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Title:	**Non-EE2: Adaptive picture-level vertical mirroring**
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Abstract

The document proposes a method for improving video coding by introducing adaptive picture-level vertical mirroring. The method involves an automatic frame pre-processing step for determining whether the mirroring should be applied without the necessity to perform a brute force search or apply additional RDO checks. The proposed method was implemented in the ECM-15.0 software and achieved an average BD-rate change of -0.23%, -0.26%, and -0.44% for Y, U, and V components in AI configuration, with no change in a decoder runtime.

1 Introduction

As our other document shows [JVET-AK0171], it can be beneficial, in terms of coding efficiency, to rotate or mirror the input frame before encoding. As was observed in the results presented in the mentioned document, most of the gain comes from vertical mirroring, while other transformations provide much more minor improvements. Additionally, besides vertical mirroring and the 180 rotation, in other transformations, the phase of chroma does not match their collocated luma, requiring additional corrections to be performed. Therefore, the proposal described below provides the automatic method for picture-level vertical mirroring.

2 Proposed method

The selection of optimal transform is performed before encoding the whole picture. No additional in-loop optimizations have to be performed, and no additional coding modes are introduced in the computational graph, reducing the computational burden of an encoder.

Due to using only the vertical mirroring, the phase of chroma samples still matches their collocated luma samples, so no change is required.

Input image I_{org} (each component independently) is filtered using a 3x3 Sobel filter for 45-degree edges detection (resulting in image I_{45}) and a 3x3 Sobel filter for 135-degree edges detection (resulting in image I_{135}).

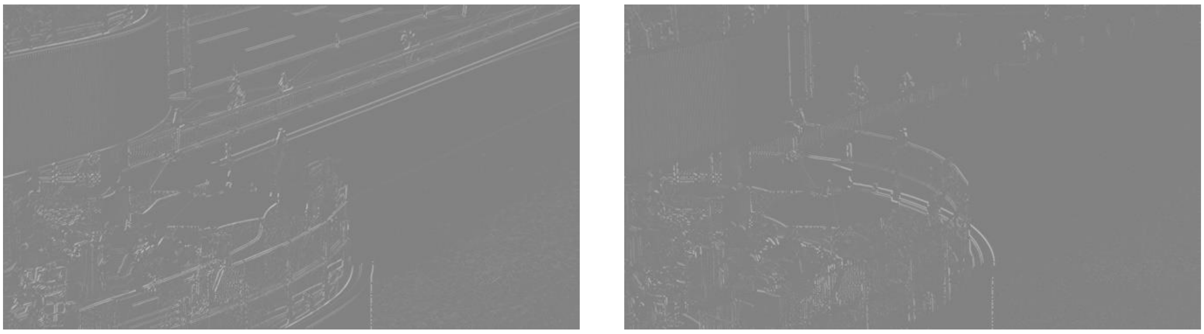

Fig. 1. The result of the 3x3 Sobel filter for 45-degree (left) and 135-degree (right) edges detection.

For each pixel (x,y), it is checked whether one of the edge directions is dominant, i.e., the difference between $I_{45}(x,y)$ and $I_{135}(x,y)$ greater than a threshold (set, e.g., to 160 for a 10-bps video). If so, only the dominant pixel value persists, and the other is set to zero.

Then, all the non-zero values of I_{45} and I_{135} are counted:

$$S_{45} = \sum_{x,y} \left| I_{45}^{Y}(x,y) \right| > 0\ ?\ 1 : 0 + \sum_{x,y} \left| I_{45}^{Cb}(x,y) \right| > 0\ ?\ 1 : 0 + \sum_{x,y} \left| I_{45}^{Cr}(x,y) \right| > 0\ ?\ 1 : 0\,,$$

$$S_{135} = \sum_{x,y} \left| I_{135}^{Y}(x,y) \right| > 0\ ?\ 1 : 0 + \sum_{x,y} \left| I_{135}^{Cb}(x,y) \right| > 0\ ?\ 1 : 0 + \sum_{x,y} \left| I_{135}^{Cr}(x,y) \right| > 0\ ?\ 1 : 0\,.$$

If $S_{135} > (S_{45} + TH)$, the frame is not mirrored. Otherwise, it is mirrored vertically. The threshold is introduced to give the possibility of favoring the selection of not changing the image. In the presented results, TH was set to -6000.

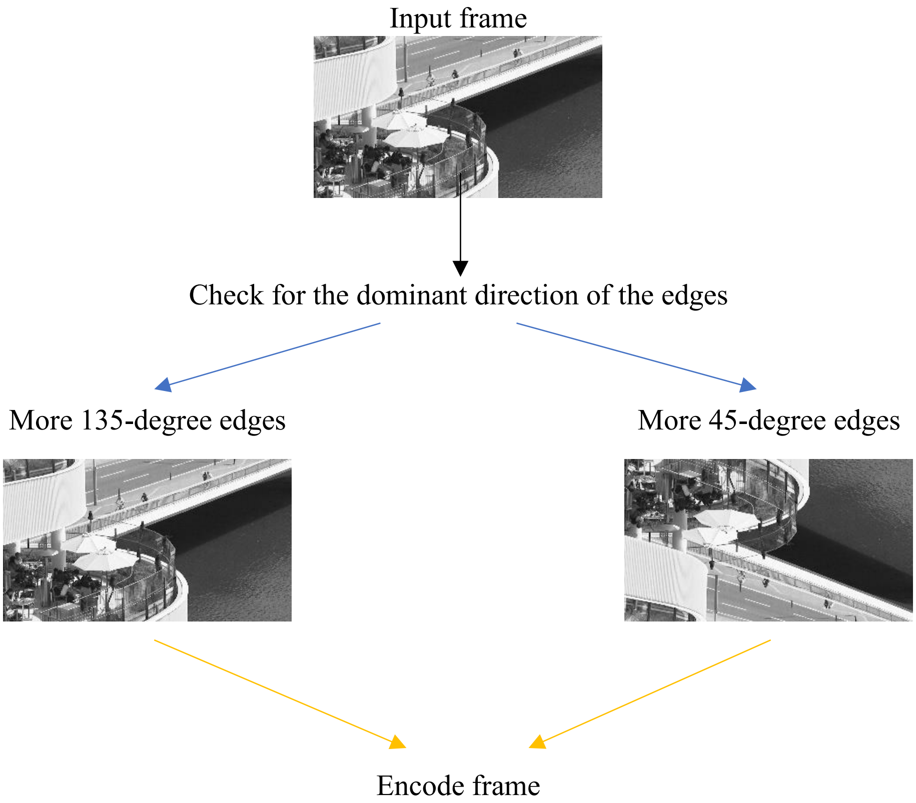

Fig. 2. The overall scheme of the encoder in the proposal.

Naturally, after decoding the frame, the original orientation of the image is restored. The signaling for each frame, in this case, is limited to only 1 bit for indicating the use of the method and 1 bit for signaling that the frame was mirrored.

3 Experimental results

In Table 1, the CTC-based results for AI configuration are presented. As can be seen, a noticeable BD-rate change occurs, especially for A1, A2 and B classes (on average -0.32%, -0.30%, -0.56% for these classes).

While the results for encoding time are not reliable (a different cluster was used for the anchor), the results for decoding were obtained from one machine.

Table 1. CTC-based results of the proposal in comparison with ECM 15.0.

	All Intra Main 10						
	Over ECM-15.0						
	Y	U	V	EncT	DecT	EncVmPeak	DecVmPeak
Class A1	-0.17%	-0.09%	-0.23%	101.8%	101.4%	101.2%	100.1%
Class A2	-0.22%	0.17%	-0.05%	101.4%	99.5%	105.0%	99.6%
Class B	-0.58%	-0.99%	-1.39%	101.2%	100.2%	92.4%	100.2%
Class C	0.01%	0.01%	-0.03%	100.7%	98.8%	100.5%	100.0%
Class E	0.00%	0.00%	0.00%	102.9%	100.1%	101.0%	100.0%
Overall	-0.23%	-0.26%	-0.44%	101.5%	100.0%	99.1%	100.0%

Table 2 presents the results from document [JVET-AK0171] for an *a posteriori* selection of the best mode for vertical mirroring. Therefore, all frames were encoded two times – without transformation and with vertical mirroring. Then, the selection was made for each frame independently to optimize the Y BD-rate. While these results show that higher bitrate savings are possible for luma, it comes with a cost of smaller savings in chromas (and doubled encoding runtime). Therefore, the proposal shows a trade-off between the savings for all components.

Table 2. CTC-based results of an *a posteriori* selection of best mode (vertical mirroring or no transformation) when optimizing Y BD-rate.

	All Intra Main 10		
	Over ECM-15.0		
	Y	U	V
Class A1	-0.23%	0.00%	-0.18%
Class A2	-0.82%	-0.02%	-0.27%
Class B	-0.89%	-0.70%	-0.89%
Class C	-0.03%	0.06%	0.04%
Class E	0.00%	0.00%	0.01%
Overall	-0.43%	-0.18%	-0.31%

4 Conclusions

This document has explored the potential of picture-level vertical mirroring as a pre-processing step to enhance video coding efficiency. The results demonstrate notable improvements in coding efficiency, especially for A1, A2, and B classes, and no change in the decoding runtime.

5 Recommendations

It is recommended to include the experiment for adaptive picture-level frame mirroring in EE2.

6 Patent rights declaration(s)

Poznan University of Technology may have current or pending patent rights relating to the technology described in this contribution and, conditioned on reciprocity, is prepared to grant licenses under reasonable and non-discriminatory terms as necessary for implementation of the resulting ITU-T Recommendation | ISO/IEC International Standard (per box 2 of the ITU-T/ITU-R/ISO/IEC patent statement and licensing declaration form).