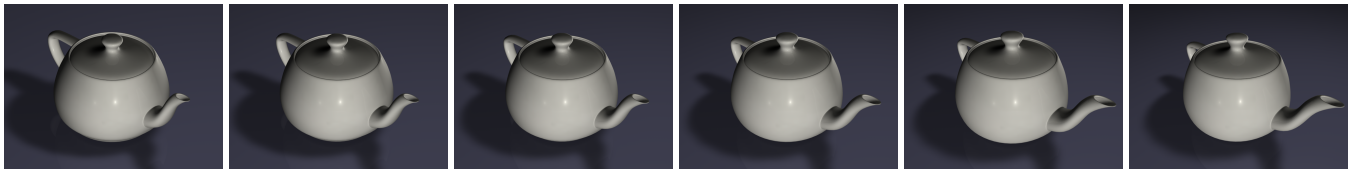
# Perception of Perspective Distortions of Man-Made Virtual Objects

Frank Steinicke and Gerd Bruder
Visualization and Computer Graphics
University of Münster

Scott Kuhl
Department of Computer Science
Michigan Technological University



(a) GFOV=10° (b) GFOV=20° (c) GFOV=30° (d) GFOV=40° (e) GFOV=50° (f) GFOV=60°

**Figure 1:** *Perspective distortions of a Utah teapot rendered with different geometric fields of view and adapted viewpoints.*

## 1 Introduction and Background

In computer graphics one is often concerned with representing 3D objects on 2D displays, which provide often only a limited *display field of view* (DFOV) to the observer. Usually, planar geometric projections, in particular linear *perspective projections*, are applied, which make use of a straightforward mapping of graphical entities in a 3D *view frustum* to a 2D image plane. Corresponding to the DFOV introduced for computer screens, the aperture angle of the virtual camera is often denoted as *geometric field of view* (GFOV) [Kjelldahl and Prime 1995]. Projections of virtual objects on a computer screen are affected by the interplay between the GFOV that is used to render the scene, and the DFOV (see Figure 1). In this context, only little research has been conducted to identify perspective projections that appear realistic to users. Instead, graphics designers and developers often choose GFOVs that vary significantly from the DFOV [Steinicke et al. 2009].

In this poster we take some first steps to analyze the user's ability to detect perspective distortions of man-made virtual objects displayed on a computer screen. We describe a psychophysical experiment, which reveals how computer graphics projections have to be adjusted such that users perceive a realistic view to a virtual object.

## 2 Psychophysical Experiment

### 2.1 Procedure

For the experiment we recruited 20 (age 23-32, $\varnothing$ : 26.1) experts in the domain of computer graphics, architectural design, 3D modeling, and CAD, each with at least 4 years professional experience. Subjects were positioned in front of two screens (from which one was dissembled) with their head fixed by a chin-rest, resulting in a DFOV of 26°. We arranged a physical Utah teapot inside the frame of the dissembled right screen, whereas on the left screen we displayed sequentially two images of a corresponding virtual replica of the physical teapot that we rendered with different GFOVs. In each trial the subject's task was to decide, which of the two rendered teapots was a more realistic model of the real teapot (based on a two-alternative force choice task). We tested gains $g_F$ between 0.2 and 1.8 in steps of 0.2, which were applied to the $GFOV = 26°$.

### 2.2 Results

Figure 2 shows the pooled results together with the standard error over all subjects for the discrimination task. The $x$-axis shows the applied gain $g_F$, the $y$-axis shows the probability that subjects estimate the virtual teapot that was rendered with a larger GFOV as a more realistic model of the physical teapot. From the fitted sigmoid function we determined an insignificant bias for the point of subjective equality (PSE $= 0.9891$). The PSE shows that if the GFOV matches the DFOV, subjects perceive physical and virtual teapot as identical objects in terms of metric properties and proportions. We measured lower and upper (75%) *detection thresholds* at gains $g_F = 0.4$ and $g_F = 1.6$.

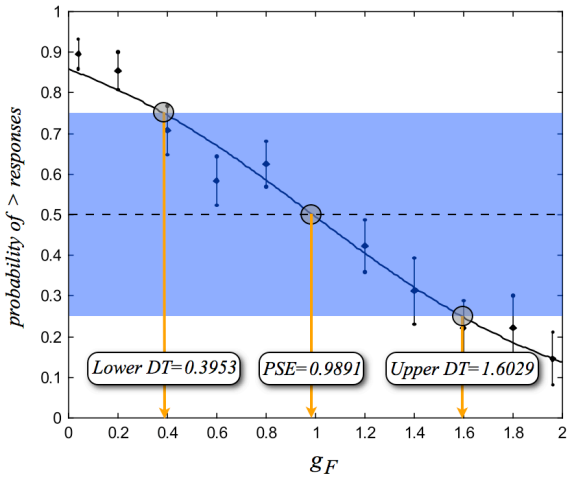



**Figure 2:** *Pooled results of the discrimination between physical and virtual teapots.*

## 3 Conclusion

The results of our experiment suggest that perspective projections of virtual objects are perceived as most realistic by subjects when the GFOV matches the DFOV. In addition, when the GFOV used for perspective rendering varies less than $\pm 60\%$, subjects cannot detect reliably a perspective distortion of a rendered 3D object.

## References

KJELLDAHL, L., AND PRIME, M. 1995. A study on how depth perception is affected by different presentation methods of 3D objects on a 2D display. *Computers & Graphics 19*, 2, 199–202.

STEINICKE, F., BRUDER, G., KUHL, S., WILLEMSEN, P., LAPPE, M., AND HINRICHS, K. 2009. Judgment of natural perspective projections in head-mounted display environments. In *Proceedings of ACM Symposium on Virtual Reality Software and Technology (VRST)*, 35–42.