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Source	**Poznań University of Technology (PUT), Poznań, Poland; Electronics and Telecommunications Research Institute (ETRI), Daejeon, Republic of Korea**
Status	**Input**
Title	**MIV CE3.2: Color-based patch analysis**
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1 Introduction

This document presents a technical description of the PUT/ETRI experiment on color-based patch analysis (MPEG Immersive Video CE3.2). In the proposed solution, the mean value of each color component of every patch is set to a neutral color (512, 512, 512). The original mean value is being sent within metadata.

2 Proposed technique

In TMIV6, all the patches within atlases have their original color. We propose to unify their mean values (i.e. to set the mean value of each component of each patch to 512 – Fig. 1). Such an approach allows decreasing the number of edges in the atlas and their amplitude. Operations are performed independently for each color component.

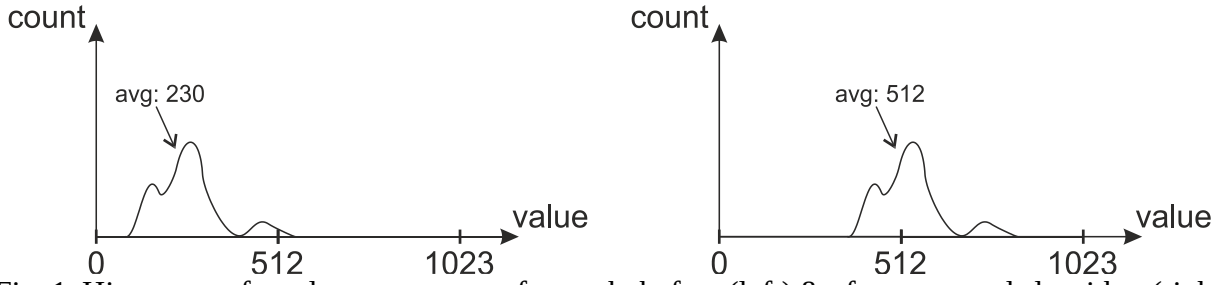

Fig. 1. Histogram of a color component of a patch: before (left) & after proposed algorithm (right).

If the presented solution would cause an overflow for some values, the average value is modified by the size of the overflow (Fig. 2). Analogous operation is performed, if there would be an overflow at the left border of the histogram (negative values). Such a modification ensures that the proposed solution is fully reversible in the decoder.

Of course, to provide proper decoding, the original mean value of each patch has to be sent to the decoder.

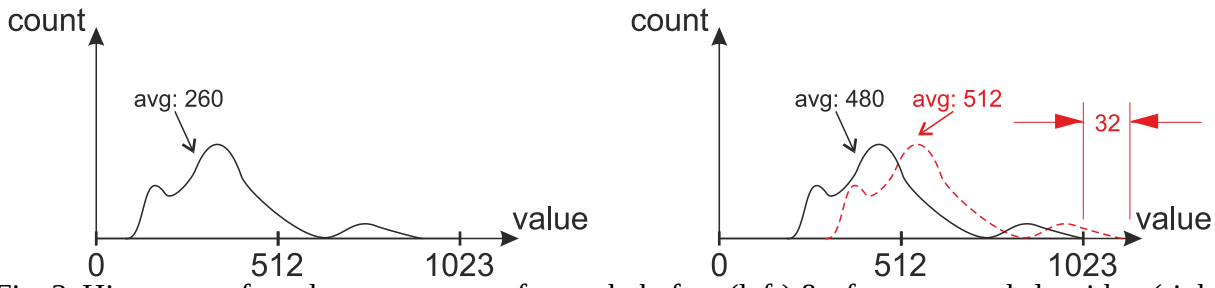

Fig. 2. Histogram of a color component of a patch: before (left) & after proposed algorithm (right), the mean value of the patch after the proposed modification is different than 512 to avoid overflows.


Fig. 3. Atlas generated with TMIV with color-based patch analysis (bottom) vs. anchor (top).

Fig. 4. Atlas generated with TMIV with color-based patch analysis (right) vs. anchor (left).

3 Experimental results

Table 1. Objective evaluation of the proposed technique.

Mandatory content - Proposal vs. Low/High-bitrate Anchors

Sequence		High-BR BD rate Y-PSNR	Low-BR BD rate Y-PSNR	Max delta Y-PSNR	High-BR BD rate VMAF	Low-BR BD rate VMAF	High-BR BD rate IV-PSNR	Low-BR BD rate IV-PSNR
ClassroomVideo	SA	-0.4%	-1.2%	1.96	4.0%	1.2%	-0.3%	-0.7%
Museum	SB	0.3%	0.4%	16.70	0.4%	0.6%	0.3%	0.4%
Hijack	SC	-1.7%	-2.9%	9.73	-1.0%	-2.5%	-0.9%	-2.3%
Chess	SN	0.6%	-0.3%	16.62	0.6%	-0.1%	0.3%	-0.4%
Kitchen	SJ	0.8%	1.1%	16.85	1.2%	1.3%	0.9%	1.4%
Painter	SD	-2.1%	-3.7%	8.19	-2.0%	-3.9%	-1.4%	-3.3%
Frog	SE	-1.0%	-1.2%	5.98	-0.7%	-1.1%	-0.5%	-0.7%
Carpark	SP	-0.3%	-0.6%	7.51	-0.0%	-0.2%	-0.0%	-0.3%
MIV		**-0.5%**	**-1.1%**	**10.44**	**0.3%**	**-0.6%**	**-0.2%**	**-0.7%**

Optional content - Proposal vs. Low/High-bitrate Anchors

Fencing	SL	-1.5%	-1.6%	12.91	-1.2%	-1.6%	-1.4%	-1.8%
Hall	ST	-0.7%	-1.4%	12.94	-0.2%	-1.0%	-0.4%	-1.0%
Street	SU	0.4%	0.3%	10.56	0.6%	0.1%	0.4%	0.2%
Group	SR	-0.7%	-1.2%	11.86	-0.4%	-1.0%	-0.4%	-0.8%
Fan	SO	-0.7%	-0.9%	9.05	-0.4%	-0.5%	0.1%	0.0%
MIV		**-0.7%**	**-1.0%**	**11.46**	**-0.3%**	**-0.8%**	**-0.3%**	**-0.7%**

The objective gains presented in Table 1 do not seem to be significant. However, due to the reduction of edges in the attribute atlases, there are less disturbing artifacts visible as rectangles of a different color – especially for higher compression (Fig. 5).

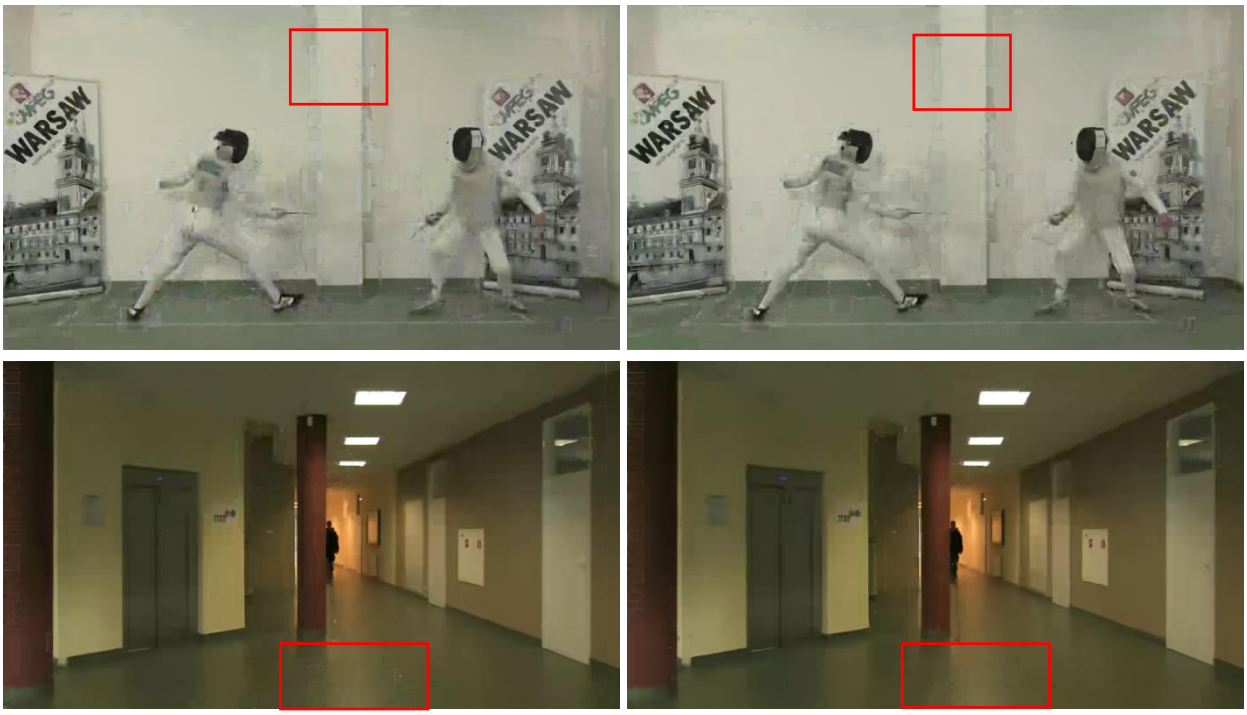

Fig. 5. Proposed TMIV with color-based patch analysis (right) vs. anchor (left).

The average bitrate reduction of the attribute atlases (compared to anchor) is presented in Table 2.

Table 2. Bitrate reduction – averaged over all sequences.

Test point	Bitrate reduction
QP1	0.82 %
QP2	1.49 %
QP3	3.46 %
QP4	7.59 %
QP5	13.35 %

The bitrate of geometry did not change, bitrate of metadata increased on average by 0.097 Mbps.

4 Syntax and semantics

4.1 Syntax (§7.3.7.4)

pdu_miv_extension(tileId, p) {	**Descriptor**
if(vme_max_entities_minus1 > 0)	
pdu_entity_id[tileId][p]	u(v)
if(asme_depth_occ_threshold_flag)	
pdu_depth_occ_threshold[tileId][p]	u(v)
for(compIdx = 0; compIdx <= 2; compIdx++) {	
pdu_offset[compIdx][tileId][p]	u(8)
}	
}	

4.2 Semantics (§7.4.7.4)

pdu_offset[compIdx][tileId][p] is used to derive the PduOffset[compIdx][tileId][p] that indicates the offset that shall be added to all samples of color component with index equal to compIdx within the patch with index equal to p, in the tile with id tileId. The variable PduOffset[compIdx][tileId][p] is derived as follows:

PduOffset[compIdx][tileId][p] = pdu_offset[compIdx][tileId][p] << (bitDepth – 7)

4.3 Decoding process (Annex H)

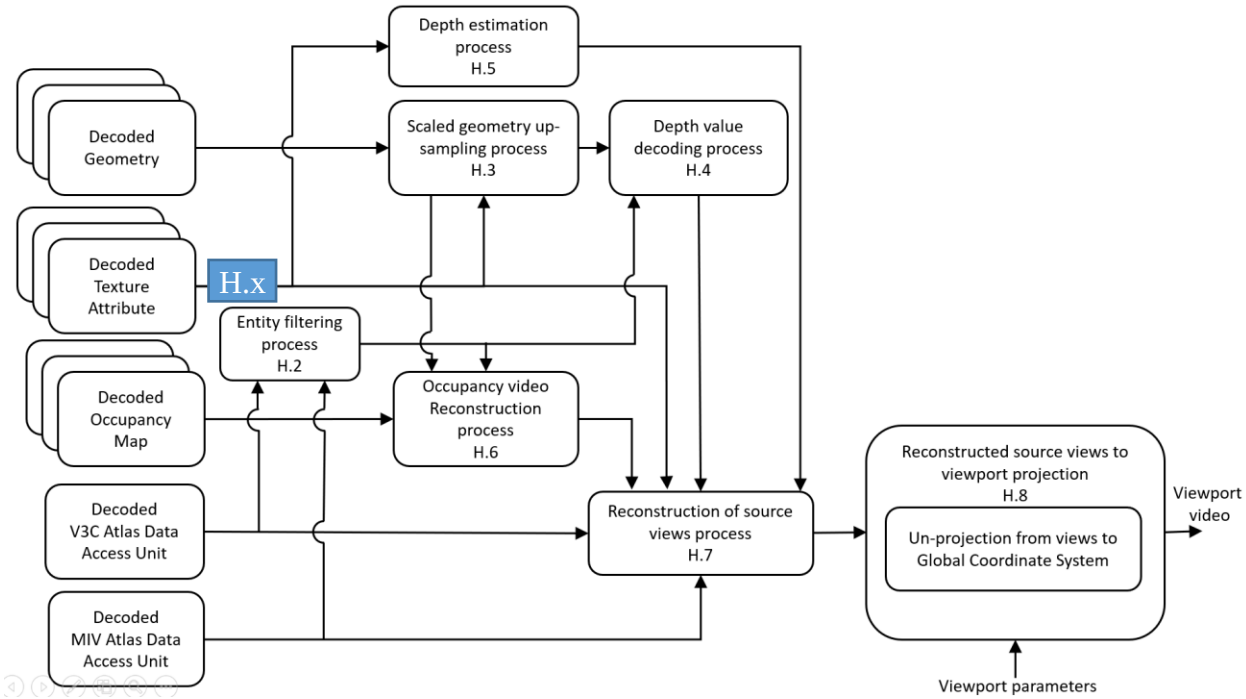

Figure H.1: Block diagram of hypothetical view renderer

H.x Patch color recovery process

Inputs to this process are:

- decAttrFrame[0][0][0][compIdx][y][x] with compIdx in 0 .. 2
- atlas parameters for all atlases

Output of this process are atlases with recovered color of patches.

```
for(a= 0; a <= vps_atlas_count_minus1; a++)
  for( y = 0; y < AspsFrameHeight[ a ]; y++ )
    for( x = 0; x < AspsFrameWidth[ a ]; x++) {
      bSz = AtlasPatchPackingBlockSize[ a ]
      p = BlockToPatchMap[ y  / bSz ][ x / bSz ]
      decAttrFrame [ a ][ y ][ x ] = Clip(decAttrFrame [ a ][ y ][ x ] + PduOffset [ compIdx ][ tileId ][ p ],
            0, 2^bitDepth – 1) for compIdx = 0..2
    }
```

5 Acknowledgement

This work was supported by Institute of Information & Communications Technology Planning & Evaluation (IITP) grant funded by the Korea government (MSIT) (No. 2018-0-00207, Immersive Media Research Laboratory).

6 Recommendations

We recommend:

- to include the proposed technique into TMIV7,
- to adopt proposed syntax and semantics,
- to continue the Core Experiment 3.