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| *Title:* | **Improved Chroma Intra Mode Signaling** | | |
| *Status:* | Input Document to JCT-VC | | |
| *Purpose:* | Proposal | | |
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# Abstract

The intra coding of current HM uses unified intra prediction [1]. Depending on the PU size, the possible number prediction modes of luma component can be up to 34 (33 directions plus DC). For chroma components, there are 5 different modes regardless of the PU size (vertical, horizontal, DC, diagonal down right, and “same as luma”). Study shows that the “same as luma” mode is usually a good mode, but in the current implementation this mode is encoded using more bits than the other modes during entropy coding. Accordingly, this contribution proposes a modified binarization/codeword assignment for chroma intra mode signaling. Results show that with the proposed change a BD rate saving of -0.7% for all intra high efficiency and -0.6% for all intra low complexity with no added encoder or decoder complexity can be achieved. This result has been cross checked and confirmed as shown in [2].

# Overview of Current Chroma Intra Mode Signaling

Table 1 shows the current binarization / VLC codeword assignment scheme used in HM. As can be seen from the table, the “same as luma” mode is coded using 4 bins/bits. To understand the efficiency of such codeword assignment, occurrence frequency of the 5 modes is collected on 100 frames for class B, C, D videos on all intra low complexity configuration for QP 32. Results are shown in Table 2. One note wothy point is that since the actually luma intra prediction mode can be one of 0, 1, 2 and 3, it’s not completely mutually exclusive between the first 4 modes and the “same as luma” mode.

1. Specification of intra prediction mode for chroma component

|  |  |
| --- | --- |
| **intra\_pred\_mode\_chroma** | **Binarization/VLC Codeword** |
| 0 (vertical) | 0 |
| 1(horizontal) | 10 |
| 2 (DC) | 110 |
| 3 (diagonal down right) | 1110 |
| 4 (same as luma) | 1111 |

1. Frequencies of chroma mode chosen

|  |  |
| --- | --- |
| **intra\_pred\_mode\_chroma** | **Binarization/VLC Codeword** |
| 0 (vertical) | 31% |
| 1(horizontal) | 15% |
| 2 (DC) | 14% |
| 3 (diagonal down right) | 12% |
| 4 (same as luma) | 27% |

# Proposed Approach

## Improved binarization/codeword assignment

In general, because of the texture pattern correlation between luma and chroma components, the “same as luma” mode is likely to be a better mode than the others. Therefore we propose to redefine the binarization / VLC codeword scheme using truncated unary code as presented inTable 3.

1. Improved binarization/codeword assignment for chroma intra modes

|  |  |  |  |
| --- | --- | --- | --- |
| **intra\_pred\_mode\_chroma** | **Binarization/VLC Codeword Current** | **Binarization/VLC Codeword Proposed** | |
| 0 (vertical) | 0 | 01 | (1) |
| 1(horizontal) | 10 | 001 | (2) |
| 2 (DC) | 110 | 0001 | (3) |
| 3 (diagonal down right) | 1110 | 0000 | (4) |
| 4 (same as luma) | 1111 | 1 | (0) |

## Further codeword space reduction

As discussed in the first section that the chroma intra modes are not mutually exclusive. For example, given the luma intra mode being vertical, and the “same as luma” not chosen, the chroma mode codeword can never be vertical any more. It is therefore proposed to use codeword space reduction to further improve coding efficiency, such that if the luma intra mode is one of vertical, horizontal, DC and diagonal down right, the corresponding mode is removed from the chroma mode list, and accordingly, the codeword space of the truncated unary code is reduced from 0-4 to 0-3. Table 4 gives a complete list of the codewords.

1. Codeword space reduction for chroma intra modes

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **intra\_pred\_mode\_chroma** | **intra\_pred\_mode\_luma** | | | | |
| 0 | 1 | 2 | 3 | others |
| 0 (vertical) | n/a | 01 | 01 | 01 | 01 |
| 1(horizontal) | 01 | n/a | 001 | 001 | 001 |
| 2 (DC) | 001 | 001 | n/a | 000 | 0001 |
| 3 (diagonal down right) | 000 | 000 | 000 | n/a | 0000 |
| 4 (same as luma) | 1 | 1 | 1 | 1 | 1 |

# Simulation Results

## BD Rate Performance

Table 5 and Table 6 show the BD Rate performance for all test sequences, using the intra high efficiency and intra low complexity settings specified in the common coding conditions [2]. The anchor software is HM 1.0 (TMuC 0.9). A negative value indicates better efficiency. As can be seen, the average BD Rate saving is 0.7% for intra high efficiency settings and 0.6% for intra low complexity settings. The shaded cells in Table 6 indicates further bit rate saving achieved by using codeword space reduction.

1. BD rate performance without codeword space reduction

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | Intra High Efficiency | | | Intra Low Complexity | | |
| Y BD-rate (%) | U BD-rate (%) | V BD-rate (%) | Y BD-rate (%) | U BD-rate (%) | V BD-rate (%) |
| Class A | -0.8 | 0.2 | 0.5 | -0.5 | -0.2 | 0.1 |
| Class B | -0.7 | 0.2 | 0.3 | -0.5 | -0.4 | -0.2 |
| Class C | -0.7 | 0.3 | 0.5 | -0.7 | -0.4 | -0.3 |
| Class D | -0.5 | 0.4 | 0.5 | -0.5 | -0.2 | -0.1 |
| Class E | -1.0 | -0.4 | -0.1 | -0.5 | 0.3 | 0.1 |
| All | -0.7 | 0.2 | 0.3 | -0.6 | -0.2 | -0.1 |

1. BD rate performance with codeword space reduction

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | Intra High Efficiency | | | Intra Low Complexity | | |
| Y BD-rate (%) | U BD-rate (%) | V BD-rate (%) | Y BD-rate (%) | U BD-rate (%) | V BD-rate (%) |
| Class A | -0.8 | 0.0 | 0.3 | -0.6 | -0.3 | -0.1 |
| Class B | -0.7 | 0.1 | 0.1 | -0.6 | -0.5 | -0.4 |
| Class C | -0.7 | 0.1 | 0.2 | -0.7 | -0.5 | -0.4 |
| Class D | -0.6 | 0.2 | 0.3 | -0.5 | -0.3 | -0.3 |
| Class E | -1.1 | -0.5 | -0.2 | -0.5 | -0.1 | -0.2 |
| All | -0.7 | 0.0 | 0.1 | -0.6 | -0.4 | -0.3 |

## Complexity

The changes proposed in Section 2.1 only modifies the binarization/VLC code assignment scheme with no effect on the complexity for either encoder or decoder. The codeword space reduction scheme proposed in Section 2.2 makes the codeword assignment conditioned on the luma mode. The complexity increase is negligible.

# Conclusion

In this proposal, a new binarization/VLC codeword assignment scheme is proposed to make entropy coding of chroma intra modes more efficient. Simulation results show that this technique improves BD Rate performance by 0.7% for intra high efficiency and 0.6% for intra low complexity.

We recommend that this proposal be adopted into HM and studied in Core Experiments.

# References

1. JCT-VC, Summary of HEVC working draft 1 and HEVC test model (HM), JCTVC-C405, 3rd JCT-VC meeting, Guangzhou, October 2010.
2. Cross verification of Improved Chroma Intra mode Signaling, JCTVC-D220, 4th JCT-VC meeting, Daegu, January 2011.
3. JCT-VC, Common test conditions and software reference configurations, JCTVC-C500, 3rd JCT-VC meeting, Guangzhou, October 2010.

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