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Source	**Poznań University of Technology (PUT), Poznań, Poland** **Electronics and Telecommunications Research Institute (ETRI), Daejeon, Republic of Korea**
Status	**Input**
Title	**[MPEG-I Visual] PUT/ETRI proposal for improved TMIV rendering method**
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1 Introduction

This document presents a technical description of the PUT/ETRI proposal of TMIV rendering method improvement. Proposed technique allows to reduce blending artifacts thus improve subjective quality of synthesized virtual views.

2 Description of the proposed technique

The original assumption of the experiment (CE4.1 experiment in the previous meeting cycle [W18468], withdrawn due to lack of time) was to replace TMIV 2.0 synthesizer by PUT/ETRI Advanced View Syntheser (AVS). However, many techniques used in AVS (e.g. view prioritization or color correction) do not improve virtual view quality when input views (atlases) have limited redundancy, as in TMIV. Moreover, some parts of AVS are already in TMIV (e.g. inpainter). Therefore, we have added a crucial technique from AVS, which is missing in TMIV: depth-based view blending with threshold.

In TMIV 2.0 two pixels are blended together using weighted average with normalized weights `w_a` and `w_b`:

```
return w_a * a + w_b * b;
```

in line 46 of blend.hpp file. When the foreground object and the background are too close to each other, this approach performs improperly resulting in blending instead of choosing closer object.

We propose to modify blending algorithm by adding a threshold:

```
if (std::abs(w_a - w_b) > 0.1)
  return (w_a > w_b) ? a : b;
else
  return w_a * a + w_b * b;
```

The value of the threshold was set arbitrarily to 0.1.

3 Experimental results

Proposed rendering method was compared to MIV anchor using the Common Test Conditions [W18563]. The results are presented in Table 1. Note that value 0.0% represents value of BD-rate that could not be calculated (because two of measured sets of values did not overlap). If such value is green, then the proposal achieved much better results than the anchor, if value is red, then the anchor was better.

Table 1. Proposed rendering vs. TMIV anchor.

Proposal vs. Low/High-bitrate Anchors

Test class	Sequence	Anchor	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 MS-SSIM	Low-BR BD rate MS-SSIM	High-BR BD rate IV-PSNR	Low-BR BD rate IV-PSNR	Pixel rate ratio
CG	ClassroomVideo	A1 (MIV)	37.4%	16.9%	0.34	-26.8%	-8.9%	8.4%	3.7%	-7.4%	-4.1%	0.00%
	TechnicolorMuseum	B1 (MIV)	0.4%	2.5%	0.44	-15.3%	-9.9%	-1.1%	-0.1%	-10.5%	-6.7%	0.00%
	TechnicolorHijack	C1 (MIV)	-6.9%	5.2%	1.14	-48.3%	-34.8%	-13.4%	-3.4%	-32.6%	-22.4%	0.00%
	OrangeKitchen	J1 (MIV)	0.0%	-57.6%	-2.83	0.0%	-72.9%	-79.0%	-41.0%	0.0%	-76.3%	0.00%
		MIV	7.7%	-8.2%	-0.23	-22.6%	-31.6%	-21.3%	-10.2%	-12.6%	-27.4%	0.00%
NC	TechnicolorPainter	D1 (MIV)	21.5%	15.9%	0.95	-25.2%	-14.7%	11.3%	9.6%	-12.2%	-6.9%	0.00%
	IntelFrog	E1 (MIV)	107.1%	47.2%	0.98	5.4%	2.1%	47.9%	25.7%	75.9%	21.5%	0.00%
	PoznanFencing	L1 (MIV)	-4.0%	-8.7%	-1.64	-35.5%	-24.8%	-6.8%	-1.1%	-54.1%	-47.4%	0.00%
		MIV	41.5%	18.1%	0.10	-18.4%	-12.5%	17.4%	11.4%	3.2%	-10.9%	0.00%

Test class	Sequence	Anchor	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 MS-SSIM	Low-BR BD rate MS-SSIM	High-BR BD rate IV-PSNR	Low-BR BD rate IV-PSNR	Pixel rate ratio
All		MIV	22.2%	3.0%	-0.09	-20.8%	-23.4%	-4.7%	-0.9%	-5.9%	-20.3%	0.00%

For sequences SJ and SL we modified "depthParameter" from 20 to 200. Without this change in some areas of the virtual view the background was synthesized in front of foreground objects (weight for background pixels was higher than for foreground ones – Fig. 3). Changing of this parameter wass just a workaround of a possible bug (hopefully corrected in TMIV version 3.0).

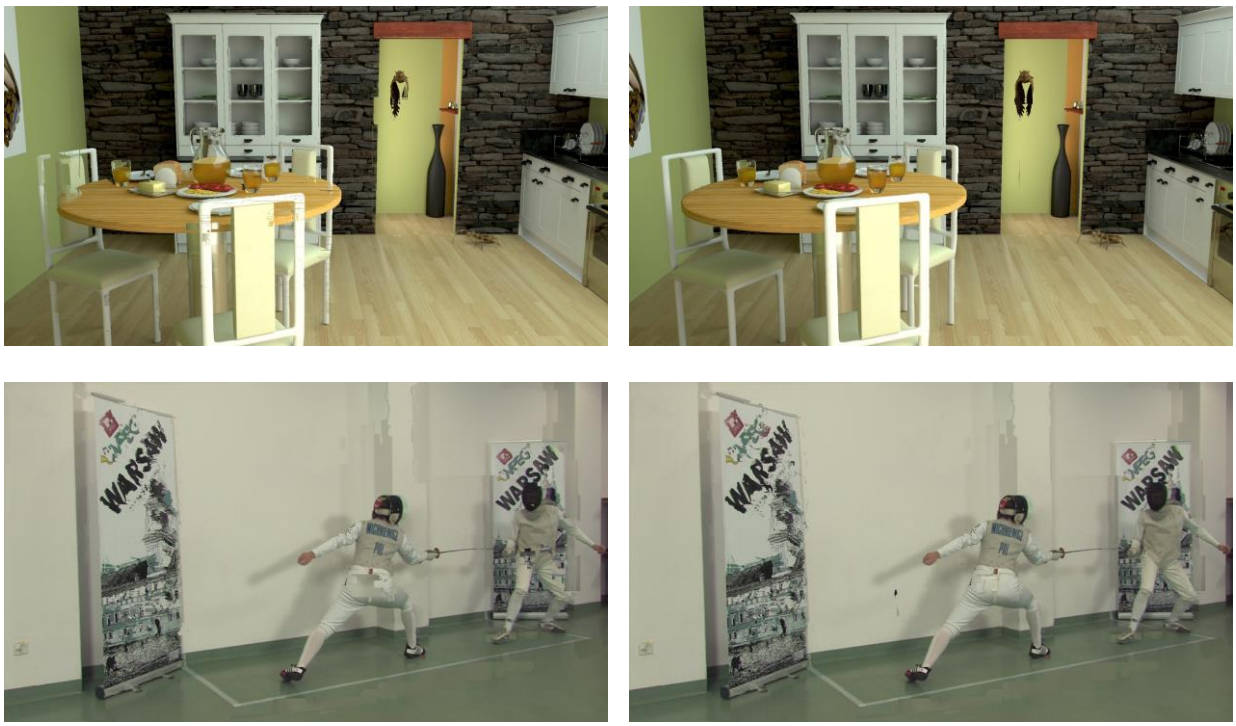

Fig. 3. Proposed blending with depthParameter = 20 (left) and 200 (right).

In order to present fair comparison, we have also calculated modified anchors: for sequences SJ and SL we modified "depthParameter" the same way, as in proposal (from 20 to 200).

Table 2. Proposed rendering vs. TMIV modified anchor ("depthParameter" = 200 for J1 and L1).

Proposal vs. Low/High-bitrate Anchors

Test class	Sequence	Anchor	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 MS-SSIM	Low-BR BD rate MS-SSIM	High-BR BD rate IV-PSNR	Low-BR BD rate IV-PSNR	Pixel rate ratio
CG	ClassroomVideo	A1 (MIV)	37.4%	16.9%	0.34	-26.8%	-8.9%	8.4%	3.7%	-7.4%	-4.1%	0.00%
	TechnicolorMuseum	B1 (MIV)	0.4%	2.5%	0.44	-15.3%	-9.9%	-1.1%	-0.1%	-10.5%	-6.7%	0.00%
	TechnicolorHijack	C1 (MIV)	-6.9%	5.2%	1.14	-48.3%	-34.8%	-13.4%	-3.4%	-32.6%	-22.4%	0.00%
	OrangeKitchen	J1 (MIV)	13.3%	12.1%	0.64	-21.2%	-11.8%	3.2%	3.5%	8.2%	5.5%	0.00%
		MIV	11.1%	9.2%	0.64	-27.9%	-16.4%	-0.7%	0.9%	-10.6%	-6.9%	0.00%
NC	TechnicolorPainter	D1 (MIV)	21.5%	15.9%	0.95	-25.2%	-14.7%	11.3%	9.6%	-12.2%	-6.9%	0.00%
	IntelFrog	E1 (MIV)	107.1%	47.2%	0.98	5.4%	2.1%	47.9%	25.7%	75.9%	21.5%	0.00%
	PoznanFencing	L1 (MIV)	70.5%	6.9%	0.60	-11.5%	-9.9%	31.9%	-1.9%	15.3%	-5.6%	0.00%
		MIV	66.4%	23.3%	0.84	-10.4%	-7.5%	30.4%	11.1%	26.3%	3.0%	0.00%

Test class	Sequence	Anchor	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 MS-SSIM	Low-BR BD rate MS-SSIM	High-BR BD rate IV-PSNR	Low-BR BD rate IV-PSNR	Pixel rate ratio
All		**MIV**	34.8%	15.2%	0.73	-20.4%	-12.6%	12.6%	5.3%	5.2%	-2.7%	0.00%

As shown in Fig. 1, proposed method significantly reduces blending artifacts, eliminating the problem of blending foreground objects with the background.

Fig. 1. TMIV 2.0 blending (left) vs. proposed blending with threshold (right).

Proposed method also exposes small artifacts (mostly caused by wrong depth values, Fig. 2), however they seem to be less irritating than large improperly-blended areas.

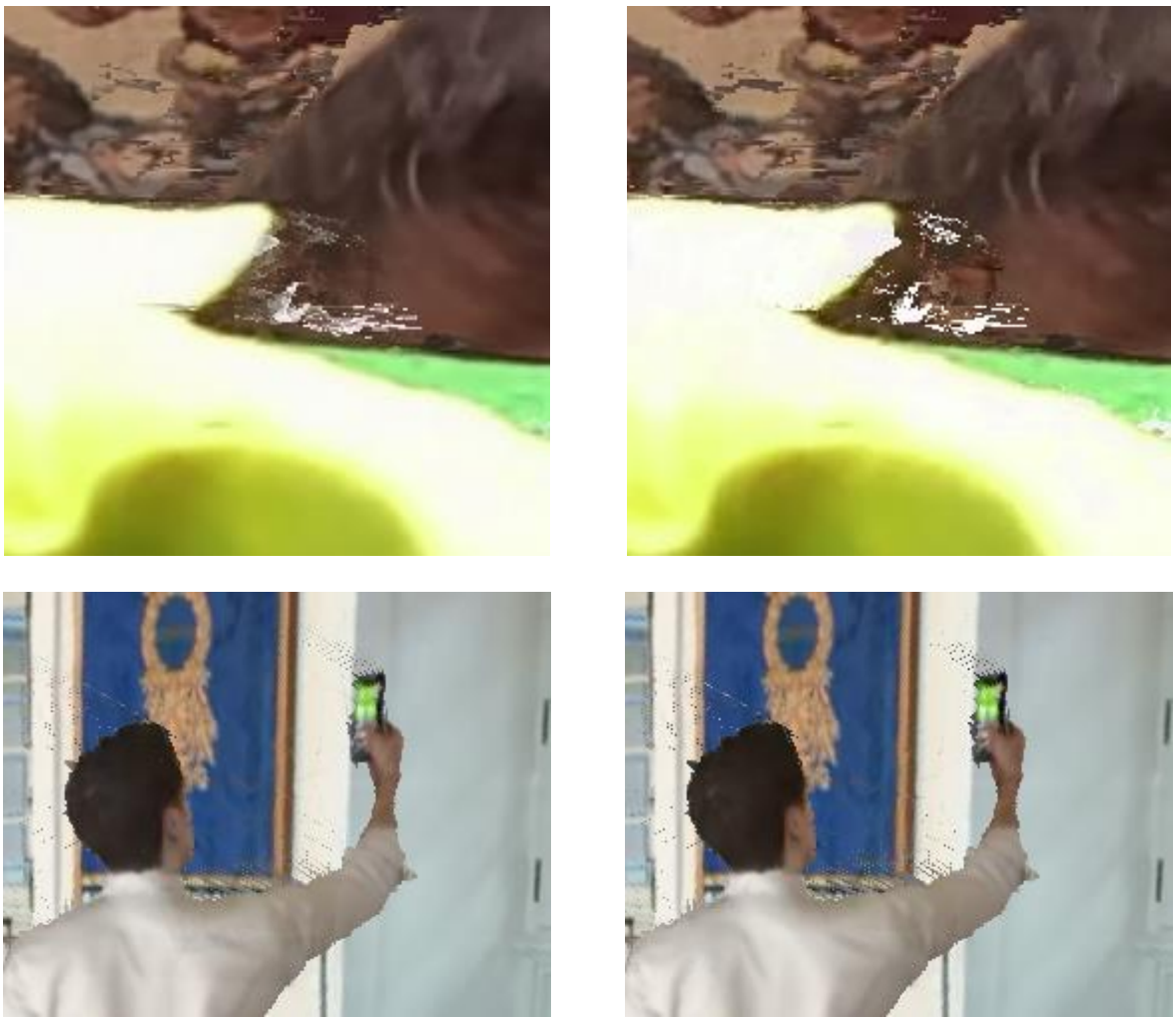

Fig. 2. TMIV 2.0 blending (left) vs. proposed blending with threshold (right).

4 Acknowledgement

This work was supported by Institute of Information & Communications Technology Planning & Evaluation (IITP) grant funded by the Korea government (MSIT) (No. 2018-0-00207, Immersive Media Research Laboratory).

5 Recommendations

We propose to include proposed rendering modification in TMIV 3.0.

6 References

[W18468] Description of Immersive Video Core Experiments 4, ISO/IEC JTC 1/SC 29/WG 11 N18468, Geneva, Switzerland, March 2019.

[W18563] J. Jung, B. Kroon, J. Boyce, Common Test Conditions for Immersive Video, ISO/IEC JTC1/SC29/WG11 MPEG/N18563, July. 2019, Goeteborg, Switzerland.