Effective Encoding of Binary Phase Hologram using Error Diffusion

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ABSTRACT

The paper proposed the algorithm to improve the performance of the conventional BERD in transforming the complex hologram into binary phase hologram to be applied into binary phase-only SLM. We can get the image quality more than PSNR 16dB in the experiment of the numerical reconstruction of the binary phase hologram generated from a complex hologram according to the proposed method.

1 INTRODUCTION

The SLM (Spatial Light Modulator) is the key component of holographic display to reconstruct the digital hologram. The phase-only and amplitude-only SLMs are mainly manufactured as commercial products because the complex-type SLM is difficult to be technically realized. We need to transform the complex hologram into the phase hologram if we use phase-only SLM in holographic display. The simple method that obtains the phase hologram by removing only the amplitude value from the complex hologram, has the drawback to deteriorate the quality of the reconstructed image because the phase hologram lose the much more information from the complex hologram. There exist main methods such as IFTA(Iterative Fourier Transform Algorithm)[1], DBS(Direct Binary Search)[2], ED(Error Diffusion)[3] to transform the complex hologram into the phase hologram in optimizing the image quality. BERD(Bidirectional Error Diffusion)[3] is recently proposed as the most effective method among ED algorithms.

BERD, however, could not generate the binary phase hologram properly from complex hologram as shown in Fig 1. The paper proposed the new method based on BERD to obtain the binary phase hologram with the improved quality of the reconstructed image. Fig 2 illustrates the algorithm scheme to consist three steps using BERD. The first step in Fig 2(b) is to transform the complex hologram into phase hologram without the quantization of phase value by using BERD. The phase hologram in first step is converted into the phase hologram with N quantization by using BERD in the second step (N is greater than 1 bit and less than N_{max} bit) in Fig 2(c). The N-bit phase hologram is finally quantized into the binary phase hologram in Fig 2(d).

2 EXPERIMENTAL RESULTS

Fig 3 shows both the intensity image of the phase hologram obtained in each step and the intensity image reconstructed from the binary phase hologram generated from the proposed algorithm as shown in Fig 2. The resolution of Lena and Mandrill used in the experiment is 2,048 x 2,048. The complex hologram was obtained by propagating their images from 0 m to 0.3 m.

The input 2D image (Lena and Mandrill) is numerically propagated by a distance of 30 cm according to the Huygens convolution diffraction equation in order to generate the complex hologram. The Fig 3(a) show the intensity image of the 8-bit phase hologram generated using the BERD according to the first step in Fig 2(b). The 8-bit phase hologram is converted into the 2-bit phase hologram according to the second step in Fig 2(c) by quantizing the 8-bit phase hologram by the 2-bit level through the BERD. FIG 3(c) illustrates the binary phase hologram binarized from the 2-bit hologram according to the final step in Fig 2(d).

Fig 3(d) shows the intensity images reconstructed from the binary phase hologram reconstructed according to Huygens convolution diffraction equation. The intensity images reconstructed from the binary phase hologram calculated according to the method proposed in Fig 2 are much clearer than those reconstructed from the binary phase hologram generated by using only BERD as shown Fig 1(c) and Fig 3(d).

The PSNR of the reconstructed image is improved more than approximately 16 dB as shown in Table 1.

3 CONCLUSIONS

The paper proposed the effective method overcome the performance limit of conventional BERD in transforming the complex hologram into binary phase hologram as shown in Fig 3 and Table 1. The proposed method based on BERD to obtain the binary phase hologram with the improved the quality of the reconstructed image.

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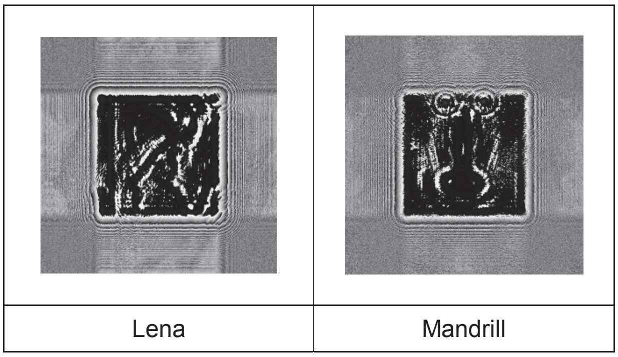
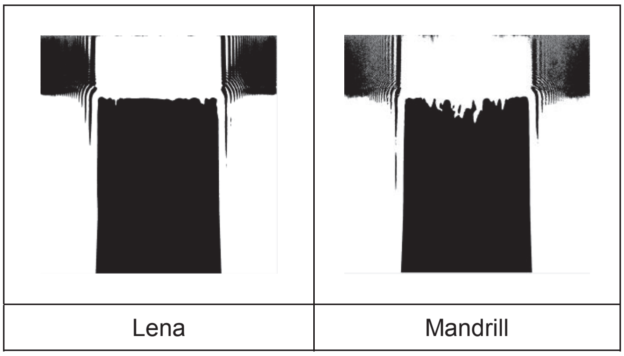
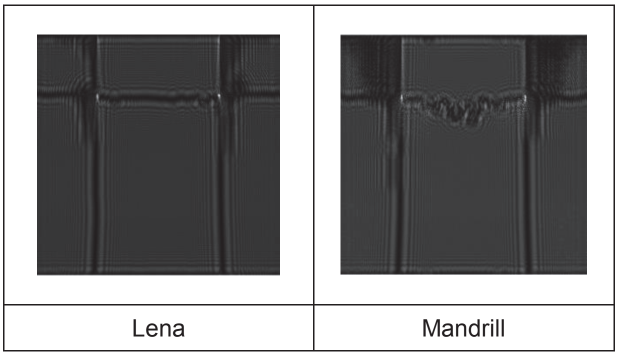


(a) Original Complex Hologram



(b) Binary Phase Hologram using BERD



(c) Reconstruction from Binary Phase Hologram

Fig. 1 Generation and reconstruction of binary phase hologram by using the conventional BERD

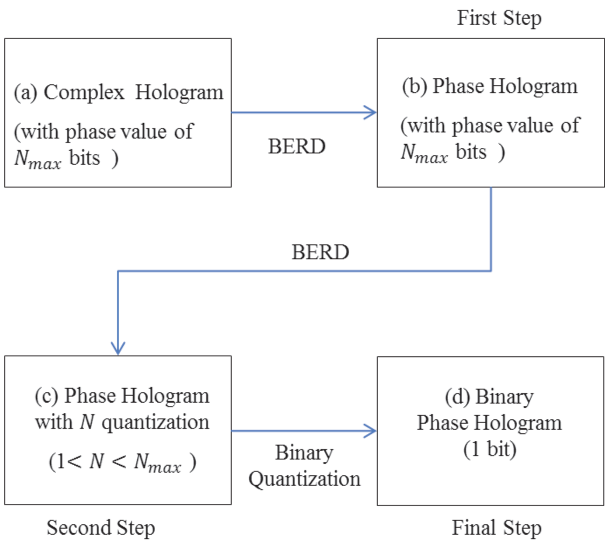
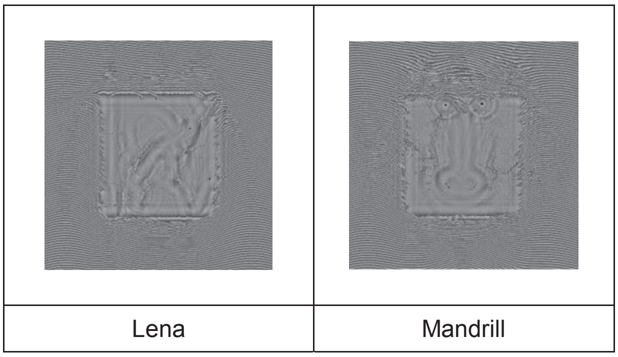
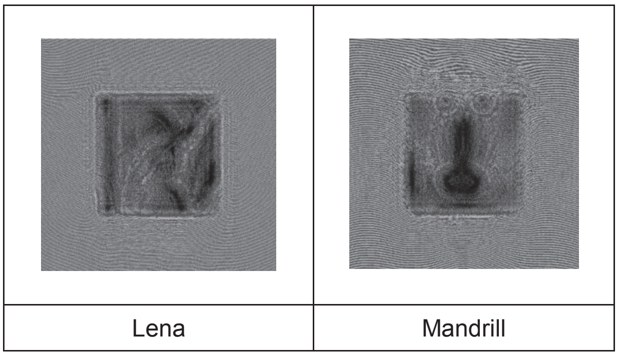


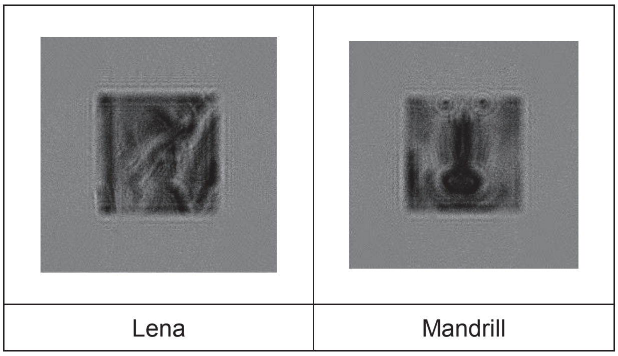
Fig. 2 Algorithm of Three-step binary phase hologram generation



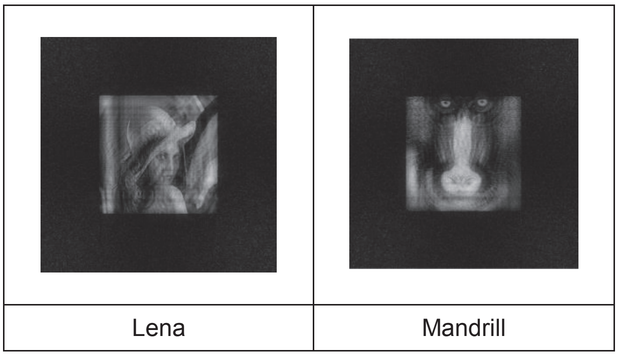
(a) 8-bit Phase Hologram



(b) 2-bit Phase Hologram



(c) Binary Phase Hologram (1bit)



(d) Reconstruction from binary phase hologram
(z= 0.3m)

Fig. 3 Reconstruction Three-step binary phase hologram generation

Table 1 The PSNR of reconstruction image from binary phase hologram generated by the proposed algorithm

	Lena	Mandrill
PSNR	16.8dB	16.6dB