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Title [G-PCC] CE13.15 report on LoD generation for spatial scalability
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Abstract

This document provides a report of Core Experiment 13.15 on LoD generation for spatial scalability.

1 Introduction

The goal of Core Experiment 13.15 is to evaluate the Level of Details generation method for the lifting scheme for the spatial scalability.

The performance of the technique [3] is evaluated in the scope of the CE 13.15, in terms of RD performance and computational complexity.

2 Mandates

The mandates for CE are as follows:

1. To study the coding performance compared with the anchor scalable lifting algorithm
2. To study the complexity (e.g. decoding time) of the proposed method for the spatial scalability
3. To evaluate the visual quality for the lower resolution point cloud with the common rendering software

3 Participants

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(P=proponent, C=cross checker)

4 CE activity

4.1 Code preparation

The proposal is implemented on top of tmc13-version 7.0 software. The code is submitted to MPEG Git on 24 Sep 2019.

Git repository: <http://mpegx.int-evry.fr/software/MPEG/PCC/CE/mpeg-pcc-tmc13.git>

Branch: /mpeg127/ce13.15/LodGenerationForSpatialScalability

Since G-PCC v7.1 is not available yet, the CE code include modification for lifting scalability.

Test3-1 evaluates proposed method1 which prohibit prediction form leaf node to one level above of leaf node.

Test3-2 evaluates proposed method2 which prohibit prediction and set Quantization Weight of one level above of leaf node to 1. Figure 1 shows example of the number of Lod for each Test.

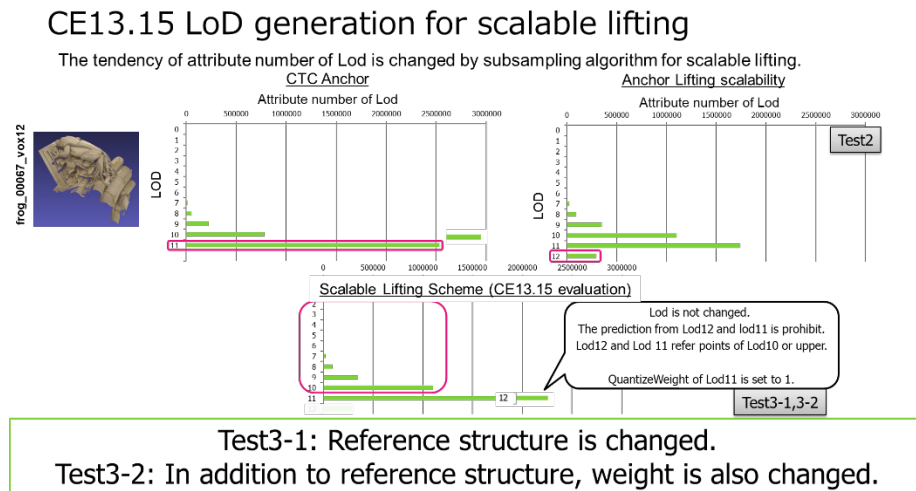


Figure 1 CE13.15[3] Test

4.2 Cross check activity

Test	Proponent	Crosschecker
1. anchor	CTC	
2. anchor spatial scalability coding	Sony	Hanyang University
3-1. Proposal using reference structure	Sony	LG Electronics Inc.
3-2. Proposal using reference structure and weight value	Sony	Panasonic

4.3 Proposed text

The proposed text is provided in the Annex B.

5 Test setting

5.1 Single coding anchor

Same as CTC.

5.2 Anchor with scalable lifting (Test2)

Configuration: The config files are same as the CTC.

Cat1 is executed with option “`--aps_scalable_enable_flag=1 --attribute=color`”.

Cat3-fused is executed with option “`--aps_scalable_enable_flag=1 --lodDecimation=0 --attribute=reflectance --aps_scalable_enable_flag=1 --lodDecimation=0 --attribute=color`”.

Cat3-frame is executed with option “`--lodDecimation=0 --aps_scalable_enable_flag=1 --attribute=reflectance`”.

Note that “`--attribute = reflectance`” is placed before “`--attribute = color`” to uniquely determine the `attr_attr_parameter_set_id` for Cat3-fused.

5.3 Proposal using reference structure (Test3-1)

Configuration: The config files are same as the CTC.

For Encoder

Cat1 is executed with option “`--aps_scalable_enable_flag=1 --attribute=color --CE13.15=1`”.

Cat3-fused is executed with option “`--aps_scalable_enable_flag=1 --lodDecimation=0 --attribute=reflectance --aps_scalable_enable_flag=1 --lodDecimation=0 --attribute=color --CE13.15=1`”.

Cat3-frame is executed with option “`--lodDecimation=0 --aps_scalable_enable_flag=1 --attribute=reflectance --CE13.15=1`”.

Note that “`--attribute = reflectance`” is placed before “`--attribute = color`” to uniquely determine the `attr_attr_parameter_set_id` for Cat3-fused.

For Decoder

Cat1 and Cat3 is executed with option “`--CE13.15=1`”

5.4 Proposal using reference structure and weight value (Test3-2)

Configuration: The config files are same as the CTC.

For Encoder

Cat1 is executed with option “`--aps_scalable_enable_flag=1 --attribute=color --CE13.15=1 --Qweight_change=1`”.

Cat3-fused is executed with option “`--aps_scalable_enable_flag=1 --lodDecimation=0 --attribute=reflectance --aps_scalable_enable_flag=1 --lodDecimation=0 --attribute=color --CE13.15=1 --Qweight_change=1`”.

Cat3-frame is executed with option “`--lodDecimation=0 --aps_scalable_enable_flag=1 --attribute=reflectance --CE13.15=1 --Qweight_change=1`”.

Note that “`--attribute = reflectance`” is placed before “`--attribute = color`” to uniquely determine the `attr_attr_parameter_set_id` for Cat3-fused.

For Decoder

Cat1 and Cat3 is executed with option “--CE13.15=1 --Qweight_change=1”.

6 Results

For Test2 anchor spatial scalability coding

m50741_pcc-tmc13-v7.0+scalableLifting__vs__tmc13v7.0.xlsm

For Test3-1 Proposal using reference structure

m50741_pcc-tmc13-v7.0+scalableLifting+CE13.15-1__vs__tmc13v7.0+scalableLifting.xlsm

For Test3-2 Proposal using reference structure and weight value

m50741_pcc-tmc13-v7.0+scalableLifting+CE13.15-2__vs__tmc13v7.0+scalableLifting.xlsm

6.1 BD rate

Table 3 shows the BD rate of Test3-1 compared with Test2.

Test3-1 is better than the anchor scalability. There is no impact for the sequence which is dense because Lod structure is like Figure 1 top left. Table 4 is average BD rate where the proposal has a performance impact. In average 2.9% luma gain is observed for Cat1-A.

Table 5 shows the BD rate of Test3-2 compared with Test2. Test3-2 have 5% chroma gain than Test3-1. However, there are 2% loss in luminance for several sequences like façade_00009/00015, house_without_roof and shiva.

C1_ai – lossless geometry, lossy attr										
Class	Sequence	End-to-End BD-AttrRate [%]				End-to-End BD-TotalRate [%]				
		Luma	Chroma Cb	Chroma Cr	Reflectance	Luma	Chroma Cb	Chroma Cr	Reflectance	
cat1-A	basketball_player_vox11_0000	0.0%	0.0%	0.0%		0.0%	0.0%	0.0%		
	boxer_viewdep_vox12	-3.3%	-1.6%	-2.0%		-0.3%	-0.1%	-0.1%		
	dancer_vox11_00000001	0.0%	0.0%	0.0%		0.0%	0.0%	0.0%		
	egyptian_mask_vox12	0.0%	0.0%	0.0%		0.0%	0.0%	0.0%		
	facade_00009_vox12	-0.3%	-0.3%	-0.4%		0.0%	-0.1%	-0.1%		
	facade_00015_vox14	-0.7%	-0.7%	-0.8%		-0.1%	-0.1%	-0.1%		
	facade_00064_vox11	0.0%	0.0%	0.0%		0.0%	0.0%	0.0%		
	frog_00067_vox12	-6.7%	-3.3%	-4.4%		-0.6%	-0.4%	-0.4%		
	head_00039_vox12	-9.9%	-6.1%	-5.0%		-1.6%	-1.0%	-0.7%		
	house_without_roof_00057_vox12	-2.0%	-1.8%	-2.1%		-0.3%	-0.2%	-0.3%		
	longdress_viewdep_vox12	-3.9%	-2.0%	-2.7%		-0.8%	-0.5%	-0.6%		
	longdress_vox10_1300	0.0%	0.0%	0.0%		0.0%	0.0%	0.0%		
	loot_viewdep_vox12	-2.2%	-0.9%	-1.5%		-0.2%	0.0%	-0.1%		
	loot_vox10_1200	0.0%	0.0%	0.0%		0.0%	0.0%	0.0%		
	queen_0200	0.0%	0.0%	0.0%		0.0%	0.0%	0.0%		
	redandblack_viewdep_vox12	-2.7%	-1.7%	-2.8%		-0.4%	-0.3%	-0.4%		
	redandblack_vox10_1550	0.0%	0.0%	0.0%		0.0%	0.0%	0.0%		
	shiva_00035_vox12	-0.2%	-0.2%	0.0%		0.0%	0.0%	0.0%		
	soldier_viewdep_vox12	-2.6%	-0.4%	-0.9%		-0.3%	-0.1%	-0.1%		
	soldier_vox10_0690	0.0%	0.0%	0.0%		0.0%	0.0%	0.0%		
	thaidancer_viewdep_vox12	0.0%	0.0%	0.0%		0.0%	0.0%	0.0%		
	ulb_unicorn_vox13	0.0%	0.0%	0.0%		0.0%	0.0%	0.0%		
cat3-fused	citytunnel_q1mm	-0.3%	-0.2%	-0.3%	-0.2%	-0.1%	-0.1%	-0.1%	0.0%	
	overpass_q1mm	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	
	tollbooth_q1mm	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	
cat3-frame	ford_01_q1mm				0.0%				0.0%	
	ford_02_q1mm				0.0%				0.0%	
	ford_03_q1mm				0.0%				0.0%	
	qnxadas-junction-approach				0.0%				0.0%	
	qnxadas-junction-exit				0.0%				0.0%	
	qnxadas-motorway-join				0.0%				0.0%	
	qnxadas-navigating-bends				0.0%				0.0%	
	Cat1-A average	-1.6%	-0.9%	-1.0%		-0.2%	-0.1%	-0.1%		
	Cat1-B average	#DIV/0!	#DIV/0!	#DIV/0!		#DIV/0!	#DIV/0!	#DIV/0!		
	Cat3-fused average	-0.1%	-0.1%	-0.1%	-0.1%	0.0%	0.0%	0.0%	0.0%	
	Cat3-frame average				0.0%				0.0%	
	Overall average	-1.4%	-0.8%	-0.9%	0.0%	-0.2%	-0.1%	-0.1%	0.0%	

Table 1 BD bitrate of proposal (Test3-1) in C1 lossy geometry – lossy attribute

C1_ai – lossless geometry, lossy attr										
Class	Sequence	End-to-End BD-AttrRate [%]				End-to-End BD-TotalRate [%]				
		Luma	Chroma Cb	Chroma Cr	Reflectance	Luma	Chroma Cb	Chroma Cr	Reflectance	
cat1-A	basketball_player_vox11_0000	0.0%	0.0%	0.0%		0.0%	0.0%	0.0%		
	boxer_viewdep_vox12	-3.3%	-1.6%	-2.0%		-0.3%	-0.1%	-0.1%		
	dancer_vox11_00000001	0.0%	0.0%	0.0%		0.0%	0.0%	0.0%		
	egyptian_mask_vox12	-2.0%	-2.3%	-2.6%		-0.1%	-0.1%	-0.1%		
	facade_00009_vox12	2.6%	-5.8%	-4.2%		0.6%	-1.1%	-0.7%		
	facade_00015_vox14	2.6%	-7.4%	-7.6%		0.6%	-0.8%	-0.9%		
	facade_00064_vox11	0.0%	0.0%	0.0%		0.0%	0.0%	0.0%		
	frog_00067_vox12	-5.6%	-9.4%	-10.3%		-0.4%	-1.1%	-1.1%		
	head_00039_vox12	-8.0%	-13.2%	-13.1%		-1.1%	-2.1%	-2.1%		
	house_without_roof_00057_vox12	0.7%	-4.6%	-4.9%		0.1%	-0.5%	-0.6%		
	longdress_viewdep_vox12	-3.9%	-2.0%	-2.7%		-0.8%	-0.5%	-0.6%		
	longdress_vox10_1300	0.0%	0.0%	0.0%		0.0%	0.0%	0.0%		
	loot_viewdep_vox12	-2.2%	-0.9%	-1.5%		-0.2%	0.0%	-0.1%		
	loot_vox10_1200	0.0%	0.0%	0.0%		0.0%	0.0%	0.0%		
	queen_0200	0.0%	0.0%	0.0%		0.0%	0.0%	0.0%		
	redandblack_viewdep_vox12	-2.7%	-1.7%	-2.8%		-0.4%	-0.3%	-0.4%		
	redandblack_vox10_1550	0.0%	0.0%	0.0%		0.0%	0.0%	0.0%		
	shiva_00035_vox12	2.0%	-5.4%	-6.6%		0.7%	-0.4%	-0.8%		
	soldier_viewdep_vox12	-2.6%	-0.4%	-0.9%		-0.3%	-0.1%	-0.1%		
	soldier_vox10_0690	0.0%	0.0%	0.0%		0.0%	0.0%	0.0%		
	thaidancer_viewdep_vox12	0.0%	0.0%	0.0%		0.0%	0.0%	0.0%		
	ulb_unicorn_vox13	0.0%	-1.8%	-1.8%		0.1%	-0.1%	-0.1%		
cat3-fused	citytunnel.q1mm	-0.2%	-0.7%	-0.7%	-0.5%	0.0%	0.0%	0.0%	-0.3%	
	overpass.q1mm	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	
	tollbooth.q1mm	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	
cat3-frame	ford_01.q1mm				0.0%				0.0%	
	ford_02.q1mm				0.0%				0.0%	
	ford_03.q1mm				0.0%				0.0%	
	qnxadas-junction-approach				0.0%				0.0%	
	qnxadas-junction-exit				0.0%				0.0%	
	qnxadas-motorway-join				0.0%				0.0%	
	qnxadas-navigating-bends				0.0%				0.0%	
					0.0%				0.0%	
Cat1-A average		-1.0%	-2.6%	-2.8%		-0.1%	-0.3%	-0.3%		
Cat1-B average		#DIV/0!	#DIV/0!	#DIV/0!		#DIV/0!	#DIV/0!	#DIV/0!		
Cat3-fused average		-0.1%	-0.2%	-0.2%	-0.2%	0.0%	0.0%	0.0%	-0.1%	
Cat3-frame average					0.0%				0.0%	
Overall average		-0.9%	-2.3%	-2.5%	-0.1%	-0.1%	-0.3%	-0.3%	0.0%	

Table 2 BD bitrate of proposal (Test3-2) in C1 lossy geometry – lossy attribute

Test 3-1		End-to-End BD-AttrRate [%]			
		Luma	Chroma Cb	Chroma Cr	Reflectance
Test 3-1	Cat1-A	-2.9%	-1.6%	-1.9%	
	Cat3-fused	-0.3%	-0.2%	-0.3%	-0.2%
Test3-2	Cat1-A	-1.9%	-4.2%	-4.6%	
	Cat3-fused	-0.2%	-0.7%	-0.7%	-0.5%

Table 3 average BD bitrate of sequences except for no change.

6.2 Decoding time

The geometry and attribute decoding time is shown as Table 7.

The difference of decoding time between Test2 and Test3 could be additional `computeNearestNeighbors()`. There is no difference in the geometry algorithm.

		CTC anchor [sec]	Test2 [sec]	Test3-1 [sec]	Test3-2 [sec]
Frog_00067_vox12 C1 r4	Geometry octree	10.91	11.13	11.12	11.24
	Attribute color	20.63	18.73	19.78	20.02

Table 4 Decoding time comparison (compiled by GCC 6.3.0)

6.3 Visual quality

Figure 1 shows visual quality of the scalable decoding (with `-skipLayerNum=1`). Flog has difference BD bitrate gain during test items. The proposal method does not introduce artifact. Test2.PNG, Test3-1.PNG and Test3-2.PNG is attached in document zip file.



Figure 2 Visual quality comparison of Frog 00067_vox12 R4 with -skipLayerNum=1 VoxelSize = 3.65(Left: Test2 Center: Test3-1 Right: Test3-2)

7 Discussion

The modification of the reference structure is effective from the result of Test 3-1.

It was found that changing the weight has a significant effect on performance even with only one Lod from the result of Test 3-2. There is value for further consideration about weight derivation. In the m50743, another weight derivation is proposed as a new contribution.

8 Conclusion

We propose to adapt the modification of reference structure (Test3-1) in the lifting scalability of the G-PCC standard.

9 References

- [1] “G-PCC Test Model 7”, ISO/IEC JTC1/SC29/WG11 MPEG2019 Doc. w18664, Goteborg, Sweden, July 2019
- [2] “Common Test Conditions for PCC” ISO/IEC JTC1/SC29 WG11 MPEG2019”, ISO/IEC JTC1/SC29/WG11 MPEG2019 Doc. w18665, Goteborg, Sweden, July 2019
- [3] “[G-PCC] CE13.15 Related on improved spatial scalable lifting”, ISO/IEC JTC1/SC29 WG11 (MPEG) input document m49044, Gothenburg, SE, July 2019

10 Annex B: Proposed text

LightBlue highlighted is additional description.

Level of Detail Generation

```
endIndex = assignedPointCount
```

```
currentLayer = levelDetailCount - 1
```

```
if( lod == 1 && endIndex - startIndex > startIndex - 0){
    int tmpNodeSizeLod2 = lod -1;
    computeNearestNeighbours(PointPos, searchRange , 0, startIndex, currentLayer,
    assignedPointIndexes, McodeUnsorted, numPredNearestNeighbours,
    nonAssignedPointCount, nonNassignedPointIndexes, tmpNodeSizeLod2);
}
```

```
computeNearestNeighbours(PointPos, searchRange , startIndex, endIndex, currentLayer,
assignedPointIndexes, McodeUnsorted, numPredNearestNeighbours,
nonAssignedPointCount, nonAssignedPointIndexes, nodeSizeLod2);
```

```
unprocessedPointCountPerLevelOfDetail[lod+1] = nonAssignedPointCount;
```

Quantization weights derivation process

```
if ( lifting_scalability_enabled_flag ){
    index = 0;
    tmpPointNum = 0;
    for (lodIndex = 0; lodIndex < lodCount; lodIndex++){
        tmpPointNum += PointsNumPerLoD[lodIndex];
        for (i = 0; i < PointsNumPerLoD[lodIndex]; i++){
            quantizationWeights[index ] = (1 << kFixedPointWeightShift);

            if (numCancelLayer == 0 && lodIndex != lodCount - 1)
                quantizationWeights[index] *= (PointNum / PointsNumPerLoD[lodIndex]);

            if (numCancelLayer < 2){
                if( lodIndex = lodCount -2 + numCancelLayer &&
                    gsh_num_points - tmpPointNum < PointsNumPerLoD[lodIndex] )
                    quantizationWeights[index] = (1 << kFixedPointWeightShift);
            }
            index++;
        }
    }
}
```