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Fast block mode decision algorithm in H.264/AVC video coding

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Abstract

The recent video coding standard H.264/AVC show extremely higher coding efficiency compare to any other previous standards. H.264/AVC can achieve over 50% of bit rate saving with same quality using the rate–distortion process, but it brings high computational complexity. In this paper, we propose an algorithm that can reduce the complexity of the codec by reducing the block mode decision process adaptively. Block mode decision process in H.264/AVC consists of inter mode decision process and intra mode decision process. We deal with reduction method for inter and intra mode decision. In this paper an efficient method is proposed to reduce the inter mode decision complexity using the direct prediction methods based on block correlation and adaptive rate distortion cost threshold for early stopping. The fast intra mode reduction algorithm based on inter mode information is also proposed to reduce the computational complexity. The experimental results show that the proposed algorithm can achieve up to 63.34–77.39% speed up ratio with a little PSNR loss. Increment in bit requirement is also not much noticeable.

Keywords: Video coding; Image compression; Image coding; Prediction methods; Video processing

1. Introduction

High quality video requires an increase in the amount of video data to be processed. Transfer of a large amount of data over limited bandwidth requires acceleration in the development of a video coding standard with high compression efficiency.

MPEG-4 Part-10 H.264/AVC is the latest video coding standard [1]. It has been approved by the joint video team of ISO/IEC MPEG and ITU-T VCEG. Several techniques including variable block size to find out accurate motion vectors and to consider more detailed texture edges or object boundaries, multiple reference pictures, and quarter-pel accurate motion vectors motion compensation are used for high compression performance compared to previous video coding standards. Especially, rate distortion optimization (RDO) is the powerful coding technique which is adopted in H.264/AVC. It considers not only inter frame distortion but also motion vector cost to find minimum error surface. Also, context-based adaptive binary arithmetic coding (CABAC) is adopted in entropy coding.

H.264/AVC achieves excellent performance with these coding techniques but it is also highly complex. Because of very high computational complexity, there are some limitations in using the H.264/AVC codec in real-time applications or embedded systems. To reduce the computational complexity of H.264/AVC, a number of fast algorithms have been proposed. In the fast motion estimation algorithm to determine the best matching point early [2], the inter-mode prediction that determines proper block modes among variable block mode [3–10] and intra mode prediction [10–15].

Problems with H.264/AVC as remain as ever, including a complex and time-consuming inter mode decision process with variable block size motion estimation and intra mode decision process to reduce the spatial redundancy. The block sizes for inter mode decision are SKIP, 16×16, 16×8, 8×16, 8×8, 8×4, 4×8 and 4×4. Generally,

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SKIP, 16×16, 16×8, and 8×16 are called large block size modes, 8×8, 8×4, 4×8, and 4×4 are called small size block or sub block modes ($P8\times8$) (Fig. 1).

Intra-modes have been divided into the four categories of I16MB prediction, I8MB prediction, I4MB prediction, and 8×8 chroma prediction modes. Each prediction mode has several sub-prediction types. I4MB has nine modes for each 4×4 luma block, I16MB has four prediction modes, and 8×8 chroma prediction has four prediction modes for each chroma sample (Fig. 2). For I8MB prediction, nine modes have been adopted for the High Profile. A variable block size for block mode decision maximizes the coding efficiency based on rate–distortion optimization (RDO) where all modes (inter and intra) should be checked for every macroblock. Therefore, it is essential to reduce the block mode decision complexity.

Herein, we introduce a new fast block mode (inter and intra) decision algorithm to reduce the overall complexity of H.264/AVC. A fast inter mode decision algorithm using a direct prediction with some spatial correlations was proposed. We know the temporal correlations are very high between adjacent frames. Based on this property and some statistical analysis, the direct prediction which used for the mode information of the correlated macroblcok (MB) in time-successive frame is proposed. Also, the early termination method by rate distortion cost threshold is used for more accurate decision. Using this threshold, we can determine the modes to check. A prediction method using a spatial correlation is also suggested. Between adjacency blocks which have same object or texture boundary, big correlation to determine the inter mode decision exist.

We also introduce a fast intra-mode decision algorithm to reduce the overall complexity of H.264/AVC intra-prediction by using the best inter-mode information. When the inter-best mode is determined, the direction of the local edge and the movement of objects can influence the inter-mode decision. For example, with only background image blocks or a few activity blocks, a 16×16 block size is usually used. On the other hand, a fast moving object requires a smaller block size. Rectangular block types, such as 16×8, 8×16, 8×4, and 4×8, can be used to determine the direction of the local texture edge, or an object boundary. We have observed that the inter-best mode block shape and the direction for intra-mode prediction are highly correlated.

2. The fast inter mode decision using a block correlation

2.1. The direct prediction and early termination

The proposed algorithm can be divided into two steps, including direct prediction to determine the initial check mode and early termination to increase the speed. We know strong correlations exist between adjacent inter frames. In just one second there are more than 15 frames. The proposed algorithm uses temporal correlation properties to determine proper modes that are used in the initial check. The proposed method to determine the initial search mode is called direct prediction. To determine the initial search mode, the best mode information of a correlated MB in the time-successive frame is used. We check that the probability of the best mode of a correlated MB in the time-successive frame and the current MB is the same. This probability is high, based on a statistical analysis of approximately 20 sequences. Experimental results are shown in Table 1. Correlations are especially strong for the SKIP(mode 0) and 16×16 modes (mode 1).

The direct prediction algorithm has two steps. First, we determine the initial search mode with correlated MB mode information if the correlated MB mode is included in the large size block mode (Modes 0, 1, 2, 3), Otherwise (sub-macroblock), we use a full mode search.

The direct prediction algorithm for the initial search can be described as follows:

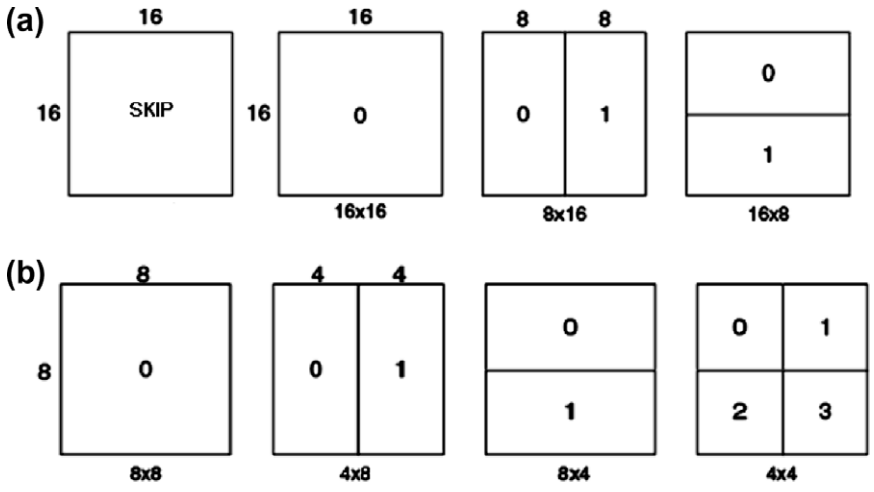

Fig. 1. Variable inter mode block sizes for RD optimization. (a) Large block partitions: SKIP, 16×16, 8×16 and 16×8. (b) Sub_block partitions: 8×8, 4×8, 8×4 and 4×4.