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Title: EE2: Results of View Synthesis on 'Pantomime' Sequence
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1. Introduction

This document reports the experimental results of view synthesis software on 'Pantomime' sequence as a response to EE2 of 3D Video [1]. During the last Lausanne meeting, integration of view synthesis software has been discussed, and three institutes, GIST, Thomson, and Nagoya University, have agreed with it. The new version of VSRS includes both 1D mode and boundary noise removal. In this experiment, we conducted all possible test combinations, and chose one best configuration. In this document, we describe some interesting properties of the test results and show the result of best configuration.

2. Experiments of View Synthesis

The new integrated software of view synthesis is distributed on 3rd April 2009 and updated several times. The previous techniques of ViSBD integrated into 1D mode, and the conventional method of VSRS is maintained in the general mode. The boundary noise removal is maintained and modified in the new version of software. In the following sub-chapter, we explain the whole procedure of experiments in detail.

2.1. Generation of Depth Video

Since view synthesis employs the depth data as input, we need to generate accurate depth data in advance. As we reported in EE1 document, we have obtained the depth videos as described in Table 1. We used the latest version of depth estimation software. The semi-automatic depth estimation software was somehow not sufficient; hence we did not use the software. Except for the newly added method on depth estimation, all parameters are referred to the results of previous EE documents. More precisely, we used half-pel precision, temporal enhancement, smoothing coefficient 3.00 etc.

Table. 1. Configuration for Depth Estimation

Target View Positions	View 38	View 41
Reference Views	View 37, View 39	View 40, View 42
Disparity Range	0 ~ 32	
Total Number of Frames	500	
DepthType	1	
Precision	Half-pel	
SearchLevel	Half-pel	
BaselineBasis	1	
Filter	MPEG-4 AVC 6-tap	
SmoothingCoefficient2	3.00	
MatchingMethod	Disparity-based	
TemporalEnhancement	On	
	Threshold	1.00
MatchingBlock	3x3 Block matching	
ImageSegmentation	Off	

2.2. Configuration of View Synthesis

The new version of view synthesis software includes three kinds of techniques: 3D warping based general mode, disparity based 1D mode, and boundary noise removal. Since the objective of this experiment is to evaluate them and find their properties, we set eight possible combinations as described in Table 2.

Table. 2. Mode Settings for Experiments

Synthesis Mode	Boundary Noise Removal	View Blending	Experiments
General Mode	Off	Off	Exp1
		On	Exp2
	On	Off	Exp3
		On	Exp4
1D Mode	Off	Off	Exp5
		On	Exp6
	On	Off	Exp7
		On	Exp8

3. Experimental Results

Based on the testing combinations above, we synthesized 500 frames for two intermediate views. Then, we calculated the PSNR values. Table 3 shows the results. The best setting was;

{General Mode, BoundaryNoiseRemoval Off, ViewBlending Off}

The highest average PSNR value was 34.688 using above setting. More precise analysis on the results is described in the following subchapters.

Table 3. Experimental Results of View Synthesis

Synthesis Mode	Boundary Noise Removal	View Blending	Exp.	Target Viewpoint	PSNR (dB)	
General Mode	Off	Off	Exp1	View 39	34.876	**34.688**
				View 40	34.501	
		On	Exp2	View 39	35.294	33.488
				View 40	31.682	
	On	Off	Exp3	View 39	34.777	34.620
				View 40	34.462	
		On	Exp4	View 39	35.175	33.426
				View 40	31.677	
1D Mode	Off	Off	Exp5	View 39	34.066	34.475
				View 40	34.884	
		On	Exp6	View 39	34.066	34.475
				View 40	34.884	
	On	Off	Exp7	View 39	32.266	33.892
				View 40	35.519	
		On	Exp8	View 39	29.656	30.680
				View 40	31.705	

3.1. Comparison of Synthesis Mode

In the Table 3, we can analyze the results of synthesis mode by comparing Exp1 with Exp5. In the PSNR manner, general mode showed better performance than that of 1D mode. In subjective manner, however, those two results are almost the same. In other

words, it is hard to find the visual difference between two results. Figure 1 shows the comparison of two synthesis modes focusing on the visual artifacts. Both modes generate annoying artifacts but not the same. We thought that the difference of PSNR values is due to this difference of artifacts. Although we can see that the general mode showed higher PSNR value, it is hard to say it is always best.

(a) 204th frame of view 39: General Mode(left), 1D Mode (right)

(b) 250th frame of view 39: General Mode(left), 1D Mode (right)

(c) 270th frame of view 39: General Mode(left), 1D Mode (right)

Fig. 1. Comparison of Visual Artifacts for Two Synthesis Modes

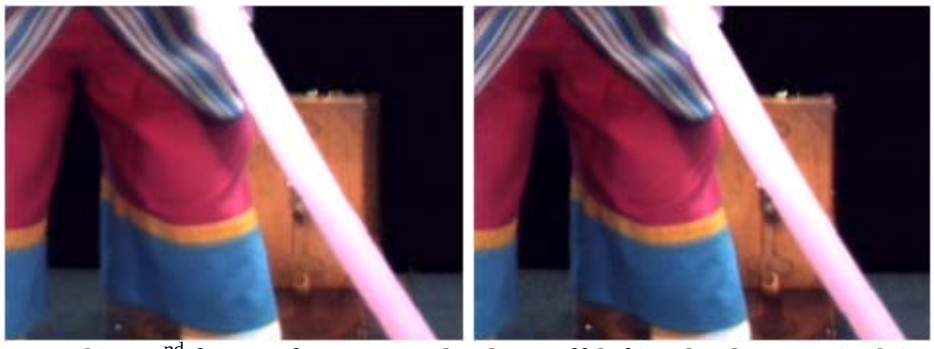
3.2. Comparison of Boundary Noise Removal

The new version of VSRS includes the boundary noise removal technique. By comparing Exp1 with Exp3, we can analyze its performance. The boundary noise removal eliminates the boundary noises when the depth value around depth discontinuity is incorrect. In the last EE report, we had described that ‘pantomime’ sequence has boundary noises and the method eliminated them. However, we could not find the boundary noise except for the distortion of shape. The boundary noise removal didn’t do its functionality, and the PSNR values were almost the same as the results of Exp1.

3.3. Comparison of View Blending

Nagoya University has proposed the view bending method and implemented on VSRS. We can see the performance by comparing Exp1 and Exp2 or Exp3 and Exp4. Figure 2 shows the comparison of view blending. We can easily find the effect of view blending mode in Fig. 2. When we set the blending mode on, the ghosting effects are significantly reduced. One interesting property is change of PSNR values. The PSNR value of left view is improved considerably, but the right one has been degraded. Although the average PSNR of view blending has degraded, it gives us positive performance since it reduces the visual artifacts.

(a) 121nd frame of view 39: Blending Off(left), Blending On (right)



(b) 251nd frame of view 39: Blending Off(left), Blending On (right)

Fig. 2. Comparison on View Blending

4. Conclusion

We have described results of the view synthesis software. We conducted experiment of view synthesis using newly integrated software VSRS 3.0. Both synthesis modes showed quit stable performance on ‘Pantomime’ sequence even though general mode showed slightly higher PSNR value. View blending method reduced the ghosting artifacts, but the PSNR values were inconsistent; left view was improved but right view was degraded. For viewing test, we brought results of view synthesis which are generated by view blending. As conclusion, we suggest that 3D video group needs to maintain current methods and add more methods to be proposed.

5. Acknowledgements

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6. References

[1] ISO/IEC JTC1/SC29/WG11 “Description of Exploration Experiments in 3D Video Coding”, N10360, February 2009.