Generation of Uniform Laser Beam with Iterative Flexible Dummy Area Method

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Abstract

Kinoform is a kind of a computer hologram only with a phase modulation, and it has utilization efficiency of high light in order not to modulate the amplitude of incidence light. Kinoform must stabilize amplitude distribution because it does not have amplitude modulation. Iterative dummy area method is an algorithm which reduces the noise of a reproduction image. However, this method is undesirable for error exist in the surrounding dummy domain of an original picture image in utilization efficiency of light. We compare with Iterative dummy area method with flexible dummy area size for the design of kinoform and Iterative dummy area method using the square distribution image. From the result of the reproduction image, there is no obvious noise around an original image.

Keywords: kinoform, Iterative dummy area, flexible dummy area.

1. Introduction

Kinoform is a kind of a computer hologram only with a phase modulation, and it has utilization efficiency of high light in order not to modulate the amplitude of incidence light. Kinoform must stabilize amplitude distribution because it does not have amplitude modulation. This brings big error to reproduction images. This error can be reduced by repetition dummy domain method. The problem is that the noise concentrates on the original image by using this repetition dummy domain method. In order to improve this problem, we propose Iterative dummy area method with flexible dummy area size for the design of kinoform. In this paper, we simulate the performance about generation of a uniform laser light using this method, and show the result.

2. Principle of the kinoform

Fig.1 shows Fourier transformation type kinoform playback optical system. Two-dimensional intensity distribution should represent in $I(x, y)$, sampled data in $I(m, n)$, kinoform distribution data calculate by using $I(m, n)$. Kinoform distribution data represented as $W(k, l)$. Amplitude distribution of reconstructed image in the sampled point is represented by the following equation.

$$g(m, n) = \sum_{k=-\frac{N}{2}}^{\frac{N}{2}-1} \sum_{l=-\frac{N}{2}}^{\frac{N}{2}-1} W(k, l) \exp \left[-\frac{j2\pi}{N^2} (mk + nl) \right] \quad (1)$$

N is the number of the sampled dispersed points.

Generally, when manufacturing Kinoform, it becomes constant area distribution using the Kinoform distribution data $W(k, l)$. If this is expressed with one dimension, it will become like Fig.2.

Fig.1. Fourier transformation type

Fig.2. Amplitude distribution of the kinoform

Changed discrete value into continuation value in order to have constant area. Therefore, collapse a rectangle wave in a discrete value.

$$H(u) = W(k) * \text{rect}(u) \quad (2)$$

$$k = \text{int} \left(\frac{u + 0.5}{\Delta u} \right) \quad (3)$$

k is the kinoform data number, int is the integer functions. Reproduction image is obtained by Fourier transform $H(u)$. This become multiply square wave Fourier transform and Fourier transformation of kinoform size distribution data. Because the sinc function is the Fourier transform of the rectangular wave, would put the sinc function in the reconstructed image. Therefore, reproduction image which sampled points in the optical playback is computed by follow equation.

$$g'(m, n) = g(m, n) * \text{rect}(u) \quad (4)$$

3. Iterative dummy area method

Kinoform must make amplitude distribution regularity. However, error arises in reproduction image by replacing amplitude distribution uniformly. Iterative dummy area method is an algorithm which reduces this error. The flow of this repetition dummy domain method is shown in Fig.3. Reduction with error is possible by adding the dummy domain of the initial value 0 to the surroundings of an original picture image, use this picture as input picture, using the amplitude of a dummy domain and the flexibility of a phase.

Fig.3. Iterative dummy area method

Fig.4. Dummy area

Fig.4 shows the original image add a blank space. And, using random phase for the phase of the original image.

As a restriction condition, perform amplitude regularity and band limiting in a hologram side. A reproduction image is obtained by Fourier-transforming the signal after transposing amplitude to a steady value after performing a restriction condition. Moreover, the output obtained by the reproduction image surface is considered as a new input as a restriction condition in the reproduction image surface. It carries out by repeating this.

4. Iterative dummy area method with flexible dummy area size for the design of kinoform

In optical reproduction, it is undesirable for error exist in the surrounding dummy domain of an original picture image in utilization efficiency of light. Then, when reproducing a computer hologram, modulate a horizontal direction and a perpendicular direction with sinc function feature which becomes dark. We add variable region to the surroundings of an original picture image.

This variable region including an original picture image set as new original image. This is shown in Fig.5. We performed repetition dummy domain method to this image. Variable region is gradually decreased as a repetition progresses. This variable region changes in a dummy domain at the maximum, in range of an original picture image domain at the minimum.

Fig.5. Variable area

5. Simulation and results

Show a simulation condition next.

- Images Images with 64×64 pixel shown in Fig.6
- Initial phase Random phase
- Dummy area 256×256 [pixel]
- Band limiting $1/2$
- It is repeatedly a frequency 1000 times

We use square image of Fig.6 as original picture image. The result of Iterative dummy area method in Fig.7 and The result of Iterative dummy area method with flexible dummy area size for the design of kinoform is shown in Fig.8.

Fig.6. Original image

Fig.7. The result of Iterative dummy area method

Fig.8. The result of Iterative dummy area method with flexible dummy area size for the design of kinoform

An error produces a lot in the dummy domain around the original image in Fig.7. Compare with Fig.7 and Fig.8, there is no obvious error around an original image. In addition, the quality of the reproduction image is same level in comparison with the normal repetition dummy region method.

6. Conclusion

Iterative dummy area method is an algorithm which reduces the error of a reproduction image. However, this method is undesirable for error exist in the surrounding dummy domain of an original picture image in utilization efficiency of light. We compare with Iterative dummy area method with flexible dummy area size for the design of kinoform and Iterative dummy area method using the square distribution image. From the result of the reproduction image, there is no obvious noise around an original image. The use efficiency of the light became big, too.

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