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| **Joint Collaborative Team on Video Coding (JCT-VC)**  **of ITU-T SG16 WP3 and ISO/IEC JTC1/SC29/WG11**  7th Meeting: Geneva, CH, 21-30 November, 2011 | Document: JCTVC-G869  WG11 Number: m22446 |

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| *Title:* | **CE6: Combinations of MPM derivation and remaining mode** | | |
| *Status:* | Input Document to JCT-VC | | |
| *Purpose:* | Report | | |
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# Abstract

This document provides the results of unified binarization (between LC and HE) and ranking for efficient coding of Intra prediction modes [1]. Unlike the current Intra mode coding technique, the proposed approach uses the same binarization and adaptation in Low Complexity (LC) and High Efficiency (HE) and does not require any VLC or initialization tables. Using this approach 400 bytes VLC tables are removed and, on average, a compression gain of 0.4% and 0.3% were observed in HE and LC settings, respectively.

# Algorithm description

The currently reference software (HM4.0), uses fixed-length codes in High Efficiency (HE) settings and Huffman codes in Low Complexity (LC) settings. For the LC case, 8 sets of VLC tables (4 tables for 4x4 and 4 for the rest of PU sizes) and 8 sets of mode order initializations need to be stored in the ROM. These VLC and initialization tables have a combined size of 400 bytes (assuming 1 byte per stored number). The approach in [1], on the other hand, does not require any VLC or mode initialization tables, thus, reducing the required storage memory by 400 bytes. Furthermore, it utilizes the same binarization and adaptation scheme for both LC and HE and therefore harmonizes the Intra prediction mode coding of HE and LC. The binarization employed in this implementation is shown in Tables 1 and 2. All the remainder bits (fixed length part) are send through the bypass mode in CABAC since their probability distribution is flat (on average).

In this implementation, one array of size 19 and one of size 35 hold the rank (order) of Intra prediction modes of 4x4 and 8x8/16x16/32x32 PU sizes, respectively. Initially the rank of each mode is the same as its mode number. When an Intra prediction mode is selected and coded into the bit stream its rank is swapped with the mode that has exactly one lower rank. This process is carried out each time a mode is selected regardless of the coding profile (LC or HE). This adaptation scheme is the same as LC Intra mode coding in HM4.0 with the exception that the statistics of each Intra mode is kept separately.

Table . Codewords for Intra mode coding of 4x4 PUs.

|  |  |  |
| --- | --- | --- |
| Rank range | Prefix (Unary code) | Remainder (fixed length) |
| 0-1 | 0 | x (1 bit) |
| 2-5 | 10 | xx (2 bits) |
| 6-9 | 110 | xx (2 bits) |
| 10-18 | 111 | xxx (3 bits) |

Table . Codewords for Intra mode coding of 8x8, 16x16, and 32x32 PUs.

|  |  |  |
| --- | --- | --- |
| Rank range | Prefix (Unary code) | Remainder (fixed length) |
| 0-1 | 0 | x (1 bit) |
| 2-5 | 10 | xx (2 bits) |
| 6-13 | 110 | xxx (3 bits) |
| 14-21 | 1110 | xxx (3 bits) |
| 22-35 | 1111 | xxxx (4 bits) |

## Re-ordering based on local information

An alternative more general view to most probable modes (MPM), is referred to as "re-ordering based on local information" in this document. In this view, each mode has its own rank which is updated once a mode is selected in the RDO process. Moreover, each rank has its own codeword such that lower ranks generally have shorted codewords (Table 1 and 2). However, based on some information from the neighboring blocks, the rank of certain modes may be modified temporarily just before coding an Intra mode for a block. The decoder will follow the exact same re-ordering to interpret the parsed value and map the rank to the correct Intra mode.

For example let Table 3 (first two columns), denote the possible modes and their ranks. Let modes 2 and 3 be the modes of the neighboring blocks (also known as MPMs). Furthermore, let's assume that other modes such as Mode 0 (planar) and Mode 1 (vertical) are known to have strong correlation with modes 2 and 3 (these modes are often called MPRMs). Then, the rank associated to these 4 modes will be re-ordered to have the lowest ranks (in the order of decreasing probability of selection by RDO). In this example, the ranks for coding of modes (and parsing at the decoder) will be according to Table 3's third column. In the current implementation, the modes that correlate the mode with a certain mode are experimentally calculated and are listed in Table 4. Three modes with the most correlation with a given mode (first column) are shown in this table. The number of ranks re-ordered based on local information is set as follows:

a) Up to 4 if a PU has only one neighboring mode

b) Up to 5 if a PU has two neighboring mode.

The decoder always parses the codeword Tables 1 and 2. However, the ranks can later be interpreted to point to a certain Intra prediction mode.

Table . Mode ranks based on global and local information. Third column shows the actual ranks used for coding: light color indicates ranks derived from local information while dark color indicates ranks derived from global information (ranks).

|  |  |  |
| --- | --- | --- |
| Mode | Global rank | Rank (after local re-ordering) |
| 0 | 1 | 2 |
| 1 | 5 | 3 |
| 2 | 4 | 0 |
| 3 | 2 | 1 |
| 4 | 3 | 5 |
| 5 | 0 | 4 |

Table . Mode correlation table.

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

# Results

The proposed algorithm was implemented into HM-4.0 reference software. Based on the description in CE6, the following results were obtained.

Table . Results of local + global ranking (up to 3 MPRMs and 2 MPMs).

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | **All Intra HE** | | | **All Intra LC** | | |
|  | Y | U | V | Y | U | V |
| Class A | -0.4% | -0.1% | -0.1% | -0.2% | -0.1% | -0.2% |
| Class B | -0.3% | -0.1% | 0.0% | -0.3% | -0.2% | -0.2% |
| Class C | -0.4% | -0.1% | -0.2% | -0.3% | -0.3% | -0.3% |
| Class D | -0.3% | -0.1% | -0.2% | -0.2% | -0.1% | -0.2% |
| Class E | -0.5% | -0.1% | -0.1% | -0.4% | -0.3% | -0.2% |
| **Overall** | -0.4% | -0.1% | -0.1% | -0.3% | -0.2% | -0.2% |
|  | -0.4% | -0.1% | -0.1% | -0.3% | -0.2% | -0.2% |
| Enc Time[%] | 100% | | | 101% | | |
| Dec Time[%] | 100% | | | 101% | | |

Table . Results of ranking + only 2 MPMs.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | **All Intra HE** | | | **All Intra LC** | | |
|  | Y | U | V | Y | U | V |
| Class A | -0.4% | -0.1% | -0.1% | -0.2% | -0.1% | -0.1% |
| Class B | -0.2% | 0.0% | 0.0% | -0.2% | -0.2% | -0.2% |
| Class C | -0.3% | -0.2% | -0.2% | -0.2% | -0.2% | -0.2% |
| Class D | -0.2% | -0.1% | -0.1% | -0.1% | -0.1% | -0.1% |
| Class E | -0.2% | -0.1% | 0.0% | -0.1% | 0.0% | 0.0% |
| **Overall** | -0.3% | -0.1% | -0.1% | -0.2% | -0.1% | -0.1% |
|  | -0.3% | -0.1% | -0.1% | -0.2% | -0.1% | -0.1% |
| Enc Time[%] | 101% | | | 102% | | |
| Dec Time[%] | 100% | | | 98% | | |

# Patent rights declaration(s)

Sony Electronics 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. E. Maani, Ali Tabatabai, “**Unifying binarizations of Intra modes in HE and LC**”, Doc. JCTVC-F091, Torino, Italy, Jul 2011.