Authentication of the reconstructed image from Computer Generated Hologram: To use the digital watermark.

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Abstract: Computer Generated Hologram has been targeting the application areas such as a reconstruction three dimensional image, project the image of virtual object, optical information processing and optical memory. Laser beam is not required when synthesis and reconstruct CGH. In addition, it is expected to function as a digital watermarking. Digital watermarking is a technology to embed data into digital content. Digital content needs information security. Digital watermarking is used for information security. In this paper, the correlation between original image and watermark image are taken. Watermark image is made from CGH. Phase Only Correlation is adopted as a correlation method. As a result, have expanded the size of the image, little negative impact did not appear on the correlation value. It is possible to identify self and others using the image correlation value a state of the image of expanded size. These results suggest that the using of this proposal can be considered easier to identify the state between the auto correlation and cross correlation. In addition, we found that even large images are identified. Therefore, this proposal will be able to increase the possibility of adaptation to the authentication of the reconstructed image calculated by CGH.
Keywords: Computer Generated Hologram (CGH), Complex Hadamard Transform (CHT), authentication

I. INTRODUCTION

Computer Generated Hologram has been targeting the application areas such as a reconstruction three dimensional image, project the image of virtual object, optical information processing and optical memory.[1] Laser beam is not required when synthesis and reconstruct CGH. In addition, it is expected to function as a digital watermarking. Digital watermarking is a technology to embed data into digital content. Digital content needs information security. Digital watermarking is used for information security.[2] CGH is considered to be the practical application of information security as a first purpose. Therefore, authentication of the reconstructed image from CGH is necessary for digital watermarking. In this paper, the correlation between original image and watermark image are taken. Watermark image is made from CGH. Phase Only Correlation is adopted as a correlation method.

II. EXPERIMENT

1. Complex Hadamard Transform

Hadamard transform is the orthogonal transformation. Processing can be performed by the sum of the product of Hadamard matrix and the input data.[3] The basis of Hadamard transformation is a Hadamard matrix. Hadamard matrix is described as follows.

$$H(0)=[1] \tag{1}$$

$$H(n)=\begin{bmatrix} H(n-1) & H(n-1) \\ H(n-1) & -H(n-1) \end{bmatrix} \tag{2}$$

At this time, the size of the input image should be the same as that of Hadamard matrix. Two dimensional Hadamard Transform is described as Eq.(3) of follows.

$$F=(1/n)HfH^T \tag{3}$$

$$HH^T=I \tag{4}$$

f: input	*H*: Hadamard matrix
F: output	H^T: transposed Hadamard matrix

Inverse Hadamard Transform is Eq.(5).

$$f=nHFH^T \tag{5}$$

Complex Hadamard transform is used to complex Hadamard matrix. Complex Hadamard matrix is using the real and imaginary parts. Complex Hadamard matrix is described as follows.

$$H(0)=[1] \tag{6}$$

$$H(n)=\begin{bmatrix} H(n-1) & iH(n-1) \\ iH(n-1) & H(n-1) \end{bmatrix} \tag{7}$$

Complex Hadamard Transform is as similar processing as Eq.(3), and use complex conjugate of transposed matrix. The character similar to Eq.(4) is approved to Complex Hadamard Transform because complex conjugate matrix is similar to inverse matrix.

$$F=(1/n)HfH^* \tag{8}$$

$$f=nHFH^* \tag{9}$$

H^*: complex conjugate Hadamard matrix

2. Sample images

512 × 512 pixels on the image of the black, starting at the top left of the image of the alphabet A ~ Z of the one which created the characters are written in white letters. Image files are created with 256 colors bitmap format. This image as original image, used to convert those who applied.

Under the same conditions, 256 × 256 pixels images are made.

Each images shown in Fig.1, Fig.2 and Fig.3.

3. Experiment

Correlation values of images are measured in the following combination of image groups. Correlation values in type 1 and type 2 are measured with a combination of brute force. FT is Fourier Transform

Table 1. Combination of image groups

	Type 1	Type 2
1	Original image	Reconstructed image from CGH made by FT
2	Original image	Reconstructed image from CGH made by CHT
3	Reconstructed image from CGH made by FT	Reconstructed image from CGH made by FT
4	Reconstructed image from CGH made by CHT	Reconstructed image from CGH made by CHT
5	Original image	Original image

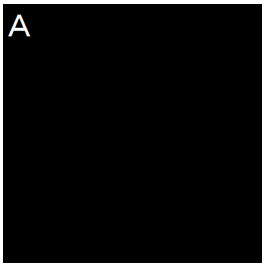

Fig.1. Original image (A)

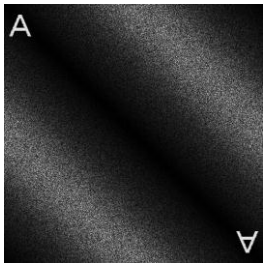

Fig.2. Reconstructed image from CGH made by FT (A)

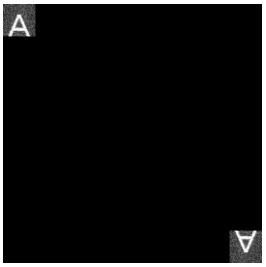

Fig.3. Reconstructed image from CGH made by CHT (A)

III. RESULTS AND CONSIDERATION

The threshold is set to identify "self" and "other". Threshold is set as the value shall be uniform in each of the correlation. Threshold is set between "autocorrelation" (maximum) value and the second highest correlation value. The width between maximum value and the second highest correlation value should be broad as possible. The second highest correlation values were as follows.

In the experiment No.1 and No.2, maximum values which a state of "autocorrelation" are not in 1.0. Therefore, in the process of dividing the value of each element in that series the maximum value of the series (normalization process) are done.

Table 2. Combination of image groups and correlation value: The second highest correlation value

	a. 512 × 512	b. 256 × 256	a - b
1	0.89104747	0.80709695	0.08395052
2	0.91058764	0.83366690	0.07692074
3	0.03422546	0.03426302	-0.00003756
4	0.16488647	0.14813232	0.01675415
5	0.69196076	0.56340830	0.12855246

In the experiment No.2, the width between maximum value and the second highest correlation value is about 0.08941236. Set of threshold is difficult.

Meanwhile, result of experiment No.3 is the best value. And, result of experiment No.4 is the second best value.

In the experiment No.4, the width has been reduced to 86% of the width of experiment No.3. This result is better than the result of experiment No.5. Threshold setting is easily if the width of this level can be secured.

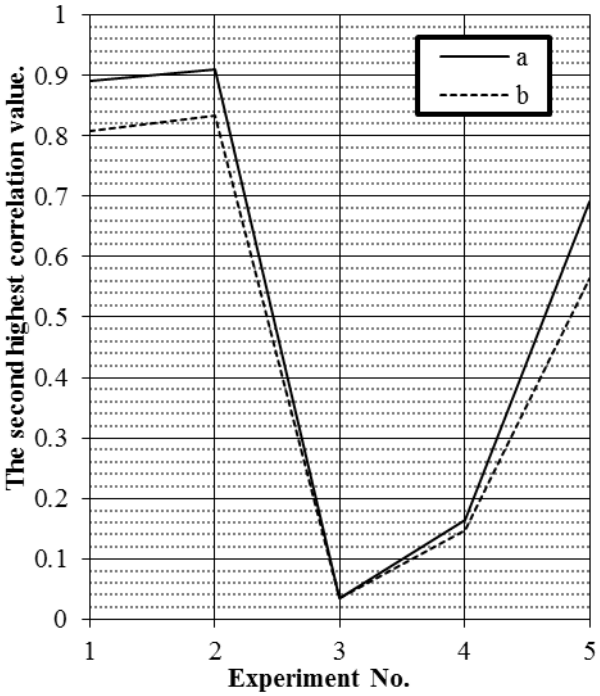

Fig.4. Combination of image groups and correlation value

VI. CONCLUSION

Reconstructed image from CGH made by CHT is compared with reconstructed image from CGH made by FT at the points of the detection accuracy with correlation value. And this study, to expand the size of the original image and the watermark image are tried.

Using a combination of autocorrelation can be obtained. It is possible to identify self and others using the image correlation value. These results suggest that the using of this proposal can be considered easier to identify the state between the auto correlation and cross correlation.

Therefore, there is a good possibility that the adaptation to authentication, in the case of this proposal using for calculation method.

REFERENCES

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