Human visual system for evaluation of holographic image quality

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1. Introduction

In this paper, we present a unified framework for evaluating the visual quality of holographic images based on *Human Visual System (HVS)*. Analyzing what holographic image and its three-dimensional features really look like to the human eye is the purpose of this study. By exploiting schematic eye based on HVS, we focus on the tracing of lights that is emitted from holographically reconstructed image and propagates through intraocular structure of the human eye. In particular, we perform, based on wave theory, numerical simulation that aims at complex wave-field distribution of intraocular lights, to effectively deal with holographic properties.

2. Holographic Image Quality

Holographic display system optically reconstructs 3D image with a set of real volume pixels (voxels) distributed in space. The *wave-optics* properties of holography, such as diffraction and interference, are able to represent an optical image point where light from the holographic display converges to [1]. Holographic image provides the *depth* and *parallax* in space as 3D features, by modulating the intensity or phase of the planar wave emitted from a coherent light source using a spatial light modulator (SLM), according to a fringe pattern (hologram). These optical procedures can be well simulated by numerical reconstruction algorithms [1]. However, such a reconstructed image is just ideally computer-simulated result, not the image that human observer really see. At this point, we need to consider HVS model to figure out what holographic 3D image really looks like. Moreover, the emergence of near-eyed holographic display in [2] confirms the necessity of this study for eye safety as well as quality evaluation.

3. Human Visual System Model

3.1 Eye Model

Many different types of schematic eye have been reported in the literature over the past few decades. In this study, we use the eye models of different levels, from the simplest reduced eye with only one refraction surface, to more sophisticated model [3]. Finite schematic eye has aspherical surfaces for cornea and crystalline lens, the decentration and tilt of pupil, and wide-viewing field of curved retina, all of which aims to model and evaluate the optical effects of various ocular aberrations due to refraction anomalies, astigmatism, and high-order aberration.

3.2 Wave Optics Analysis

Optical analysis methods for almost all eye models have performed based on geometrical optics by ray tracing. However, in addition to simple refraction anomalies and astigmatism, many complex ocular wave aberrations need more effective analysis schemes. Also, considering the optical properties of holography, we make use of optical analysis for HVS based on wave theory. Particularly, for intraocular propagation we design a *cascaded* propagation scheme that consists of a series of *angular spectrums* for precise analysis and evaluation.

4. Experimental Results

Numerical simulation using schematic eyes with holographic image are performed and experimental results are analyzed for evaluating the retinal image quality of holographically reconstructed 3D object.

5. Acknowledgements

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6. References

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[2] A. Maimone *et al.*, "Holographic Near-Eye Displays for Virtual and Augmented Reality," ACM Trans. Graphics, Vol. 36, No. 4, 2017.
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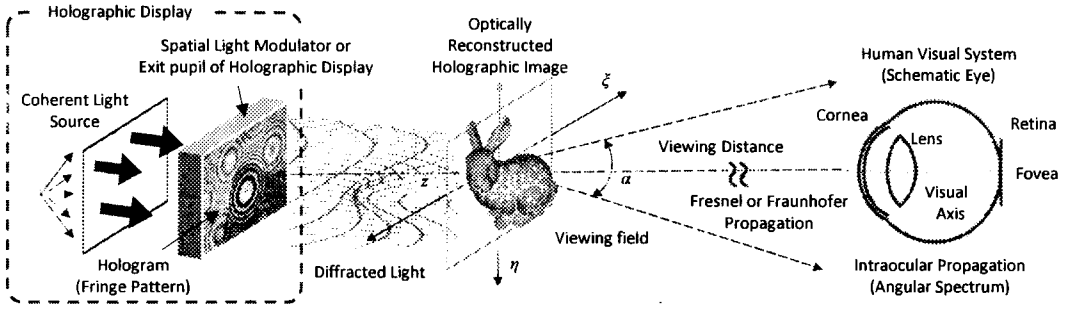

Figure 1: Human visual system model for quality evaluation of holographic image