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# Multi-rays computational floating light-field display based on holographic functional screen

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ABSTRACT

A computational light-field display system is designed to realize floating three-dimensional (3D) visual effect. To simulate the natural vision of 3D scene, a multi-rays computational encryption method is proposed to obtain the image which is displayed on the LCD. In the process of encrypting image, N × N light rays are evenly involved in optimization to obtain the value of a pixel. The quality of reconstructed 3D image is correlated to N. As the value of N increases, the sharpness is improved and the ringing artifacts are eliminated. Here, the proposed computational light-field display system based on holographic functional screen (HFS) can provide floating 3D visual effect to observers with high quality. The constructed 3D image has continuously varying viewpoints with 40° viewing angle in horizontal and vertical directions. The displayed depth is more man 20 cm, and the center of the 3D object is on the surface of HFS.

## 1. Introduction

The technology of achieving 3D images floating in air is an important goal in display research. Recent developments in floating 3D display have continuously attracted considerable attention of engineers and scientists [1,2]. Light field display is a three-dimensional display technology based on light-ray reconstruction to approximate the original light field of target displayed objects with all depth cues in human vision including binocular disparity, motion parallax, color hint and correct occlusion relationship. It has the potential to realize the floating 3D effect. There are several typical forms of light field display including multilayer light field display systems, projector-array-type light field display, holographic light field display, integral imaging display and so on [3]. Integral imaging (II) is a common method to obtain continuously varying viewpoints and full parallax with liquid crystal display (LCD) and a lens array [4–6]. With the elemental images and the lens array, II addresses the distribution of light rays and reconstructs the 3D image. There are many research efforts are implemented about this technique, such as the extension of depth of field (DOF) [7,8], the enlarging of viewing angle [9–11] and the improvement of resolution [12,13]. A light field system combining II and the holographic functional screen (HFS) and is proposed to obtain more natural image quality [14]. However, in the process of image encryption, the modulation function of light rays by introducing the HFS has not been considered. Here, a multi-rays computational encryption optimization algorithm based on floating computational three-dimensional display is proposed, inspired by these above-mentioned publications and the previous 3D research based on HFS [15]. The modulation function and realizing method of HFS are described in literature [16] in detail. Different from previous light field encryption algorithm for correcting parallax images [17], multi-rays are evenly

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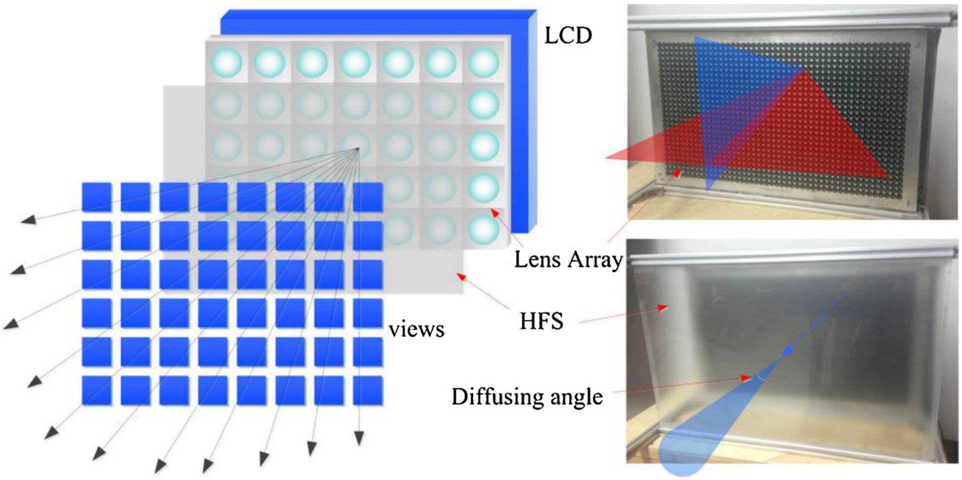

**Fig. 1.** Structure diagram of the computational light field display system.

involved in optimization to obtain the encryption image based on the HFS in this paper. Through experiments, it can be found that when the number of light rays which are used to calculate the pixel on the panel increases, the sharpness is improved and the ringing artifacts are eliminated. According to quality improvement curve, the applicable number of light rays can be adopted. In the experiment, the light field 3D display system with the multi-rays computational encryption method can provide full parallax and continuously varying viewpoints with obvious floating 3D visual effect.

## 2. Implementation

### 2.1. Basic structure

The proposed floating computational light-field system is composed of HFS, lens array and LCD as shown in Fig. 1. The HFS diffuses the incident light rays in a certain angle. The LCD is employed to load the encryption image. Light rays emitted from the LCD can be modulated on different directions when passing through the lens array and HFS. Through the modulation of optic elements, the target views can be obtained.

The implementation of the proposed computational light field display is shown in Fig. 2, which contains two steps. The first one is the discrete sampling of the light waves emitted from the 3D object, and obtains a series of light rays. The next step is coding the light rays as an encryption image, according to the structure of the proposed floating light-field display. To guarantee the reconstructed 3D image is consecutive and uniform, the diffused angle of the HFS is required to eliminate the gap between the lenses, exactly. As shown in Fig. 2 (c), $lc$ is gap between the lens array and the HFS, $g$ is the center distance of two adjacent lenses, $p$ is the pitch of the lens.

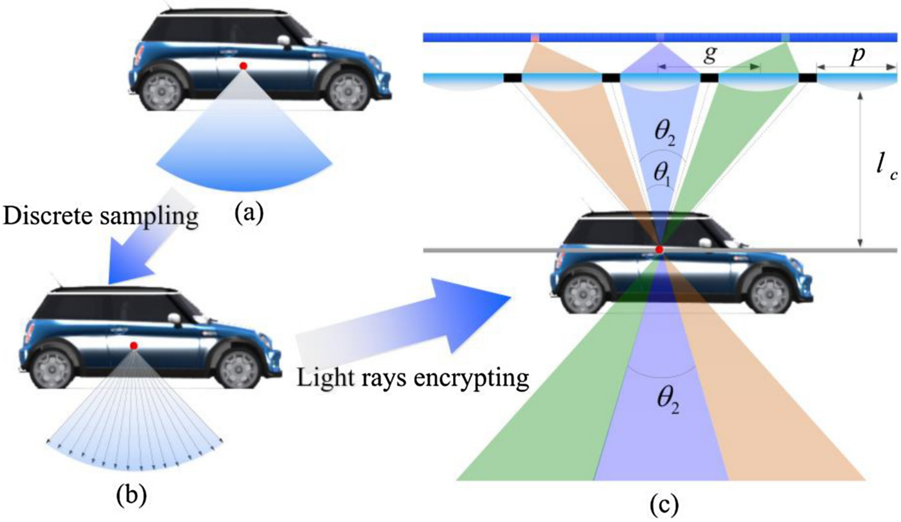

**Fig. 2.** Implementation of the computational light field display.