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Title	**Application of Middle Level Hypothesis algorithm for improvement of depth maps produced by Depth Estimation Reference Software.**
Sub group	**Video**
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1 Introduction

The current version of MPEG FTV 3DTV reference package (DERS), kindly provided by Nagoya University [1], provides sub-pixel precision for estimated depth maps. Because the sub-pixel precision is obtained by straight-forward resampling of the input image pair, the quality gain is not significant [2] and is occupied by considerable complexity gain. This document presents an alternative method for producing pixel-precise depth maps with use of Middle Level Hypothesis (MLH) tool. The MLH tool have been introduced as a part of PUT depth estimation software, described in [3], but as presented in this paper, can also be used as a post-processing tool for depth maps produced with DERS.

2 Experiments

All the experiments were performed according to guidelines for Exploration Experiments in "Description of Exploration Experiments in 3D Video Coding" [3]. Quality of depth estimation and view synthesis software setup was evaluated by quality of two views (SL, SR), synthesized from side-views (NL, NR) compared to quality of original views (OL, OR) (Figure 1). The steps of each experiment were as follows:

1. **Estimate depth maps** for two side-views NL and NR from neighboring views (for example NL-1, NL, NL+1 and NR-1, NR, NR+1 respectively, for camera distance equal to 1) **with Depth Estimation Reference Software**, with Pel-precision.

2. **Improve the precision** of depth maps**,** basing on neighboring views, with use of **MLH tool.**

3. **Synthesize views** SL and SR placed at positions of OL and OR with use of NL+depth and NR+depth with **View Synthesis Reference Software**, HPel-precision.

4. **Compare synthesized views** SL, SR with original views OL, OR subjectively and by PSNR.

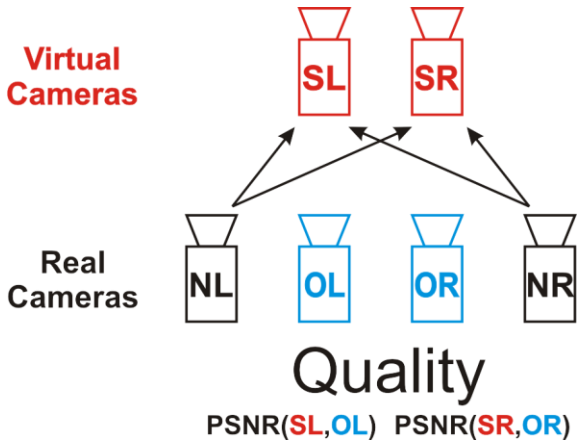

Figure 1. Setup of experiments for depth-estimation and view-synthesis software evaluation.

Due to limitations of computational power, only a few of MPEG 3DTV test sequences were chosen for experiments:

- 'Outdoor Alt Moabit' sequence (kindly provided by HHI),
- 'Book Arrival' sequence (kindly provided by HHI),
- 'Newspaper' sequence (kindly provided by GIST),
- 'Dog' sequence (kindly provided by Nagoya University),
- 'Lovebird 1' sequence (kindly provided by ETRI).

The MLH tool has been upgraded to support configuration files and file formats used by the Reference Software.

Depth Estimation Reference Software 2.0 with Pel and HPel precision was used as an reference for proposed technique.

3 Results

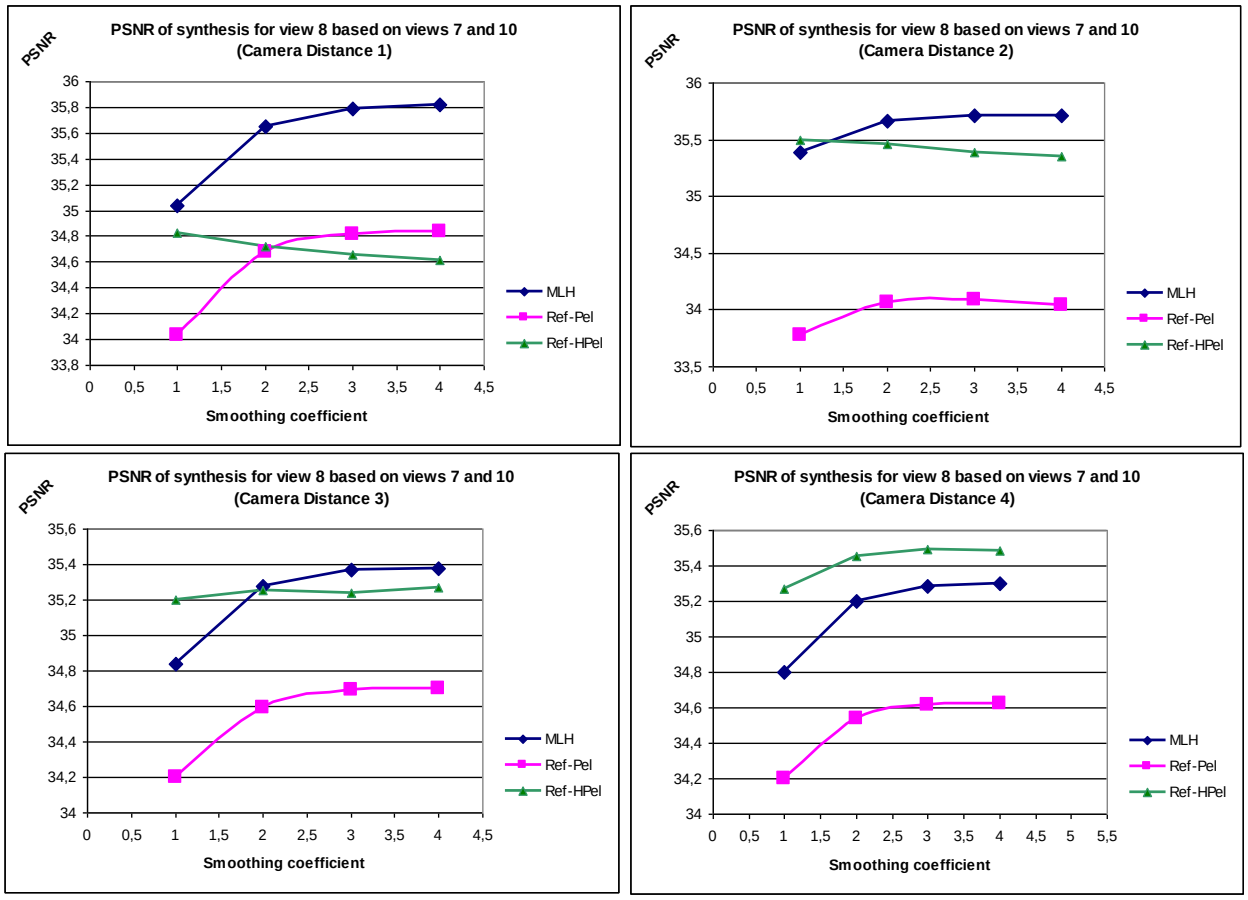

Figure 2. Performance comparision for ‘Alt Moabit’ sequence.

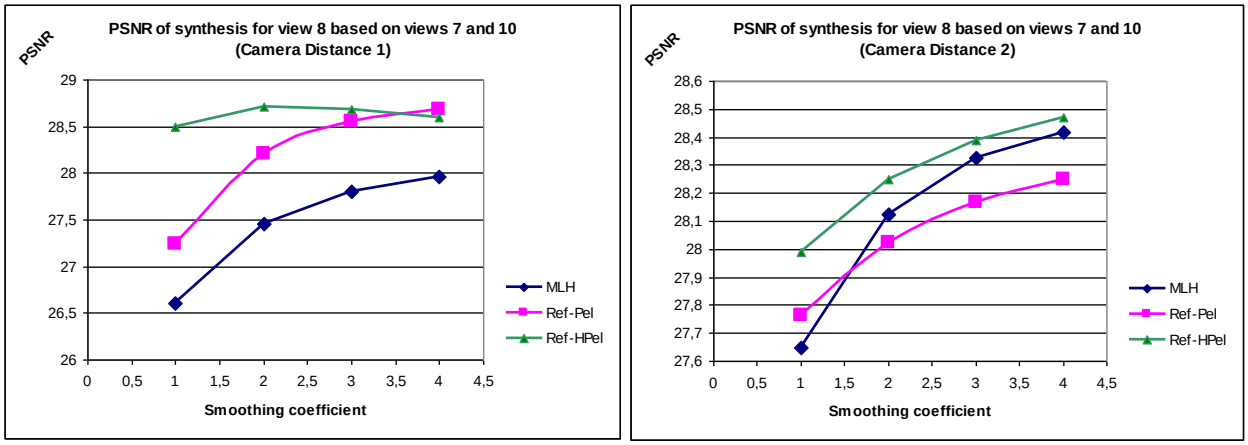

Figure 3. Performance comparision for ‘Lovebird 1’ sequence.

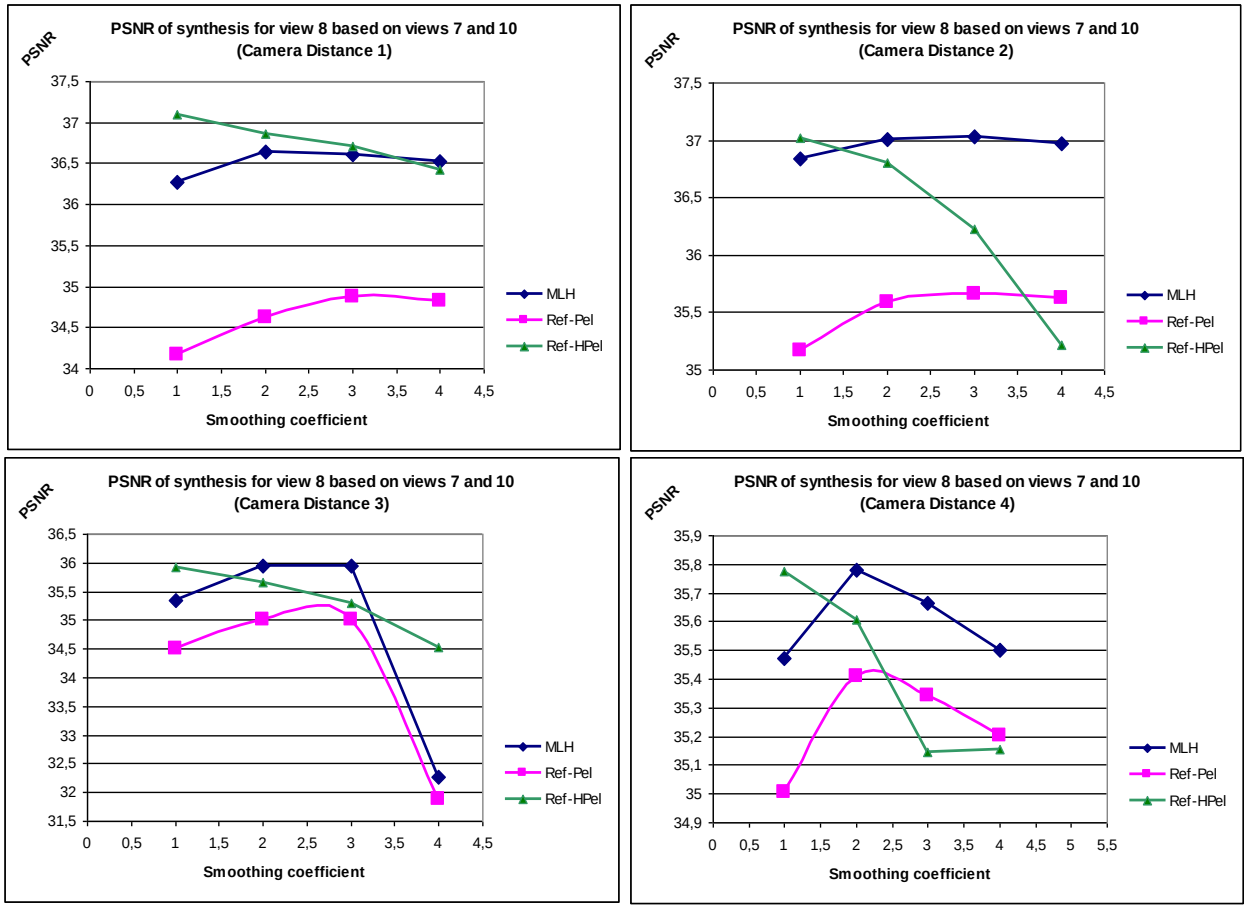

Figure 4. Performance comparision for 'Book arrival' sequence.

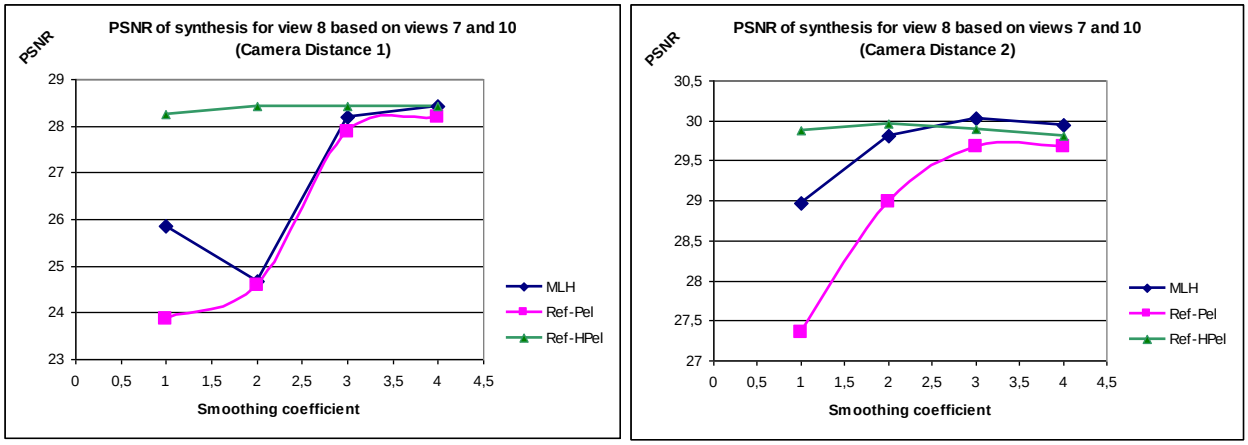

Figure 5 Performance comparision for 'Newspaper' sequence.

4 Conclusions

- The MLH tool improves the precision of depth maps at low computational cost.
- Due to introduced configuration files compability with DERS, little effort is required for use of MLH tool.
- Application of MLH tool improves quality of synthesized views by about 0.5 dB to 2 dB of PSNR compared to reference software with Pel precision,
- Application of MLH tool improves quality of synthesized views up to 1 dB of PSNR compared to reference software with HPel precision,
- Further test over variety of sequences are encouraged.

5 References

[1] http://www.tanimoto.nuee.nagoya-u.ac.jp/ - MPEG-FTV web-page, Tanimoto Laboratory, Nagoya University.

[2] K. Wegner, O. Stankiewicz, "Analysis of sub-pixel precision in Depth Estimation Reference Software and View Synthesis Reference Software" MPEG 2008/M16027, Lausanne input document, Switzerland, February 2009.

[3] O. Stankiewicz, K. Wegner, "Depth Map Estimation Software", MPEG 2008/M15338, Archamps, France, April 2008.