ISO/IEC JTC 1/SC 29/WG 11

Coding of moving pictures and audio

Convenorship: UNI (Italy)

Document type:	Approved WG 11 document
Title:	G-PCC TMC13v10 performance evaluation and anchor results
Status:	Final
Date of document:	2020-05-29
Source:	3DG
Expected action:	None
No. of pages:	12
Email of convenor:	leonardo@chiariglione.org
Committee URL:	mpeg.chiariglione.org

INTERNATIONAL ORGANISATION FOR STANDARDISATION
ORGANISATION INTERNATIONALE DE NORMALISATION
ISO/IEC JTC 1/SC 29/WG 11
CODING OF MOVING PICTURES AND AUDIO

<div align="right">

ISO/IEC JTC 1/SC 29/WG 11 N19326
Online – April 2020

</div>

Source: 3DG

Title: G-PCC TMC13v10 performance evaluation and anchor results

---

Abstract

This document provides the reference anchor results for experiments on point cloud compression for dynamically acquired content (category three) and high density content (category one) using the N19324 common test conditions [1].

Summary

This report contains the following:

report_*.txt	verification report of all data points
pcc–$B__vs__$A.xlsm	results reporting $B against $A

Bitstreams and results were generated on a heterogeneous 64bit linux cluster using revision release-v10.0 of TMC13 built with gcc-5.3.1:

    CMAKE_BUILD_TYPE:STRING=Release
    CMAKE_CXX_FLAGS:STRING=-g -O3
    CMAKE_CXX_FLAGS_RELEASE:STRING=-O3 -DNDEBUG

Anchor results are produced using pc_error version release-0.13.5. All other measurements are made using version release-0.13.4 unless otherwise indicated. Due to the nature of the cluster environment, reported run time changes are approximate only.

Subsequent to verification, the tag "release-v10.0" is available from http://mpegx.int-evry.fr/software/MPEG/PCC/TM/mpeg-pcc-tmc13. Further software documentation and usage description is available [2, 3].

Anchor results according to common test conditions

Anchor results using the following common test conditions of N19324 are reported in the enclosed reporting sheets[1][2]:

    C1: (near) lossless geometry, lossy attributes [all intra],
    C2: lossy geometry, lossy attributes [all intra],
    CW: (near) lossless geometry, lossless attributes [all intra],
    CX: (near) lossless geometry, near lossless attributes [all intra],

NOTE — TMC13 is currently an intra only codec supporting random access.

---

[1] pcc-tmc13-tmc13v10.0_octree_raht__vs__tmc13v10.0_octree_predlift.xlsm
[2] pcc-tmc13-tmc13v10.0_trisoup_raht__vs__tmc13v10.0_trisoup_predlift.xlsm

Summary analysis of v10.0 against v9.0 results

Compression results comparing v10.0 against v9.0 on test sequences from categories one and three using both the lod-based lifting/predicting transforms and RAHT are provided with this report[3456] and summarised in tables 1 to 4.

Table 1 – Summary performance of octree geometry and predlift attribute coding using release v10.0 relative to v9.0 results

Condition	Class	BPP Ratio [%] Geometry	Colour	Refl	BD-Rate [Δ%] D1	D2	Y	Cb	Cr	R	Avg. of ratio maxrssk [%] Encoder	Decoder	Ratio of avg. runtime [%] Encoder	Decoder
C1_ai	cat1-A				−1.6	−1.6	0.1	−0.5	−0.5		99	100	94	96
C1_ai	cat1-B				0.3	0.3	−0.9	−1.6	−1.9		83	80	88	83
C1_ai	cat3-fused				0.1	0.1	−0.8	−1.1	−1.1	−0.9	86	88	93	89
C1_ai	cat3-frame				−13.5	−13.5				−1.8	101	102	98	98
C1_ai	overall				−2.2	−2.2	−0.4	−1.0	−1.2	−1.5	92	91	92	90
C2_ai	cat1-A				−1.0	−0.9	−0.5	−0.2	−1.1		87	100	89	95
C2_ai	cat1-B				−0.4	−0.4	−1.0	−1.7	−2.8		77	98	87	94
C2_ai	cat3-fused				−0.5	−0.5	−0.2	−1.4	−1.3	−0.6	77	95	91	95
C2_ai	cat3-frame				−5.0	−5.1				−2.0	94	99	92	97
C2_ai	overall				−1.2	−1.2	−0.7	−1.0	−2.0	−1.6	83	99	88	95
CW_ai	cat1-A	98.6	98.0								100	100	97	103
CW_ai	cat1-B	100.6	97.2								82	80	91	90
CW_ai	cat3-fused	100.1	97.2	97.0							82	87	95	75
CW_ai	cat3-frame	87.1		97.0							101	101	93	95
CW_ai	overall	98.4	97.5	97.0							92	91	94	95
CY_ai	cat1-A				−1.6	−1.6	0.1	0.1	0.1		100	100	100	97
CY_ai	cat1-B				0.3	0.3	−0.8	−0.8	−0.8		82	80	90	85
CY_ai	cat3-fused				0.1	0.1	−1.8	−1.8	−1.8	−0.5	82	86	86	86
CY_ai	cat3-frame				−13.5	−13.5				−0.9	101	102	93	93
CY_ai	overall				−2.2	−2.2	−0.5	−0.5	−0.5	−0.8	92	91	94	91

NOTE — Condition CY metrics reported using Hausdorff PSNR.

Table 2 – Summary performance of octree geometry and RAHT attribute coding using release v10.0 relative to v9.0 results

Condition	Class	BPP Ratio [%] Geometry	Colour	Refl	BD-Rate [Δ%] D1	D2	Y	Cb	Cr	R	Avg. of ratio maxrssk [%] Encoder	Decoder	Ratio of avg. runtime [%] Encoder	Decoder
C1_ai	cat1-A				−1.6	−1.6	−0.6	−3.2	−4.2		110	114	91	92
C1_ai	cat1-B				0.3	0.3	−0.2	−2.4	−3.5		88	91	88	86
C1_ai	cat3-fused				0.1	0.1	0.3	−0.6	−0.5	0.4	94	100	95	92
C1_ai	cat3-frame				−13.5	−13.5				−0.8	101	101	94	94
C1_ai	overall				−2.2	−2.2	−0.3	−2.6	−3.6	−0.4	99	102	90	90
C2_ai	cat1-A				−1.0	−0.9	−1.0	−2.9	−3.0		90	111	88	85
C2_ai	cat1-B				−0.4	−0.4	−0.2	−1.6	−2.2		77	110	85	89
C2_ai	cat3-fused				−0.5	−0.5	0.4	−0.3	−0.1	0.7	77	111	86	90
C2_ai	cat3-frame				−5.0	−5.1				−0.7	94	99	89	94
C2_ai	overall				−1.2	−1.2	−0.5	−2.1	−2.4	−0.3	84	109	87	88

Table 3 – Summary performance of trisoup geometry and lifting based attribute coding using release v10.0 relative to v9.0 results

Condition	Class	BPP Ratio [%] Geometry	Colour	Refl	BD-Rate [Δ%] D1	D2	Y	Cb	Cr	R	Avg. of ratio maxrssk [%] Encoder	Decoder	Ratio of avg. runtime [%] Encoder	Decoder
C2_ai	cat1-A				−0.4	−0.6	0.0	−0.1	−0.2		77	101	87	100
C2_ai	cat1-B				−0.2	−0.3	−0.6	−0.5	−0.9		81	101	88	99
C2_ai	overall				−0.3	−0.4	−0.3	−0.3	−0.6		79	101	87	99

Table 4 – Summary performance of trisoup geometry and RAHT attribute coding using release v10.0 relative to v9.0 results

Condition	Class	BPP Ratio [%] Geometry	Colour	Refl	BD-Rate [Δ%] D1	D2	Y	Cb	Cr	R	Avg. of ratio maxrssk [%] Encoder	Decoder	Ratio of avg. runtime [%] Encoder	Decoder
C2_ai	cat1-A				−0.4	−0.6	−0.8	−2.8	−3.9		80	111	85	92
C2_ai	cat1-B				−0.2	−0.3	−0.3	−1.6	−2.4		82	110	85	95
C2_ai	overall				−0.3	−0.4	−0.6	−2.2	−3.1		81	110	85	93

---

[3] `pcc-tmc13-tmc13v10.0_octree_predlift__vs__tmc13v9.0_octree_predlift.xlsm`
[4] `pcc-tmc13-tmc13v10.0_octree_raht__vs__tmc13v9.0_octree_raht.xlsm`
[5] `pcc-tmc13-tmc13v10.0_trisoup_lift__vs__tmc13v9.0_trisoup_lift.xlsm`
[6] `pcc-tmc13-tmc13v10.0_trisoup_raht__vs__tmc13v9.0_trisoup_raht.xlsm`

Date saved: 2020-05-29

Cross checking

A cross-check of release v10.0, -rc1, and -rc2 were kindly performed by BlackBerry, Panasonic and Sony over all CTC configurations (octree, trisoup, RAHT, predlift) and conditions (C1, C2, CW, CX). All cross-checks[7][8][9][10]completed successfully and any deviation in exact reported results due to average calculation methods is negligible.

Tool verification

Following the integration of each tool, tests are made to verify the integration with differential results provided with the report.

The general progression of coding performance with successive integrations is shown in tables 5 to 10.

Table 5 – Octree & lifting transform progression – C1_ai,overall

Condition	Class	BPP Ratio [%]			BD-Rate [Δ%]						Avg. of ratio maxrssk [%]		Ratio of avg. runtime [%]	
		Geometry	Colour	Refl	D1	D2	Y	Cb	Cr	R	Encoder	Decoder	Encoder	Decoder
C1_ai	00=attrfix				−0.0	−0.0	0.0	0.0	0.0	0.0	100	100	97	98
C1_ai	01=attrl1nn				−0.0	−0.0	0.5	0.1	0.1	−0.4	100	100	98	98
C1_ai	02=attrcoding				−0.0	−0.0	−0.4	−0.8	−0.7	−1.3	100	100	98	99
C1_ai	03=attrdiv				−0.0	−0.0	−0.4	−1.0	−1.2	−1.5	100	100	98	99
C1_ai	04=attrmisc				−0.0	−0.0	−0.4	−1.0	−1.2	−1.5	100	100	97	99
C1_ai	05=attrscale				−0.0	−0.0	−0.4	−1.0	−1.2	−1.5	100	100	97	99
C1_ai	06=geommisc				−0.1	−0.1	−0.4	−1.0	−1.2	−1.5	100	100	98	99
C1_ai	07=geomiocc				−0.8	−0.8	−0.4	−1.0	−1.2	−1.5	100	100	97	96
C1_ai	08=geomqtbt				−0.8	−0.8	−0.4	−1.0	−1.2	−1.5	100	100	95	95
C1_ai	09=geomplanar				−0.5	−0.5	−0.4	−1.0	−1.2	−1.5	92	91	92	89
C1_ai	10=geomang				−2.2	−2.2	−0.4	−1.0	−1.2	−1.5	92	91	93	91
C1_ai	11=geomqp				−2.2	−2.2	−0.4	−1.0	−1.2	−1.5	92	91	93	91
C1_ai	12=predgeom				−2.2	−2.2	−0.4	−1.0	−1.2	−1.5	92	91	92	90
C1_ai	tmc13v10.0-rc1=dmetric-0.13.4				−2.2!	−2.2!	−0.4!	−1.0!	−1.2!	−1.5	92	91	91	88
C1_ai	tmc13v10.0-rc2=dmetric-0.13.4				−2.2	−2.2	−0.4	−1.0	−1.2	−1.5	92	91	92	90

Table 6 – Octree & lifting transform progression – C2_ai,overall

Condition	Class	BPP Ratio [%]			BD-Rate [Δ%]						Avg. of ratio maxrssk [%]		Ratio of avg. runtime [%]	
		Geometry	Colour	Refl	D1	D2	Y	Cb	Cr	R	Encoder	Decoder	Encoder	Decoder
C2_ai	00=attrfix				−0.0	−0.0	0.0	0.0	0.0	0.0	100	100	99	96
C2_ai	01=attrl1nn				−0.0	−0.0	0.3	0.2	−0.4	−0.3	100	100	99	99
C2_ai	02=attrcoding				−0.0	−0.0	−0.7	−0.9	−1.5	−1.3	100	100	97	98
C2_ai	03=attrdiv				−0.0	−0.0	−0.8	−1.4	−2.1	−1.7	100	100	100	100
C2_ai	04=attrmisc				−0.0	−0.0	−0.8	−1.4	−2.1	−1.7	100	100	99	99
C2_ai	05=attrscale				−0.0	−0.0	−0.8	−1.4	−2.1	−1.7	100	100	100	99
C2_ai	06=geommisc				−0.1	−0.1	−0.8	−1.4	−2.1	−1.7	84	100	88	98
C2_ai	07=geomiocc				−0.7	−0.7	−0.8	−1.4	−2.1	−1.7	84	100	90	98
C2_ai	08=geomqtbt				−0.7	−0.7	−0.8	−1.4	−2.1	−1.7	84	100	88	94
C2_ai	09=geomplanar				−0.6	−0.6	−0.8	−1.4	−2.1	−1.7	84	99	88	
C2_ai	10=geomang				−1.2	−1.2	−0.8	−1.4	−2.1	−1.7	83	99	89	95
C2_ai	11=geomqp				−1.2	−1.2	−0.8	−1.4	−2.1	−1.7	83	99	88	94
C2_ai	12=predgeom				−1.2	−1.2	−0.8	−1.4	−2.1	−1.7	83	99	88	95
C2_ai	tmc13v10.0-rc1=dmetric-0.13.4				−1.2	−1.2	−0.8	−1.4	−2.1	−1.7	83	99	87	93
C2_ai	tmc13v10.0-rc2=dmetric-0.13.4				−1.2	−1.2	−0.7	−1.0	−2.0	−1.6	83	99	88	95

---

[7]`report_tmc13v10.0_octree_predlift_apple__vs__panasonic.txt`

[8]`report_tmc13v10.0_trisoup_predlift_apple__vs__panasonic.txt`

[9]`report_tmc13v10.0_octree_raht_apple__vs__panasonic.txt`

[10]`report_tmc13v10.0_trisoup_raht_apple__vs__panasonic.txt`

Date saved: 2020-05-29

Table 7 – Octree & predicting transform progression – CW_ai,overall

Condition	Class	BPP Ratio [%]				D1	D2	BD-Rate [Δ%]			R	Avg. of ratio maxrssk [%]		Ratio of avg. runtime [%]	
		Geometry	Colour	Refl				Y	Cb	Cr		Encoder	Decoder	Encoder	Decoder
CW_ai	00=attrfix	100.0	100.0	100.0								100	100	96	98
CW_ai	01=attrl1nn	100.0	100.0	100.0								100	100	98	99
CW_ai	02=attrcoding	100.0	97.5	97.0								100	100	98	101
CW_ai	03=attrdiv	100.0	97.5	97.0								100	100	100	101
CW_ai	04=attrmisc	100.0	97.5	97.0								100	100	101	103
CW_ai	05=attrscale	100.0	97.5	97.0								100	100	100	103
CW_ai	06=geommisc	99.9	97.5	97.0								100	100	98	99
CW_ai	07=geomiocc	99.7	97.5	97.0								100	100	99	101
CW_ai	08=geomqtbt	99.7	97.5	97.0								100	100	98	97
CW_ai	09=geomplanar	100.3	97.5	97.0								91	91	92	91
CW_ai	10=geomang	98.4	97.5	97.0								92	91	91	94
CW_ai	11=geomqp	98.4	97.5	97.0								92	91	94	92
CW_ai	12=predgeom	98.4	97.5	97.0								92	91	94	96
CW_ai	tmc13v10.0-rc1=dmetric-0.13.4	98.4	97.5	97.0								91	91	91	88
CW_ai	tmc13v10.0-rc2=dmetric-0.13.4	98.4	97.5	97.0								92	91	94	95

Table 8 – Octree & RAHT progression – C1_ai,cat1-A

Condition	Class	BPP Ratio [%]				D1	D2	BD-Rate [Δ%]			R	Avg. of ratio maxrssk [%]		Ratio of avg. runtime [%]	
		Geometry	Colour	Refl				Y	Cb	Cr		Encoder	Decoder	Encoder	Decoder
C2_ai	00=attrfix					−0.0	−0.0	0.0	0.0	0.0		100	101	100	94
C2_ai	02=attrcoding					−0.0	−0.0	−1.5	−1.6	−1.5		100	101	98	96
C2_ai	03=attrdiv					−0.0	−0.0	−1.0	−0.5	0.2		100	101	97	86
C2_ai	04=attrmisc					−0.0	−0.0	−1.1	−2.8	−2.6		100	101	100	86
C2_ai	12=predgeom					−1.0	−1.0	−1.1	−2.8	−2.5		88	101	88	85
C2_ai	tmc13v10.0-rc1=dmetric-0.13.4					−1.0	−1.0	−1.1	−2.8	−2.5		88	101	88	83
C2_ai	tmc13v10.0-rc2=dmetric-0.13.4					−1.0	−0.9	−1.0	−2.9	−3.0		90	111	88	85

Table 9 – Octree & RAHT progression – C1_ai,cat1-B

Condition	Class	BPP Ratio [%]				D1	D2	BD-Rate [Δ%]			R	Avg. of ratio maxrssk [%]		Ratio of avg. runtime [%]	
		Geometry	Colour	Refl				Y	Cb	Cr		Encoder	Decoder	Encoder	Decoder
C2_ai	00=attrfix					−0.0	−0.0	0.0	0.0	0.0		100	100	96	97
C2_ai	02=attrcoding					−0.0	−0.0	−0.7	−0.7	−0.5		100	100	95	98
C2_ai	03=attrdiv					−0.0	−0.0	−0.1	0.5	0.1		100	100	97	89
C2_ai	04=attrmisc					−0.0	−0.0	−0.2	−1.7	−2.2		100	100	98	92
C2_ai	12=predgeom					−0.4	−0.4	−0.2	−1.6	−2.2		74	99	86	84
C2_ai	tmc13v10.0-rc1=dmetric-0.13.4					−0.4	−0.4	−0.2	−1.6	−2.2		74	99	83	85
C2_ai	tmc13v10.0-rc2=dmetric-0.13.4					−0.4	−0.4	−0.2	−1.6	−2.2		77	110	85	89

Table 10 – Trisoup & lifting transform progression – C2_ai,cat1-A

Condition	Class	BPP Ratio [%]				D1	D2	BD-Rate [Δ%]			R	Avg. of ratio maxrssk [%]		Ratio of avg. runtime [%]	
		Geometry	Colour	Refl				Y	Cb	Cr		Encoder	Decoder	Encoder	Decoder
C2_ai	00=attrfix					−0.0	−0.0	0.0	0.0	0.0		100	100	96	98
C2_ai	01=attrl1nn					−0.0	−0.0	0.9	0.7	0.6		100	100	100	99
C2_ai	02=attrcoding					−0.0	−0.0	−0.2	−0.4	−0.5		100	100	94	98
C2_ai	03=attrdiv					−0.0	−0.0	0.0	−0.2	−0.2		100	100	98	99
C2_ai	04=attrmisc					−0.0	−0.0	0.0	−0.2	−0.2		100	100	98	98
C2_ai	12=predgeom					−0.5	−0.6	0.0	−0.2	−0.2		77	102	88	97
C2_ai	tmc13v10.0-rc1=dmetric-0.13.4					−0.5	−0.5	0.0	−0.1	−0.2		77	102	85	95
C2_ai	tmc13v10.0-rc2=dmetric-0.13.4					−0.4	−0.6	0.0	−0.1	−0.2		77	101	87	100

Date saved: 2020-05-29

Table 11 – List of integration results

Integration	Config	Reference	Reporting workbook
00=attrfix	Octree-LoD	v9.0	pcc-tmc13-tmc13v9.1+integration00=attrfix_octree_predlift.xlsm
01=attrl1nn	Octree-LoD	00=attrfix	pcc-tmc13-tmc13v9.1+integration01=attrl1nn_octree_predlift.xlsm
02=attrcoding	Octree-LoD	01=attrl1nn	pcc-tmc13-tmc13v9.1+integration02=attrcoding_octree_predlift.xlsm
03=attrdiv	Octree-LoD	02=attrcoding	pcc-tmc13-tmc13v9.1+integration03=attrdiv_octree_predlift.xlsm
04=attrmisc	Octree-LoD	03=attrdiv	pcc-tmc13-tmc13v9.1+integration04=attrmisc_octree_predlift.xlsm
05=attrscale	Octree-LoD	04=attrmisc	pcc-tmc13-tmc13v9.1+integration05=attrscale_octree_predlift.xlsm
06=geommisc	Octree-LoD	05=attrscale	pcc-tmc13-tmc13v9.1+integration06=geommisc_octree_predlift.xlsm
07=geomiocc	Octree-LoD	06=geommisc	pcc-tmc13-tmc13v9.1+integration07=geomiocc_octree_predlift.xlsm
08=geomqtbt	Octree-LoD	07=geomiocc	pcc-tmc13-tmc13v9.1+integration08=geomqtbt_octree_predlift.xlsm
09=geomplanar	Octree-LoD	08=geomqtbt	pcc-tmc13-tmc13v9.1+integration09=geomplanar_octree_predlift.xlsm
10=geomang	Octree-LoD	09=geomplanar	pcc-tmc13-tmc13v9.1+integration10=geomang_octree_predlift.xlsm
11=geomqp	Octree-LoD	10=geomang	pcc-tmc13-tmc13v9.1+integration11=geomqp_octree_predlift.xlsm
12=predgeom	Octree-LoD	11=geomqp	pcc-tmc13-tmc13v9.1+integration12=predgeom_octree_predlift.xlsm
rc1	Octree-LoD	12=predgeom	pcc-tmc13-tmc13v10.0-rc1=dmetric-0.13.4_octree_predlift__vs__tmc13v9.0_octree_predlift.xlsm
rc2	Octree-LoD	rc1	pcc-tmc13-tmc13v10.0-rc2=dmetric-0.13.4_octree_predlift__vs__tmc13v9.0_octree_predlift.xlsm
00=attrfix	Octree-RAHT	v9.0	pcc-tmc13-tmc13v9.1+integration00=attrfix_octree_raht.xlsm
02=attrcoding	Octree-RAHT	00=attrfix	pcc-tmc13-tmc13v9.1+integration02=attrcoding_octree_raht.xlsm
03=attrdiv	Octree-RAHT	02=attrcoding	pcc-tmc13-tmc13v9.1+integration03=attrdiv_octree_raht.xlsm
04=attrmisc	Octree-RAHT	03=attrdiv	pcc-tmc13-tmc13v9.1+integration04=attrmisc_octree_raht.xlsm
12=predgeom	Octree-RAHT	04=attrmisc	pcc-tmc13-tmc13v9.1+integration12=predgeom_octree_raht.xlsm
rc1	Octree-RAHT	12=predgeom	pcc-tmc13-tmc13v10.0-rc1=dmetric-0.13.4_octree_raht__vs__tmc13v9.0_octree_raht.xlsm
rc2	Octree-RAHT	rc1	pcc-tmc13-tmc13v10.0-rc1=dmetric-0.13.4_octree_raht__vs__tmc13v9.0_octree_raht.xlsm
00=attrfix	Trisoup-LoD	v9.0	pcc-tmc13-tmc13v9.1+integration00=attrfix_trisoup_predlift.xlsm
02=attrcoding	Trisoup-LoD	00=attrfix	pcc-tmc13-tmc13v9.1+integration02=attrcoding_octrtrisoup_predlift.xlsm
03=attrdiv	Trisoup-LoD	02=attrcoding	pcc-tmc13-tmc13v9.1+integration03=attrdiv_trisoup_predlift.xlsm
04=attrmisc	Trisoup-LoD	03=attrdiv	pcc-tmc13-tmc13v9.1+integration04=attrmisc_trisoup_predlift.xlsm
12=predgeom	Trisoup-LoD	04=attrmisc	pcc-tmc13-tmc13v9.1+integration12=predgeom_trisoup_predlift.xlsm
rc1	Trisoup-LoD	12=predgeom	pcc-tmc13-tmc13v10.0-rc1=dmetric-0.13.4_trisoup_predlift__vs__tmc13v9.0_trisoup_predlift.xlsm
rc2	Trisoup-LoD	rc1	pcc-tmc13-tmc13v10.0-rc1=dmetric-0.13.4_trisoup_predlift__vs__tmc13v9.0_trisoup_predlift.xlsm
00=attrfix	Trisoup-RAHT	v9.0	pcc-tmc13-tmc13v9.1+integration00=attrfix_trisoup_raht.xlsm
02=attrcoding	Trisoup-RAHT	00=attrfix	pcc-tmc13-tmc13v9.1+integration02=attrcoding_trisoup_raht.xlsm
03=attrdiv	Trisoup-RAHT	02=attrcoding	pcc-tmc13-tmc13v9.1+integration03=attrdiv_trisoup_raht.xlsm
04=attrmisc	Trisoup-RAHT	03=attrdiv	pcc-tmc13-tmc13v9.1+integration04=attrmisc_trisoup_raht.xlsm
12=predgeom	Trisoup-RAHT	04=attrmisc	pcc-tmc13-tmc13v9.1+integration12=predgeom_trisoup_raht.xlsm
rc1	Trisoup-RAHT	12=predgeom	pcc-tmc13-tmc13v10.0-rc1=dmetric-0.13.4_trisoup_raht__vs__tmc13v9.0_trisoup_raht.xlsm
rc2	Trisoup-RAHT	rc1	pcc-tmc13-tmc13v10.0-rc1=dmetric-0.13.4_trisoup_raht__vs__tmc13v9.0_trisoup_raht.xlsm

Date saved: 2020-05-29

Integration 0 — Minor fixes

hls: fix incorrect conversion from xyz to stv axes

raht: remove useless isqrt computation

attr: fix incorrect point count used in scalable lod generation

Integration 1 — Nearest neighbour search

m51011: use L1 norm for nearest neighbour search

Integration 2 — Attribute coefficient coding

m53678: use explicit bypass bin to code coefficient sign

m52720: alphabet partition coding of coefficient remainders

Integration 3 — Attribute division removal / approximation

m52951: calculate square roots using inverse

m52951: replace divisions in raht

m53619: approximate division in lod attribute coding

m53619: replace square root in lifting update operator

m53619: prune lod predictor neighbours to avoid overflow

Integration 4 — Miscellaneous attribute coding changes

m52995: increase inherited raht dc coefficient precision

m53633: rdo for inter-component prediction

Integration 5 — Scalable attribute coding

m52331: partition scalable lod using distance to centroid

m52315: use node centre for partial geometry reconstruction

m52823: match scalable lifting weight generation to lod

m52314: limit maximum neighbour distance for scalable lods

Integration 6 — Miscellaneous geometry changes

m52392: code attributes in morton or canonical order

m53723: fix derivation of ctxIdxMapIdx

geom: fix angular qtbt derivation when qtbt is disabled

enc: maintain input point order in quantizePositionsUniq

Integration 7 — Intra geometry occupancy prediction

m52327: use adjacent neighbours in intra occupancy prediction

Integration 8 — QtBt related

m53421: adjust child neighbour lookup under qtbt

m53390: explicitly signal qtbt partitioning

Integration 9 — Geometry planar mode

m52345: reduce planar buffer size to 32KiB

Integration 10 — Angular coding modes

m51596: add azimuthal angular mode

m52956: decouple planar and idcm mode angular coding

m53428: tune angular qtbt parameters

m53693: use 8 contexts for angular mode vertical position

Integration 11 — In-tree geometry quantisation

> m52522: change qp mapping to produce integer step sizes
>
> m42523: add quantization support to early idcm nodes
>
> geom: signal valid qp offset depth when qp offsets disabled

Integration 12 — Predictive tree geometry coding

> m52515: add predictive geometry codec with kd-tree search
>
> m52520: code number of duplicate points
>
> m53538: remove sign bit coding for direct residual
>
> m53538: condition duplicate point count signalling
>
> slice: add partitioning method to slice input every n points
>
> enc: add sorting of input points by azimuth angle

Integration 13 (rc1) — Slice partitioning

> m53392: unify slice refinement methods

Integration 14 (rc2) — High-level syntax

> m53385: reverse order of bypass chunk data
>
> m53652: don't signal threshold when max_num_direct_predictors=0
>
> m53693: signal differential theta|z for angular mode
>
> m53655: remove gps_box_present_flag
>
> m53684: merge first two octree entropy streams
>
> m53684: signal number of octree entropy streams
>
> m53682: constrain qp to minimum scaling node dimension
>
> m53685: move geom_num_points_minus1 to slice footer
>
> m53683: signal sps bounding box at conformance scale
>
> m53683: add physical unit for scale factor
>
> m53541: permit signalling explicit tile_id in inventory
>
> m53683: add sps reference to tile inventory
>
> m53683: make tile inventory relative to sps origin
>
> n19088: add additional known attribute labels
>
> m53680: replace attribute_label_four_bytes with oid
>
> m53680: generalised attribute descriptor blocks
>
> m53541: add source scaling attribute descriptor
>
> m53681: add default attribute value descriptor
>
> m53681: decode constant attribute data unit
>
> m53635: remove trisoup num_vertices_minus1
>
> m53635: move trisoup syntax to geometry slice header
>
> m53652: add region chroma qp offset signalling
>
> m53652: derive chroma qp from offset luma qp
>
> m53652: use minus1 form to signal attr region size
>
> m53652: add syntax to support multiple qp regions

Release v9.1

This release contains the integration of, or aspects relating to high-level syntax adoptions of the 129th meeting. [4, 5, 6, 7, 8, 9, 10, 11]

Changes between v9.0 and v9.1

    hls/m52527: infer geom_planar_idcm_threshold if planar is disabled
    hls/m52521: convert geom_base_qp to _minus4 form
    hls/m52521: move geom scaling parameters to end of slice header
    hls/m52527: signal fixed length point count at start of slice header
    enc/m52527: signal actual number of points coded in slice header
    hls/m52390: explicitly signal the number of qp layers
    hls/m52390: condition num_detail_levels on lod generation method
    hls/m52392: condition lod_decimation_enabled_flag on num_detail_levels
    hls/m52342: condition secondary bitdepth on attribute dimensionality
    hls/m52342: signal parameter set id near start of sps
    hls/m52527: convert geom_num_points to _minus1 form
    hls/m52527: convert attr_num_dimensions to _minus1 form
    hls/m52527: convert num_unuqie_segments, num_vertices to _minus1 form
    hls/m52527: convert attr_bitdepth* to _minus1 form
    hls/m52527: convert num_pred_nearest_neighbours to _minus1 form
    hls/m52521: convert init_qp to _minus4 form
    hls/m52527: configure and signal lod subsampling period
    hls/m52342: signal dist2 using a differential model
    hls/m52885: scale sps_bounding_box_offset by offset scale factor
    hls/m52885: use fixed-length representation of tile inventory elements
    attr/m52501: clip/limit qp values to 51
    attr/m52501: extend maximum qp based upon attribute bitdepth
    hls/m52526: use xyz axis order for sps parameters
    hls/m52526: use xyz axis order for geometry parameters
    hls/m52526: use xyz axis order for attribute parameters
    hls/m52526: use xyz axis order for tile inventory parameters
    hls: remove signalling of geom_occupancy_ctx_reduction_factor
    hls: don't set attr_instance_id = attrId
    release: update version to v9.1

Release v10.0

This release contains the integration of, or aspects relating to: [12, 13, 14, 15, 16, 17, 18, 19, 6, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49]

General comments

- CTC configurations are provided for the following test conditions:

    octree + pred/lift transforms [C1, C2, CW, CY]
    octree + RAHT [C1, C2]
    trisoup + pred/lift transforms [C2]
    trisoup + RAHT [C2]

- A review of the CTC conditions is still required for the next meeting, since several test points cause issues in calculating reportable results. In particular:

  – some sequences have so few points that decoding is instantaneous (causes issues for geometric mean).

  – some trisoup test points are lossless.

- some trisoup geometry configuration results are identical over multiple test points causing the failure of BD-rate calculations.

- the current sequence categorisation does not facilitate identifying the type of content providing compression gains or losses.

- The software may be configured to output either ASCII or binary ply files using the `outputBinaryPly` option. Be aware that under certain test conditions this will affect the re-scaled geometry values due to the difference in precision of the two representations. Anchor results have been generated using the ASCII option.

Location of changes between v9.1 and v10.0

```
cfg/octree-liftt-ctc-lossless-geom-lossy-attrs.yaml          |  10 +-
cfg/octree-liftt-ctc-lossy-geom-lossy-attrs.yaml             |  10 +-
cfg/octree-predt-ctc-lossless-geom-lossless-attrs.yaml       |  10 +-
cfg/octree-predt-ctc-lossless-geom-nearlossless-attrs.yaml   |  10 +-
cfg/octree-raht-ctc-lossless-geom-lossy-attrs.yaml           |  10 +-
cfg/octree-raht-ctc-lossy-geom-lossy-attrs.yaml              |  10 +-
cfg/sequences-cat3.yaml                                       |  43 ++
dependencies/nanoflann/nanoflann.hpp                         |  17 +-
doc/README.options.md                                        | 101 +++-
doc/mpeg-pcc-tmc13-sw-manual.tex                             |   6 +-
scripts/gen-cfg.pl                                           |  19 +-
tmc3/AttributeCommon.cpp                                     |  33 ++
tmc3/AttributeCommon.h                                       |  12 +
tmc3/AttributeDecoder.cpp                                    | 118 +++--
tmc3/AttributeEncoder.cpp                                    | 176 ++++---
tmc3/AttributeEncoder.h                                      |   1 +
tmc3/BitWriter.h                                             |  20 +
tmc3/CMakeLists.txt                                          |   6 +-
tmc3/OctreeNeighMap.cpp                                      |  17 +-
tmc3/PCCMath.h                                               |  83 ++-
tmc3/PCCMisc.h                                               |  22 +
tmc3/PCCTMC3Common.h                                         | 452 ++++++++--------
tmc3/PCCTMC3Decoder.h                                        |   1 +
tmc3/PCCTMC3Encoder.h                                        |  25 +-
tmc3/RAHT.cpp                                                | 162 +++---
tmc3/RAHT.h                                                  |   8 +-
tmc3/TMC3.cpp                                                | 251 +++++++--
tmc3/decoder.cpp                                             |  95 +++-
tmc3/encoder.cpp                                             | 256 +++++-----
tmc3/entropychunk.h                                          |  24 +-
tmc3/geometry.h                                              |  24 +-
tmc3/geometry_intra_pred.cpp                                 |  73 +--
tmc3/geometry_octree.cpp                                     | 346 ++++++++++---
tmc3/geometry_octree.h                                       | 181 +++----
tmc3/geometry_octree_decoder.cpp                             | 550 +++++++++++-------
tmc3/geometry_octree_encoder.cpp                             | 637 ++++++++++++--------
tmc3/geometry_params.h                                       |  79 +++
tmc3/geometry_predictive.h                                   | 158 ++++++
tmc3/geometry_predictive_decoder.cpp                         | 231 +++++++++
tmc3/geometry_predictive_encoder.cpp                         | 497 +++++++++++++++++
tmc3/geometry_trisoup_decoder.cpp                            |  29 +-
tmc3/geometry_trisoup_encoder.cpp                            |  36 +-
tmc3/hls.h                                                   | 237 ++++++---
tmc3/io_hls.cpp                                              | 908 ++++++++++++++++++++++----------
tmc3/io_hls.h                                                |   7 +
tmc3/misc.cpp                                                | 147 ++++--
```

```
tmc3/partitioning.cpp                              | 364 +++++--------
tmc3/partitioning.h                                |  16 +-
tmc3/ply.cpp                                        |   2 +-
tmc3/ply.h                                          |   2 +-
tmc3/pointset_processing.cpp                        | 151 ++++--
tmc3/pointset_processing.h                          |  25 +-
tmc3/quantization.cpp                               |  60 ++-
tmc3/quantization.h                                 |  32 +-
54 files changed, 4839 insertions(+), 1961 deletions(-)
```

References

[1] 3DG, "Common Test Conditions for PCC," ISO/IEC JTC1/SC29/WG11, 130th meeting, Alpbach, Tech. Rep. w19324, Apr. 2020.

[2] ——, "G-PCC Test Model v10," ISO/IEC JTC1/SC29/WG11, 130th meeting, Alpbach, Tech. Rep. w19323, Apr. 2020.

[3] ——, "G-PCC codec description," ISO/IEC JTC1/SC29/WG11, 130th meeting, Alpbach, Tech. Rep. w19331, Apr. 2020.

[4] B. Ray, A. K. Ramasubramonian, G. V. der Auwera, and M. Karczewicz, "[G-PCC] High level syntax cleanup of G-PCC," ISO/IEC JTC1/SC29/WG11, 129th meeting, Brussels, Tech. Rep. m52342, Jan. 2020.

[5] T. Sugio and S. Kuma, "[G-PCC] [new proposal] High Level Syntax Modification on Layer QP Delta For Attribute Coding," ISO/IEC JTC1/SC29/WG11, 129th meeting, Brussels, Tech. Rep. m52390, Jan. 2020.

[6] T. Sugio, "[G-PCC] [new proposal] High Level Syntax modification and skip sorting process based on Morton code for low delay attribute coding," ISO/IEC JTC1/SC29/WG11, 129th meeting, Brussels, Tech. Rep. m52392, Jan. 2020.

[7] A. K. Ramasubramonian, B. Ray, G. V. der Auwera, and M. Karczewicz, "[G-PCC] On quantization parameters in G-PCC," ISO/IEC JTC1/SC29/WG11, 129th meeting, Brussels, Tech. Rep. m52501, Jan. 2020.

[8] D. Flynn and K. Mammou, "G-PCC: Minor simplifications and fixes to in-tree geometry quantisation," ISO/IEC JTC1/SC29/WG11, 129th meeting, Brussels, Tech. Rep. m52521, Jan. 2020.

[9] ——, "G-PCC: Geometry swizzling dependent syntax elements," ISO/IEC JTC1/SC29/WG11, 129th meeting, Brussels, Tech. Rep. m52526, Jan. 2020.

[10] ——, "G-PCC: High-level syntax issues," ISO/IEC JTC1/SC29/WG11, 129th meeting, Brussels, Tech. Rep. m52527, Jan. 2020.

[11] O. Nakagami, "Suggested DoC on ISO/IEC CD 23090-9," ISO/IEC JTC1/SC29/WG11, 129th meeting, Brussels, Tech. Rep. m52885, Jan. 2020.

[12] D. Flynn and K. Mammou, "G-PCC: An IDCM specific QP for in-tree geometry quantisation," ISO/IEC JTC1/SC29/WG11, 129th meeting, Brussels, Tech. Rep. m52523, Jan. 2020.

[13] Z. Gao, D. Flynn, A. Tourapis, and K. Mammou, "[G-PCC][New proposal] Using L1 norm for nearest neighbour search in Prediction and Lifting schemes," ISO/IEC JTC1/SC29/WG11, 128th meeting, Geneva, Tech. Rep. m51011, Oct. 2019.

[14] S. Lasserre and J. Taquet, "[GPCC] [CE13.22 related] The azimuthal coding mode," ISO/IEC JTC1/SC29/WG11, 129th meeting, Brussels, Tech. Rep. m51596, Jan. 2020.

[15] H. Hur and S. Oh, "[G-PCC][new proposal] on nearest neighbour search for spatial scalability," ISO/IEC JTC1/SC29/WG11, 129th meeting, Brussels, Tech. Rep. m52314, Jan. 2020.

[16] ——, "[G-PCC][New Proposal] on geometry reconstruction for spatial scalability," ISO/IEC JTC1/SC29/WG11, 129th meeting, Brussels, Tech. Rep. m52315, Jan. 2020.

[17] S. Wan, Z. Wang, Y. Yu, and Y. Liu, "[G-PCC][New proposal] On geometry occupancy intra prediction," ISO/IEC JTC1/SC29/WG11, 129th meeting, Brussels, Tech. Rep. m52327, Jan. 2020.

[18] S. Kuma and O. Nakagami, "[G-PCC](New Proposal) CE13.15 Related on improved LoD generation for spatial scalability," ISO/IEC JTC1/SC29/WG11, 129th meeting, Brussels, Tech. Rep. m52331, Jan. 2020.

[19] J. Taquet and S. Lasserre, "[G-PCC] [CE13.22 related] Planar mode buffer optimization," ISO/IEC JTC1/SC29/WG11, 129th meeting, Brussels, Tech. Rep. m52345, Jan. 2020.

[20] D. Flynn and K. Mammou, "G-PCC CE13.22 report on predictive geometry coding," ISO/IEC JTC1/SC29/WG11, 129th meeting, Brussels, Tech. Rep. m52515, Jan. 2020.

[21] ——, "G-PCC: Duplicate point handling in predictive geometry coding," ISO/IEC JTC1/SC29/WG11, 129th meeting, Brussels, Tech. Rep. m52520, Jan. 2020.

[22] ——, "G-PCC: Integer step sizes for in-tree geometry quantisation," ISO/IEC JTC1/SC29/WG11, 129th meeting, Brussels, Tech. Rep. m52522, Jan. 2020.

[23] S. Yea, S. Wenger, and S. Liu, "[G-PCC] Alphabet-partition coding of transform coefficients," ISO/IEC JTC1/SC29/WG11, 129th meeting, Brussels, Tech. Rep. m52720, Jan. 2020.

[24] J.-S. Han, H. Hur, and S. Oh, "[G-PCC][New Proposal] on weight derivation of spatial scalability," ISO/IEC JTC1/SC29/WG11, 129th meeting, Brussels, Tech. Rep. m52823, Jan. 2020.

[25] S. Lasserre and J. Taquet, "[GPCC] Division-free RAHT coding scheme," ISO/IEC JTC1/SC29/WG11, 130th meeting, Alpbach, Tech. Rep. m52951, Apr. 2020.

[26] ——, "[GPCC][CE13.22 related] On decoupling planar and IDCM in angular mode," ISO/IEC JTC1/SC29/WG11, 130th meeting, Alpbach, Tech. Rep. m52956, Apr. 2020.

[27] J. Taquet and S. Lasserre, "[GPCC][new] Increasing internal precision of inter-depth prediction for RAHT," ISO/IEC JTC1/SC29/WG11, 130th meeting, Alpbach, Tech. Rep. m52995, Apr. 2020.

[28] S. Lasserre and J. Taquet, "[GPCC][new] On bypassed bit coding and chunks," ISO/IEC JTC1/SC29/WG11, 130th meeting, Alpbach, Tech. Rep. m53385, Apr. 2020.

[29] D. Flynn and K. Mammou, "G-PCC EE13.35 report on qtbt partition signalling," ISO/IEC JTC1/SC29/WG11, 130th meeting, Alpbach, Tech. Rep. m53390, Apr. 2020.

[30] Y. Park and S. Oh, "[GPCC][New proposal] Integration of refining slices on existing partitioning methods," ISO/IEC JTC1/SC29/WG11, 130th meeting, Alpbach, Tech. Rep. m53392, Apr. 2020.

[31] X. Zhang, W. Gao, and S. Liu, "[G-PCC][New Proposal] Fixing neighbor context accessing in QTBT," ISO/IEC JTC1/SC29/WG11, 130th meeting, Alpbach, Tech. Rep. m53421, Apr. 2020.

[32] ——, "[G-PCC][CE13.22 related] QTBT parameter tuning in azimuthal coding mode," ISO/IEC JTC1/SC29/WG11, 130th meeting, Alpbach, Tech. Rep. m53428, Apr. 2020.

[33] K. L. Loi and T. Sugio, "[G-PCC][New][EE13.8 related] Predictive tree encoding modifications," ISO/IEC JTC1/SC29/WG11, 130th meeting, Alpbach, Tech. Rep. m53538, Apr. 2020.

[34] N. Iguchi, "[G-PCC][New] High Level Syntax and Specification Modification," ISO/IEC JTC1/SC29/WG11, 130th meeting, Alpbach, Tech. Rep. m53541, Apr. 2020.

[35] K. Mammou, D. Flynn, and A. Tourapis, "[G-PCC][New proposal] Division-free Implementation of the Lifting/Prediction scheme," ISO/IEC JTC1/SC29/WG11, 130th meeting, Alpbach, Tech. Rep. m53619, Apr. 2020.

[36] B. Ray, A. K. Ramasubramonian, G. V. der Auwera, L. Kerofsky, and M. Karczewicz, "[G-PCC][software] Encoder improvement for inter-component residual prediction," ISO/IEC JTC1/SC29/WG11, 130th meeting, Alpbach, Tech. Rep. m53633, Apr. 2020.

[37] ——, "[G-PCC][new]On trisoup-syntax signaling cleanup," ISO/IEC JTC1/SC29/WG11, 130th meeting, Alpbach, Tech. Rep. m53635, Apr. 2020.

[38] ——, "[G-PCC][new] Attribute related high level syntax - fixes and improvements," ISO/IEC JTC1/SC29/WG11, 130th meeting, Alpbach, Tech. Rep. m53652, Apr. 2020.

[39] A. K. Ramasubramonian, B. Ray, G. V. der Auwera, L. Kerofsky, and M. Karczewicz, "[G-PCC][New proposal] Geometry-related HLS refinements to G-PCC," ISO/IEC JTC1/SC29/WG11, 130th meeting, Alpbach, Tech. Rep. m53655, Apr. 2020.

[40] D. Flynn and K. Mammou, "G-PCC: Coding of significant attribute coefficients," ISO/IEC JTC1/SC29/WG11, 130th meeting, Alpbach, Tech. Rep. m53678, Apr. 2020.

[41] ——, "G-PCC: Extensible signalling of attribute descriptions," ISO/IEC JTC1/SC29/WG11, 130th meeting, Alpbach, Tech. Rep. m53680, Apr. 2020.

[42] ——, "G-PCC: Signalling of default attribute values," ISO/IEC JTC1/SC29/WG11, 130th meeting, Alpbach, Tech. Rep. m53681, Apr. 2020.

[43] ——, "G-PCC: Geometry octree QP constraints," ISO/IEC JTC1/SC29/WG11, 130th meeting, Alpbach, Tech. Rep. m53682, Apr. 2020.

[44] ——, "G-PCC: Specification of SPS bounding box and scale factors," ISO/IEC JTC1/SC29/WG11, 130th meeting, Alpbach, Tech. Rep. m53683, Apr. 2020.

[45] ——, "G-PCC: Review of parallel octree sub-streams," ISO/IEC JTC1/SC29/WG11, 130th meeting, Alpbach, Tech. Rep. m53684, Apr. 2020.

[46] ——, "G-PCC : Review of slice point count signalling," ISO/IEC JTC1/SC29/WG11, 130th meeting, Alpbach, Tech. Rep. m53685, Apr. 2020.

[47] G. V. der Auwera, B. Ray, L. Kerofsky, A. K. Ramasubramonian, and M. Karczewicz, "[GPCC][New Proposal] Angular mode simplifications and HLS refinements," ISO/IEC JTC1/SC29/WG11, 130th meeting, Alpbach, Tech. Rep. m53693, Apr. 2020.

[48] S. Wan, Z. Wang, Y. Yu, and Y. Liu, "[G-PCC][Software] Harmonization for Planar Mode and Occupancy Intra Prediction," ISO/IEC JTC1/SC29/WG11, 130th meeting, Alpbach, Tech. Rep. m53723, Apr. 2020.

[49] 3DG, "Text of ISO/IEC 23090-9 DIS Geometry-based PCC," ISO/IEC JTC1/SC29/WG11, 129th meeting, Brussels, Tech. Rep. w19088, Jan. 2020.

Date saved: 2020-05-29