SIMPLIFIED AMVP FOR HIGH EFFICIENCY VIDEO CODING

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ABSTRACT

In High Efficiency Video Coding (HEVC), advanced motion vector prediction (AMVP) is adopted to predict current motion vector by utilizing a competition-based scheme from a given candidate set, which include both the spatial and temporal motion vectors. In order to enhance the practicability of the AMVP, a simplified AMVP is proposed. Firstly, by analyzing the importance of the spatial and temporal candidates, we reduce the number of the candidates involved in the competition set and simplify the redundancy checking process, which will decrease the complexity of the decoder as well as improve the robustness of the decoder. Secondly, we simplify the zero motion adding process which will occur only when the number of existing candidates is less than the predefined number. Experimental results show that the proposed scheme provides no loss in random access and low delay conditions. These two simplifications have been proposed and adopted into the HEVC standard.

***Index Terms*—**video coding, HEVC, motion vector prediction, AMVP

1. INTRODUCTION

In H.264/AVC [2], the motion vector predictor of current block is formed by only spatial neighboring motion vectors. There are 7 types for motion partitions, which are 16x16, 16x8, 8x16, 8x8, 4x8, 8x4 and 4x4. For each motion partition size, there is a special rule for getting the best motion vector predictor among all existing candidates. The encoder and decoder share the same rule that there is no need for encoder to transmit the index of the best motion vector predictor to the decoder.

In HEVC, AMVP is one of the most important coding tools, which predict the motion vector of current block by making full use of spatial and temporal correlation of the neighboring partitions. [3]. In the encoder side, the Rate Distortion Optimization (RDO) process is provided to select the best motion vector predictor from the candidate set. And then, the index for the selected candidate is encoded and transmitted to the decoder. Therefore, instead of RDO process, the best motion predictor can be directly obtained in the decoder by the index.

Although there is no RDO process for AMVP in the decoder side, the candidate list reconstruction is also complicated for the decoder side, which is the same as that in the encoder side. There are three procedures in the list reconstruction process. Firstly, the decoder should get the spatial and temporal motion vectors from the memory buffer to form the candidate set. Secondly, a redundancy checking process is utilized to remove the duplicated motion vectors in the candidate set. Thirdly, a zero motion checking process is optionally employed to check the existence of zero motion in the candidate set.

In order to reduce the AMVP complexity and improve the error resilience of the decoder side, we simplify the candidate list forming process. Firstly, we reduce the number of candidates in the candidate set and redundancy checking process by analyzing the importance of the spatial and temporal candidates. Secondly, we investigate the complexity of the zero motion adding process and simplify it.

The remainder of this paper is organized as follows. Section 2 presents an overview of current AMVP in HEVC. Section 3 gives a detailed description of the proposed simplifications in AMVP. Experimental results are shown in Section 4. Finally, this paper is concluded.

2. CANDIDATE SET IN AMVP

In the competition candidate set of AMVP, there are at most two spatial neighboring candidates and one co-located temporal candidates. After the derivation of spatial and temporal candidates, a redundancy checking process is employed to remove the duplicated motion vectors among all existing candidates. As a result, the number of existing candidates may be smaller than 2. When this case happens, a zero motion adding process is utilized to make sure that there is a zero motion vector in the candidate set. The flowchart of the AMVP process is illustrated in the Fig.1 [1][7].

In the following, we will describe the derivation process of spatial and temporal candidates in detail.

2.1 Spatial Candidates

The potential AMVP spatial neighboring candidates are located at the bottom-left, left, above-right, above and above-left positions of the current partition. They are categorized into two classes. Left and bottom-left candidates are categorized in the first class while above-right, above and above-left candidates are categorized in the second class [4]. It is illustrated in Fig.2 [4]. The scanning order is from the bottom to top in the first class and from the right to left in the second group respectively.

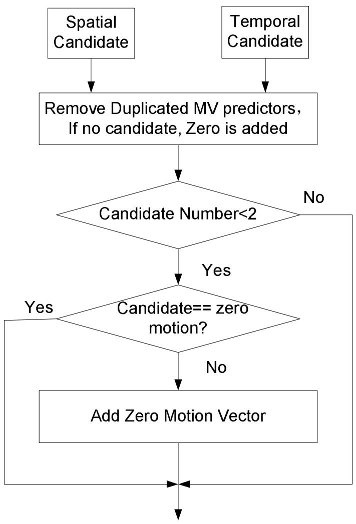

Fig.1 AMVP candidate list reconstruction

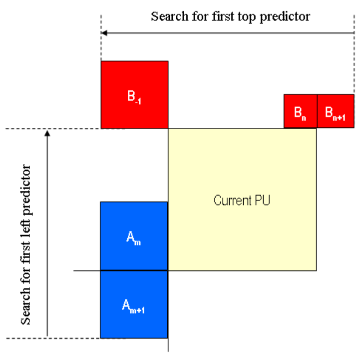

Fig.2 Spatial candidates for AMVP

2.2 Temporal Candidates

In the derivation of temporal candidates, motion vector of the co-located PU is scaled to the given reference frame by using the POC distance. Position of co-located PU is selected between 2 candidate positions, C3 and H, as depicted in Fig.3. If PU at position H is not available or intra coded, or outside of current LCU, position C3 will be used. Otherwise, position H is used for the derivation of temporal candidate [1] [4].

3. PROPOSED SIMPLIFICATIONS FOR AMVP

In this section, a simplified algorithm for AMVP is described, including problem statement and proposed simplifications. We start with problem statement, which provide useful guidelines for AMVP simplification. And then, the problem mentioned in the problem statement will be solved in the simplified AMVP.

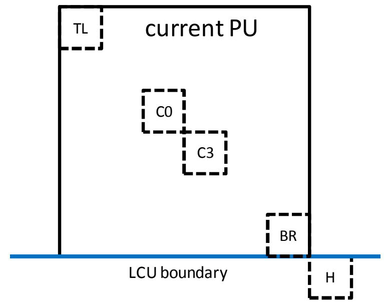

Fig.3 Positions of temporal candidates for AMVP

3.1 Problem Statement

In the AMVP candidate list, there are at most two spatial candidates and one temporal candidate. After the derivation process, a redundancy checking process is employed to remove the duplicated motion vectors. However, the predefined number for AMVP candidate is 2. If all three candidates are different from each other, the temporal candidate which has the largest rank will be exempted from the candidate list in current HM5.0. Instead of temporal candidate, if we remove one of the spatial candidates from the candidate list, we will have 0.2% BD-rate loss. Furthermore, even if we move the temporal candidates to the first position of the candidate list, about 0.3% BD-rate loss will be obtained. It is revealed that the importance of the temporal candidates is smaller than the spatial candidates.

However, in current HM5.0, temporal candidates have the same priority with the spatial candidates both in candidate derivation process and redundancy checking process. Therefore in our first proposed simplifications, we take the advantage of the different importance of the spatial candidates and temporal candidates. In the derivation process, the spatial candidates will always be derived while the temporal candidates will be optionally derived. In the redundancy checking process, the temporal candidate will be exempted.

When the number of existing candidates is smaller than 2 after redundancy checking process, a zero motion adding process is employed current HM5.0, which includes two checking processes. However, we find that the checking process is unnecessary for the AMVP list reconstruction. So in the second proposed simplification, we remove the checking process from the zero motion adding process.

3.2 Proposed AMVP Simplifications

In the proposed algorithm, firstly we simplify the AMVP list construction by treating spatial candidates and temporal candidates differently. Secondly, we simplify the zero motion adding process.

3.2.1 Simplified AMVP List Construction

Firstly, we get temporal candidates only when two spatial candidates have the same motion value or one of the spatial candidates is not available. If two spatial candidates have different motion vectors, there is no need to get the temporal candidates into the memory. Because the predefined number of the AMVP list is two, the candidate with the rank larger than the predefined number will be finally removed from the candidate list. There are two benefits from this simplification. On the one hand, the memory bandwidth for the decoder side will be reduced. On the other hand, the error resilience of the decoder will be improved, because that the temporal candidates may be lost due to the transmission error. If the selected candidate is the spatial candidate and the spatial candidates are different from each other, the decoder will crash because of the miss of temporal candidates. Because that the temporal candidates must be always derived in current HM5.0. After our simplification, this problem has been solved because of the absent derivation of temporal candidates.

Secondly, we employ spatial candidates into the redundancy checking process and exempt the temporal candidates. As a result, the number of comparisons can be reduced from three to one at the worst case in each candidate list reconstruction process. For each PU, where AMVP is used, one candidate list reconstruction process will be recalled in the decoder side. Therefore, the complexity of decoder can be decreased significantly.

3.2.2 Simplified Zero Motion Adding Process

In HM5.0, the zero motion adding process (ZMAP) contains two processes, which are motion vector candidate list empty check and the duplicate check of zero motion vectors. ZMAP is performed after the redundancy checking process as described in Fig. 4. The list empty check is performed in order to add a zero motion vector when the candidate list is empty. Also, the duplicate check of zero motion vectors is performed in order to add a zero motion vector when the number of motion vector candidate is less than the predefined number of motion vector candidates. As a result, at most one zero motion will exist in the motion vector candidate list. However, these two checking operations cannot gain any coding performance.

In our simplification, motion vector candidate list empty check and zero motion vector duplicate check are both removed from the candidate list construction process. When the number of motion vector candidate in the motion vector candidate list is less than the predefined number of motion vector candidate, a zero motion vector is always added in the motion vector candidate list. Thus, at most two zero motion vectors exist in the motion vector candidate list in the proposed method. The proposed simplification on AMVP list construction is described in Fig. 5.

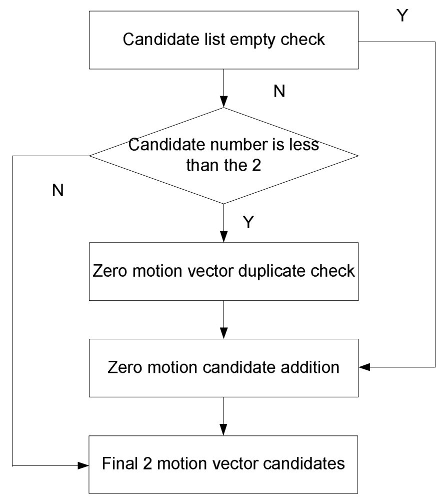

Fig.4 Zero motion adding process in HM5.0

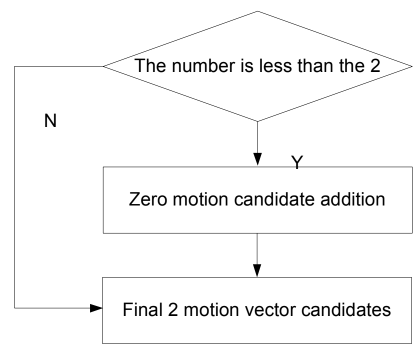

Fig.5 Proposed zero motion adding process

For the above two simplifications, the AMVP candidate list reconstruction process can be simplified in the Fig. 6. From the flowchart, we can clearly observe that the list reconstruction process has been simplified significantly.

4. EXPERIMENTAL RESULTS

To verify the performance of the proposed AMVP simplification, it was implemented in the fifth test model HM5.0 [5] of HEVC. Since we focus on the performance of random access (RA) and low delay (LD) configurations, experiments are carried out for both high efficiency and low complexity conditions. According to the specifications provided in [6], four test conditions are conducted in our experiments.

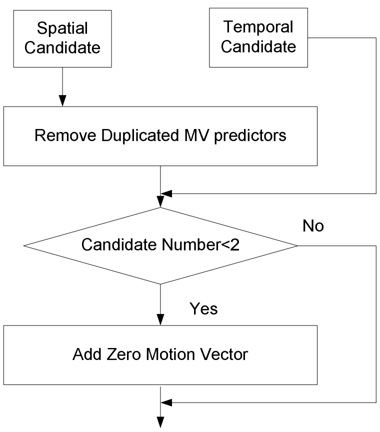

Fig.6 Simplified AMVP list construction

The test platform used is Inter® Xeon® X5450-3.00GHz with eight cores, 8.0 GB RAM. A group of experiments were carried out on the recommended sequences with quantization parameters 22, 27, 32 and 37 as specified by [6]. Here the reference test model HM5.0 of HEVC is treated as the anchor. The "Time" in the following tables depicts the encoder time with proposed method compared to the anchor with default settings. In the Table I~II, the class A, B, C, D and E indicate the different resolutions for the picture.

Table I. BD-rates and encoder complexity of RA

	RA-HE			RA-LC		
	Y	U	V	Y	U	V
Class A	0.0	0.0	-0.1	0.0	0.1	0.0
Class B	0.0	0.0	0.0	0.0	0.0	0.0
Class C	0.0	0.0	0.0	0.0	0.0	0.0
Class D	0.0	-0.1	0.1	0.0	-0.1	-0.1
Class E						
All	0.0	0.0	0.0	0.0	0.0	0.0
Enc-Time	100%			100%		
Dec-Time	99%			99%		

Table II. BD-rates and encoder complexity of LD

	LD-HE			LD-LC		
	Y	U	V	Y	U	V
Class A						
Class B	0.0	0.1	0.2	0.0	-0.2	0.5
Class C	0.0	-0.2	-0.1	0.1	0.0	-0.1
Class D	0.1	-0.1	-0.1	0.0	0.3	0.1
Class E	0.1	0.2	0.2	0.0	-0.5	0.2
All	0.0	0.0	0.0	0.0	-0.1	0.2
Enc-Time	100%			100%		
Dec-Time	99%			99%		

The coding performance and encoder complexity compared to HM5.0 are shown in the above tables (Table I~II). From Table I~II, it can be drawn that our proposed AMVP simplification achieves almost the same coding efficiency while reducing the complexity of the encoder.

5. CONCLUSIONS

This paper proposes a simplified AMVP algorithm, which aims to simplify the AMVP candidate list construction and improve the error resilience of the AMVP process. Firstly, we simplify the AMVP list construction by treating spatial candidates and temporal candidates differently. Secondly, a zero motion vector is directly added to the end of the candidate list when the number of exiting candidates is smaller than the predefined number. Experimental results show that the proposed scheme provides no loss in random access conditions and low delay conditions.

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