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| *Title:* | **Non-CE6: Intra mode coding with fixed length binarization** | | | |
| *Status:* | Input Document to JCT-VC | | | |
| *Purpose:* | Proposal | | | |
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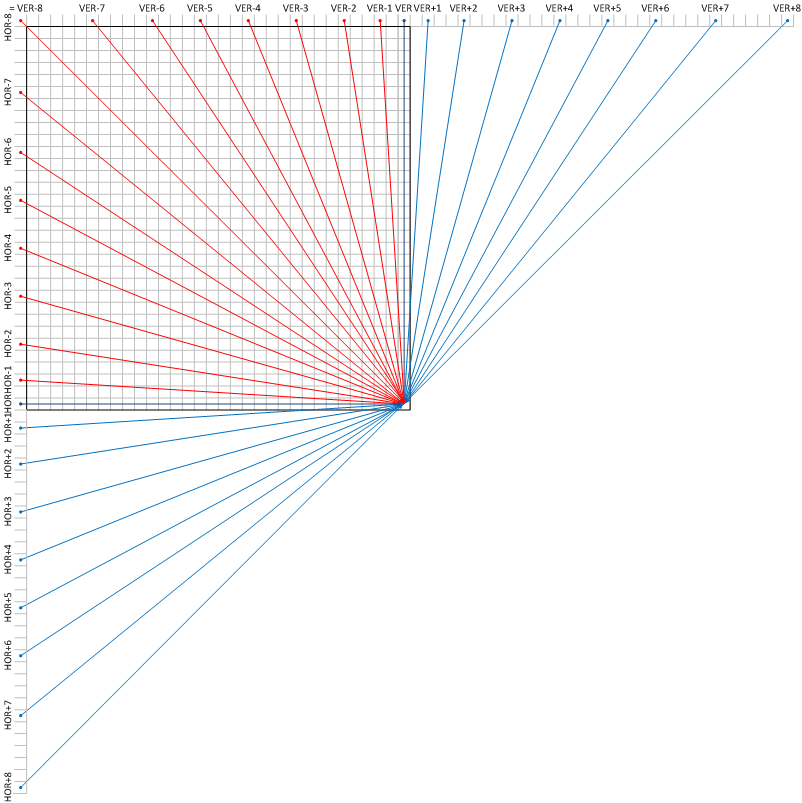
# Abstract

This contribution proposes two methods for unifying intra mode coding. In method 1, the HOR+6 prediction mode is added for 4x4 intra prediction and 3 most probable modes (MPMs) are used for all size intra predictions. As a result, the remaining modes can be represented by fixed length code words. By integrating method 1 in HM5.0, experimental results report average 0.2% BD-rate reduction for All Intra HE and average 0.3% BD-rate reduction for All Intra LC. The encoding and decoding time are similar to HM5.0 anchor. In method 2, the HOR+7 prediction mode is removed from 8x8 to 64x64 intra prediction. As a result, the remaining modes can be represented by fixed length code words. By integrating method 2 in HM5.0, experimental results report average 0.0% BD-rate change for All Intra HE and All Intra LC. The encoding and decoding time are almost the same as HM5.0.

1. Introduction

In HM5, the PU size can be 64x64, 32x32, 16x16, 8x8 and 4x4.for 4x4 PU, 18 prediction modes can be selected; for 32x32 PU, 16x16 PU and 8x8 PU, 35 prediction modes can be selected. Among the 35 modes, 33 are directional prediction modes as illustrated in Fig.1. In order to achieve better compression efficiency, a most-probable-modes (MPM) based scheme is used to encode the mode syntax. Simply speaking, the prediction mode of the top neighbor PU of current PU and the prediction mode of the left neighbor PU of current PU are selected as the two most probable modes. If they are same or one is not available, another mode (Planar or DC mode) is added as the second most probable mode. If the prediction mode of the current PU is the same as either of the most probable modes, a shorter code word is used to encode the current mode. Otherwise, a longer code word is used.

For 4x4 PU, 18 prediction modes can be selected. Besides the DC and PLANAR mode, the directions highlighted by blue circle are selected as the prediction candidates. Apparently, the direction highlighted by red circle is missing. The full directional coverage cannot be obtained. For 32x32 PU, 16x16 PU and 8x8 PU, 35 prediction modes can be selected. Besides of the two MPM, there are 33 remaining modes exist. In order to code these 33 modes, at least six bins (bits) have to be used. Since five bins (bits) are enough to code 32 modes, use six bins (bits) to code 33 modes is not an optimal solution.



Mode 34

Figure 1. Directional Intra Prediction

# Proposed Methods

## Proposed method 1

In method 1, the amount of candidate modes is selected to have a full directional coverage with 19 candidates instead of the 18 candidate modes (with one direction missing) in the current HEVC for 4x4 PU. The 19 candidates include DC, PLANAR, the 16 directional modes highlighted by blue circle and the directional mode highlighted by red circle. By using the current mode ordering method in HEVC, MODE 0~18 are selected as the candidates. For all PUs, 3 MPMs are selected instead of 2 MPMs in the current HEVC.

If the top neighbor and left neighbor of the current PU have different mode, the mode with smaller order is selected as the first MPM and the other mode is selected as the second MPM. The third MPM is selected by the following method.

* If none of first and second MPMs is PLANAR, PLANAR is selected as third MPM. Otherwise, if none of first and second MPMs is DC, DC is selected as third MPM. Otherwise, VERTICAL is selected as third MPM.

If the top neighbor and left neighbor of the current PU use same mode, it is selected as the first MPM. The second (Pred[1]) and third (Pred[2]) MPM can be selected by two procedures. The procedure 1 is described as following.

* If the first MPM is PLANAR, DC and VERTICAL are used as the other two MPMs.
* If the first MPM is DC, PLANAR and VERTICAL are used as the other two MPMs.
* If the first MPM is a directional mode, PLANAR and DC are used as the other two MPMs.

The procedure 2 is based on the reasoning of utilizing the immediate left and right neighbors of the first MPM as the second and third MPM. The mode neighboring relationship is illustrated in Figure 1. The actual second and third MPM selection is based on Table 1 and Table 2.

Table 1. Second and third MPM selection for 4x4 PU

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **MPM** | **0** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **13** | **14** | **15** | **16** | **17** | **18** |
| Pred[1] | 3 | 12 | 16 | 0 | 11 | 11 | 13 | 14 | 15 | 17 | 18 | 4 | 5 | 1 | 6 | 4 | 8 | 2 | 9 |
| Pred[2] | 1 | 13 | 17 | 1 | 15 | 12 | 14 | 0 | 16 | 18 | 0 | 5 | 1 | 6 | 7 | 8 | 2 | 9 | 10 |

Table 2. Second and third MPM selection for 8x8, 16x16, 32x32 PU

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **MPM** | **0** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **13** | **14** | **15** | **16** | **17** |
| Pred[1] | 3 | 22 | 30 | 0 | 19 | 20 | 24 | 26 | 28 | 32 | 34 | 19 | 21 | 23 | 25 | 27 | 29 | 31 |
| Pred[2] | 1 | 23 | 31 | 1 | 27 | 21 | 25 | 14 | 29 | 33 | 18 | 20 | 22 | 24 | 26 | 28 | 30 | 32 |
| **MPM** | **18** | **19** | **20** | **21** | **22** | **23** | **24** | **25** | **26** | **27** | **28** | **29** | **30** | **31** | **32** | **33** | **34** |  |
| Pred[1] | 33 | 4 | 11 | 5 | 12 | 1 | 13 | 6 | 14 | 4 | 15 | 8 | 16 | 2 | 17 | 9 | 18 |  |
| Pred[2] | 34 | 11 | 5 | 12 | 1 | 13 | 6 | 14 | 7 | 15 | 8 | 16 | 2 | 17 | 9 | 18 | 10 |  |

## Proposed method 2

In method 2, intra mode number for PU sizes of 8x8~64x64 is reduced from 35 to 34 by simply removing the mode Hor+7, i.e. mode 34, as illustrated in Figure 1. As a result, 5-bit fixed length codewords could be used to represent the 32 remaining modes. Since mode 34 is not used for 4x4 PU, 4-bit fixed length codewords are still used to represent the 16 remaining modes. In this method, the decoder does not need to support this angular mode (34) any more, which can also decrease the cost in hardware design.

# Experimental Results

Simulations were conducted following common test conditions defined in JCTVC-G1000 [1]. Anchor data was generated using HM5.0 software [2].

## Proposed method 1

The results for the proposed method 1 are reported in table 3 and table 4.

Table 3 Results for proposed method 1a (Procedure 1).

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | **All Intra HE** | | | **All Intra LC** | | |
|  | Y | U | V | Y | U | V |
| Class A (8bit) | -0.3% | 0.1% | 0.2% | -0.4% | -0.1% | -0.1% |
| Class B | -0.2% | -0.1% | 0.0% | -0.3% | -0.2% | -0.1% |
| Class C | -0.1% | -0.1% | 0.0% | -0.2% | -0.1% | -0.1% |
| Class D | -0.2% | 0.0% | 0.0% | -0.2% | -0.1% | -0.1% |
| Class E | -0.1% | 0.1% | 0.3% | -0.2% | -0.2% | 0.0% |
| **Overall** | -0.2% | 0.0% | 0.0% | -0.2% | -0.1% | -0.1% |
|  | -0.2% | 0.0% | 0.0% | -0.2% | -0.1% | -0.1% |
| Class F | 0.0% | 0.0% | 0.0% | -0.1% | 0.1% | 0.0% |
| Enc Time[%] | 100.6% | | | 100.8% | | |
| Dec Time[%] | 99.6% | | | 100.0% | | |

Table 4 Results for proposed method 1b (Procedure 2).

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | **All Intra HE** | | | **All Intra LC** | | |
|  | Y | U | V | Y | U | V |
| Class A (8bit) | -0.3% | 0.0% | 0.1% | -0.4% | -0.2% | -0.1% |
| Class B | -0.2% | -0.1% | 0.0% | -0.3% | -0.1% | -0.1% |
| Class C | -0.2% | -0.1% | -0.1% | -0.2% | -0.1% | -0.1% |
| Class D | -0.2% | 0.0% | -0.1% | -0.2% | -0.1% | -0.2% |
| Class E | -0.3% | 0.0% | 0.2% | -0.4% | -0.3% | -0.1% |
| **Overall** | -0.2% | 0.0% | 0.0% | -0.3% | -0.2% | -0.1% |
|  | -0.2% | 0.0% | 0.0% | -0.3% | -0.2% | -0.1% |
| Class F | -0.1% | 0.0% | 0.0% | -0.1% | 0.0% | -0.1% |
| Enc Time[%] | 100.5% | | | 100.8% | | |
| Dec Time[%] | 99.9% | | | 100.2% | | |

## Proposed method 2

The results for the proposed method 2 are reported in table 5.

Table 5 Results for proposed method 2.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | **All Intra HE** | | | **All Intra LC** | | |
|  | Y | U | V | Y | U | V |
| Class A (8bit) | 0.1% | 0.1% | 0.1% | 0.1% | 0.1% | 0.1% |
| 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% | 0.0% | 0.0% | 0.0% | 0.0% |
| Class E | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| **Overall** | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
|  | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| Class F | 0.0% | 0.1% | 0.0% | 0.0% | 0.0% | 0.0% |
| Enc Time[%] | 99.5% | | | 99.4% | | |
| Dec Time[%] | 99.9% | | | 99.9% | | |

# Conclusions

This contribution reports the methods and results for the proposed intra prediction mode coding. Experimental results reportedly show the proposed method 1 obtains the average BD-rate reductions of 0.2% and 0.3% for All Intra HE for All Intra LC settings, respectively. With current version implementation, encoder runtime is increased by less than 1% for All Intra HE and LC settings; decoding runtime difference is negligible. Experimental results reportedly show the proposed method 2 obtains the average 1% encoding time reduction with average 0.0% BD-rate change for All Intra HE for All Intra LC settings, respectively. Decoding runtime difference is negligible. These two methods provide two different designs to unify the intra mode coding for different PU sizes. It is recommended to include one of these two proposed methods in HM.

# Patent rights declaration(s)

**MediaTek Inc. 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).**

# References

1. Frank Bossen, “Common test conditions and software reference configurations”, JCTVC-G1000, Joint Collaborative Team on Video Coding (JCT-VC) of ITU-T VCEG and ISO/IEC MPEG, Geneva, Switzerland, Nov 2011.
2. HM 5.0 Software, <http://hevc.kw.bbc.co.uk/trac/browser/tags/HM-5.0>.