Edge-Based Fast Intra Mode Decision in HEVC

Sangkwon Na, Wonjae Lee, Kyohyuk Lee and Kiwon Yoo
Samsung Electronics

요 약

High efficiency video coding (HEVC) appears due to the demand on high compression video coding beyond H.264/AVC in ultra-high definition (UHD) videos. As for intra prediction, HEVC has 35 prediction modes while H.264/AVC has 9 intra modes. To exploit the spatial correlation, we adopt an edge detection method, establish the edge map, and adaptively select the candidate modes using the acquired edge information in a block. The number of the candidate modes is determined through trade-off between computational complexity and coding efficiency. Besides, the range of coding unit sizes is determined using the uniqueness of the edge directions for the given image block. As a result, we 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 (HM 6.0 [1]).

1. Introduction

Due to the demand on ultra-high-definition (UHD) resolution videos, the need for the successor of H.264/AVC arises, which achieves higher coding efficiency at UHD videos. A Joint Collaborative Team of Video Coding (JCT-VC) was established with the objective to improve the coding efficiency of a new video coding standard compared with H.264/AVC. With key features of high efficiency video coding (HEVC), the bit-rate of coded bit-stream is reduced by about 50% at the similar objective video quality compared to H.264/AVC.

The encoding complexity of HEVC becomes extremely larger than that of H.264/AVC because of newly introduced coding tools. Especially, intra prediction introduces 35 prediction modes including directional modes [2], while H.264/AVC has 9 intra prediction modes. Coupled with a recursive quad-tree partitioning, the increased modes of intra prediction in HEVC face the serious difficulties in the encoding complexity. There are many proposals to solve the complexity problem of intra prediction in H.264/AVC [3-7]. In those papers, fast mode decision algorithms utilize the spatial correlation of the image block to estimate likely prediction modes, i.e. the pixels along the direction of local edge normally have similar values.

2. Proposed Algorithm

The major edge direction in an image block can be obtained using an edge detection algorithm. As Pan used Sobel edge operator to determine the primary edge direction and select a small number of the prediction modes in H.264/AVC [3], we also adopt Sobel edge operator.

For each pixel in 4x4 block, the amplitude of the edge is predicted by the sum of the absolute edge features. By simple thresholding method, the edge histogram is created to determine the major edge direction in 4x4 block among the vertical, horizontal, 45-degree, and 135-degree direction. The four conditional functions including threshold parameters are derived from [3]. If any condition for four directions is not met or the amplitude of the edge is less than the threshold, that pixel is classified into *DC* which means the corresponding pixel is assumed to be placed in the middle of smooth area. The value of the threshold is characterized with QP (quantization parameter) through numerical analysis.

Various block sizes in HEVC increase the computation complexity to find the best prediction modes and block sizes in terms of rate-distortion optimization. Because intra prediction uses the spatial correlation, blocks in the area which contains a regular directional pattern tend to be coded with a large block. In a quad-tree block, if four blocks have the identical major edge direction, they are merged into one larger block. On the other hand, four blocks are coded separately in case when any edge direction is different with the others.

After the candidate CU sizes are determined, it is needed to find the best intra prediction mode for the given CU. The distribution of the best mode for the given major edge is characterized to organize the set of the candidate modes for each edge direction. DC, planar, vertical and horizontal modes are chosen as the common candidate modes. As shown in Fig. 1, the prediction modes are lined up in a descending order of the distribution when the corresponding mode is selected as the best one. This statistical analysis is performed for 18 sequences from Class A to E used in Call for Proposal (CfP) of HEVC.

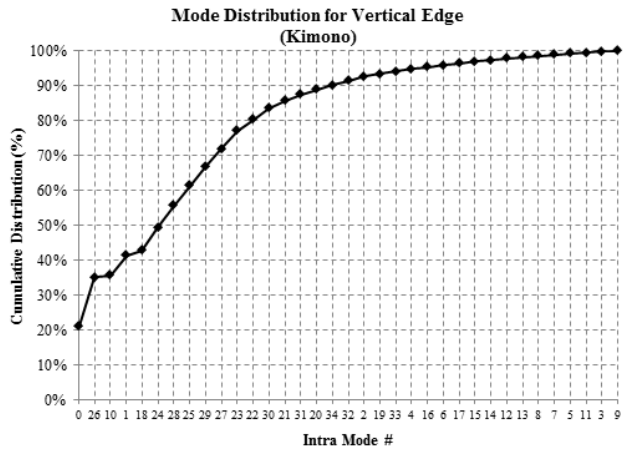

Fig. 1 Best mode distribution in a descending order when the major edge direction is vertical in *Kimono* sequence.

After the determination of the major edge direction in the given block, intra prediction is done with candidate modes in accordance with the given CU size.

3. Experimental Results

The proposed algorithm reduces the total encoding time by 56.8% at the cost of 2.5% BD-BR increase on average compared to HM 6.0 [1] Full mode.

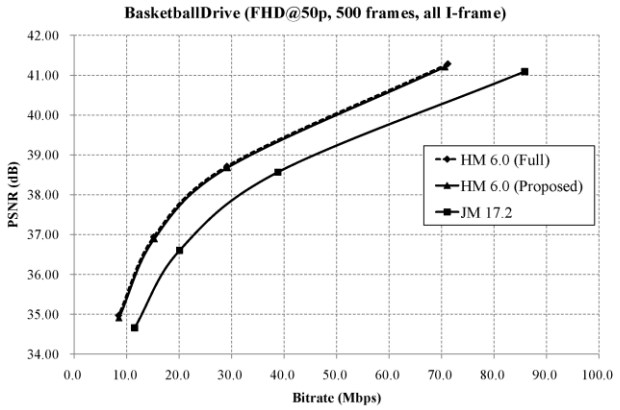

Fig. 2. Rate-distortion chart of HM 6.0 (Full mode), JM 17.2 (H.264/AVC reference software) and the proposed method for BasketballDrive (1920x1080@50fps, 500 frames, all-I frame).

The RD curve in Fig. 2 represents the compression performance of the proposed method is almost equal to that of HM 6.0 Full mode while using about half of the encoding time for intra prediction.

4. Conclusion

In this paper, we demonstrated a fast mode decision algorithm that utilizes Sobel edge operator. The range of CU (coding unit) sizes was determined by the uniqueness of the edge direction of the image block. In this manner, the proposed scheme reduced the computational complexity in the reconstruction path. Moreover, the proposed scheme skipped unlikely prediction modes so as to minimize unnecessary rate-distortion optimization procedure. As a result, the proposed algorithm achieved 56.8% of the encoding time reduction at the sacrifice of 2.5% bit-rate increase compared to HM 6.0 Full mode.

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