Estimation of Virtual Interpupillary Distances for Immersive Head-Mounted Displays

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Abstract

Head-mounted displays (HMDs) allow users to observe virtual environments (VEs) from an egocentric perspective. In order to present a realistic stereoscopic view, the rendering system has to be adjusted to the characteristics of the HMD, e. g., the display's field of view (FOV), as well as to characteristics that are unique for each user, in particular her interpupillary distance (IPD). Typically, the user's IPD is measured, and then applied to the *virtual* IPD used for rendering, assuming that the HMD's display units are correctly adjusted in front of the user's eyes. A discrepancy between the user's IPD and the virtual IPD may distort the perception of the VE.

In this poster we analyze the user's perception of a VE in a HMD environment, which is displayed stereoscopically with different IPDs. We conducted an experiment to identify virtual IPDs that are identified as natural by subjects for different FOVs. In our experiment, subjects had to adjust the IPD for a rendered virtual replica of our real laboratory until perception of the virtual replica matched perception of the real laboratory. We found that the virtual IPDs subjects estimate as most natural are often not identical to their IPDs, and that the estimations were affected by the FOV of the HMD and the virtual FOV used for rendering.

Keywords: Head-mounted displays, interpupillary distance

1 Experiment

We used a within-subject design. 8 subjects were instructed to visualize and memorize the laboratory. After donning the HMD, the subjects' task was to change the virtual IPD until the subject judged the virtual view to match their impression of the real laboratory. In order to do so, subjects could adjust the gain $g \in \mathbb{R}_0^+$, which we used as a factor for the subject's IPD to compute the virtual IPD: $IPD_{virtual} = g \cdot IPD_{subject}$.

We simulated FOVs of different HMDs by scaling the viewport during the rendering process, i. e., a part of the display was blackened and the remaining area was used for rendering. Using this software-based approach we simulated HMDs with diagonal FOVs of 20, 40, 60 and 76.88 degrees (our HMD's FOV [Steinicke et al. 2009]). For each of these simulated HMD conditions, we applied two different FOVs to the rendering process—the correct FOV of the simulated HMD and the FOVs that subjects reported as most natural in [Steinicke et al. 2009]: 29.53, 53.85, 72.33, and 88.34 degrees. We tested these conditions to evaluate possible influences of a depth and size mismatch as described in [Kuhl et al. 2009].

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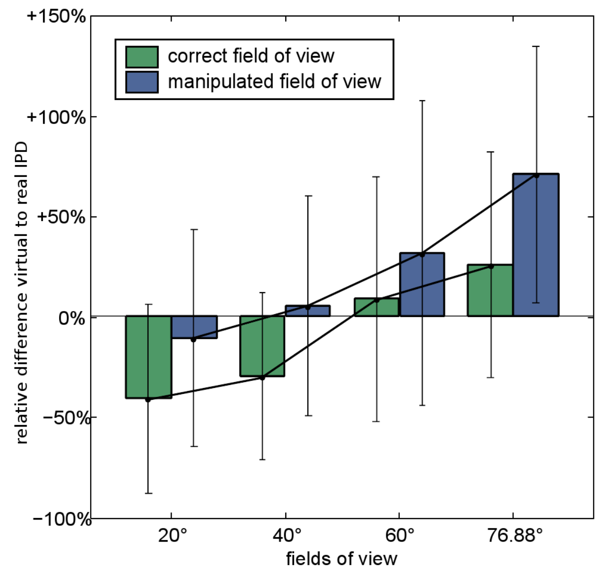

Figure 1: *Pooled results of the experiment showing the different simulated FOVs on the horizontal axis plotted against the relative deviation of the subjects' virtual IPDs from the subjects' IPDs. The green plots represent the results from the condition with matching real and virtual FOVs of* 20°, 40°, 60° *and* 76.88°, *the blue plots represent the results for the manipulated virtual FOVs of* 29.53°, 53.85°, 72.33° *and* 88.34°.

Figure 1 shows that the subjects' average judgment of a "natural" IPD deviates significantly from their IPD. The mean points of subjective equality (PSEs) in the experiment are given at a virtual IPD that is -41.50% compared to the subject's IPD for HMDs with a diagonal FOV of 20°. In the other cases the virtual IPD was adjusted -30.13% (40°), +8.46% (60°), and +25.29% (76.88°) relative to the subject's IPD. For the conditions, in which we manipulated the FOVs used to render the virtual scene compared to the simulated HMDs' FOVs, we found PSEs at -10.87% (29.53°), +4.87% (53.85°), +30.95% (72.33°) and +70.46% (88.34°) compared to the subject's IPD. Figure 1 shows that the IPDs which appear most natural to subjects may be decreased for HMDs with a smaller FOV, and increased for HMDs with a larger FOV.

References

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