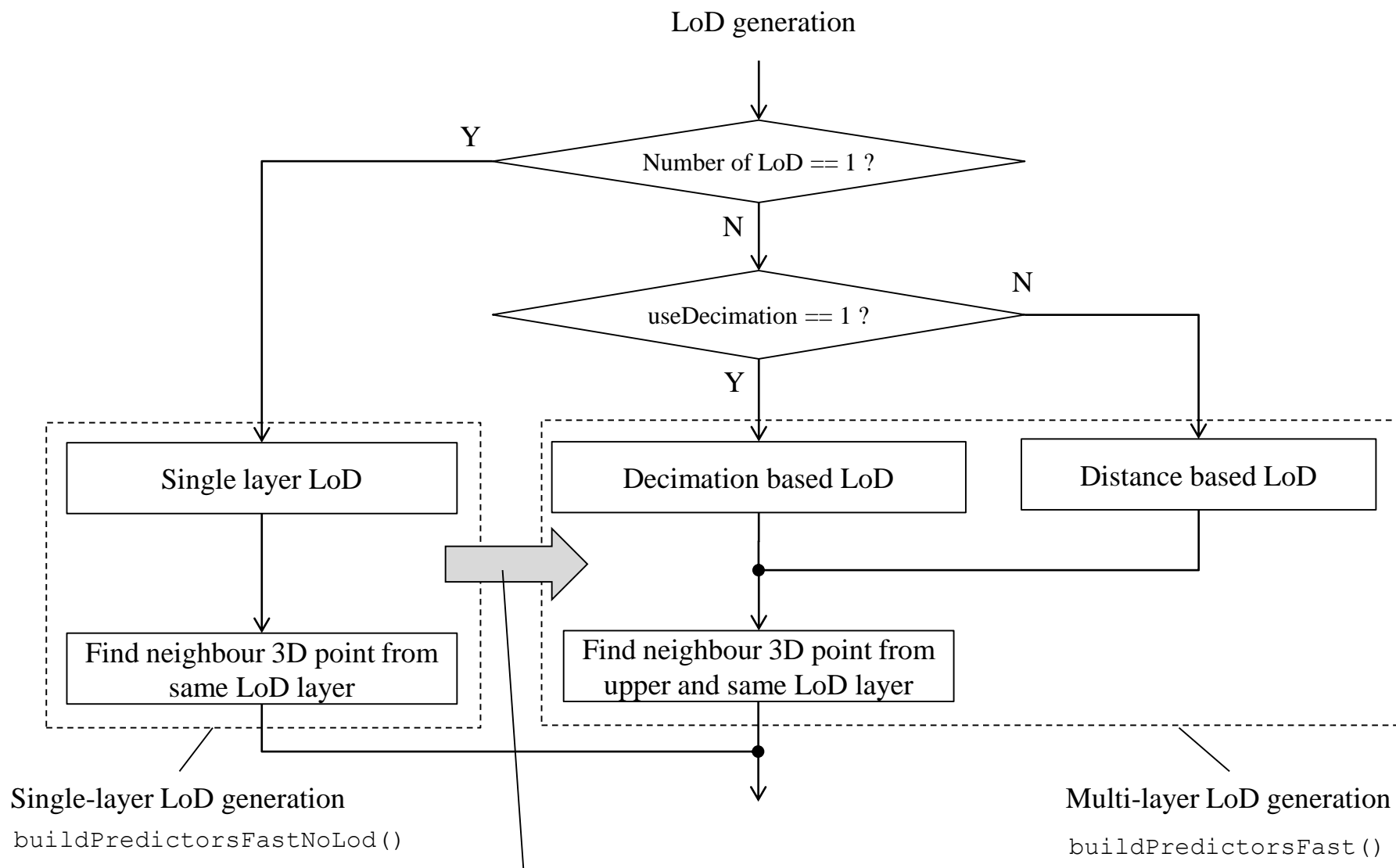


m49628:

[G-PCC] On the unification of single-layer and multi-layer LoD in TMC13

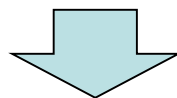
- In last meeting, m47406 proposed to unify single-layer and multi-layer LoD generation process in TMC13 software
- It was adopted as non-normative modification
- However, during TMC13v6 integration, it was pointed out that the result was changed before and after by this modification
- After analysis, we found the reason on it and propose further two modifications to achieve the unification



The function on Single layer LoD generation has already been covered by multi-layer LoD generation → Could be unified

- In last meeting, m47406 proposed to unify single-layer and multi-layer LoD generation process in TMC13 software
- It was adopted as non-normative modification
- However, during TMC13v6 integration, it was pointed out that the result was changed before and after by this unification
 - It should produce same result, but not...
- After analysis, we found the reason on it and propose further two modifications to achieve the unification

- Intra LoD prediction which allows to refer same LoD layer was adopted in last meeting
- However, we found that intra LoD prediction was not applied for top layer in TMC13v6 unexpectedly due to our insufficient implementation
- It was also not applied for single-layer LoD case after unification



We suggest to modify TMC13v6 software (software bug fix)

Modification 2: on insertNeighbor() function

- insertNeighbor() function
 - To select neighbour points for prediction
 - Swap process is conducted based on the weight value and **predictorIndex** in order to sort neighbours as following,

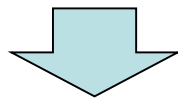
```
neighbour point a, b:  
if a.weight == b.weight then  
    if a.predictorIndex < b.predictorIndex then swap(a, b)  
    else no swap  
else  
    if a.weight < b.weight then swap(a, b)  
    else no swap
```

- In TMC13 software, **predictorIndex** to be used is different
 - Single-layer function: Morton code based index
 - Multi-layer function: 3D point index
 - It caused mismatch result before and after unification

- To solve this issue, one way is to modify swap process not to use predictorIndex as following,

```
neighbour point a, b:  
if a.weight == b.weight then  
    if a.predictorIndex < b.predictorIndex then swap(a, b)  
    else no swap  
else  
    if a.weight < b.weight then swap(a, b)  
    else no swap
```

- It's normative change



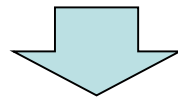
By applying modification 1 and 2-1,
the unification code produced same result as before and after

Modification 2-2: on insertNeighbor() function

- Another way is to modify swap process as following,

```
neighbour point a, b:  
current point cur:  
if a.weight == b.weight then  
    if a.predictorIndex < b.predictorIndex then swap(a, b)  
    if | a.Morton - cur.Morton | < | b.Morton - cur.Morton | then swap(a, b)  
    else no swap  
else  
    if a.weight < b.weight then swap(a, b)  
    else no swap
```

- Beneficial for encoder and decoder to search neighbour point in parallel



By applying modification 1 and 2-2,
the unification code produced same result as before and after

Experimental result compared to TMC13v6

- Modification 1: bug fix on intra LoD prediction for top layer

lossless geometry, lossy attributes [all intra]						
C1_ai	End-to-End BD-AttrRate [%]					
	Luma	Chroma Cb	Chroma Cr	Reflectan		
Cat1-A average	0.0%	0.0%	0.0%			
Cat3-fused average	0.0%	0.0%	0.0%	0.0%		
Cat3-frame average				0.0%		
Overall average	0.0%	0.0%	0.0%	0.0%		
Avg. Enc Time [%]			100%			
Avg. Dec Time [%]			100%			
lossy geometry, lossy attributes [all intra]					Geom. BD-TotGeomRate [%]	
C2_ai	End-to-End BD-AttrRate [%]					
	Luma	Chroma Cb	Chroma Cr	Reflectan	D1	D2
Cat1-A average	0.0%	0.0%	0.0%		0.0%	0.0%
Cat1-B average	#VALUE!	#VALUE!	#VALUE!		0.0%	0.0%
Cat3-fused average	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Cat3-frame average				0.0%	0.0%	0.0%
Overall average	#VALUE!	#VALUE!	#VALUE!	0.0%	0.0%	0.0%
Avg. Enc Time [%]				96%		
Avg. Dec Time [%]				#NUM!		
lossless geometry, lossless attributes [all intra]						
CW_ai	bpip ratio [%]					
	Geometry	Colour	Reflectanc	Total		
Cat1-A average	100.0%	100.0%		100.0%		
Cat1-B average	100.0%	#VALUE!		100.0%		
Cat3-fused average	100.0%	100.0%	100.0%	100.0%		
Cat3-frame average	100.0%		100.0%	100.0%		
Overall average	100.0%	#VALUE!	100.0%	100.0%		
Avg. Enc Time [%]				98%		
Avg. Dec Time [%]				97%		
lossless geometry, near-lossless attributes [all						
CY_ai	EtE Hausdorff BD-AttrRate [%]					
	Luma	Chroma Cb	Chroma Cr	Reflectan		
Cat1-A average	0.0%	0.0%	0.0%			
Cat3-fused average	0.0%	0.0%	0.0%	0.0%		
Cat3-frame average				0.0%		
Overall average	0.0%	0.0%	0.0%	0.0%		
Avg. Enc Time [%]			100%			
Avg. Dec Time [%]			100%			

Experimental result compared to TMC13v6

- Modification 2-1: on insertNeighbor() function

lossless geometry, lossy attributes [all intra]						
C1_ai	End-to-End BD-AttrRate [%]					
	Luma	Chroma Cb	Chroma Cr	Reflectance		
Cat1-A average	0.0%	0.0%	0.0%			
Cat3-fused average	0.0%	0.0%	0.0%	0.0%		
Cat3-frame average				0.0%		
Overall average	0.0%	0.0%	0.0%	0.0%		
Avg. Enc Time [%]			99%			
Avg. Dec Time [%]			99%			
lossy geometry, lossy attributes [all intra]					Geom. BD-TotGeomRate [%]	
C2_ai	End-to-End BD-AttrRate [%]					
	Luma	Chroma Cb	Chroma Cr	Reflectance	D1	D2
Cat1-A average	0.0%	0.1%	-0.1%		0.0%	0.0%
Cat1-B average	#VALUE!	#VALUE!	#VALUE!		0.0%	0.0%
Cat3-fused average	-0.2%	-0.1%	-0.1%	0.0%	0.0%	0.0%
Cat3-frame average				0.0%	0.0%	0.0%
Overall average	#VALUE!	#VALUE!	#VALUE!	0.0%	0.0%	0.0%
Avg. Enc Time [%]				100%		
Avg. Dec Time [%]				#NUM!		
lossless geometry, lossless attributes [all intra]						
CW_ai	bpip ratio [%]					
	Geometry	Colour	Reflectance	Total		
Cat1-A average	100.0%	100.1%		100.1%		
Cat1-B average	100.0%	#VALUE!		100.0%		
Cat3-fused average	100.0%	100.0%	100.0%	100.0%		
Cat3-frame average	100.0%		100.0%	100.0%		
Overall average	100.0%	#VALUE!	100.0%	100.0%		
Avg. Enc Time [%]			100%			
Avg. Dec Time [%]			101%			
lossless geometry, near-lossless attributes [all intra]						
CY_ai	EtE Hausdorff BD-AttrRate [%]					
	Luma	Chroma Cb	Chroma Cr	Reflectance		
Cat1-A average	0.5%	0.5%	0.5%			
Cat3-fused average	0.0%	0.0%	0.0%	0.0%		
Cat3-frame average				0.0%		
Overall average	0.4%	0.4%	0.4%	0.0%		
Avg. Enc Time [%]			98%			
Avg. Dec Time [%]			98%			

Experimental result compared to TMC13v6

- Unification result (modification 1 + 2-1 + remove single LoD layer)

lossless geometry, lossy attributes [all intra]						
C1_ai	End-to-End BD-AttrRate [%]					
	Luma	Chroma Cb	Chroma Cr	Reflectance		
Cat1-A average	0.0%	0.0%	0.0%			
Cat3-fused average	0.0%	0.0%	0.0%	0.0%		
Cat3-frame average				0.0%		
Overall average	0.0%	0.0%	0.0%	0.0%		
Avg. Enc Time [%]	100%					
Avg. Dec Time [%]	99%					
lossy geometry, lossy attributes [all intra]						
C2_ai	End-to-End BD-AttrRate [%]				Geom. BD-TotGeomRate [%]	
	Luma	Chroma Cb	Chroma Cr	Reflectance	D1	D2
Cat1-A average	0.0%	0.0%	0.0%		0.0%	0.0%
Cat1-B average	#VALUE!	#VALUE!	#VALUE!		0.0%	0.0%
Cat3-fused average	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Cat3-frame average				0.0%	0.0%	0.0%
Overall average	#VALUE!	#VALUE!	#VALUE!	0.0%	0.0%	0.0%
Avg. Enc Time [%]	100%					
Avg. Dec Time [%]	#NUM!					
lossless geometry, lossless attributes [all intra]						
CW_ai	bpip ratio [%]					
	Geometry	Colour	Reflectance	Total		
Cat1-A average	100.0%	100.0%		100.0%		
Cat1-B average	100.0%	#VALUE!		100.0%		
Cat3-fused average	100.0%	100.0%	100.0%	100.0%		
Cat3-frame average	100.0%		100.0%	100.0%		
Overall average	100.0%	#VALUE!	100.0%	100.0%		
Avg. Enc Time [%]	96%					
Avg. Dec Time [%]	94%					
lossless geometry, near-lossless attributes [all intra]						
CY_ai	EtE Hausdorff BD-AttrRate [%]					
	Luma	Chroma Cb	Chroma Cr	Reflectance		
Cat1-A average	0.0%	0.0%	0.0%			
Cat3-fused average	0.0%	0.0%	0.0%	0.0%		
Cat3-frame average				0.0%		
Overall average	0.0%	0.0%	0.0%	0.0%		
Avg. Enc Time [%]	100%					
Avg. Dec Time [%]	95%					

Experimental result compared to TMC13v6

- Modification 2-2: on insertNeighbor() function

lossless geometry, lossy attributes [all intra]						
C1_ai	End-to-End BD-AttrRate [%]					
	Luma	Chroma Cb	Chroma Cr	Reflectance		
Cat1-A average	0.0%	0.1%	0.0%			
Cat3-fused average	0.0%	0.0%	0.0%	0.0%		
Cat3-frame average				0.0%		
Overall average	0.0%	0.0%	0.0%	0.0%		
Avg. Enc Time [%]	101%					
Avg. Dec Time [%]	102%					
lossy geometry, lossy attributes [all intra]						
C2_ai	End-to-End BD-AttrRate [%]				Geom. BD-TotGeomRate [%]	
	Luma	Chroma Cb	Chroma Cr	Reflectance	D1	D2
Cat1-A average	0.0%	0.1%	0.1%		0.0%	0.0%
Cat1-B average	#VALUE!	#VALUE!	#VALUE!		0.0%	0.0%
Cat3-fused average	0.1%	0.1%	-0.1%	0.0%	0.0%	0.0%
Cat3-frame average				0.0%	0.0%	0.0%
Overall average	#VALUE!	#VALUE!	#VALUE!	0.0%	0.0%	0.0%
Avg. Enc Time [%]	100%					
Avg. Dec Time [%]	#NUM!					
lossless geometry, lossless attributes [all intra]						
CW_ai	bpip ratio [%]					
	Geometry	Colour	Reflectance	Total		
Cat1-A average	100.0%	100.4%		100.3%		
Cat1-B average	100.0%	#VALUE!		100.0%		
Cat3-fused average	100.0%	100.0%	100.0%	100.0%		
Cat3-frame average	100.0%		100.0%	100.0%		
Overall average	100.0%	#VALUE!	100.0%	100.1%		
Avg. Enc Time [%]	101%					
Avg. Dec Time [%]	103%					
lossless geometry, near-lossless attributes [all intra]						
CY_ai	EtE Hausdorff BD-AttrRate [%]					
	Luma	Chroma Cb	Chroma Cr	Reflectance		
Cat1-A average	1.1%	1.1%	1.1%			
Cat3-fused average	0.0%	0.0%	0.0%	0.0%		
Cat3-frame average				0.0%		
Overall average	1.0%	1.0%	1.0%	0.0%		
Avg. Enc Time [%]	102%					
Avg. Dec Time [%]	102%					

Experimental result compared to TMC13v6

- Unification result (modification 1 + 2-2 + remove single LoD layer)

lossless geometry, lossy attributes [all intra]						
C1_ai	End-to-End BD-AttrRate [%]					
	Luma	Chroma Cb	Chroma Cr	Reflectance		
Cat1-A average	0.0%	0.0%	0.0%			
Cat3-fused average	0.0%	0.0%	0.0%	0.0%		
Cat3-frame average				0.0%		
Overall average	0.0%	0.0%	0.0%	0.0%		
Avg. Enc Time [%]			100%			
Avg. Dec Time [%]			100%			
lossy geometry, lossy attributes [all intra]						
C2_ai	End-to-End BD-AttrRate [%]				Geom. BD-TotGeomRate [%]	
	Luma	Chroma Cb	Chroma Cr	Reflectance	D1	D2
Cat1-A average	0.0%	0.0%	0.0%		0.0%	0.0%
Cat1-B average	#VALUE!	#VALUE!	#VALUE!		0.0%	0.0%
Cat3-fused average	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Cat3-frame average				0.0%	0.0%	0.0%
Overall average	#VALUE!	#VALUE!	#VALUE!	0.0%	0.0%	0.0%
Avg. Enc Time [%]				100%		
Avg. Dec Time [%]				#NUM!		
lossless geometry, lossless attributes [all intra]						
CW_ai	bip ratio [%]					
	Geometry	Colour	Reflectance	Total		
Cat1-A average	100.0%	100.0%		100.0%		
Cat1-B average	100.0%	#VALUE!		100.0%		
Cat3-fused average	100.0%	100.0%	100.0%	100.0%		
Cat3-frame average	100.0%		100.0%	100.0%		
Overall average	100.0%	#VALUE!	100.0%	100.0%		
Avg. Enc Time [%]			99%			
Avg. Dec Time [%]			98%			
lossless geometry, near-lossless attributes [all intra]						
CY_ai	EtE Hausdorff BD-AttrRate [%]					
	Luma	Chroma Cb	Chroma Cr	Reflectance		
Cat1-A average	0.0%	0.0%	0.0%			
Cat3-fused average	0.0%	0.0%	0.0%	0.0%		
Cat3-frame average				0.0%		
Overall average	0.0%	0.0%	0.0%	0.0%		
Avg. Enc Time [%]			99%			
Avg. Dec Time [%]			95%			

- Two modifications were proposed
 - Modification 1: software bug fix on intra LoD prediction for top layer
 - Modification 2: normative change on insertNeighbor() function
- The result shows no significant coding loss
- By applying modification 1 and 2-1 or 2-2, the unification code of single and multi-layer LoD produced same result as before and after
- We suggest including this modification in next TMC13 software