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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 N106 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-v14.0-rc1 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. Due to the nature of the cluster environment, reported run time changes are approximate only.

Subsequent to verification, the tag "release-v14.0" 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 N106 are reported in the enclosed reporting sheets[1][2][3]:

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

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

[1] `pcc-tmc13-v14.0_octree_raht__vs__v14.0_octree_predlift.xlsm`
[2] `pcc-tmc13-v14.0_trisoup_raht__vs__v14.0_trisoup_predlift.xlsm`
[3] `pcc-tmc13-v14.0_predgeom_raht__vs__v14.0_octree_predlift.xlsm`

Summary analysis of v14.0 against v13.0 results

Compression results comparing v14.0 against v13.0 on test sequences from categories one and three using both the lod-based lifting/predicting transforms and RAHT are provided with this report[4][5][6][7][8][9] and summarised in tables 1 to 5. Results are not presented for trisoup due to changes in the test conditions.

Table 1 – Summary performance of octree geometry and lod attribute coding using release v14.0 relative to v13.0 results

		BPP Ratio [%]			BD-Rate [Δ%]						Avg. of ratio maxrssk [%]		Ratio of avg. runtime [%]	
Condition	Class	Geometry	Colour	Refl	D1	D2	Y	Cb	Cr	R	Encoder	Decoder	Encoder	Decoder
C1_ai	cat1-A				0.0	0.0	0.0	0.0	0.0		100	100	98	96
C1_ai	cat1-B				0.0	0.0	0.0	0.0	0.0		100	100	99	97
C1_ai	cat3-fused				0.0	0.0	0.0	0.0	0.0	0.0	111	100	90	87
C1_ai	cat3-frame				0.0	0.0				−0.2	100	100	109	111
C1_ai	overall				0.0	0.0	0.0	0.0	0.0	−0.1	101	100	99	98
C2_ai	cat1-A				0.0	0.0	0.0	0.0	0.0		100	100	97	97
C2_ai	cat1-B				0.0	0.0	0.0	0.0	0.0		100	100	97	99
C2_ai	cat3-fused				0.0	0.0	0.0	0.0	0.0	0.0	109	100	98	98
C2_ai	cat3-frame				0.0	0.0				−0.5	100	100	104	117
C2_ai	overall				0.0	0.0	0.0	0.0	0.0	−0.3	100	100	98	100
CW_ai	cat1-A	100.0	100.0								100	100	95	92
CW_ai	cat1-B	100.0	100.0								100	100	105	102
CW_ai	cat3-fused	100.0	100.0	100.1							111	100	103	100
CW_ai	cat3-frame	100.0		100.0							100	100	99	98
CW_ai	overall	100.0	100.0	100.1							101	100	100	97
CY_ai	cat1-A				0.0	0.0	−1.9	−1.9	−1.9		100	100	95	94
CY_ai	cat1-B				0.0	0.0	−0.8	−0.8	−0.8		100	100	98	96
CY_ai	cat3-fused				0.0	0.0	−0.0	−0.0	−0.0	0.5	111	100	94	91
CY_ai	cat3-frame				0.0	0.0				0.0	100	100	91	90
CY_ai	overall				0.0	0.0	−1.2	−1.2	−1.2	0.2	101	100	96	94

NOTE — Condition CY metrics reported using Hausdorff PSNR.

Table 2 – Summary performance of octree geometry and RAHT attribute coding using release v14.0 relative to v13.0 results

		BPP Ratio [%]			BD-Rate [Δ%]						Avg. of ratio maxrssk [%]		Ratio of avg. runtime [%]	
Condition	Class	Geometry	Colour	Refl	D1	D2	Y	Cb	Cr	R	Encoder	Decoder	Encoder	Decoder
C1_ai	cat1-A				0.0	0.0	0.0	0.0	0.0		100	100	100	98
C1_ai	cat1-B				0.0	0.0	0.0	0.0	0.0		100	100	96	94
C1_ai	cat3-fused				0.0	0.0	0.0	0.0	0.0	0.0	109	100	97	95
C1_ai	cat3-frame				0.0	0.0				−0.1	100	100	90	90
C1_ai	overall				0.0	0.0	0.0	0.0	0.0	−0.0	101	100	97	95
C2_ai	cat1-A				0.0	0.0	0.0	0.0	0.0		100	100	94	92
C2_ai	cat1-B				0.0	0.0	0.0	0.0	0.0		100	100	97	96
C2_ai	cat3-fused				0.0	0.0	0.0	0.0	0.0	0.0	109	100	94	92
C2_ai	cat3-frame				0.0	0.0				−0.0	100	100	93	92
C2_ai	overall				0.0	0.0	0.0	0.0	0.0	−0.0	100	100	95	94

[4] pcc-tmc13-v14.0-rc1__vs__v13.0-rc1_octree_predlift.xlsm
[5] pcc-tmc13-v14.0-rc1__vs__v13.0-rc1_octree_raht.xlsm
[6] pcc-tmc13-v14.0-rc1__vs__v13.0-rc1_predgeom_raht.xlsm
[7] pcc-tmc13-v14.0-rc1__vs__v13.0-rc1_predgeom_predlift.xlsm
[8] pcc-tmc13-v14.0-rc1__vs__v13.0-rc1_trisoup_lift.xlsm
[9] pcc-tmc13-v14.0-rc1__vs__v13.0-rc1_trisoup_raht.xlsm

Table 3 – Summary performance of predictive geometry and lod attribute coding using release v14.0 relative to v13.0 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				0.0	0.0	0.0	0.0	0.0		100	100	95	95
C1_ai	cat1-B				0.0	0.0	0.0	0.0	0.0		100	100	97	96
C1_ai	cat3-fused				−1.1	−1.1	0.0	0.0	0.0	0.0	112	100	74	89
C1_ai	cat3-frame				−5.0	−5.0				−2.2	100	100	104	114
C1_ai	overall				−0.7	−0.7	0.0	0.0	0.0	−1.5	101	100	96	97
C2_ai	cat1-A				0.0	0.0	0.0	0.0	0.0		100	100	94	97
C2_ai	cat1-B				0.0	0.0	0.0	0.0	0.0		100	100	96	95
C2_ai	cat3-fused				−0.8	−0.8	0.0	0.0	−0.0	0.0	110	100	84	91
C2_ai	cat3-frame				−12.1	−16.5				−1.8	100	100	95	113
C2_ai	overall				−1.6	−2.1	0.0	0.0	−0.0	−1.2	101	100	95	98
CW_ai	cat1-A	100.0	100.0								100	100	94	91
CW_ai	cat1-B	100.0	100.0								100	100	94	93
CW_ai	cat3-fused	99.0	100.0	100.1							112	100	93	122
CW_ai	cat3-frame	94.9		99.8							100	100	87	94
CW_ai	overall	99.4	100.0	99.9							101	100	93	93
CY_ai	cat1-A				0.0	0.0	−1.9	−1.9	−1.9		100	100	97	97
CY_ai	cat1-B				0.0	0.0	−0.8	−0.8	−0.8		100	100	99	99
CY_ai	cat3-fused				−1.1	−1.1	−0.0	−0.0	−0.0	0.5	112	100	73	90
CY_ai	cat3-frame				−5.0	−5.0				−0.3	100	100	93	93
CY_ai	overall				−0.7	−0.7	−1.2	−1.2	−1.2	−0.1	101	100	96	97

NOTE — Condition CY metrics reported using Hausdorff PSNR.

Table 4 – Summary performance of predictive geometry and RAHT attribute coding using release v14.0 relative to v13.0 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				0.0	0.0	0.0	0.0	0.0		100	100	96	95
C1_ai	cat1-B				0.0	0.0	0.0	0.0	0.0		100	100	96	93
C1_ai	cat3-fused				−1.1	−1.1	0.0	0.0	0.0	0.0	111	100	83	98
C1_ai	cat3-frame				−5.0	−5.0				−1.3	100	101	93	95
C1_ai	overall				−0.7	−0.7	0.0	0.0	0.0	−0.9	101	100	95	94
C2_ai	cat1-A				0.0	0.0	0.0	0.0	0.0		100	100	98	97
C2_ai	cat1-B				0.0	0.0	0.0	0.0	0.0		100	100	98	95
C2_ai	cat3-fused				−0.8	−0.8	−0.0	0.0	0.0	0.0	108	100	83	89
C2_ai	cat3-frame				−12.1	−16.5				−1.3	101	101	92	97
C2_ai	overall				−1.6	−2.1	−0.0	0.0	0.0	−0.9	101	100	96	96

Table 5 – Summary performance of trisoup geometry and lod attribute coding using release v14.0 relative to v13.0 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				−0.2	0.3	0.7	0.0	0.3		100	100	99	100
C2_ai	cat1-B				0.0	0.5	0.2	0.2	0.3		100	100	96	97
C2_ai	overall				−0.1	0.4	0.4	0.1	0.3		100	100	97	98

Cross checking

A cross-check of release v14.0 was kindly performed by Panasonic, Sony and Xiaomi over all CTC configurations (octree, trisoup, RAHT, predlift) and conditions (C1, C2, CW, CY). All cross-checks[10][11][12][13][14][15][16][17][18][19][20][21] completed successfully and any deviation in exact reported results due to average calculation methods is negligible.

[10] report_tmc13v14.0_octree_predlift_apple__vs__panasonic.txt
[11] report_tmc13v14.0_predgeom_predlift_apple__vs__panasonic.txt
[12] report_tmc13v14.0_trisoup_predlift_apple__vs__panasonic.txt
[13] report_tmc13v14.0_octree_raht_apple__vs__panasonic.txt
[14] report_tmc13v14.0_predgeom_raht_apple__vs__panasonic.txt
[15] report_tmc13v14.0_trisoup_raht_apple__vs__panasonic.txt
[16] report_tmc13v14.0_octree_predlift_apple__vs__sony.txt
[17] report_tmc13v14.0_predgeom_predlift_apple__vs__sony.txt
[18] report_tmc13v14.0_trisoup_predlift_apple__vs__sony.txt
[19] report_tmc13v14.0_octree_raht_apple__vs__sony.txt
[20] report_tmc13v14.0_predgeom_raht_apple__vs__sony.txt
[21] report_tmc13v14.0_trisoup_raht_apple__vs__sony.txt

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 6 to 15. The performance of v12.1 – .4 are compared against to v12.0, while the performance of v14.0-rc1 is compared against v13.0.

Table 6 – Octree & lifting transform progression – C1_ai,overall

		BPP Ratio [%]			BD-Rate [Δ%]						Avg. of ratio maxrssk [%]		Ratio of avg. runtime [%]	
Condition	Integration	Geometry	Colour	Refl	D1	D2	Y	Cb	Cr	R	Encoder	Decoder	Encoder	Decoder
C1_ai	v12.1				0.0	0.0	0.0	0.0	0.0	0.0	100	120	101	101
C1_ai	v12.2				−0.0	−0.0	0.0	0.0	0.0	0.0	99	120	102	101
C1_ai	v12.3				−0.0	−0.0	−0.0	−0.0	−0.0	−0.2	99	120	106	105
C1_ai	v12.4				−0.0	−0.0	−0.0	−0.0	−0.0	−0.2	99	120	97	95
C1_ai	v14.0-rc1				0.0	0.0	0.0	0.0	0.0	−0.1	101	100	99	98

Table 7 – Octree & lifting transform progression – C2_ai,overall

		BPP Ratio [%]			BD-Rate [Δ%]						Avg. of ratio maxrssk [%]		Ratio of avg. runtime [%]	
Condition	Integration	Geometry	Colour	Refl	D1	D2	Y	Cb	Cr	R	Encoder	Decoder	Encoder	Decoder
C2_ai	v12.1				0.0	0.0	0.0	0.0	0.0	0.0	100	112	102	
C2_ai	v12.2				−0.0	−0.0	0.0	0.0	0.0	0.0	99	113	101	99
C2_ai	v12.3				−0.0	−0.0	−0.0	−0.0	−0.0	−0.4	99	113	101	
C2_ai	v12.4				−0.0	−0.0	−0.0	−0.0	−0.0	−0.4	99	113	95	
C2_ai	v14.0-rc1				0.0	0.0	0.0	0.0	0.0	−0.3	100	100	98	100

Table 8 – Octree & predicting transform progression – CW_ai,overall

		BPP Ratio [%]			BD-Rate [Δ%]						Avg. of ratio maxrssk [%]		Ratio of avg. runtime [%]	
Condition	Integration	Geometry	Colour	Refl	D1	D2	Y	Cb	Cr	R	Encoder	Decoder	Encoder	Decoder
CW_ai	v12.1	100.0	100.0	100.0							100	121	98	96
CW_ai	v12.2	100.0	100.0	100.0							99	120	96	94
CW_ai	v12.3	100.0	100.0	100.1							99	120	99	97
CW_ai	v12.4	100.0	100.0	100.1							99	120	92	90
CW_ai	v14.0-rc1	100.0	100.0	100.1							101	100	100	97

Table 9 – Octree & predicting transform progression – CY_ai,overall

		BPP Ratio [%]			BD-Rate [Δ%]						Avg. of ratio maxrssk [%]		Ratio of avg. runtime [%]	
Condition	Integration	Geometry	Colour	Refl	D1	D2	Y	Cb	Cr	R	Encoder	Decoder	Encoder	Decoder
CY_ai	v12.1				0.0	0.0	0.0	0.0	0.0	0.0	100	120	103	103
CY_ai	v12.2				−0.0	−0.0	0.0	0.0	0.0	0.0	99	120	103	102
CY_ai	v12.3				−0.0	−0.0	−0.0	−0.0	−0.0	0.1	99	120	98	97
CY_ai	v12.4				−0.0	−0.0	−0.0	−0.0	−0.0	0.1	99	120	94	93
CY_ai	v14.0-rc1				0.0	0.0	−1.2	−1.2	−1.2	0.2	101	100	96	94

NOTE — Condition CY metrics reported using Hausdorff PSNR.

Table 10 – Octree & RAHT progression – C1_ai,overall

		BPP Ratio [%]			BD-Rate [Δ%]						Avg. of ratio maxrssk [%]		Ratio of avg. runtime [%]	
Condition	Integration	Geometry	Colour	Refl	D1	D2	Y	Cb	Cr	R	Encoder	Decoder	Encoder	Decoder
C2_ai	v12.1				0.0	0.0	0.0	0.0	0.0	0.0	100	107	99	97
C2_ai	v12.2				−0.0	−0.0	0.0	0.0	0.0	0.0	98	104	99	97
C2_ai	v12.3				−0.0	−0.0	0.0	0.0	0.0	0.0	98	104	97	95
C2_ai	v12.4				−0.0	−0.0	0.0	0.0	0.0	0.0	98	104	93	91
C2_ai	v14.0-rc1				0.0	0.0	0.0	0.0	0.0	−0.0	100	100	95	94

Table 11 – Octree & RAHT progression – C2_ai,overall

Condition	Integration	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	v12.1				0.0	0.0	0.0	0.0	0.0	0.0	100	107	99	97
C2_ai	v12.2				−0.0	−0.0	0.0	0.0	0.0	0.0	98	104	99	97
C2_ai	v12.3				−0.0	−0.0	0.0	0.0	0.0	0.0	98	104	97	95
C2_ai	v12.4				−0.0	−0.0	0.0	0.0	0.0	0.0	98	104	93	91
C2_ai	v14.0-rc1				0.0	0.0	0.0	0.0	0.0	−0.0	100	100	95	94

Table 12 – Predgeom & lifting transform progression – C1_ai,overall

Condition	Integration	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	v12.1				0.0	0.0	0.0	0.0	0.0	0.0	100	121	99	97
C1_ai	v12.2				−0.0	−0.0	0.0	0.0	0.0	0.0	100	121	98	98
C1_ai	v12.3				−0.0	−0.0	−0.0	−0.0	−0.0	−0.2	100	121	99	103
C1_ai	v12.4				−0.0	−0.0	−0.0	−0.0	−0.0	−0.2	100	121	93	98
C1_ai	v14.0-rc1				−0.7	−0.7	0.0	0.0	0.0	−1.5	101	100	96	97

Table 13 – Predgeom & lifting transform progression – C2_ai,overall

Condition	Integration	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	v12.1				0.0	0.0	0.0	0.0	0.0	0.0	100	112	100	
C2_ai	v12.2				−0.0	−0.0	0.0	0.0	0.0	0.0	100	113	100	99
C2_ai	v12.3				−0.0	−0.0	0.0	−0.0	−0.0	−0.2	100	113	99	
C2_ai	v12.4				−0.0	−0.0	0.0	−0.0	−0.0	−0.2	100	113	92	100
C2_ai	v14.0-rc1				−1.6	−2.1	0.0	0.0	−0.0	−1.2	101	100	95	98

Table 14 – Predgeom & RAHT progression – C1_ai,overall

Condition	Integration	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	v12.1				0.0	0.0	0.0	0.0	0.0	0.0	100	112	100	98
C1_ai	v12.2				−0.0	−0.0	0.0	0.0	0.0	0.0	97	109	100	98
C1_ai	v12.3				−0.0	−0.0	0.0	0.0	0.0	0.0	97	109	98	98
C1_ai	v12.4				−0.0	−0.0	0.0	0.0	0.0	0.0	97	109	92	89
C1_ai	v14.0-rc1				−0.7	−0.7	0.0	0.0	0.0	−0.9	101	100	95	94

Table 15 – Predgeom & RAHT progression – C2_ai,overall

Condition	Integration	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	v12.1				0.0	0.0	0.0	0.0	0.0	0.0	100	108	100	99
C2_ai	v12.2				−0.0	−0.0	0.0	0.0	0.0	0.0	98	103	100	99
C2_ai	v12.3				−0.0	−0.0	0.0	0.0	0.0	0.0	98	103	99	98
C2_ai	v12.4				−0.0	−0.0	0.0	0.0	0.0	0.0	98	104	92	91
C2_ai	v14.0-rc1				−1.6	−2.1	−0.0	0.0	0.0	−0.9	101	100	96	96

v12.3 – aspects from 134th meeting

Fixes:

- Fix incorrect sharing of predictor modes between attributes
- Align sequence parameter set with specification
- Align attribute parameter set with specification
- Align attr_encoding enumeration with specification
- Use minus1 form for laser count

Normative changes:

- m56959: Use minus1 form for attr_scale
- m56959: Use ue(v) to signal num_attribute_parameters
- m56959: Use minus11 form for geom_angular_azimuth_scale_log2

m56959: Add frame_ctr_lsb to frame boundary marker
m56959: Decouple sequence bounding box origin and size

Non-normative changes:

Add option to disable automatic sequence origin computation
Add option to configure coordinate system for conformance output.
m56810: Use attribute scaling parameters for reflectance scaling
m56959: Support fixed-point geometry conformance output

v12.4 – fixes to first edition support

Fixes:

Conditionally signal spherical_coord_flag
Use minus1 form for sequence unit
Use minus1 form for max_neigh_range
Fix byte alignment in attribute parameter inventory

Normative changes:

m53679: Add raw attribute coding

v14.0

This release incorporates v12.3 and v12.4.

Normative changes:

m55979: Quantize azimuth residual according to radius
m55860: Add quantization weighting in predicting transform
m55952: Use vertex range to determine dominant trisoup axis

Non-normative changes:

m56740: Use source laser elevation to presort points

Release v14.0

This release contains the integration of, or aspects relating to: [4, 5, 6, 7, 8, 9, 10]

General comments

- These releases do not include the ability to signal profiles or levels. This will be added when the specification and software are fully aligned.
- The software defaults to binary ply output (`outputBinaryPly`). The common test condition anchor results of since v13.0 (but not v12.x) are now generated using the binary ply format.
- CTC configurations are provided for the following test conditions:

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

- A review of the common test 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).
- the current sequence categorisation does not facilitate identifying the type of content providing compression gains or losses.

Location of changes between v13.0 and v14.0

```
cfg/cfg-predgeom.yaml                                    |  52 +++---
cfg/octree-liftt-ctc-lossless-geom-lossy-attrs.yaml      |  12 +-
cfg/octree-liftt-ctc-lossy-geom-lossy-attrs.yaml         |  12 +-
cfg/octree-predt-ctc-lossless-geom-lossless-attrs.yaml   |  14 +-
cfg/octree-predt-ctc-lossless-geom-nearlossless-attrs.yaml |  14 +-
cfg/octree-raht-ctc-lossless-geom-lossy-attrs.yaml       |  14 +-
cfg/octree-raht-ctc-lossy-geom-lossy-attrs.yaml          |  14 +-
cfg/sequences-cat3.yaml                                  |  35 ++--
cfg/trisoup-raht-ctc-lossy-geom-lossy-attrs.yaml         |   2 +-
doc/README.options.md                                    | 117 ++++++++++----
tmc3/AttributeDecoder.cpp                                |  42 ++++-
tmc3/AttributeEncoder.cpp                                |  54 +++++-
tmc3/CMakeLists.txt                                      |   5 +-
tmc3/PCCMath.h                                           |  42 ++++-
tmc3/PCCPointSet.h                                       |  59 ++++++-
tmc3/PCCTMC3Common.h                                     |  29 +++-
tmc3/PCCTMC3Decoder.h                                    |   3 +
tmc3/PCCTMC3Encoder.h                                    |  10 ++
tmc3/TMC3.cpp                                            | 281 ++++++++++++++++++++++++------
tmc3/attribute_raw.h                                     |  72 ++++++++
tmc3/attribute_raw_decoder.cpp                           |  92 ++++++++++
tmc3/attribute_raw_encoder.cpp                           |  83 +++++++++
tmc3/coordinate_conversion.cpp                           |  25 ++-
tmc3/coordinate_conversion.h                             |   3 +-
tmc3/decoder.cpp                                         |  21 ++-
tmc3/encoder.cpp                                         |  54 +++++--
tmc3/frame.cpp                                           |  34 +++-
tmc3/frame.h                                             |   9 +-
tmc3/geometry_octree_decoder.cpp                         |   6 +-
tmc3/geometry_octree_encoder.cpp                         |   6 +-
tmc3/geometry_params.h                                   |   7 +-
tmc3/geometry_predictive.h                               |   4 +-
tmc3/geometry_predictive_decoder.cpp                     |  17 +-
tmc3/geometry_predictive_encoder.cpp                     | 116 ++++++++++---
tmc3/geometry_trisoup_decoder.cpp                        |  34 ++--
tmc3/hls.h                                               |  40 +++--
tmc3/io_hls.cpp                                          | 296 ++++++++++++++++++++++++-------
tmc3/io_hls.h                                            |   4 +
tmc3/ply.cpp                                             |  13 ++
tmc3/pointset_processing.cpp                             |  85 +++++++++-
tmc3/pointset_processing.h                               |  10 ++
41 files changed, 1458 insertions(+), 384 deletions(-)
```

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