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**ISO/IEC JTC1/SC29/WG4 MPEG/M56955
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Source PUT, Philips
Status Input
Title [MIV] Reason of difference in TMIV8.0.2 and TMIV8.2 performance
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1 Abstract

This is an informative contribution reporting the reason of different performance of TMIV8.0.2 and TMIV8.2, resulting from commit 8818ad19 (adaptive texture pruning fix).

2 Introduction

At the 132nd MPEG meeting the adaptive texture-based pruning was introduced [M54893]. The adaptive texture-based pruning is an extension of the texture-based pruning [M54177]. In this technique, pixels are pruned if they fulfill both conditions:

1. The depth of a pixel and a pixel reprojected from a view higher in the pruning graph is lower than the `maxDepthError` parameter (set in `.json` file),
2. The luma of a pixel (and all 8 pixels around it) and a pixel reprojected from a view higher in the pruning graph is lower than the `maxLumaError` parameter (set in `.json` file, default: 0.04).

In the adaptive texture-based pruning, the luma pruning threshold (`maxLumaError`) is changed to adapt to sequence characteristics (i.e. noise).

Therefore, if the sequence is noisy, the luma pruning threshold is increased to preserve pruning effectiveness (i.e. to prune areas which have similar colors but differ because of the noise). On the other hand, if there is no noise, the luma pruning threshold is lowered to allow preserving more areas with slightly different colors (e.g. due to non-lambertian reflectances).

If the changed luma pruning threshold is low, the pruning process is less effective. In this case, some of the patches could not fit into the atlas. In order to avoid such a wrong behavior, if the atlas is overfilled, the luma pruning threshold is iteratively increased until one of two conditions is fulfilled:

1. the total area of all patches is smaller than 80% of the atlas size,
2. the pruning luma threshold exceeds its initial value (in this case it is set to the value set in `.json` file).

This algorithm was implemented in TMIV8.0.

3 Bug

Unfortunately, due to a bug, the atlas size value needed at the pruning step was improperly calculated and always set to 0.

In this case, the first condition was never met, so for all sequences with lowered luma pruning threshold, it was iteratively increased until it exceeds initial value of 0.04. Therefore, the code was slowing down the calculations while changing nothing.

4 Fix

In the commit 8818ad19, only few lines were changed, as shown below. However, after a fix, atlas width and height are taken from `m_params.vps` instead of `atlas.asps`, which is not initialized at the moment of calling (so the width and height are set to 0).

```
▼ source/Encoder/src/Encoder_prepareSequence.cpp
... @@ -110,10 +110,11 @@ void Encoder::prepareSequence(const MivBitstream::SequenceConfig
&sequenceConfig
110
111     setGiGeometry3dCoordinatesBitdepthMinus1();
112
113 -   const auto sampleBudget = std::accumulate(
114 -     m_params.atlas.cbegin(), m_params.atlas.cend(), int64_t{}, [](auto sum, const auto &atlas) {
115 -       return sum + atlas.asps.asps_frame_width() * atlas.asps.asps_frame_height();
116 -     });
117
118     // Register pruning relation
119     m_params.viewParamsList = m_pruner->prepareSequence(Pruner::PrunerParams{
...
View file @ 8818ad19
... @@ -110,10 +110,11 @@ void Encoder::prepareSequence(const MivBitstream::SequenceConfig
&sequenceConfig
110
111     setGiGeometry3dCoordinatesBitdepthMinus1();
112
113 +   int32_t sampleBudget = 0;
114 +   for (size_t k = 0; k <= m_params.vps.vps_atlas_count_minus1(); ++k) {
115 +     const auto j = m_params.vps.vps_atlas_id(k);
116 +     sampleBudget += (m_params.vps.vps_frame_width(j) * m_params.vps.vps_frame_height(j));
117 +   }
118
119     // Register pruning relation
120     m_params.viewParamsList = m_pruner->prepareSequence(Pruner::PrunerParams{
...

```

5 TMIV with vs. without fix (SN, 1 frame)

TMIV encoder log (no fix)

```

Loading multiview frame 0 with start frame offset 60 (= 60).
DepthQualityAssessor -> View #0 done !
DepthQualityAssessor -> View #1 done !
DepthQualityAssessor -> View #2 done !
DepthQualityAssessor -> View #3 done !
DepthQualityAssessor -> View #4 done !
DepthQualityAssessor -> View #5 done !
DepthQualityAssessor -> View #6 done !
DepthQualityAssessor -> View #7 done !
DepthQualityAssessor -> View #8 done !
DepthQualityAssessor -> View #9 done !
DepthQualityAssessor -> OK
Basic view count is limited by maximum basic view fraction.
Forward central view is v1.
Initial centroids: v1 v5 (cost: 5.55556 m^-2)
Basic views: v1 v5
Additional views: v0 v2 v3 v4 v6 v7 v8 v9
The maxAtlases constraint is a limiting factor.
The maxLumaPictureSize constraint is a limiting factor.
Nominal atlas frame sizes: { [2048, 4352] [2048, 4352] }
Pruning graph:
( v1 v5 ) <- v2 <- v6 <- v3 <- v7 <- v4 <- v8 <- v0 <- v9 <- s0
Access unit: [0, 1)
Loading multiview frame 0 with start frame offset 60 (= 60).
Basic view 1 ( v1 ): 4194304 vertices (100.00% of full view)
Basic view 5 ( v5 ): 4194304 vertices (100.00% of full view)
Prune view 2 ( v2 ): 1398951 vertices (33.35% of full view)
Prune view 6 ( v6 ): 816474 vertices (19.47% of full view)
Prune view 3 ( v3 ): 983631 vertices (23.45% of full view)
Prune view 7 ( v7 ): 565229 vertices (13.48% of full view)
Prune view 4 ( v4 ): 560961 vertices (13.37% of full view)
Prune view 8 ( v8 ): 283981 vertices (6.77% of full view)
Prune view 0 ( v0 ): 435215 vertices (10.38% of full view)
Prune view 9 ( v9 ): 1685824 vertices (40.19% of full view)
Skipping inpainted view s0
Non-pruned luma samples per frame is 30.774372M
Pruning luma threshold: 0.016383
Non-pruned exceeds 80% of total sample budget (inf%)
Pruning luma threshold changed
Basic view 1 ( v1 ): 4194304 vertices (100.00% of full view)
Basic view 5 ( v5 ): 4194304 vertices (100.00% of full view)
Prune view 2 ( v2 ): 1316636 vertices (31.39% of full view)
Prune view 6 ( v6 ): 796432 vertices (18.99% of full view)
Prune view 3 ( v3 ): 844829 vertices (20.14% of full view)
Prune view 7 ( v7 ): 503536 vertices (12.01% of full view)
Prune view 4 ( v4 ): 462121 vertices (11.02% of full view)
Prune view 8 ( v8 ): 240822 vertices (5.74% of full view)
Prune view 0 ( v0 ): 404965 vertices (9.66% of full view)
Prune view 9 ( v9 ): 1439306 vertices (34.32% of full view)
Skipping inpainted view s0
Non-pruned luma samples per frame is 29.329842M
Pruning luma threshold: 0.024575
Non-pruned exceeds 80% of total sample budget (inf%)
Pruning luma threshold changed
Basic view 1 ( v1 ): 4194304 vertices (100.00% of full view)
Basic view 5 ( v5 ): 4194304 vertices (100.00% of full view)
Prune view 2 ( v2 ): 1242675 vertices (29.63% of full view)
Prune view 6 ( v6 ): 782086 vertices (18.65% of full view)
Prune view 3 ( v3 ): 738560 vertices (17.61% of full view)
Prune view 7 ( v7 ): 465469 vertices (11.10% of full view)
Prune view 4 ( v4 ): 403329 vertices (9.62% of full view)
Prune view 8 ( v8 ): 221175 vertices (5.27% of full view)
Prune view 0 ( v0 ): 384589 vertices (9.17% of full view)
Prune view 9 ( v9 ): 1204793 vertices (28.72% of full view)
Skipping inpainted view s0
Non-pruned luma samples per frame is 28.197104M
Pruning luma threshold: 0.036863
Non-pruned exceeds 80% of total sample budget (inf%)
Pruning luma threshold changed
Basic view 1 ( v1 ): 4194304 vertices (100.00% of full view)
Basic view 5 ( v5 ): 4194304 vertices (100.00% of full view)
Prune view 2 ( v2 ): 1227345 vertices (29.26% of full view)
Prune view 6 ( v6 ): 777529 vertices (18.54% of full view)
Prune view 3 ( v3 ): 719430 vertices (17.15% of full view)
Prune view 7 ( v7 ): 459703 vertices (10.96% of full view)
Prune view 4 ( v4 ): 396267 vertices (9.45% of full view)
Prune view 8 ( v8 ): 218375 vertices (5.21% of full view)
Prune view 0 ( v0 ): 380003 vertices (9.06% of full view)
Prune view 9 ( v9 ): 1160263 vertices (27.66% of full view)
Skipping inpainted view s0
Non-pruned luma samples per frame is 27.989522M
Pruning luma threshold: 0.040000
Aggregated luma samples per frame is 27.989522M
Maximum luma samples per frame is 27989522
Total size is 10770 B (86.16 kb)
Frame count is 1
Frame rate is 30.0 Hz
Total bitrate is 2584.7999999999997 kbps
Total Time: 463.329 sec.

```

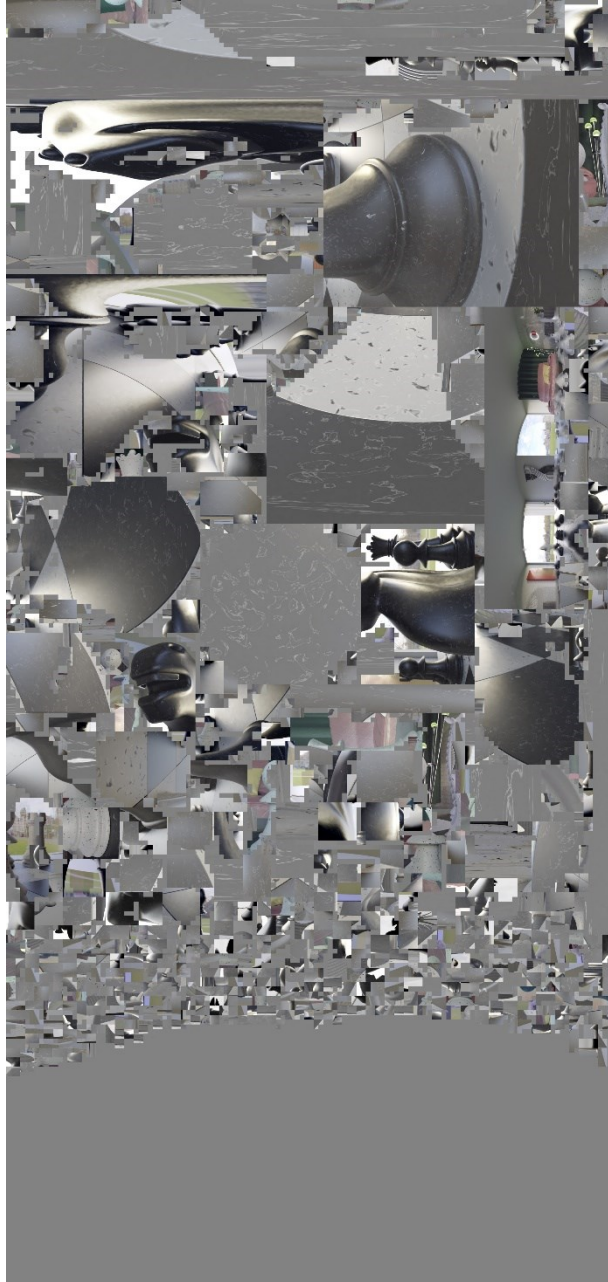
TMIV encoder log (with fix)

```

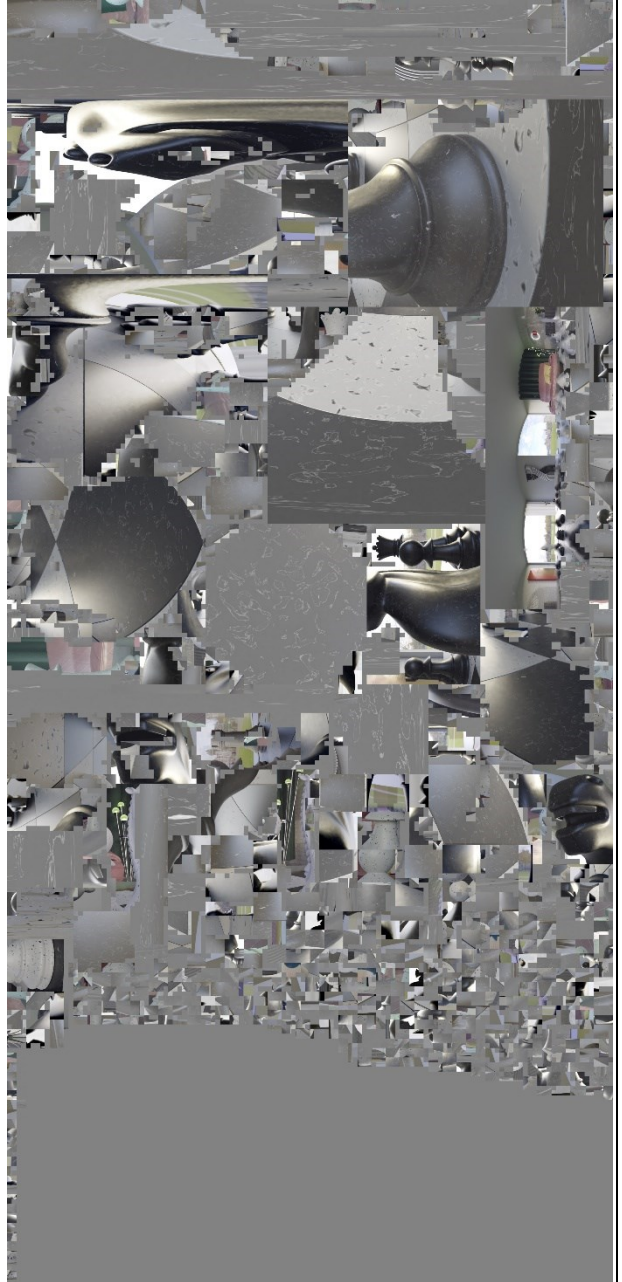
Loading multiview frame 0 with start frame offset 60 (= 60).
DepthQualityAssessor -> View #0 done !
DepthQualityAssessor -> View #1 done !
DepthQualityAssessor -> View #2 done !
DepthQualityAssessor -> View #3 done !
DepthQualityAssessor -> View #4 done !
DepthQualityAssessor -> View #5 done !
DepthQualityAssessor -> View #6 done !
DepthQualityAssessor -> View #7 done !
DepthQualityAssessor -> View #8 done !
DepthQualityAssessor -> View #9 done !
DepthQualityAssessor -> OK
Basic view count is limited by maximum basic view fraction.
Forward central view is v1.
Initial centroids: v1 v5 (cost: 5.55556 m^-2)
Basic views: v1 v5
Additional views: v0 v2 v3 v4 v6 v7 v8 v9
The maxAtlases constraint is a limiting factor.
The maxLumaPictureSize constraint is a limiting factor.
Nominal atlas frame sizes: { [2048, 4352] [2048, 4352] }
Pruning graph:
( v1 v5 ) <- v2 <- v6 <- v3 <- v7 <- v4 <- v8 <- v0 <- v9 <- s0
Access unit: [0, 1)
Loading multiview frame 0 with start frame offset 60 (= 60).
Basic view 1 ( v1 ): 4194304 vertices (100.00% of full view)
Basic view 5 ( v5 ): 4194304 vertices (100.00% of full view)
Prune view 2 ( v2 ): 1398951 vertices (33.35% of full view)
Prune view 6 ( v6 ): 816478 vertices (19.47% of full view)
Prune view 3 ( v3 ): 983634 vertices (23.45% of full view)
Prune view 7 ( v7 ): 565250 vertices (13.48% of full view)
Prune view 4 ( v4 ): 561080 vertices (13.38% of full view)
Prune view 8 ( v8 ): 283981 vertices (6.77% of full view)
Prune view 0 ( v0 ): 435219 vertices (10.38% of full view)
Prune view 9 ( v9 ): 1685874 vertices (40.19% of full view)
Skipping inpainted view s0
Non-pruned luma samples per frame is 30.774774M
Pruning luma threshold: 0.016383
Non-pruned exceeds 80% of total sample budget (86.320916%)
Pruning luma threshold changed
Basic view 1 ( v1 ): 4194304 vertices (100.00% of full view)
Basic view 5 ( v5 ): 4194304 vertices (100.00% of full view)
Prune view 2 ( v2 ): 1316646 vertices (31.39% of full view)
Prune view 6 ( v6 ): 796433 vertices (18.99% of full view)
Prune view 3 ( v3 ): 844833 vertices (20.14% of full view)
Prune view 7 ( v7 ): 503559 vertices (12.01% of full view)
Prune view 4 ( v4 ): 462015 vertices (11.02% of full view)
Prune view 8 ( v8 ): 240822 vertices (5.74% of full view)
Prune view 0 ( v0 ): 405008 vertices (9.66% of full view)
Prune view 9 ( v9 ): 1439330 vertices (34.32% of full view)
Skipping inpainted view s0
Non-pruned luma samples per frame is 29.329840M
Pruning luma threshold: 0.024575
Non-pruned exceeds 80% of total sample budget (82.267986%)
Pruning luma threshold changed
Basic view 1 ( v1 ): 4194304 vertices (100.00% of full view)
Basic view 5 ( v5 ): 4194304 vertices (100.00% of full view)
Prune view 2 ( v2 ): 1242675 vertices (29.63% of full view)
Prune view 6 ( v6 ): 782086 vertices (18.65% of full view)
Prune view 3 ( v3 ): 738560 vertices (17.61% of full view)
Prune view 7 ( v7 ): 465470 vertices (11.10% of full view)
Prune view 4 ( v4 ): 403332 vertices (9.62% of full view)
Prune view 8 ( v8 ): 221100 vertices (5.27% of full view)
Prune view 0 ( v0 ): 384588 vertices (9.17% of full view)
Prune view 9 ( v9 ): 1204751 vertices (28.72% of full view)
Skipping inpainted view s0
Non-pruned luma samples per frame is 28.197056M
Pruning luma threshold: 0.036862
Aggregated luma samples per frame is 28.197056M
Maximum luma samples per frame is 28197056
Total size is 10740 B (85.92 kb)
Frame count is 1
Frame rate is 30.0 Hz
Total bitrate is 2577.6 kbps
Total Time: 345.177 sec.

```

Atlas 01 (no fix)



Atlas 01 (fix)



6 Comparison of TMIV8.0.2 and TMIV8.2

Date: 2021-04-20										Max pixel-rate			Runtime ratio (%)			
Anchor CTC [N 0051]		TMIV branch 'v8.0-dev', CTC [N 0051] condition A, gcc, Philips Research Eindhoven (PRE)								1.070 GP/s						
Proposal v8.2-rc1		TMIV branch 'v8.2-rc1', CTC [N 0051] condition A, gcc, Philips Research Eindhoven (PRE)														
Frame config: rf - 17fr																
Mandatory content - Proposal vs. Low/High-bitrate Anchors																
Sequence		High-BR BD rate Y-PSNR	Low-BR BD rate Y-PSNR	Max delta Y-PSNR	High-BR BD rate VMAF	Low-BR BD rate VMAF	High-BR BD rate IV-PSNR	Low-BR BD rate IV-PSNR	Pixel rate [%]	Pixel rate [GP/s]	Frame rate [Hz]	TMIV encoding	Video encoding	Video decoding	TMIV decoding	
ClassroomVideo	A	1.9%	0.8%	1.22	1.5%	0.4%	0.3%	0.2%	63%	0.67	30	93.7%	96.7%	#####	96.8%	
Museum	B	1.7%	2.0%	16.17	1.2%	1.4%	1.5%	1.6%	63%	0.67	30	101.5%	106.1%	#####	99.0%	
Fan	O	0.0%	-0.0%	8.02	0.0%	0.3%	0.4%	0.2%	62%	0.67	30	101.5%	98.1%	#####	97.1%	
Kitchen	J	-11.8%	-3.6%	15.95	-12.3%	-1.9%	-6.8%	-1.2%	62%	0.67	30	99.6%	93.9%	#####	98.9%	
Painter	D	2.4%	3.6%	7.90	3.2%	4.0%	3.3%	3.9%	63%	0.67	30	101.7%	103.1%	#####	97.9%	
Frog	E	0.0%	-0.0%	6.76	0.1%	-0.0%	0.1%	0.0%	62%	0.67	30	110.0%	110.3%	#####	96.8%	
Carpark	P	-1.0%	-0.4%	7.30	-0.6%	-0.0%	-0.3%	-0.0%	52%	0.56	25	88.8%	88.4%	#####	94.6%	
Chess	N	-15.7%	-7.6%	14.35	-4.5%	-1.7%	-11.6%	-5.6%	63%	0.67	30	119.2%	129.1%	#####	91.2%	
Group	R	0.0%	-0.8%	12.14	3.8%	1.0%	-0.8%	-1.3%	62%	0.67	30	109.7%	94.7%	915.2%	89.1%	
MIV		-2.5%	-0.7%	9.98	-0.9%	0.4%	-1.6%	-0.3%	61%	0.66		102.9%	102.3%	#####	95.7%	

7 References

- [M54177] D. Mieloch, A. Dziembowski, "Immersive Video CE2.7: Texture-dependent pruning", ISO/IEC JTC1/SC29/WG11 MPEG/M54177, June 2020, Online.
- [M54893] D. Mieloch, A. Dziembowski, M. Domański, „MIV CE2.7: Adaptive texture-based pruning” ISO/IEC JTC1/SC29/WG4 MPEG/M54893, October 2020, Online.