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Investigation of scattering properties of retro-reflective materials for 3D projection

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Our purpose is to construct a high quality compact 3D head mounted projection display by using two nanoprojectors, a screen and a screen tracking electronics. Our arrangement provides full parallax by projecting the appropriate image pairs for each viewing position based on accurate screen tracking. The right and left images are reflected back by a retro-reflective screen towards the right and left eye respectively The quality of 3D perception depends strongly on the cross-talk ratio of the stereoscopic images reaching the eyes. The main goal of this study is to develop a retro-reflective screen that provides a low cross-talk ratio in a wide viewing distance range.

First, we determined a theoretically ideal retro-reflective angular intensity distribution that exhibits a constant cross-talk ratio. The result is the following: the intensity of the light has to decrease as a power function of the scattering angle. Then we investigated retro-reflective screen materials which are available in practice, so we investigated glass bead retro-reflective materials. These screens reflect back the incident light into the direction of the light source with a very narrow distribution having an FWHM of approximately 1°. Retro-reflective samples have modest cross-talk ratio with the average of 0.1 at the distance interval of 0.5 m to 4 m, and the minimum ratio of 0.03 at 0.8 m. Therefore we found it necessary to decrease the cross-talk ratio and increase the length of viewing distance range where the ratio is low enough. In order to do this, we built up a screen model in ZEMAX optical design program. In the model refractive, diffractive and scattering effects are considered. We studied the variance of the diameter of the glass beads, as well as their refractive index, and calculated their effect on the backscattering. To validate the model we built a goniophotometric scattering measurement setup and compared the measurement and model data. The comparison between the measurement and the calculation showed a very good agreement. Based on these results, we reduced the cross-talk ratio of the structure by optimizing the model.

The obtained results give us the possibility of the future fabrication of the optimal structure as a screen. Furthermore we would like to measure its properties and test it during the operation of the 3D system.