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**Title: EE2: View Synthesis Results on 'Pantomime' Sequence using Thomson SW**
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## 1. Introduction

This document is a response to the exploration experiments described in N9991 [1]. We report the results of exploration experiment on view synthesis software (ViSBD) provided by Thomson. The 'Pantomime' sequence and the software of Nagoya University are used as a test sequence and depth estimation software, respectively. Two types of experiments have been performed: narrow and medium baselines.

## 2. Description of Experiment

### 2.1 Reference Software and Sequence

We used the view synthesis software provided by Thomson, which is described in M15696 [2]. Depth map is estimated from other available views using depth estimation software provided by Nagoya University [3]. The sequence we have assigned is 'Pantomime' of Nagoya University [4].

### 2.2 Experiments

As described in N9991 [1], there are two cases of baselines to synthesize intermediate view images. Table 1 contains details of the experiments. OL and OR represent the views to be synthesized using neighboring views NL and NR.

Table 1. Experiments for View Synthesis

| Baseline | Data set | OL-OR | NL-NR |
|---|---|---|---|
| Narrow | pantomime | 39-40 | 38-41 |
| Medium | pantomime | 39-40 | 37-42 |

### 2.3 Depth Estimation

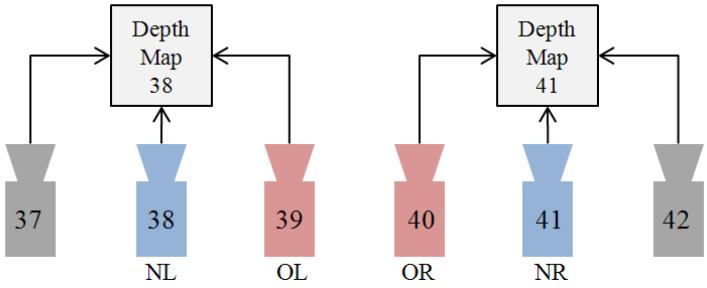
Because a depth map is necessary to synthesize intermediate views, we estimated depth map corresponding to the NL and NR by using depth estimation software of Nagoya University. In order to find suitable parameters in depth estimation software, we had pre-experiments which check PSNR values of synthesized images based on depth map made

by different combinations of parameters. The proper combination inducing the highest PSNR value is selected. The obtained parameter set is shown in table 1. We use these parameters for following experiments.

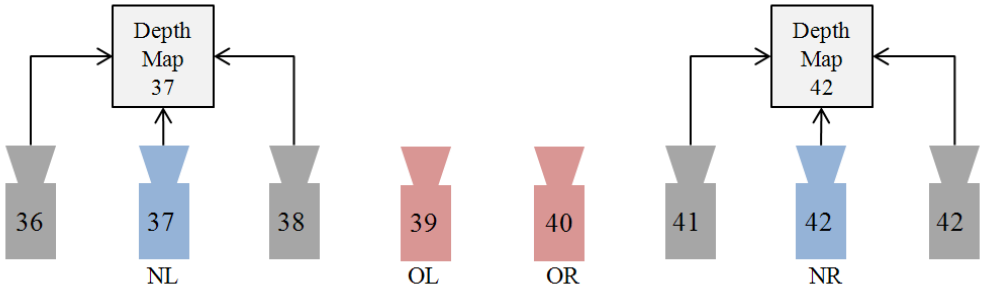
Table 2. Parameters for depth estimation

| Option | Common Parameters |
|---|---|
| SmoothingCoefficient | 5.0 |
| BaselineBasis | 0 |
| Precision | 1 |
| SearchLevel | 4 |
| Filter | 1 |
| MatchingMethod | 0 |
| MinimumValueOfDisparitySearchRange | 2 |
| MaximumValueOfDisparitySearchRange | 25 |
| MinimumValueOfDisparityRange | 0 |
| MaximumValueOfDisparityRange | 25 |

Figure 1 (a) shows the narrow baseline case experiment. The 39$^{th}$ and 40$^{th}$ views are selected as target views which will be synthesized (OL and OR).




(a) Narrow baseline case.



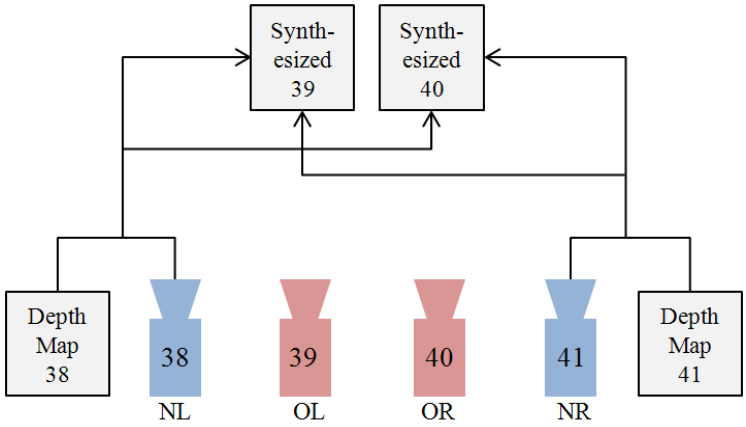

(b) Medium baseline case.

Fig. 1. Depth estimation.

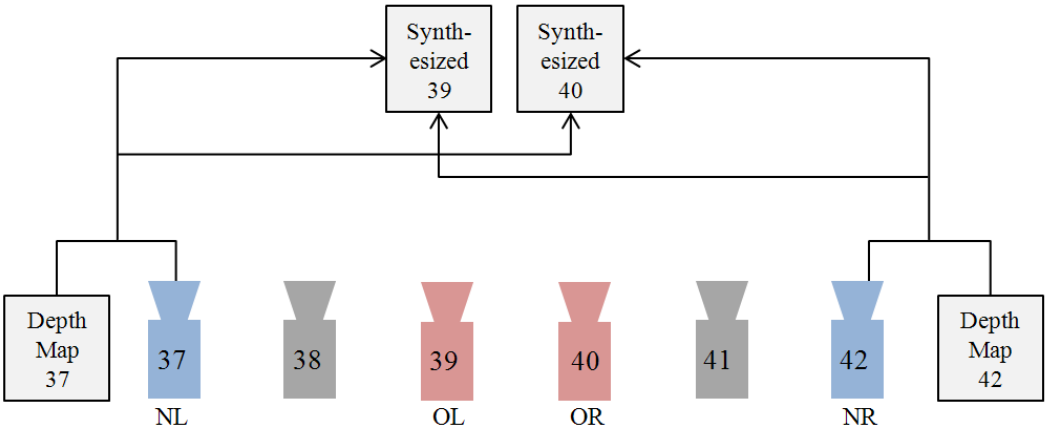
The 38th and 41st views are selected as a reference views which will be used for synthesis (NL and NR). The closest neighboring views of NL and NR are used to estimate depth map. In the case of the medium baseline experiment, the 37th and 42nd views are selected as a reference views as shown in Fig.1. (b).

### 2.4 View Synthesis

After estimating depth map, we synthesized OL and OR views from NL, NR and the depth maps of NL and LR, as shown in Fig. 2. For the synthesis, the values of 3454.569912 and 8221.650623 are used as 'NearestDepthValue' and 'FarthestDepthValue', respectively. The format of input sequences is YUV 4:2:0.




(a) Narrow baseline case




(b) Medium baseline case.
Fig. 2. View synthesis.

## 3. Results of Option Test

We generated 100 frames to examine the performance of the options implemented in the Thomson software. In Thomson software, there are two options: 'SplattingOption' and

'SubPelOption'. We synthesized the images while changing these options, and compared synthesized images to original images shown in Fig. 3. The reason why we choose 89th frame is that this frame shows the defects of synthesized image well.

(a) Original color image of 39th view (b) Original color image of 40th view

Fig. 3. Original images

### 3.1 Narrow Base Line

In this Section, the results for narrow base line are mentioned. Figure 4 shows the 89th frame of the depth maps estimated by Nagoya depth estimation software.

(a) Estimated depth map of 38th view (b) Estimated depth map of 41st view

Fig. 4. Estimated Depth Maps of Narrow Baseline Case

#### 3.1.1 SplattingOption

In order to check the performance of 'SplattingOption', we fixed 'SubPelOption' to 1 during this test. Figure 5 shows the synthesized images. In the case that 'SplattingOption' is disabled, the 39th and 40th frames have average PSNR values of 33.08 and 29.99, respectively. However, the synthesized images with 'SplattingOption' show lower PSNR values. The results are summarized in Table 3.

Table 3. Average PSNR values according to ‘SplattingOption’

| SplattingOption | 39th view | 40th view | average |
|---|---|---|---|
| 0 | 33.0879 | 29.9913 | 31.5396 |
| 1 | 30.8760 | 28.8452 | 29.8606 |

(a) SplattingOption : off (PSNR of the 89th frame= 28.72)

(b) SplattingOption : on (PSNR of the 89th frame = 27.78)

Fig. 5. Synthesized Images
(left : 39th view, right : 40th view)

### 3.1.2 SubPelOption

After ‘SplattingOption’ test, we fixed ‘SplattingOption’ to 0 because ‘SplattingOption’ showed the worse results in previous test. Table 4 shows the summary of this test. The highest PSNR value was obtained, when ‘SubPelOption’ is set to 2.

Table 4. Average PSNR values according to ‘SubPelOption’

| SubPelOption | 39th view | 40th view | average |
|---|---|---|---|
| 1 | 33.0879 | 29.9913 | 31.5396 |
| 2 | 33.5384 | 32.0316 | 32.7850 |
| 4 | 32.0908 | 31.4041 | 31.7475 |

We can observe this option influences subjective quality as well as objective quality. As you cans see in Fig. 6, the shape of the bag behind people is changed by 'SubPelOption'.

(a) SubPelOption : 1 (PSNR of the 89th frame= 28.72)

(b) SubPelOption : 2 (PSNR of the 89th frame= 31.02)

(c) SubPelOption : 4 (PSNR of the 89th frame= 29.97)

Fig. 6. Synthesized Images (SplattingOption)
(left : 39th view, right : 40th view)

### 3.2 Medium Base Line

We tested Thomson software for medium base line in same the manner of the previous test. Figure 7 shows the estimated depth maps.

(a) Estimated depth map of 37th view (b) Estimated depth map of 42st view

Fig. 7. Estimated Depth Maps of Narrow Baseline Case

### 3.2.1 SplattingOption

(a) SplattingOption : off (PSNR of the 89th frame= 26.74)

(b) SplattingOption : on (PSNR of the 89th frame= 27.59)

Fig. 8. Synthesized Images (SplattingOption)
(left : 39th view, right : 40th view)

Although 'SplattingOption' induces good result in 89th frame, 'SplattingOption' reduces the PSNR values on the average of whole frames.

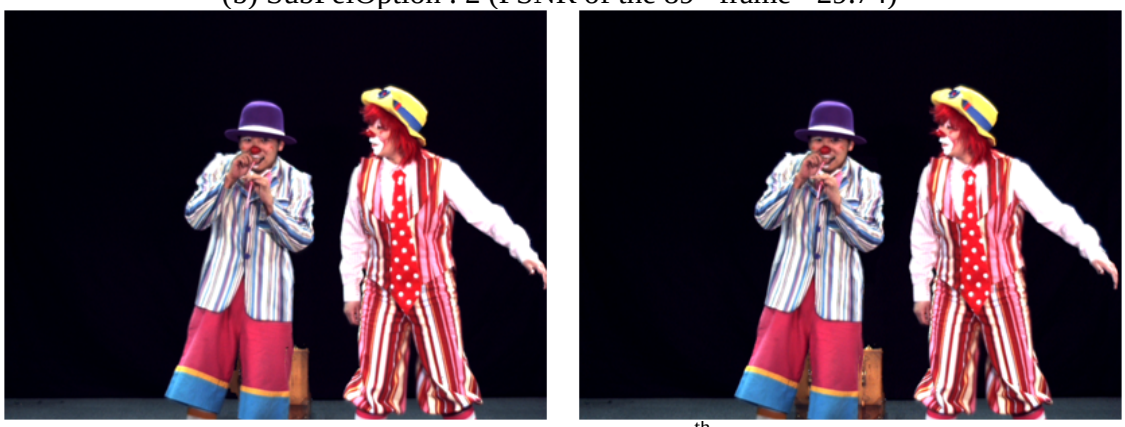
Table 5. Average PSNR values according to ‘SplattingOption’

| SplattingOption | 39th view | 40th view | average |
|---|---|---|---|
| 0 | 29.8201 | 28.3700 | 29.0951 |
| 1 | 29.2757 | 26.8272 | 28.0515 |

### 3.2.2 SubPelOption

(a) SubPelOption : 1 (PSNR of the 89th frame= 26.74)

(b) SubPelOption : 2 (PSNR of the 89th frame= 29.74)



(c) SubPelOption : 4 (PSNR of the 89th frame= 30.26)

Figure 9. Synthesized Images (SubPelOption)
(left : 39th view, right : 40th view)

Table 6. Average PSNR values according to ‘SubPelOption’

| SubPelOption | 39th view | 40th view | average |
|---|---|---|---|
| 1 | 29.8201 | 28.3700 | 29.0951 |
| 2 | 31.5217 | 30.9606 | 31.2412 |
| 4 | 31.5817 | 30.4329 | 31.0073 |

### 3.3 Summary of Option Test

In this Section, we summarize the result of option test. Table 7 shows the PSNR value of synthesized images with whole combinations of options.

Table 7. PSNR values according to different options

| (PSNR) | SplattingOption | 0 | | | 1 | | |
|---|---|---|---|---|---|---|---|
| | SubPelOption | 1 | 2 | 4 | 1 | 2 | 4 |
| Narrow Baseline Case | view 39 | 33.09 | 33.54 | 32.09 | 30.88 | 31.08 | 32.50 |
| | view 40 | 29.99 | 32.03 | 31.40 | 28.85 | 28.80 | 31.72 |
| | average | 31.54 | **32.79** | 31.75 | 29.86 | 29.94 | 32.11 |
| Medium Baseline Case | view 39 | 29.82 | 31.52 | 31.58 | 29.28 | 29.20 | 31.32 |
| | view 40 | 28.37 | 30.96 | 30.43 | 26.83 | 27.27 | 30.57 |
| | average | 29.10 | **31.24** | 31.01 | 28.05 | 28.23 | 30.95 |

As you can see in Table 7, a half-pel option induces the highest PSNR values for both baseline cases. However, as the distance between reference views is increased, the difference of PSNR values between half-pel and quarter-pel is getting smaller. When ‘SplattingOption’ is disabled, the synthesized images have the higher PSNR value. Therefore, we select half-pel option without ‘SplattingOption’ for both baseline cases.

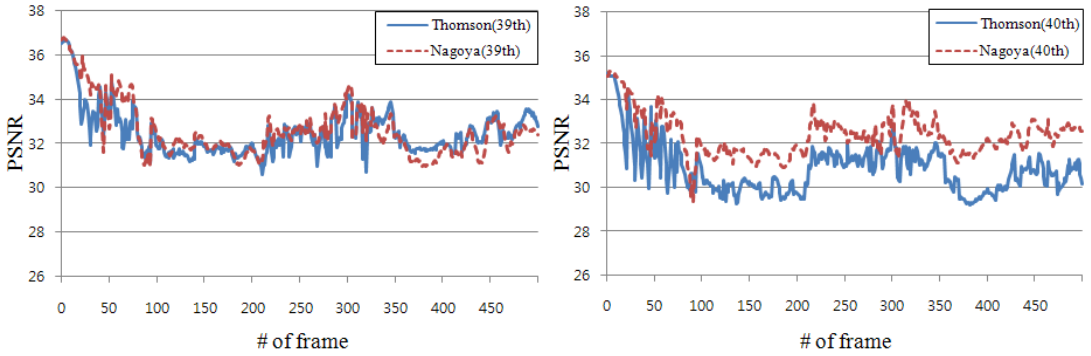
## 4. Comparison with Nagoya View Synthesis Software

We compared the performance of Thomson software with that of Nagoya view synthesis software. We used same depth map for both software and generated 500 frames, respectively. The options we selected are ‘SplattingOption = 0’ and ‘SubPelOption = 2’ for Thomson software.

### 4.1 Narrow base line

Figure 10 depicts the change of PSNR value of the synthesized images. The dotted and solid lines represent PSNR value of Nagoya and Thomson software, respectively. The overall performance of Thomson software is lower than that of Nagoya software. Especially, the gap gets larger on the frames having large disparity. Figure 11 and 12

represent the 400th frame of original and synthesized images, respectively. As you can see, the image of Thomson has errors in the part of bag.




(a) 39th view (b) 40th view

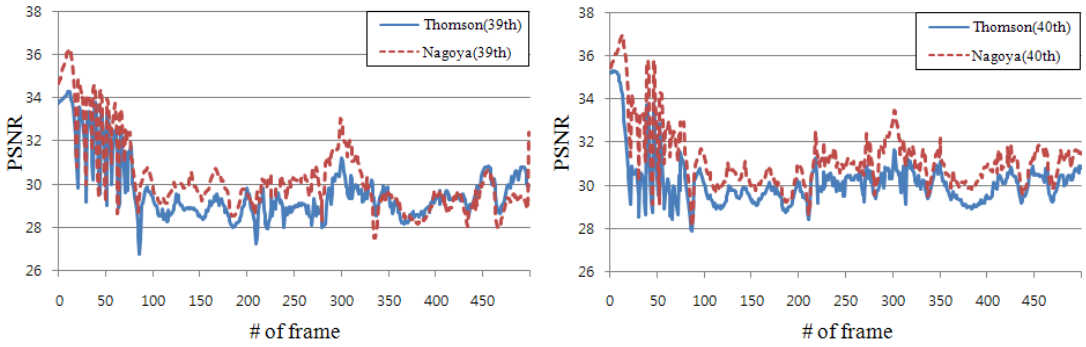
Fig. 10. The change of PSNR value (narrow base line)

Fig. 11. Original image (400th frame, 40th view)

(a) 400th frame (Thomson) (b) 400th frame (Nagoya)

Fig. 12. Synthesized 40th view (narrow base line)

### 4.2 Medium base line




(a) 39th view (b) 40th view

Fig. 13. The change of PSNR value (medium base line)

(a) 400th frame (Thomson) (b) 400th frame (Nagoya)

Fig. 14. Synthesized 40th view (medium base line)

## 5. Conclusion

We have experimented view synthesis using ViSBD software provided by Thomson with 'Pantomime' sequences. We estimated depth map of neighboring views with the depth estimation software of Nagoya University. Then, we examined the performance of options implemented in Thomson software for two different baseline cases. We can obtain the highest PSNR value of 32.79 and 31.24 for narrow and medium baseline case respectively, when "SplattingOption" is disabled and "SubPelOption" is set to 2. We synthesized the images of 500 frames using the best set of options and compared objective quality with software of Nagoya University. The performance of Thomson software is lower than that of Nagoya University's software for 'Pantomime' sequence in our experiments. We are ready to bring these files to the meeting.

## 6. Acknowledgements

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## 7. References


[1] ISO/IEC JTC1/SC29/WG11 “Description of Exploration Experiments in 3D Video Coding,” N9991, July 2008.

[2] ISO/IEC JTC1/SC29/WG11 “Simple View Synthesis,” M15696, July 2008.

[3] ISO/IEC JTC1/SC29/WG11 “Reference Software for Depth Estimation and View Synthesis,” M15377, May 2008.

[4] ISO/IEC JTC1/SC29/WG11 “1D Parallel Test Sequences for MPEG-FTV,” M15378, April 2008.