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| *Title:* | **Summary and Improvements of DCIM** | | |
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# Abstract

In this contribution, we present a summary of DCIM’s Core Experiment (CE) results, its enhancements, and visual quality evaluation. Moreover, we present the results of additional experiments that demonstrate when DCIM is used, the maximum number of Unified Intra (UI) directions can be safely reduced from 34 to 17 with a slight improvement of average coding efficiency. More precisely, these experiments show that using 17 Intra directions with DCIM performs, on average, 2.3% and 2.6% better than the HM anchors with 34 Intra directions.

# Objective evaluation

Table 1 shows the average BD rates of the original DCIM algorithm for each class as appeared in [2]. The accompanied Excel Sheet also contains information for the performance of DCIM for each individual sequence. These results illustrate that DCIM is extremely effective with video signals which contain a lot of strong edges such as computer generated graphics or sequences like “Foreman” or “BasketballDrill”. For example DCIM achieves 4.9% and 6.6% gain for the “BasketballDrill” sequence.

Table 1. Summary of DCIM results compared to HM Anchors.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | Intra | | | Intra LoCo | | |
| Y BD-rate | U BD-rate | V BD-rate | Y BD-rate | U BD-rate | V BD-rate |
| Class A | -1.7 | -0.6 | -0.3 | -1.5 | -0.8 | -0.4 |
| Class B | -2.1 | -1.1 | -1.2 | -2.2 | -1.8 | -1.9 |
| Class C | -2.4 | -1.1 | -1.2 | -2.9 | -1.9 | -2.0 |
| Class D | -1.5 | -0.4 | -0.3 | -1.8 | -0.8 | -1.0 |
| Class E | -3.1 | -2.2 | -1.9 | -3.1 | -1.5 | -1.7 |
| All | -2.1 | -1.1 | -1.0 | -2.3 | -1.4 | -1.5 |
| Enc Time[%] | 108% | | | 115% | | |
| Dec Time[%] | 106% | | | 119% | | |

The results shown in the above table have all been cross-verified with perfect match by Panasonic, NEC and NHK in submissions [2, 3, 4].

On top of the original DCIM proposal which was used in CE, two modifications are introduced in consideration of the relationship between DCIM and UI. The first modification is the change of the number of UI modes. Specifically, the number of applicable UI modes for 8x8, 16x16, and 32x32 PU is reduced from 34 to 17. With this modification, encoding time can be reduced by about 4% while achieving similar coding efficiency. The second modification is related to MPM. DC mode is always used as MPM instead of doing prediction using neighboring UI modes. With this modification, about 0.2% BD-rate gain can be achieved without any impact on encoder/decoder complexity. More information onthe MPM modificationcan be found in [5]. The results of DCIM with the aforementioned modifications, under the same conditions as in CE [2], are presented in Table 2.

Table 2. Summary of improved DCIM results with 17 UI modes

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | Intra | | | Intra LoCo | | |
| Y BD-rate | U BD-rate | V BD-rate | Y BD-rate | U BD-rate | V BD-rate |
| Class A | -1.8 | -1.8 | -1.8 | -1.8 | -1.0 | -0.6 |
| Class B | -2.3 | -2.3 | -2.3 | -2.6 | -2.0 | -2.0 |
| Class C | -2.5 | -2.5 | -2.5 | -3.0 | -2.1 | -2.2 |
| Class D | -1.6 | -1.6 | -1.6 | -2.0 | -1.0 | -1.4 |
| Class E | -3.3 | -3.3 | -3.3 | -3.2 | -1.6 | -1.8 |
| All | -2.3 | -2.3 | -2.3 | -2.6 | -1.6 | -1.7 |
| Enc Time[%] | 106% | | | 106% | | |
| Dec Time[%] | 106% | | | 117% | | |

In addition to HEVC standard sequences, NHK performed DCIM test on two Super Hi-Vision (SHV) sequences namely Nebuta and SL [3, 7, 8]. The results have been cross-verified with complete match by Sharp. Table 3 below shows the summary of the results for these additional test sequences.

Table 3. Summary of improved DCIM results with 17 UI modes for SHV sequences Nebuat and SL (NHK results)

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | Intra | | | Intra LoCo | | |
| Y BD-rate | U BD-rate | V BD-rate | Y BD-rate | U BD-rate | V BD-rate |
| Class SHV | -1.0 | -0.5 | -0.1 | -1.6 | -0.9 | -0.9 |
| Enc Time[%] | 106% | | | 107% | | |
| Dec Time[%] | 104% | | | 114% | | |

# Subjective evaluation

The two sequences for which DCIM performed well in the objective evaluation, namely BasketballDrive and BasketballDrill, were selected by NEC for visual evaluation [2]. Despite the fact that all Intra coding performed the best, it was not used for visual evaluation due to existence of Intra flicker. Therefore, as an alternative, random access was used. It was observed that the visual appearances of the anchor and that of DCIM are different, especially, in the floor areas. However, significant visual quality improvements or degradations by DCIM were not observed in play-backed videos. It should be also noted that DCIM's bit-rates were lower than those of the anchors for both sequences and all QPs. By freezing the video playback and comparing frame-by-frame appearances, significant visual quality improvements by DCIM were observed in BasketballDrive QP=37 and BasketballDrill QP=32 results [2]. As for the BasketballDrive QP=37 result, artificial vertical lines appeared on the wooden wall areas of the background in the anchor, whereas those did not appear in DCIM. As for the BasketballDrill QP=32 results, a diagonal line of the basketball backboard goal was distorted in the anchor, whereas that area was reconstructed in DCIM without any noticeable errors. Figures [1] and [2] show some examples of the areas where visual quality improvements by DCIM were observed.



Figure 1. BasketballDrive (No. 432) QP=37 results for low complexity random access (Left: Anchor 33.34dB 1684.29Kbps, Right: DCIM 33.35dB 1655.84Kbps).



Figure 2. Artificial vertical lines are avoided in DCIM result.

# Conclusions

Sony, Panasonic, Sharp, NEC, and NHK launched a comprehensive study of DCIM and conducted a thorough subjective and objective evaluation of DCIM under various settings and with many video sequences. The results of this investigation were summarized and presented in this document. Based on these results, both subjective and objective, we recommend including this technology in the HM.

# References

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# Patent rights declaration(s)

**Sony Corporation and SHARP Corporation may have IPR 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).**