

# The Impact of Stereo Rendering on the Perception of Normal Mapped Geometry in Virtual Reality

Martin Mišiak

TH Köln, Computer Graphics Group  
University Würzburg, HCI Group  
Köln, Germany  
martin.misiak@th-koeln.de

Arnulph Fuhrmann

TH Köln, Computer Graphics Group  
Köln, Germany  
arnulph.fuhrmann@th-koeln.de

Niko Wißmann

TH Köln, Computer Graphics Group  
Köln, Germany  
niko.wissmann@smail.th-koeln.de

Marc Erich Latoschik

University Würzburg, HCI Group  
Würzburg, Germany  
marc.latoschik@uni-wuerzburg.de

## ABSTRACT

This paper investigates the effects of normal mapping on the perception of geometric depth between stereoscopic and non-stereoscopic views. Results show, that in a head-tracked environment, the addition of binocular disparity has no impact on the error rate in the detection of normal-mapped geometry. It does however significantly shorten the detection time.

## CCS CONCEPTS

• **Human-centered computing** → **Virtual reality**; • **Computing methodologies** → **Perception**.

## KEYWORDS

Virtual Reality, Normal Maps, Binocular Disparity, Motion Parallax

### ACM Reference Format:

Martin Mišiak, Niko Wißmann, Arnulph Fuhrmann, and Marc Erich Latoschik. 2019. The Impact of Stereo Rendering on the Perception of Normal Mapped Geometry in Virtual Reality. In *25th ACM Symposium on Virtual Reality Software and Technology (VRST '19), November 12–15, 2019, Parramatta, NSW, Australia*. ACM, New York, NY, USA, 2 pages. <https://doi.org/10.1145/3359996.3364811>

## 1 INTRODUCTION

3D depth perception emerges as a result of various depth cues, and is a prominent and important feature of most Virtual Reality (VR) applications. Generating depth cues at interactive frame rates is one central goal of the field of real-time rendering. Although a broad spectrum of techniques for accelerating real-time rendering exists, the extent of their applicability to VR is not entirely clear.

Normal maps [Kilgard 2000] are widely used to reduce the geometric complexity of a model. By explicitly storing its normals in a texture, the underlying geometry can be extremely simplified, yet retains its shading properties [Cohen et al. 1998]. While this approximation works well on a monoscopic screen, the lack of geometry

based depth cues is more noticeable in VR. Although some general guidelines for using this technique in VR have been established [Vlachos 2015], no precise evaluations have taken place.

Binocular disparity and motion parallax are important depth cues in VR applications. While both cues have a positive impact on user performance, their individual contribution depends strongly on the performed task [Faubert 2001; Norman et al. 1996; Ragan et al. 2012; Ware and Mitchell 2005]. In this context, we evaluate the influence of binocular disparity on the perception of normal mapped geometry in a head-tracked environment.

## 2 EXPERIMENT

A total of 24 subjects (21 males, 3 females), aged 20 - 36 ( $M = 25.1$ ,  $SD = 3.8$ ) were equally divided into two test groups - mono (motion parallax only) and stereo (motion parallax + binocular disparity). In 14 trials, participants were shown 2 models of a coin (Figure 2) side by side. One model represented the geometric reference, while the other coin was flat and had its minting solely represented by a normal map. The relative position and minting strength of both models was varied in a randomized order across each trial, ranging from 0.4 mm to 7.0 mm. The experiment was designed as a 2AFC, with the goal of identifying the "flatter" normal mapped model. Response time and correctness were noted for each trial. Participants were seated 1.3 m from the monitor screen and were encouraged to perform swaying movements during the trials to engage motion parallax.

To mitigate geometric masking effects [Rushmeier et al. 2000] and to strengthen the perception of 3D shape [O'Shea et al. 2008], a white frontal light source position without cast shadows and a homogeneous diffuse color were used to shade the models. Furthermore to reduce the negative influence of display resolution, a fish tank VR setup (Figure 1 (a)) was used. It consists of a 27", 2560 × 1440 stereoscopic monitor with shutter glasses and a positional tracker. Using this setup a resolution of 95 pixels per degree was achieved when placing the observer at a distance of 1.3 m from the monitor screen.

## 3 RESULTS

Figure 1 (b) shows the average of correct responses given by the participants for each comparison pair. No statistically significant

VRST '19, November 12–15, 2019, Parramatta, NSW, Australia

© 2019 Copyright held by the owner/author(s).

This is the author's version of the work. It is posted here for your personal use. Not for redistribution. The definitive Version of Record was published in *25th ACM Symposium on Virtual Reality Software and Technology (VRST '19), November 12–15, 2019, Parramatta, NSW, Australia*, <https://doi.org/10.1145/3359996.3364811>.

