Resolution-improved 3D volumetric computational reconstruction using smart pixel mapping

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ABSTRACT−*In this paper, we propose a volumetric computational reconstruction method by use of smart pixel mapping technique in the computational integral imaging in order to overcome the problem of resolution degradation. The experimental results are presented to show the usefulness of our proposed technique.*

Integral imaging (InIm) is a 3D imaging technique which can provides observer with full parallax and continuous viewing points without complement of optical devices [1,2]. A general InIm system comprises of two parts: pickup process and reconstruction process. In the pickup process, a lenslet array is used to sample the rays come from 3D object and recorded by using a 2D image sensor, such as Charge-Coupled Device (CCD). The captured information is known as elemental images array (EIA). On the other hand, the reconstruction process can be divided into two ways: optical reconstruction and computational reconstruction. In recent, various volumetric computational reconstruction (VCR) methods have been reported for 3D visualization and recognition [3,4].

In VCR method, the resolution of reconstructed 3D scene decreases as the distance between the pinhole array and the reconstructed 3D scene increases. In order to solve this problem, we apply a direct digital mapping technique, which is called as smart pixel mapping (SPM), to the captured EIA and produce a new set of EIA [5]. The SPM is used to reverse the depth of captured 3D object for pseudoscopic-orthoscopic conversion. The newly generated EIA is used to reconstruct 3D image located far from the pinhole array by using VCR[3]. We have carried out some experiments to verify our proposed method and the results are presented.

The block diagram of the proposed system is illustrated in Fig. 1. The EIA of 3D object are obtained through the conventional pickup process. After that, SPM algorithm is applied to the EIA to generate a new set of EIA which can produce orthoscopic image. The SPM of 1D case is formulated as

$$T_{i,j} = O_{k,l} \quad \text{where} \quad l = (N+1) - j \quad \text{and} \quad k = \begin{cases} i + M/2 - j & \text{if } M \text{ is even} \\ i + (M+1)/2 - j & \text{if } M \text{ is odd} \end{cases} \qquad (1)$$

where T and O are the output EIA and the original EIA respectively. The subscripts are used to indicate the elemental cell and the pixel number in that particular elemental cell. M and N are the total number of elemental cell and the total pixel of an elemental cell respectively. For the case $k < 1$ or $k > M$, $T_{i,j}$ is set to zero.

2We have performed the experiments on a synthetic 3D object 'DS'. Fig. 2 is the sample reconstruction results at *z*=69 mm and *z*=90 mm. Peak signal-to-noise (PSNR) for both conventional and our proposed method were calculated and plotted as shown in Fig. 3. Obviously, the proposed method is working well to improve the resolution of reconstructed 3D scene as the distance, *z* increases. From the experimental results, it is shown that the proposed method can be useful to improve the resolution of reconstructed 3D scenes.

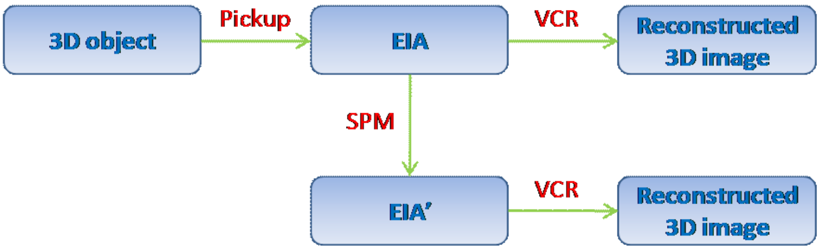

Fig. 1 Block diagram of resolution-improved VCR using SPM

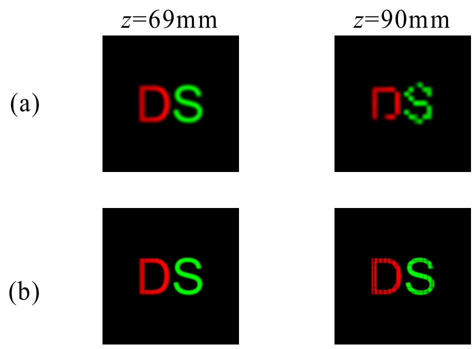

Fig. 2 Reconstructed 3D scenes (a) Conventional VCR (b) Proposed VCR

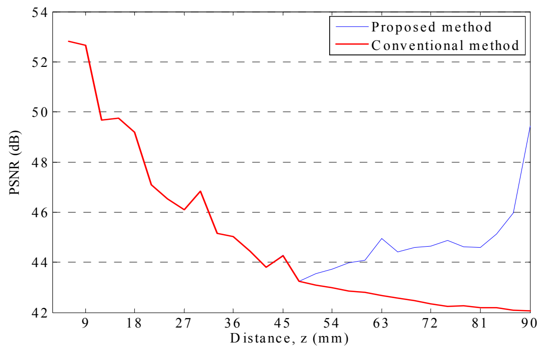

Fig. 3 PSNR results for both conventional method and proposed method

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