Review on codec-agnostic approach for MPEG V-PCC

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Abstract

In this paper, we reviewed the method on the codec-agnostic design of MPEG V-PCC. The codec-agnostic approach designed V-PCC can use any video codec for compression. Thus, adoption with other codecs beside HEVC has not been systematically discussed. Through the analysis of the design issues that related to MPEG EVC and JPEG. We provided a strategy on choosing and targeting different video codecs for V-PCC.

1. Introduction

MPEG is marching forward on the destination of standardized video-based point cloud compression (V-PCC) [1] to compress dynamic point clouds. The unique feature of V-PCC is the use of video codecs to compress point clouds after converting a 3D point cloud structure into a 2D patch video. The use of video codec for PCC is found to be beneficial not only in compression efficiency but also in the fast market penetration of V-PCC thanks to the availability of several successful video standard in most mobile devices.

V-PCC is designed with a "codec-agnostic" approach, which means that any video codec can be used for V-PCC. For example, the V-PCC profiles under discussion include the use of High Efficiency Video Coding (HEVC) and MPEG-4 Part 10 Advanced Video Coding. Currently, the test model of V-PCC (TMC2) uses the HEVC codec as a base video codec. Although it is claimed to be codec agnostic, there are only a few studies to use other video codecs than HEVC for V-PCC in the MPEG community [2][3][4].

Previously, we have designed the JPEG based V-PCC [5]. However, the compression ratio is limited by the JPEG coding efficiency and the coding structure. Compare with the HEVC, the MPEG Essential Video Coding (EVC) provides a more simplified coding design and a better compression rate on the main profile [6]. Moreover, the licensing policy provides one more solution to choosing video codecs for users.

In this paper, we analyzed the design for JPEG-based V-PCC and MPEG EVC-based V-PCC. By implementing two different V-PCC, we summarized the design points for choosing and implementing video codec. In the following sections, we present an exemplar analysis on how a video codec can be applied to V-PCC.

2. Background

The encoding process is as shown in Figure 1. The V-PCC encoder includes patch generation, patch packing, video compression, and other processes such as auxiliary information coding. First, the 3D geometry coordinates of an input point cloud are projected into 2D patches, then these patches will be packed into images which includes occupancy map (OMAP) and geometry video. Then the corresponding color attributes are also been projected into 2D patches based on reconstructed OMAP and geometry. Finally, the video coder compresses these images into a bitstream.

On the decoder side of the V-PCC, as shown in Figure 2, the demultiplexer splits the bitstream into geometry, color attribute, and OMAP video bitstream. Through video decoding, the reconstructed geometry, color, and occupancy map images will be used to convert patches to 3D point cloud representation.

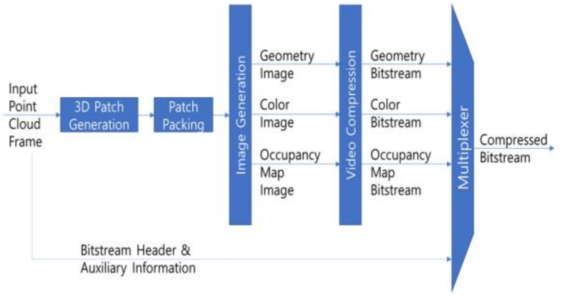

Figure 1. V-PCC Encoder Diagram

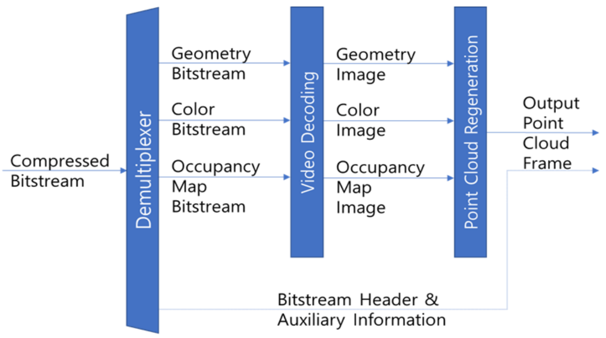

Figure 2. V-PCC Decoder Diagram

3. Design Review

In V-PCC, the converted geometry, texture, and OMAP 2D images are in different color spaces (i.e., geometry and OMAP in grayscale, and texture in 8-bit RGB). The color conversion process is necessary to compress such data by video codec. Take the V-PCC base profile as an example. The bit-depth and chroma sampling are limited because the bit depth is 8-bit on geometry, attribute, and occupancy layers, and YUV Chroma sampling is YUV420.

The extensive support of one video codec also needs to be considered. Well implemented software or hardware embedded processing unit will let the V-PCC developer deploy their application more efficiently. As a result, the V-PCC base profile suggests using AVC and HEVC.

For most of the MPEG originated video codecs, there are profiles and levels that have been designed to compress different sized video. However, some of the patch images generated from the Category 2-C sequences with 12 bits of precision may have a large video size exceeded the support of lower profile or levels.

Focusing within the codec, while multiple point cloud frames have been compressed as a group of frames (GOF). The accessibility of each frame is also very important inside the GOF. By inheriting the coding structure of video codec, all-intra, random-access and low-delay profiles in video coding provide different behavior characteristics that may be suitable for different scenarios. But for the JPEG, multiple coded jpeg files need to be processed. So, we use 7z to patch these JPG files into one archive. On the other hand, in the EVC the picture reference list is only supported in the main profile.

Furthermore, if each reference picture could be ordered to predict between D0/D1 layer of geometry and texture frames, the coding efficiency could be improved. Another point is that these patches may be at a different location in each frame. Thus, a larger motion search range would extend the inter prediction efficiency.

Because coding of the geometry and texture video depends on the reconstructed occupancy map. The lossless coding option is also very important, coding an occupancy map with a lossless method could greatly improve the final quality.

Moreover, the accessibility inside the frame such as partial decoding is also needed. Techniques including dividing one frame into tile or slice partitions that already used in the video codec would help the implement on V-PCC.

For the rate-distortion (RD) control, different HEVC compression parameter was set separately for geometry, attribute, and occupancy in V-PCC. These parameters from HEVC was called Quantization parameter (QP), which means that a lower QP result in better image quality. However, the JPEG uses compression quality factor (QF) instead, the higher quality needs the higher setting. The EVC is using a similar rate-distortion control method, which could use QF as a control parameter.

Current TMC2 needs the video decoder to tell the picture size to V-PCC for the next step, color space conversion. While the HEVC high level syntax (HLS) parser is embedded in the test model, the extracting of the width and height information of the coded picture from the other video sub-bitstream is needed.

4. Result

In our experiment, we implemented JPEG based V-PCC on TMC2 version 3.0 and EVC based V-PCC on TMC2 version 7.2. It should be noted that we only used JPEG to compress geometry and texture video. And a non-CTC lossy OMAP encoding configuration was used in the EVC experiment.

The JPEG experiment with a fixed geometry quality - QF 90. The result in Figure 3. shows that, due to the performance of JPEG, the coding efficiency gap between anchor V-PCC and JPEG based V-PCC is large.

We compared the result on soldier and long_dress sequences as shown in Figure 4. The EVC and HEVC are both using the lossy OMAP and low delay geometry-texture video encoding configuration. The 3D motion compensation was disabled, and search range of EVC extended to 512. Although the efficiency of EVC based V-PCC cannot catch up with the anchor, the encoding time reduced by EVC should be considered. It is a possible solution for V-PCC.

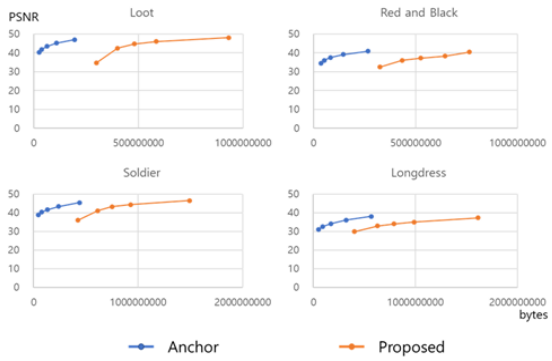

Figure 3. RD of color attribute

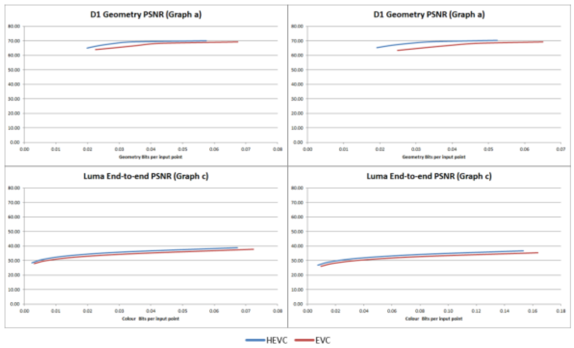

Figure 4. RD of soldier(left) and long_dress(right) sequences

5. Conclusion

Through the analysis of the design issues and implementation result that related to MPEG EVC and JPEG. We provided a strategy on choosing and targeting different video codecs for V-PCC.

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Reference

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