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# Introduction

The current V-PCC specification [1] allows attribute smoothing to be performed as the final step of the reconstruction process, based on an attribute smoothing enabling flag. However, the specification has certain problems that need to be addressed.

The first one is that attribute smoothing functionality was never tested for attributes types other than three component texture. The second problem is that the attribute smoothing process performs an RGB to YUV transformation assuming BT. 709 matrix before using the 0th component of the transformed frame to make certain smoothing decisions. However, the color space for the texture may not be BT. 709. Furthermore, the output of the video codec may not be RGB.

This issue was discussed during the face-to-face meeting in Munich. The notes related to this issue are as follows:

Discussion: It was identified that the current specification assumes that the attributes are always RGB BT. 709 data. All reconstruction operations (e.g. attribute smoothing) are based on this assumption regardless of the attribute type but also the actual coding format of the attributes e.g. YUV 4:2:0.

Recommendation: It is recommended that the specification is extended to properly handle different attribute types and color representations for texture attributes. Contributions for the next MPEG meeting are encouraged.

# Proposal for changes in attribute smoothing

We propose changes to attribute smoothing to overcome the problems stated in Section 1. In the current V-PCC specification, for each attribute, the attribute video sub-bitstream is decoded. Then, the decoded attribute video goes through upsampling as needed (section 9.2) to bring it to the same resolution, frame rate and chroma format (4:4:4). Let such a video be denoted by AttributeNR.

Currently, TMC2 v7.0 software performs conversion from YUV to RGB if necessary before reconstructing the point cloud and performing attribute smoothing. However, the current specification does not include any color conversion step. So, when the attribute type is texture, the AttributeNR video that is input to the attribute smoothing step is still in the same color space that it was coded in.

Most of the times, for compression efficiency, a three component RGB texture video would be converted to a luma-chroma format before being input to a video codec. If the RGB video is directly input to the video codec, it is usually in GBR format, where the G component may act as a proxy for the luma component. Due to this, we propose the following changes to attribute smoothing:

1. Restrict application of attribute smoothing to only texture attributes having 1 or 3 components.
2. Instead of performing an RGB to YUV transformation for making attribute smoothing decisions, use the 0th component of the decoded attribute video (before applying any color conversion, possibly based on the VUI information present in the attribute video sub-bitstream).

Other restrictions may be possible. For example, when attribute smoothing is enabled, it is applied only when the number of attribute components is equal to 1 and the attribute type is texture, transparency, reflectance or normals or when the number of attribute components is equal to 3 and the attribute type is texture.

Please note that it is anticipated that for texture attributes, the corresponding attribute video sub-bitstream will contain VUI information that would be used to perform color conversion on the smoothed attribute for display purposes. Since it is not guaranteed that a video codec may always contain VUI information, it may be worth considering a VUI for V-PCC.

# Specification text changes

### 9.6.2 Attribute smoothing process

This process is invoked when afp\_attribute\_smoothing\_enabled\_flag[ aIdx ] is equal to 1, attribute type is texture, and ai\_attribute\_dimension\_minus1[ atlasId ][ aIdx ] is equal to 2 or 0, where atlasId is the index of the current atlas and aIdx is the attribute index.

Inputs to this process are:

…

Also throughout clause 9.6, when luma is calculated using the following formula where the array attr stores components of the attribute:

luma = 0.2126 \* attr[0] + 0.7152 \* attr[1] + 0.0722 \* attr[2],

replace it with:

luma = attr[0]

# References

[1] “Text of ISO/IEC DIS 23090-5 Video-based Point Cloud Compression”, ISO/IEC JTC1/SC29/WG11 output document N18670, July 2019, Gothenburg, Sweden