DCC 2020

Secondary Intra Prediction Scheme for HEVC

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ABSTRACT

Conventional intra prediction usually utilizes the top and left reconstructed reference samples of the current block to generate prediction pixels. However, with the distance between reference samples and the predicting pixel increasing, the correlation of them becomes weaker. The loss of the bottom-right corner of the current block is bigger than that of the top-left corner. To improve the situation above mentioned, a novel secondary intra prediction scheme is proposed for video coding in this paper. In this scheme, the block will be predicted twice and the first prediction is the same as the conventional intra prediction. After the first prediction, the boundary samples of the reconstructed block can be applied as the reference samples for the second prediction. In our second prediction, the current block is predicted with a designed distance-based bi-directional prediction method. The optimal prediction is determined through the rate-distortion optimization (RDO) strategy. Experimental results show that the proposed algorithm achieves about 3.4% bitrate savings on average comparing to HEVC reference software HM16.9.

INTRODUCTION

Recently, video compression has been confronted with enormous challenges because of the explosive growth of video data. To improve the efficiency of compression, more new technologies have been proposed and incorporated into the prevailing video coding standards. The hybrid coding framework based on predictive differential coding theory is adopted into most standards because prediction plays an important role in reducing redundancy. In this framework, inter prediction and intra prediction are separately designed to reduce the temporal and spatial redundancy. In the inter prediction, the predicted block can be obtained with the motion-compensated method. As for the intra prediction, the current block is predicted based on the reference samples with the limited prediction modes. The reference samples locate at the top and left sides of the current block, which results in the poorer prediction quality of the bottom-right corner. To avoid this limitation, the current block can be predicted once again with a distance-based bi-directional prediction method.

THE PROPOSED SCHEME

The total flowchart of the proposed scheme is shown in Fig.1. As shown in this figure, the proposed scheme includes three steps (i.e., first prediction, second prediction and the optimal prediction decision). Each prediction includes prediction process and reconstruction process. The first prediction is the same as intra prediction in original HEVC. The minimum RD-cost of first prediction is preserved and indicated by `RDCost1'.

After the first prediction, the bottom and right boundaries Ψ_{R2} of the

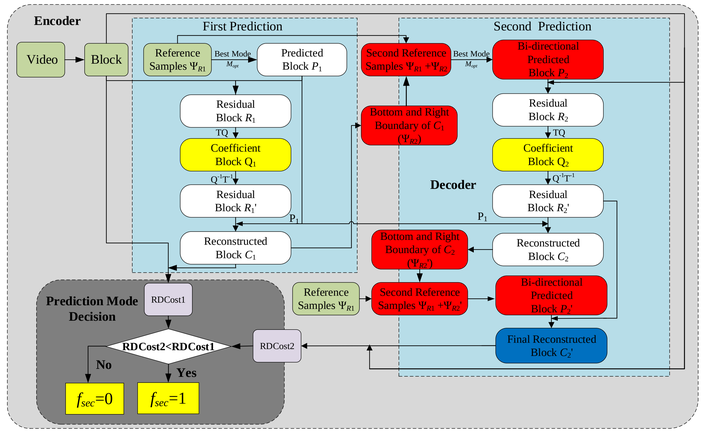

Figure 1: The flowchart of the proposed algorithm

reconstructed block (i.e., C_1) are picked out and applied as the reference pixels for second prediction combined with Ψ_{R1}. For a given $N \times N$ block, the size of pixels to be predicted once again is $(N-1) \times (N-1)$. In order not to add much coding complexity, the prediction mode in second prediction is the same as the optimal prediction mode determined in first prediction (i.e., M_{opt}). In second prediction, pixels are predicted with the distance-based bi-directional prediction method, which utilizes more reference pixels than first prediction. One example is shown in Fig.2. The predicted value g_c is calculated by

$$g_c = \frac{d_\beta(\alpha_1 + 2\alpha + \alpha_2)/4 + d_\alpha(\beta_1 + 2\beta + \beta_2)/4}{d_\alpha + d_\beta} \quad (1)$$

After second prediction process, the residual block of second prediction R_2 is transformed and quantized. To get the final reconstruction block C_2', R_2 need to be added with P_1 to get temporary reconstruction block C_2. We do this because only P_1 can be got at first in the decoder. After second reconstruction, the RD-cost of second prediction is calculated and indicated by `RDCost2'. In order to achieve higher coding gain, the optimal prediction is determined based on the RDO. If `RdCost2' is smaller than `RdCost1', second prediction can predict better for the block and the flag f_{sec} is set to 1. The quantization block Q_2 and the flag (f_{sec} = 1) will be coded. Otherwise, the flag f_{sec} is set to 0. The quantization block Q_1 and the flag (f_{sec} = 0) will be coded.

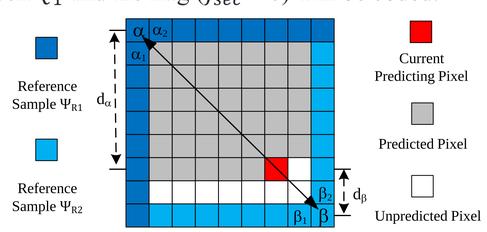

Figure 2: The distance-based bi-directional prediction

In the decoder, the flag f_{sec} is decoded at first. If f_{sec} = 0, it means that the encoder adopts the original HEVC to encode the current block. The decoding process is the same as the original HEVC. Otherwise, the current block will be predicted twice and the decoding process is the same as the second reconstruction process in Fig.1.

RESULT

The proposed intra prediction scheme is implemented on HEVC reference software HM-16.9. The all intra (AI) configuration in the common test conditions (CTCs)[1] is utilized for performance test. Meanwhile, the test sequences for RD performance evaluation include the whole range of HEVC standard test sequences in the CTC and other eight 4K sequences. All sequences are coded with 100 frames. The RD performance is measured by the Bjontegaard-Delta rate at three components. The results of proposed secondary intra prediction scheme are shown in Table 1. To further verify the performance of the proposed scheme, we compare it with Li's multiple-line-based prediction scheme[2] and Yang's multi-weights prediction scheme[3]. The results are shown in Table 2.

Table 1 BD-rate savings for the proposed algorithm for the AI configuration

Sequence	Y	U	V	Sequence	Y	U	V
4K	-1.30%	-0.20%	-0.30%	Class D	-7.00%	-8.10%	-8.00%
Class A	-0.60%	-0.10%	-0.20%	Class E	-0.90%	-0.30%	-0.40%
Class B	-2.00%	-1.70%	-1.70%	Class F	-7.20%	-8.40%	-8.50%
Class C	-6.50%	-7.60%	-7.80%	**Average**	**3.40%**	**3.36%**	**3.45%**

Table 2 Performance comparison with other algorithms

Performance	Proposed Scheme	Li's Scheme[2]		Yang's Scheme[3]
		Full Search	Fast Search	
BD-rate(Y)-4K	-1.30%	-2.70%	-2.30%	-2.41%
BD-rate(Y)-CTC	-4.10%	-2.20%	-1.90%	-2.16%
BD-rate(Y)-All	-3.40%	-2.30%	-2.00%	-2.19%
Encoding Time	154.50%	463%	212%	155%

CONCLUSION

In this paper, we proposed a novel secondary intra prediction scheme for video coding. In this scheme, each block will be predicted twice and the first prediction is the same as the conventional intra prediction. In second prediction, the reference samples come from the boundary of the reconstruction block in first prediction. In order to enhance the spatial correlation between the reference samples and the unpredicted pixels, the distance-based bi-directional prediction method is designed and applied in second prediction. Finally, the optimal prediction is determined by the RDO. Experimental results show that the proposed scheme can achieve 3.4% bitrate saving on average with lower complexity increment.

REFERENCES

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