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HPO HOLOGRAM SYNTHESIS FOR FULL-PARALLAX RECONSTRUCTION SETUP

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ABSTRACT

Digital hologram synthesis is a task that simulates a physical process. Currently, there is no working solution capable of handling continuous surfaces, solving visibility, and applying a local intensity variation efficiently. Due to the computational complexity an approximation is required. Our solution tries to address this issue by extending the most efficient HPO hologram synthesis in such way that the computed hologram does not require a special optical setup for reconstruction.

***Index Terms*—** Holography, Computer graphics, Rendering

1. INTRODUCTION

Holography is a scientific area that deals with light field capturing using the phenomena of diffraction and interference. It utilizes the wave nature of light as the fundamental building block. If coherent light is used it is possible to capture monochromatic light waves scattered from an object. It is done by interfering the reference wave with the scattered one. The image of the resulting interference pattern captured on a photosensitive material then acts later on as a diffraction grating. This grating, if illuminated by the reference wave, produces a light field which contains the original scattered wave. In the ideal case this can lead to the impression of a real scene even thought only the hologram is present, see [1] for reference. Holography is therefore a promising technology for a genuine 3D display.

Digital holography is a numerical version of the optical holography. It employs equations and relations derived for light propagation to numerically simulate the physical phenomena [2]. It deals with processing of captured holograms, extracting information stored within, and finally with the numerical synthesis of holograms. The latter one is targeted by this paper.

Currently, there is no approach to synthesis available that would be able to simulate the physical phenomena accurately enough in reasonable time. This is because of the computational complexity of the problem. To illustrate the fact, without any approximations or assumptions, to numerically simulate a propagation in a free space between two parallel planes that are sampled by $N \times N$ samples an algorithm of the computational complexity $\mathcal{O}(N^4)$ is required. Due to the nature of the problem, it is not possible to reduce the complexity without loosing some information.

One of the most drastic approximations used is the reduction or elimination of the vertical parallax in a hologram. Such holograms are called horizontal parallax only (HPO) holograms and they bring reduction of complexity by one order of magnitude. The HPO hologram is a hologram that lacks vertical parallax, i.e. the wave from a single point is not propagated vertically [3]. Therefore, the viewer does not experience parallaxing of the image if the viewer changes her position relatively to the Y-axis, i.e. up-vector.

Nevertheless, the vertical parallax is not so important as the horizontal one. It is because the human eyes are organized horizontally, thus the viewer does experience the binocular disparity in the HPO hologram, hence she does sense the depth. The drawback of HPO holograms is the necessity of a special reconstruction setup composed of cylindrical lenses [4], otherwise the reconstructed image is heavily vertically blurred.

Our main goal therefore was including additional information back into the HPO hologram so that it could be reconstructed on a common reconstruction setup without the need of special lenses or other special display device except the spatial light modulator such as LCD or DMD [2] with reasonably small element pitch. Our extension is therefore a compromise between the performance of the HPO hologram synthesis and the simple optical setup used for reconstructing the full parallax holograms. It should be emphasized again that the actual synthesis approach **is not** the main topic of this paper but the enrichment of the HPO hologram content **is**.

In order to improve the performance of our approach we used a graphical processing unit (GPU). Currently, the GPU is able to replace a specific part of the graphics pipeline with a user supplied program that can perform various tasks. Thanks to the specialization of the GPU, it offers a greater computational power than the comparable CPU [5]. The GPU has two

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