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A Study on Fast Intra Prediction Mode Decision Algorithms in HEVC

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ABSTRACT: High Efficiency video coding is a new improved next generation Video Coding Standard beyond H.264/AVC. HEVC aims to provide improved compression performance as compared to all other Video Coding Standards. To improve coding efficiency a number of new techniques have been used, for example the increased macro block size i.e. 64x64. Particularly in intra prediction 35 modes (IPM) are defined in HEVC. In this paper, we review the different methods used in fast intra mode decision algorithms to speed up the original intra coding in HEVC.

KEYWORDS: HEVC, intra prediction, mode decision

I. INTRODUCTION

The requirement of high definition ('full HD') video content, and ongoing developments towards broad application of UHD video quality, as well as the increasing deployment of high-quality video services to mobile devices led to the invention for a new video coding standard (HEVC) . To improve the coding efficiency of the previous H.264/AVC video coding standard, a joint collaborative team on video coding was formed for the development of new standard called HEVC. HEVC supports the new concept of CTU (Coding Tree Unit) in place of Macroblocks in H.264/AVC. HEVC support variable block size. Nowadays high-resolution video contents are used, so the use of larger blocks is beneficial for encoding [4]. To support this variety of bocks size in efficient manner HEVC pictures are spitted into coding tree unit (CTU) [4]. The CTU can have the sizes: 64x64, 32x32 or 16x16. All coding standard follows the same block based Hybrid coding structure [4]. This coding process consists of two parts: Encoder and Decoder. Frames are partitioned into same sized picture blocks, and each picture block goes through a predefined steps. In HEVC these picture blocks are known as coding tree unit (CTU). These picture blocks or coding unit is predicted by prediction process: Intra frame prediction or inter prediction. The residuals out of the intra and inter prediction are later transformed and compressed using arithmetic coding, particularly CABAC. Some implementations also involve other techniques like weighted prediction of entire frame, and inserting I frames at scene-cut.

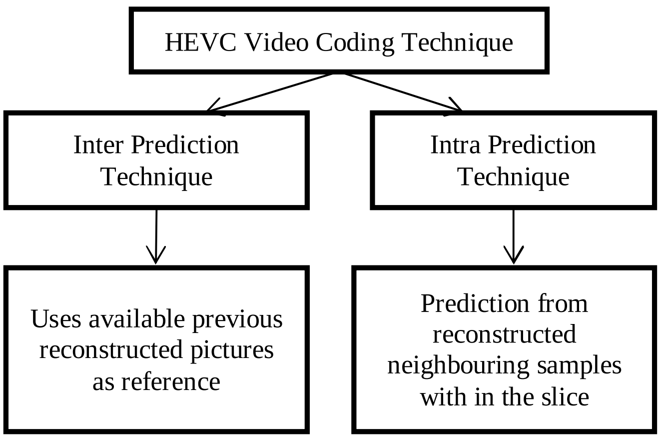

Fig.1. HEVC coding techniques

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II. INTRA PREDICTION IN HEVC

In the previous video coding standards like H.264/AVC, the intra prediction is performed based on previously encoded macro-blocks. HEVC adopts the same principle as H.264/AVC, by using the boundary pixels to predict the target block [3]. HEVC provides 35 prediction modes for PUs, which includes 33 angular direction modes and 2 non-directional modes [5]. The HEVC standard defines that a frame is Partitioned in large coding units (LCU) which are then further divided into coding units (CU) using a quad-tree structure. Each CU can also be further divided into prediction units (PUs) [6] as shown in Figure 1, and each PU can employ a different intra prediction direction. An intra coded CU can consist of one 2Nx2N PU or four NxN PUs (Figure 1), where N is half of the CU size [6].

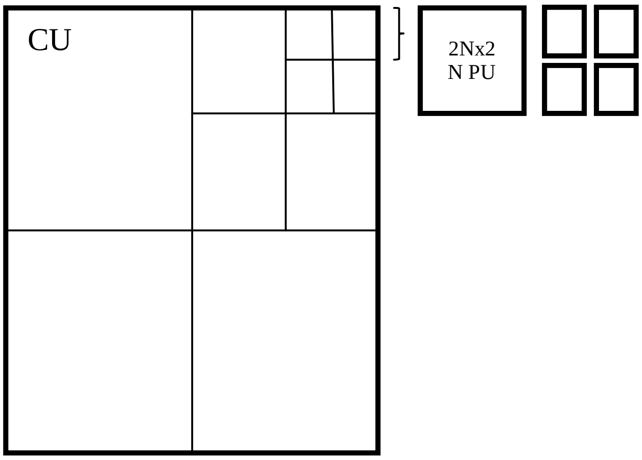

Fig.2. Block diagram of Quadtree structure

The partitioning of a CTU into CUs results in a quad tree structure of square blocks. Intra prediction is applied on square prediction block sizes as well. The prediction block size for intra prediction generally corresponds to the coding block size and the applicable intra prediction mode is coded once for the CU.

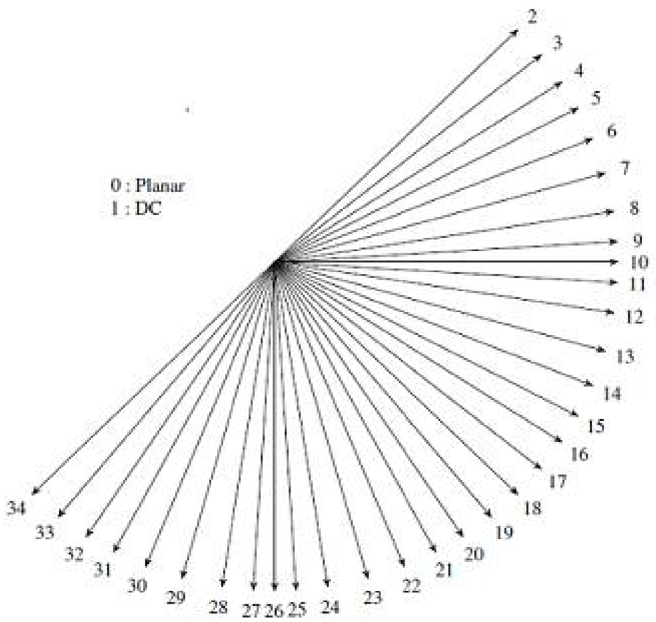

Fig.3. Intra prediction modes in HEVC

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The representation of intra prediction modes is shown in fig.2. The prediction modes 2-18 are donated as horizontal prediction modes, and from 19-34 are donated as vertical prediction modes. The modes are available for prediction block sizes from 4x4 to 32x32.
In order to calculate the value of each sample of the PB, the angular mode predict the future samples from the reference sample, depending on the direction in order to achieve lower complexity. When the direction is between 2-17, then the samples located in the left column, when the direction is in between 18 to 34, the samples located at the left column are projected as sample located in the above row, extending the top reference row [3]. In both cases the samples projected would have negative references.
In fast intra prediction mode decision algorithms, aim is to reduce the number of candidate modes using different techniques for the prediction process of the frame, because it is very time consuming to try all 35 modes to predict the block.

III. RELATED WORK

To reduce the computation of the mode decision for intra prediction, with a relative loss of coding efficiency, different algorithms have been proposed to achieve this. A fast intra prediction mode decision algorithm based on edge direction information is proposed in [6]. In this algorithm edge direction is evaluated in order to predict PU, and these edges are categorised in five types: four directional, horizontal, vertical and two diagonals (45° and 135°) and one non-directional edge [6].This algorithm decreases the number of angular modes by 73% i.e. 33 to 9 modes. The result shows that the method used in this work obtain better results than the HM4.0 method. The total intra encoding processing time was reduced by up to 32.08%. In [5], an intra direction mode decision algorithm for intra prediction mode decision in HEVC has been listed. In this algorithm only lower precision IPMs are used in the RMD process and IPM for rate distortion optimization(RDO) are reduced based on the correlation between neighbouring CUs. This algorithm combines depth range prediction of CTU, fast CU size decision and lower precision mode decision methods. Depth range prediction of current CTU is being predicted by the neighbouring encoded CTU. Using this algorithm an average of 54% encoding time can be saved and a negligible loss in RD performance.

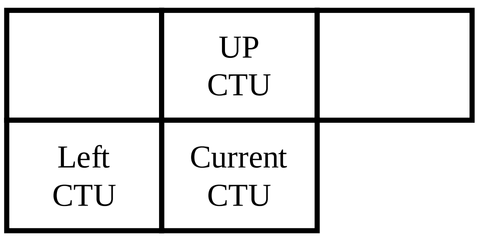

Fig.4. Current encoding CTU with neighbouring CTU

In [7], a gradient based fast mode decision algorithm for the HEVC aims to reduce the computational complexity. A gradient-mode histogram is generated for each CU, by using the gradient information. The number of the candidate modes can be reduced for the RMD and RDO process by the histogram distribution. In this paper [9], authors proposed a fast intra mode decision for the HEVC encoder, which consist of micro and macro level schemes. Instead of traversing all candidate modes, a progressive rough mode search (pRMS) based on Hadamard cost is used to check the potential modes. If the estimated R-D cost is already larger than R-D cost of the current CU, then the early coding unit (CU) split termination is introduced at macro level. In paper [8], the authors proposed a group based fast intra mode algorithm to further reduce the encoding complexity. An early termination scheme is applied if the RMD cost of first mode is greatly smaller than others. To choose the best angle direction, first the rough modes are merged according to their angles and then, an edge detection process is applied. Up to 23.52% speed up in encoding time can be achieved by using this algorithm. In paper [3], authors proposed a clustering based fast intra prediction mode decision algorithm for HEVC, an early termination scheme is applied on RMD+MPM modes. These modes are sorted in ascending order according to their Hadamard cost and are grouped together in one set. This implements early termination if the first two modes (RMD+MPM) are not angular modes or non-directional modes; otherwise the K-Medoid clustering algorithm to group modes is used to select the best one. The K-Medoid clustering algorithm is therefore used to cluster all available

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intra modes into k partitions. The K-Mediods from these k partitions are used for RDO to identify the best mode to predict the picture block.
The various Intra Prediction Techniques used in HEVC standards are shown below in Figure 5. In this figure K-Medoid clustering algorithm is used in Intra Prediction coding techniques which can use Intra- Planar Mode 0, Intra DC Mode or Intra Angular Mode 2-34. In general HEVC employs 35 different intra modes to predict a prediction block: 1. 33 Angular modes, 2. Planar mode and 3. DC mode.

IV. LIMITATIONS OF THE K-MEDOID ALGORITHM

- Distance calculation of K-Medoid clustering algorithm is computationally intensive.
- In K-Medoid clustering algorithm cost calculation is according to sequential mode hence not very efficient in terms of time i.e. time complexity is more.
- Performance is not very efficient.

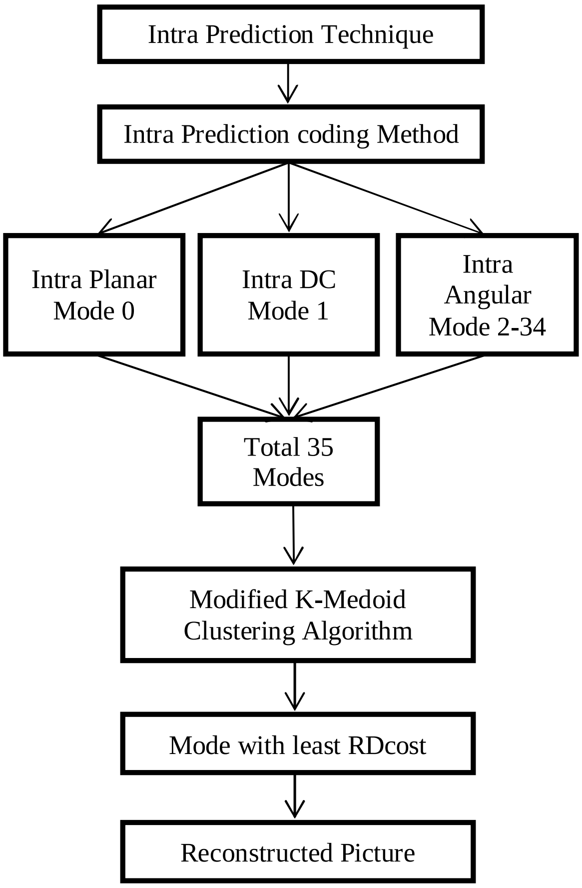

Fig.5. Techniques for intra prediction

V. CONCLUSIONS

In this paper different works on early intra mode decision for HEVC have been reviewed and presented as a review paper on different fast intra prediction techniques. Different algorithms and their summarized functioning are presented that how better they help to achieve computational efficiency in HEVC intra-prediction.

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