Three-Dimensional Image Security System Combines the Use of Smart Mapping Algorithm and Fibonacci Transformation Technique

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ABSTRACT
In this paper, a three-dimensional (3D) image security system combines the use of the smart pixel mapping (SPM) algorithm and the Fibonacci transformation technique is proposed. In order to reconstruct orthoscopic 3D images with improved image quality, a smart pixel mapping process is adopted. Based on the SPM-based computational integral imaging (CII) system, the depth-converted elemental image array (EIA) is obtained for increasing the quality of the reconstructed image. In the encryption process, the depth-converted EIA is scrambled by the Fibonacci transformation (FT) algorithm. Meanwhile, the computational integral imaging reconstruction (CIIR) technique is used to reconstruct the 3D image in the image reconstruction process. Compared with conventional CII-based 3D image encryption methods, the proposed method enable us to reconstruct high-resolution orthoscopic 3D images at long distance. To demonstrate the effectiveness of the proposed method, some numerical experiments are made to test the validity and the capability of the proposed 3D image security system.

Keywords: 3D image security; smart pixel mapping; computational integral imaging; depth-converted EIA.

1. Introduction

With the growth of the Internet and the increase of the requirement for image transmission, image encryption and watermarking are becoming more and more important [1]. Recently, Image encryption technology based on optics is an effective measure to ensure the information security and has gained great interest in the rapid development of communication technologies. Optical encryption methods own many intrinsic advantages, such as high speed and difficulty of unauthorized access [2]. Integral imaging (II) is a three-dimensional (3D) imaging technique which comprises of two optical processes: pickup process and reconstruction process [3-4]. In the pickup process, the light rays emanating from 3D images pass through the lenslet array is recorded as a two-dimensional (2D) elemental image array (EIA) with a different perspective of a 3D image. In the reconstruction process, by back-propagating light rays of the EIA through the lenslet array, the 3D image is reconstructed at the location where it was picked up. However, II systems work in their conventional configuration degrade quality of the reconstructed 3D scenes due to the lens refraction. The computational integral imaging (CII) [5-9] becomes an important part of II. In CII, the reconstructed process is accomplished on computers, and no physical noise is produced.

In recent years, image encryption methods based on II have been proposed for practical applications. Piao et al. [10] proposed an image encryption using II and pixel scrambling techniques. In this method, pixels of the cover image were scrambled with the pixel scrambling technique and elemental images (EIs) for this scrambled image are picked up through a lenslet array, the image reconstructed by applying the computational integral imaging reconstruction (CIIR) technique. The experimental results implied this method provided high robustness.

In 2013, Kim et al. [11] presented a 3D image encryption method based on II and maximum length cellular automata (CA). In this method, the picked-up EIA was encrypted by the 2D maximum length CA. The 3D image reconstruction algorithm also based on CIIR. This method has given a secure and robust encryption algorithm.

Recently, Li et al. [12] have proposed a 3D image encryption system combined the use of CII system and complemented maximum length CA. In this method, a 3D image was optically picked-up by a lenlet array, the picked-up EIA was then encrypted by the complemented maximum length CA. This method utilized the complemented CA to improve the security of the encrypted image. However, in the image reconstruction process, the quality of reconstructed image will degrade due to the interference of adjacent pixels in CIIR.

Basically, the CIIR technique allows us to reconstruct 3D images at any distance from the virtual pinhole array (VPA) by pixels superposition, according to computationally simulating geometrical optics. However, the qualities of the reconstructed images degrade due to the interference of adjacent pixels in the reconstruction process. Also, the resolution of 3D reconstructed images is dramatically degraded as the distance from the VPA increases. To overcome these problems, in this paper, we propose a modified CII method based on smart pixel mapping (SPM) [13-15] and pixel average algorithm for reconstructing orthoscopic 3D images with enhanced quality of the image. To demonstrate the usefulness of this proposed method we carry out some experiments and the results are shown.

2. Review of CII system for 3D image pickup and reconstruction

The principle of 3D image encryption using CII is that it is possible to obtain the 3D image encryption of interest. That is, we can encrypt 3D image effectively and speedily. The schematic diagram of CII system composed of the optical pickup and computational reconstruction parts is shown in Figure 1. Figure 1 (a) illustrates an optical pickup system, in which intensity and direction information of the rays coming from a 3D image through a lenslet array is optically recorded as a form of 2D EIA representing different perspectives of a 3D image in the pickup process.

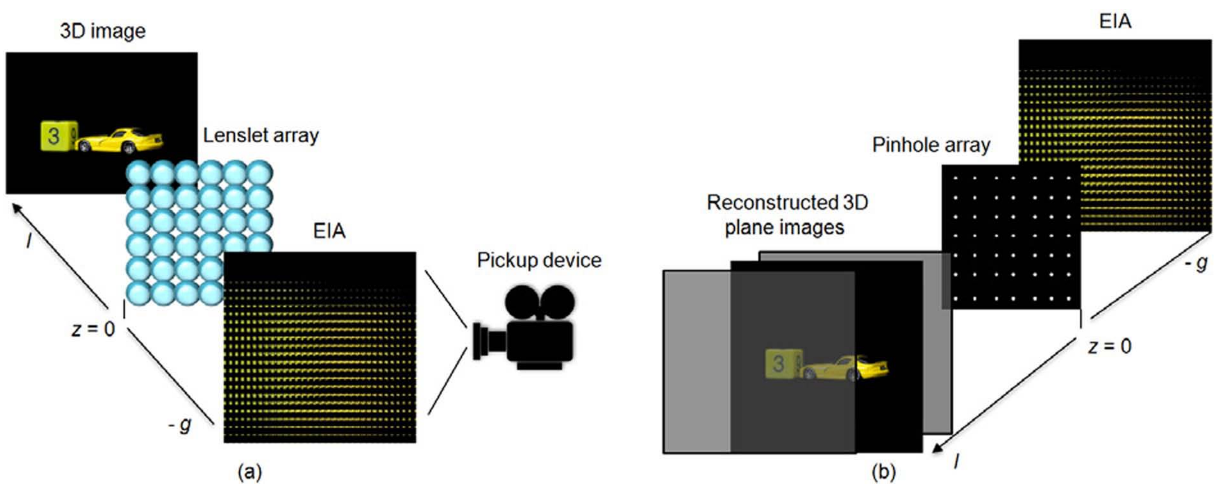

Figure 1. The structure of CII system, (a) the pickup process, (b) the CIIR process.