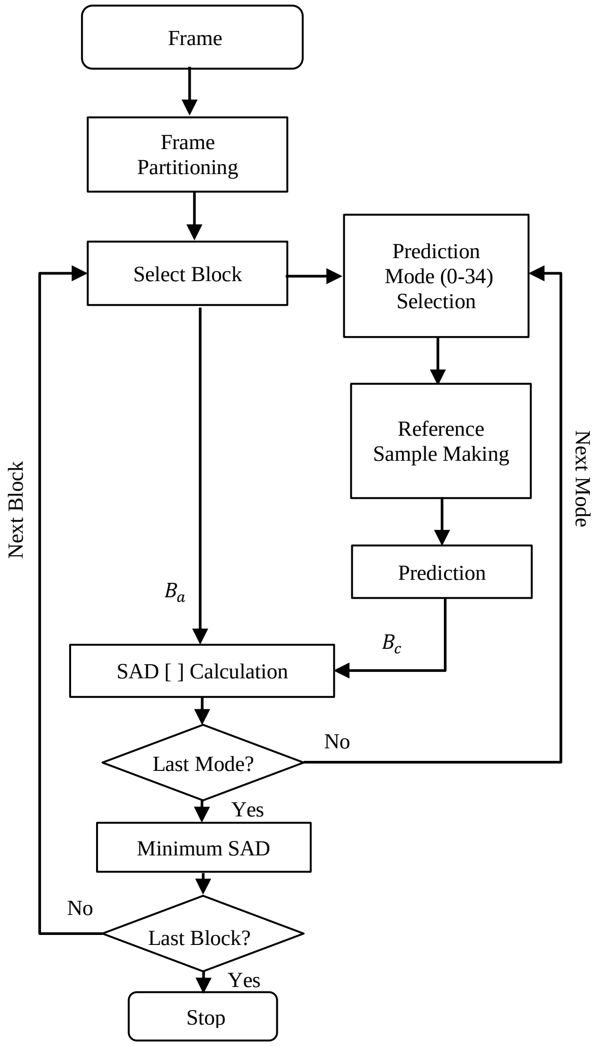

Fig. 1. Steps in Intra-Prediction

The rest of this paper is organized as follows, section-2 introduces a brief review of the Intra Prediction in HEVC. Section-3 presents the proposed algorithm for statistical optimization of intra-prediction modes in HEVC. Section-4 shows the simulation results, followed by conclusion in Section-5.

2. OVERVIEW OF INTRA PREDICTION IN HEVC

There are four kinds of redundancies identified in a picture: 1) Spatial redundancy, 2) Temporal redundancy, 3) Psycho-visual redundancy, 4) Statistical redundancy. In order to remove the spatial redundancy, Intra-Prediction process is one of the possible option. In the Intra-Prediction process, neighborhood pixels are utilized to predict pixels of the picture frame [24]. A flowchart is shown in Fig. 1 that demonstrates the working of Intra-Prediction in HEVC [28]. This flow chart is made by considering a single frame of a video to illustrate each step involved in Intra-Prediction. A block to be Intra-Predicted is represented by B_c and its corresponding predicted block is represented by B_p. Every block of frame is predicted by all the 35 available Intra-Prediction modes. Hence for a block, there are 35 different possible predictions, among these, the prediction that gives minimum Sum of Absolute Difference (SAD) is chosen. Similar procedure is followed for each and every block of given frame.

The basic steps in intra-prediction coding of a frame are described below:

A. Frame Partitioning

HEVC splits the frame into quad-tree and support variable length block size. Depending on the parameter like texture complexity and to efficiently support the various block sizes in HEVC, frames are split into Coding Tree Units (CTU) of sizes 64×64, 32×32, 16×16, 8×8, or 4×4,[25]. CTU has Luma(Y) with L×L and two Chroma components (Cb and Cr) with each L/2×L/2 samples (4:2:0). Each block is called Coding Tree Block (CTB) [26] which has the same size as CTU. Where each CTB splits into quad-tree structures [27] respectively as shown in Fig. 2. The block resulting from this partition is called as Coding Block (CB) and becomes the prediction type (Inter or Intra-Prediction) decision point.

B. Prediction Block Partioning

The CB can split into size of M×M PB or M/2×M/2 PBs. In Fig. 3.a, PB has same size as CB because CB is not split. In Fig. 3.b, CB is split into 4 equally sized PBs. In order to select, one from these two ways of partitioning a flag is used in HEVC.

C. Intra-Prediction modes

First, In HEVC, Prediction of a PB is done by using 35 different Intra-Prediction modes and these Intra-Prediction modes are categorized into Angular, Planar and DC Intra-Prediction (TABLE II) depending upon how the available neighboring samples are being combined [24].

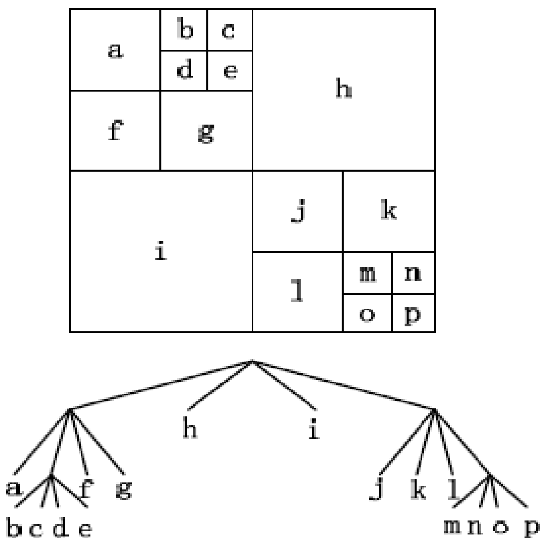

Fig. 2. Quad-tree structure of a CTB.

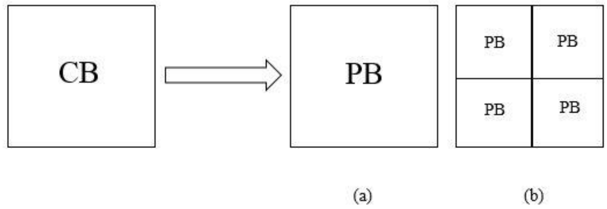

Fig. 3. Coding Block (CB) splitting into Prediction Block (PB).

TABLE II
INTRA-PREDICTION TYPE AND CORRESPONDING MODE NUMBER

Intra-Prediction Names	MODES NUMBERS
Planar	0
DC	1
Angular	2 to 34

***D**. Prediction Block Reference sample*

For Intra-Prediction the direct neighboring samples are called as Reference samples, i.e. the samples from the row just above the current block and the samples from the column just left of the current block. Depending upon the direction of prediction top-left corner $Pref_{TL}$, lower-left $Pref_{LL}$ and right-above $Pref_{RA}$ samples may also be used [Fig. 3]. This is the reason $4N_c + 1$ neighboring samples (that makes the $Pref$) are required for the prediction of $N_c \times N_c$ PU block size.

In Fig 4, B_c is a block of size $N_c \times N_c$ (where N_c size ranges from 4 to 64) that is to be predicted. The set of reference samples are represented by $Pref$. The predicted samples of B_c is denoted by $B_c(x, y)$ and the reference samples are denoted by $Pref(x, y)$ where, the top left-corner of $B_c(x, y)$ is the origin. [28].

E. Low pass smoothing of Reference samples

HEVC utilizes low-pass filtering to the reference samples in order to avoid the discontinuities introduced by Intra-Prediction [29]. This low-pass filtering is applied to the reference samples of luma blocks because chroma components are predisposed to be smooth. The smoothing of reference samples are done on the basis of size of PUs and the directionalities of Intra-Prediction [24]. Low-pass filtering is applied for the block of size $N_c > 4$.

F. Planar Intra-Prediction

Planar Intra-Prediction in HEVC is mapped to mode-0. This mode is good at providing smooth prediction signals with gradual changes [29]. Depending upon the sample location, Planar Intra-Prediction is accomplished by a weighted average of 4 reference samples. The prediction sample values are derived as

$$B_c(x,y) = \frac{y+1}{2N_c} Pref(-1, N_c) + \frac{N_c - 1 - x}{2N_c} Pref(-1, y) + \frac{N_c - 1 - y}{2N_c} Pref(x, -1) + \frac{x+1}{2N_c} Pref(N_c, -1) \quad (2)$$

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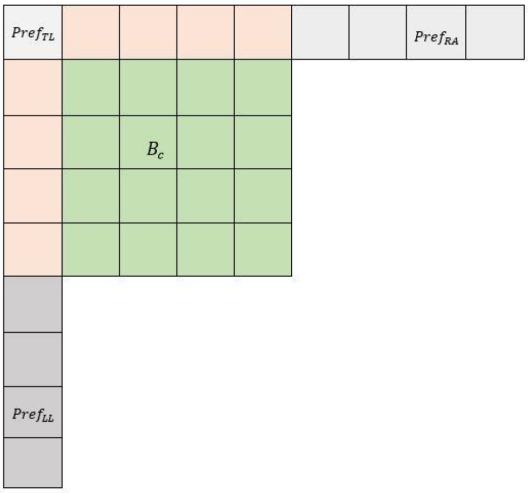

Fig. 4. Block of prediction and corresponding Reference

G. DC Intra-prediction

This modes is known as mode-1 and it is good at predicting the plane areas of an image, where, the variations are smooth [24]. A DC value V_{DC} is assigned to each samples of PB. V_{DC} is the average of the reference samples and it is derived as

$$V_{DC} = \frac{1}{2N_c}\left(\sum_{x=0}^{N_c-1} Pref(x,-1) + \sum_{y=0}^{N_c-1} Pref(-1,y)\right) \quad (3)$$

For Luma blocks, HEVC defines a slightly different way for prediction. The boundary samples (0, 0), (x, 0), (0, y) are treated separately. At these locations, a weighted average of V_{DC} and the neighboring values from $Pref$ are used for the prediction [29] by the using the formulas

$$\begin{aligned} B_c(0,0) &= \frac{1}{4}(Pref(-1,0) + Pref(0,-1) + 2V_{DC}) \\ B_c(x,0) &= \frac{1}{4}(Pref(x,-1) + 3V_{DC}) \\ B_c(0,y) &= \frac{1}{4}(Pref(-1,y) + 3V_{DC}) \end{aligned} \quad (4)$$

This is done to achieve the smoothing at the boundaries.

H. Angular Intra-Prediction

In HEVC, there are 33 Intra-Prediction modes numbered from 2 to 34. These modes are corresponding to the different prediction angles form diagonal-up to diagonal-down. In order to define these prediction angles, an offset-value, *Pang*, is defined and the values of *Pang* corresponding to the different modes are shown in Fig 5.

The scheme of assigning *Pang* values to mode number is done according to the values shown in Fig. 5. The selection of reference sample in the case of Intra Angular Prediction requires more effort. The samples from both horizontal and vertical part of $Pref$ is needed to predict the current block B_c, since a computational effort is required for the location of samples on either of the sides of $Pref$ [Fig. 4]. A scheme is proposed [29], where the reference sample $Pref$ is first converted into 1D-vector P_1ref. The Intra-Prediction mode decides the mapping of samples from $Pref$ to P_1ref. P_1ref is

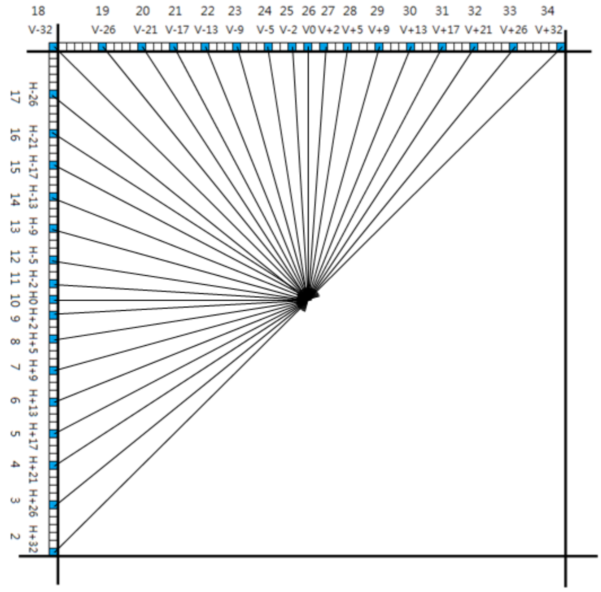

Fig. 5. Angular Intra-Prediction mode numbers and corresponding $Pang$ value [26]

made by the samples of $Pref$ that are to be used in prediction for a particular mode. After the construction of P_1ref for a prediction block B_c, the vertical prediction is performed by formula

$$\begin{aligned} B_c(x,y) = \frac{32 - i_{fact}}{32}.P_1ref(x + i_{dx} + 1) \\ + \frac{i_{fact}}{32}.P_1ref(x + i_{dx} + 2) \end{aligned} \quad (5)$$

where, $0 \le x, y < N_c$

Since the prediction of sample (x, y) is the weighted sum of the reference samples, a weighing factor i_{fact} and a sample offset i_{dx} are defined and given by.

$$\begin{aligned} i_{dx} &= (y + 1).\frac{Pang}{32} \\ i_{fact} &= [(y + 1).Pang]mod32 \end{aligned} \quad (6)$$

For the horizontal prediction this formula is used accordingly, by swapping x and y [29].

3. PROPOSED FAST INTRA-MODE DECISION SCHEME

In HEVC, the total number of Intra-prediction modes are 35. In intra-prediction coding, the CTU is divided into PUs. The size of PU can vary from 4x4 to 64x64. The encoder searches for the size of the PU and intra-prediction mode that gives best prediction. To find the best prediction sum of absolute difference (SAD) matric is computed for all possible size and modes and minimum of them will indicate the desired PU and mode. This computation has to be performed for all CTU. For example, if 5 level of block splitting is considered along with the 35 modes then for a 64x64 image, 7808 times the prediction is being done (TABLE I) and this number goes on as the size of image increases. This much of computational complexity in HEVC requires significant computational power and hence becomes challenging to be utilized in portable devices.

TABLE III
DETAILS OF VIDEOS

Videos	Resolution	Number of Frames	Class
Akiyo	512×512	300	A
Cactus	512×512	300	B
Sunset	512×512	300	C
Coastguard	512×512	300	D
RaindropHD	512×512	300	E

Therefore, we propose a fast intra mode prediction method to reduce the computational complexity of intra-prediction coding.

In the proposed method, the intra-prediction modes are reduced from 35 to n, where n is a natural number less than 35. The computational complexity will decrease as the value of n is reduced, but the quality of the encoded video will also be reduced. For a given processing capabilities of a device, optimum value of *n* may be obtained that maximizes the quality of the video. Therefore, the optimal n may be different for different devices. In this work the value of *n* is taken heuristic to demonstrate the proposed technique. For a given n, , Fig. 6 shows a flowchart of finding the best *n* modes that reduce the computational complexity of the intra-prediction coding to the desired level while compromising on negligible loss of encoded video quality. First a frame is divided into CTUs and each CTU further partitioned into PUs. Then the predicted block of the PU is obtained using all 35 modes. The SAD for a block is computed using equation (7):

$$SAD = \sum_{x=1}^{N_c}\sum_{y=1}^{N_c}|B_a(x,y) - B_c(x,y)| \qquad (7)$$

Where $B_a(x,y)$ and $B_c(x,y)$ are the pixel values of the actual and predicted block respectively.

The SAD is computed for all possible modes and stored in a table. The process is repeated for all available frames. Then based on the frequency of the modes occurring in the video, best *n* modes are selected. The top *n*-modes are obtained using the above method for different type of videos classified in groups. Finally for each group of videos, the best *n*-modes are selected. The whole process is done offline. Once the best *n*-modes are selected, in the real time encoding of a given video, its class is identified and accordingly the *n* –modes are selected. Then, the intra-prediction coding is performed restricting to these *n*-modes instead of 35.

This technique will reduce the computational complexity of the intra-prediction coding and hence may become suitable to be used in real time encoding in hand-held devices.

4. EXPERIMENTAL RESULTS

For the simulation results, we have considered different video sequences [30] of resolution 512 x 512 and classified them into five groups based on motions and texture. To test our proposed method, a video from each class is chosen as given in TABLE III. For example, the video Akiyo categorized in class A, has very slow perceptible motion in small region of frame with almost constant background. The video Cactus is categorized in class B where, the complete scenario of frame is gradually changing with time. While the Sunset video is characterized by the slow motion of object against the slowly changing background, and this video falls in class C. Coastguard video is characterized by the rotational motion against the slowly changing background and this video is classified as class D. RaindropHD is chosen from the class E video, and, is the one with very fine rotational motion against the almost constant background. The simulation is carried out using C/C++ in Linux gcc version 5.4.0 over a machine with Intel processor of 3.1 GH/s quad core and 4GB of RAM.

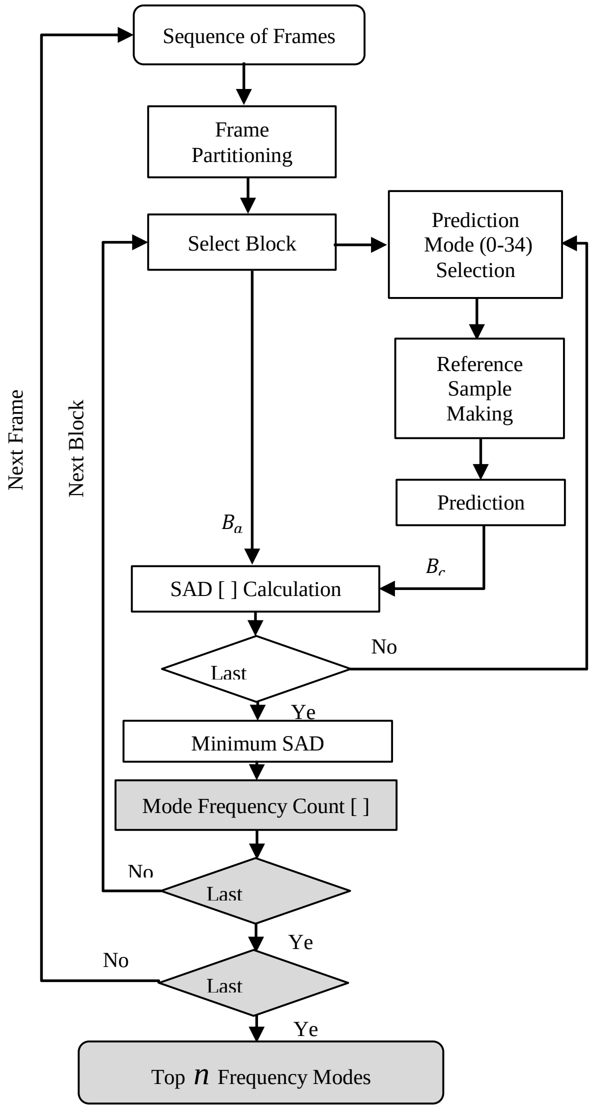

Fig. 6. Intra-Mode Decision Scheme

In order to compute the Average Frequencies of different Intra-Prediction modes for different class of videos, a C/C++ program is written by following the algorithm shown in Fig. 6. The TABLE IV depicting the distributions of modes for a PU of size 16x16. The TABLE IV shows the frequency of all the modes of HEVC for different class of videos. From the table, it can be observed that all the mode are not used uniformly in intra-prediction coding rather few modes are used more frequently. For example, in class A, the mode 0, 10, 26, and 28 have the highest frequencies.

TABLE IV
AVERAGE FREQUENCY DISTRIBUTION OVER DIFFERENT INTRA-PREDICTION MODES

Mode	Average Frequency				
	Class A	Class B	Class C	Class D	Class E
0	156.17	248	240.12	135.30	234.89
1	29.45	37.60	123.88	40.17	63.06
2	18.88	17.55	17.86	17.85	38.21
3	4.94	7.27	19.01	6.55	16.07
4	4.91	10.25	18.25	7.38	12.80
5	6.20	4.98	23.53	9.29	12.50
6	8.55	6.56	24.87	14.42	13.41
7	6.99	6.84	38.29	29.44	20.99
8	19.47	7.89	36.60	59.90	17.87
9	26.81	11.21	55.19	115.09	16.00
10	139.96	34.85	71.68	217.43	20.65
11	32.38	17.21	54.23	71.95	15.87
12	17.02	13.92	46.95	42.84	15.73
13	9.04	9.82	32.96	23.07	18.42
14	10.09	7.48	26.15	13.35	12.16
15	9.63	7.02	16.02	9.14	12.96
16	12.41	9.35	14.00	9.41	16.75
17	9.60	9.30	10.89	7.59	15.40
18	11.30	12.06	3.05	6.92	15.90
19	9.65	13.22	8.99	7.01	17.90
20	8.95	17.54	7.57	6.04	16.12
21	11.95	16.83	7.83	4.43	17.44
22	12.71	17.90	8.49	5.64	19.87
23	30.38	23.32	8.32	6.98	29.91
24	41.63	27.87	9.35	8.26	29.04
25	42.38	32.61	7.95	13.07	24.05
26	162.58	194.65	4.85	70.99	41.63
27	32.38	56.25	8.68	11.75	40.72
28	43.46	28.93	11.46	6.15	50.49
29	22.02	31.66	8.35	5.71	43.29
30	16.03	15.65	6.01	4.88	27.02
31	7.00	14.98	6.84	3.54	13.87
32	11.46	14.59	7.27	4.62	14.04
33	12.80	10.55	11.89	6.73	17.60
34	20.42	23.90	22.23	16.75	26.97

Similarly, in class B, the four highest frequencies are 0, 1, 26, and 27. Furthermore, it is also observed that top 5 modes are coming out to be different for the different classes (TABLE V). This is due to the fact that, the classes have different nature of motion and texture. For example, The Class D video has the angular motion and hence its frequency is very much distributed over the Angular Intra-Prediction modes while the Class A

TABLE V
TOP FIVE MORE FREQUENT MODES FOR DIFFERENT CLASSES

Class	Top-5 Frequent Modes
A	0,10,25,26,28
B	0,1,10,26,27
C	0,1,9,10,11
D	0,9,10,11,26
E	0,1,26,28,29

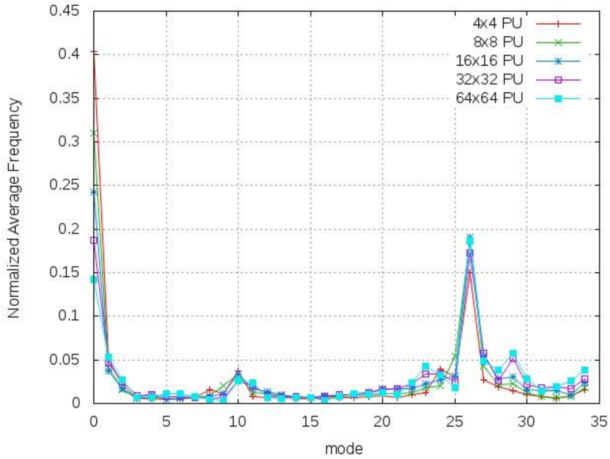

Fig. 7. Distribution of normalized average frequency over different PU sizes

video is with the least angular motion and hence its frequency is merely distributed over the Angular Intra-Prediction modes. This is because, the distribution of mode frequency over the Intra-Prediction modes is dependent on the context of the videos. The Class of videos having low frequency distribution over the different Intra-Prediction modes can be predicted by choosing the modes with higher frequency, and this fact becomes the basis for the elimination of modes with lower frequency. Hence the five most frequent modes are chosen and shown in TABLE V.

So far we have discussed how the top 5 modes are changing over the different class of videos, but now to analyze the distribution of top 5 modes over different PU sizes, we have plotted the normalized average frequency for the class B video as shown in Fig. 7.

From the Fig. 7, it is evident that the top 5 modes also change as the PU size increases. For example, for the 4x4 PU block size the top 5 frequency modes are 0, 1, 10, 24, 26 while for the 32x32 PU top 5 frequency modes are 0, 1, 26, 27, 29. This is due to fact that the contextual information of PU changes as the size of PU block increases.

TABLE VI compares the PSNR of the intra-prediction frames for PU of size 16x16 using 35 modes of HEVC and top 5 frequent modes for two cases: Firstly the video sequence which is used to train the system to get top 5 frequent modes is tested and values are shown in bold. It is observed that the PSNR is reduced when number of modes are restricted to 5, however the drop is marginal. For example, if the system is trained with the sequence of class A, then the prediction of a frame from class A video sequence using 35 modes gives PSNR

TABLE VI
PSNR MEASUREMENT FOR TEST FRAMES OF VARIOUS CLASS USING CONVENTIONAL METHOD AND PROPOSED METHOD

Training Video Class	Conventional IPMs PSNR(dB)	Proposed IPMs PSNR(dB)				
		Test Frame Sequence				
		A	B	C	D	E
A	28.88	**21.17**	22.37	23.87	18.81	21.41
B	28.27	22.39	**22.00**	24.44	19.05	22.70
C	26.80	24.14	23.88	**25.15**	19.48	25.07
D	25.16	20.70	21.60	23.84	**18.53**	20.81
E	28.09	21.09	22.06	24.76	19.63	**21.64**

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equal to 28.88dB, While, the prediction of same frame using 5 most frequent modes gives PSNR of 21.17dB.

This is the price which has to be paid to reduce the computational complexity. Secondly, the videos that are neither in the same class and nor used to train the systems are tested to observe the deterioration in the PSNR. The values demonstrate that video that is neither in any class can also be intra-frame encoded using our method with small deterioration in quality of the image so that it can be encoded over the devices with low computational complexity. For example, intra-encoding of class E frame in a system trained with class D video sequence, gives 20.81dB of PSNR value, while the intra-encoding of class D frame gives PSNR of 18.53dB.

5. CONCLUSION

In this paper, low complex intra-prediction method based on HEVC has been proposed that may be used in real time video based applications over portable devices. The technique reduces the computational complexity of the intra-prediction coding by statistically optimizing the use of modes subjected to the available processing power in the handheld devices or embedded systems. The optimization was based on the frequency distribution of the modes used in the intra-prediction coding analyzed over different classes. The top n frequent modes, based on the device processing power, are selected for each class. At real time encoding, these n modes are used rather than 35 modes of HEVC. The simulation results were presented for $n = 5$. It was found that computational complexity in the proposed method is greatly reduced with the reduction in PSNR by only 5-6 dB. The price paid in term of compression efficiency may be acceptable for the use of intra-prediction coding of HEVC in real time application over embedded systems and portable devices

REFERENCES

[1] T. L. Da Silva, L. V. Agostini, and L. A. da Silva Cruz, "Fast HEVC intra prediction mode decision based on EDGE direction information," in *Signal Processing Conference (EUSIPCO), 2012 Proceedings of the 20th European*, 2012, pp. 1214–1218.

[2] W. Jiang, H. Ma, and Y. Chen, "Gradient based fast mode decision algorithm for intra prediction in HEVC," in *Consumer Electronics, Communications and Networks (CECNet), 2012 2nd International Conference on*, 2012, pp. 1836–1840.

[3] H. Sun, D. Zhou, and S. Goto, "A low-complexity HEVC intra prediction algorithm based on level and mode filtering," in *Multimedia and Expo (ICME), 2012 IEEE International Conference on*, 2012, pp. 1085–1090.

[4] J. Vanne, M. Viitanen, and T. D. Hämäläinen, "Efficient mode decision schemes for HEVC inter prediction," *IEEE Trans. Circuits Syst. Video Technol.*, vol. 24, no. 9, pp. 1579–1593, 2014.

[5] M. Naccari, A. Gabriellini, M. Mrak, S. G. Blasi, I. Zupancic, and E. Izquierdo, "HEVC coding optimisation for ultra high definition television services," in *Picture Coding Symposium (PCS), 2015*, 2015, pp. 20–24.

[6] G. Corrêa, P. Assuncao, L. Agostini, and L. A. da Silva Cruz, "Complexity control of high efficiency video encoders for power-constrained devices," *IEEE Trans. Consum. Electron.*, vol. 57, no. 4, pp. 1866–1874, 2011.

[7] J. Leng, L. Sun, T. Ikenaga, and S. Sakaida, "Content based hierarchical fast coding unit decision algorithm for HEVC," in *Multimedia and Signal Processing (CMSP), 2011 International Conference on*, 2011, vol. 1, pp. 56–59.

[8] R. Shukla, P. L. Dragotti, M. N. Do, and M. Vetterli, "Rate-distortion optimized tree-structured compression algorithms for piecewise polynomial images," *IEEE Trans. Image Process.*, vol. 14, no. 3, pp. 343–359, 2005.

[9] R. De Forni and D. S. Taubman, "On the benefits of leaf merging in quad-tree motion models," in *Image Processing, 2005. ICIP 2005. IEEE International Conference on*, 2005, vol. 2, pp. II–858.

[10] J. Xiong, H. Li, Q. Wu, and F. Meng, "A fast HEVC inter CU selection method based on pyramid motion divergence," *IEEE Trans. Multimed.*, vol. 16, no. 2, pp. 559–564, 2014.

[11] J. Yang, J. Kim, K. Won, H. Lee, and B. Jeon, "Early SKIP detection for HEVC. JCT-VC of ITU-T SG16 WP3 and ISO," IEC JTC1/SC29/WG11, Document JCTVC-G543, 2011.

[12] S. Yang, H. J. Shim, K. Won, and B. Jeon, "Fast Inter Subpartition Prediction Unit Mode Decision for HEVC," *IEEE Int. Conf. Consum. Electron.*, pp. 15–16, Jan. 2014.

[13] L. Zhao, L. Zhang, S. Ma, and D. Zhao, "Fast mode decision algorithm for intra prediction in HEVC," in *Visual Communications and Image Processing (VCIP), 2011 IEEE*, 2011, pp. 1–4.

[14] J. Kim, J. Yang, H. Lee, and B. Jeon, "Fast intra mode decision of HEVC based on hierarchical structure," in *Information, Communications and Signal Processing (ICICS) 2011 8th International Conference on*, 2011, pp. 1–4.

[15] G. Tian and S. Goto, "Content adaptive prediction unit size decision algorithm for HEVC intra coding," in *Picture Coding Symposium (PCS), 2012*, 2012, pp. 405–408.

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

[17] G. Bjontegaard, "Calculation of average PSNR differences between RD-curves," in *ITU-T Q. 6/SG16 VCEG, 15th Meeting, Austin, Texas, USA, April, 2001*, 2001.

[18] M. B. Cassa, M. Naccari, and F. Pereira, "Fast rate distortion optimization for the emerging HEVC standard," in *Picture Coding Symposium (PCS), 2012*, 2012, pp. 493–496.

[19] Z. Kun, Y. Chun, L. Qiang, and Z. Yuzhuo, "A Fast Block Type Decision Method for H.264/AVC Intra Prediction," in *The 9th International Conference on Advanced Communication Technology*, 2007, vol. 1, pp. 673–676.

[20] Y.-K. Lin and T.-S. Chang, "Fast block type decision algorithm for intra prediction in H. 264 FRext," in *Image*

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Processing, 2005. ICIP 2005. IEEE International Conference on, 2005, vol. 1, pp. I–585.

[21] M. Shafique, L. Bauer, and J. Henkel, "A parallel approach for high performance hardware design of intra prediction in H. 264/AVC video codec," in *Proceedings of the Conference on Design, Automation and Test in Europe*, 2009, pp. 1434–1439.

[22] M. U. K. Khan, M. Shafique, and J. Henkel, "An adaptive complexity reduction scheme with fast prediction unit decision for HEVC intra encoding," in *Image Processing (ICIP), 2013 20th IEEE International Conference on*, 2013, pp. 1578–1582.

[23] M. Asif, M. A. Khan and E. Khan, "Frame Context Dependency of Intra-Prediction Modes of H.265/HEVC: An Analytical Study," in *Proceedings of 2018 5th IEEE Uttar Pradesh Section International Conference on Electrical, Electronics and Computer Engineering (UPCON)*, 2018, pp. 1-6. doi: 10.1109/UPCON.2018.8596887

[24] D. Patel, T. Lad, and D. Shah, "Review on Intra-prediction in High Efficiency Video Coding (HEVC) Standard," *Int. J. Comput. Appl.*, vol. 132, no. 13, pp. 26–29, 2015.

[25] "Resources," *Vcodex*. [Online]. Available: http://www.vcodex.com/resources/. [Accessed: 13-Feb-2018].

[26] G. J. Sullivan, J. Ohm, W.-J. Han, and T. Wiegand, "Overview of the high efficiency video coding (HEVC) standard," *IEEE Trans. Circuits Syst. Video Technol.*, vol. 22, no. 12, pp. 1649–1668, 2012.

[27] P. Helle *et al.*, "Block merging for quadtree-based partitioning in HEVC," *IEEE Trans. Circuits Syst. Video Technol.*, vol. 22, no. 12, pp. 1720–1731, 2012.

[28] "H.265 : High efficiency video coding." [Online]. Available: https://www.itu.int/rec/T-REC-H.265-201612-S/en. [Accessed: 15-Apr-2018].

[29] M. Wien, *High Efficiency Video Coding: Coding Tools and Specification*. Berlin Heidelberg: Springer-Verlag, 2015.

[30] "Xiph.org :: Derf's Test Media Collection." [Online]. Available: https://media.xiph.org/video/derf/. [Accessed: 11-Apr-2018].

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