Authentication of the reconstructed image from computer-generated hologram: synthesized by Complex Hadamard Transform.

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Abstract: Computer-Generated Hologram (CGH) has been targeting the application areas such as a reconstruction three-dimensional image, optical information processing, optical memory and scanner. The reconstructed image of CGH includes noise caused by quantization error when synthesis a hologram. Therefore, authentication of the reconstructed image by using computer is difficult. Fourier Transform (FT) is a normal way when synthesis and reconstruction CGH. This study proposes a method using Complex Hadamard Transform (CHT). CHT is used only addition and subtraction. And CHT eliminates the need for multiplication operations. In this study, CHT is compared with FT at the points of the detection accuracy. The possibility of adaptation to authentication of the reconstructed image calculated by CGH, in the case of this proposal using for calculation method, are examined. Phase-Only Correlation (POC) is adopted as a correlation method. As a result, the correlation value is better than that of the past. However, bad value appeared in several points. But, the impact of identification could reduce by choosing the optimal combination of correlation. Therefore, there is a good possibility that the adaptation to authentication, in the case of this proposal using for calculation method.

Keywords: Computer-Generated Hologram (CGH), Complex Hadamard Transform (CHT), authentication

I. INTRODUCTION

This study is about a type of steganography or digital watermarking.[1] CGH has been targeting the application areas such as a reconstruction three-dimensional image, optical information processing, optical memory and scanner.[2] The reconstructed image of CGH includes noise caused by quantization error when synthesis a hologram. Therefore, authentication of the reconstructed image by using computer is difficult.

This study proposes a method using CHT. CHT is a function of the basis for the conversion functions required by the Hadamard Matrix, using only addition and subtraction. In this study, CHT is compared with FT at the points of the detection accuracy. The possibility of adaptation to authentication of the reconstructed image calculated by CGH, in the case of this proposal using for calculation method, are examined.POC is adopted as a correlation method.

II. EXPERIMENT

1. How to create sample images for experiment

i. What is "Complex Hadamard Transform (CHT)"

Hadamard transform is the orthogonal transformation. Processing can be performed by the sum of the product of Hadamard matrix and the input data.[3] *"F"* is output. *"n"* is the number of rows or columns. *"f"* is input.

$$F = \frac{1}{\sqrt{n}} Hf \qquad (1)$$

The basis of this transformation is a Hadamard matrix. As the following equation which represents an example of a Hadamard matrix.

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

This matrix is only represented by real number. Complex Hadamard transform is used to complex Hadamard matrix. Complex Hadamard matrix is using the real and imaginary parts. As the following equation which represents an example of a Complex Hadamard matrix.

$$H = \begin{bmatrix} 1 & i \\ -i & -1 \end{bmatrix} \qquad (3)$$

Two-dimensional Complex Hadamard transform, as in the case of two-dimensional Fourier transform, first horizontally, second vertically are in the process.

ii. Sample images

256 × 256 pixels on the image of the black, starting at the top left of the image of the alphabet A ~ Z of the one who 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. Each images shown in Fig.1, Fig.2 and Fig.3.

2. 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.

Table 1.Combination of image groups

N	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

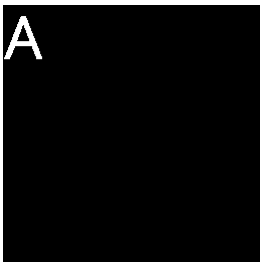

Fig.1.Original image (A)

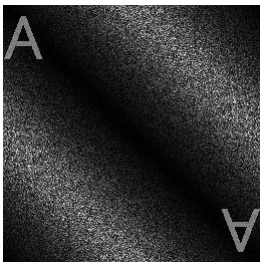

Fig.2.Reconstructed image from CGH made by FT (A)

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" value (maximum value) and the next highest correlation value. The width between maximum value and the next highest correlation value should be broad as possible. The next 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

N	Type 1	Type 2	The next highest correlation value
1	Original image	Reconstructed image from CGH made by FT	0.8070969482
2	Original image	Reconstructed image from CGH made by CHT	0.9895463015
3	Reconstructed image from CGH made by FT	Reconstructed image from CGH made by FT	0.0342630240
4	Reconstructed image from CGH made by CHT	Reconstructed image from CGH made by CHT	0.2378456832
5	Original image	Original image	0.5634082960

In the experiment No.2, the width between maximum value and the next highest correlation value is about 0.01045. This width is very narrow. Set of threshold is difficult.

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

In the experiment No.4, the width has been reduced to 79% of the width of experiment No.3. But, threshold setting is easily if the width of this level can be secured. This result is better than the result of experiment No.5.

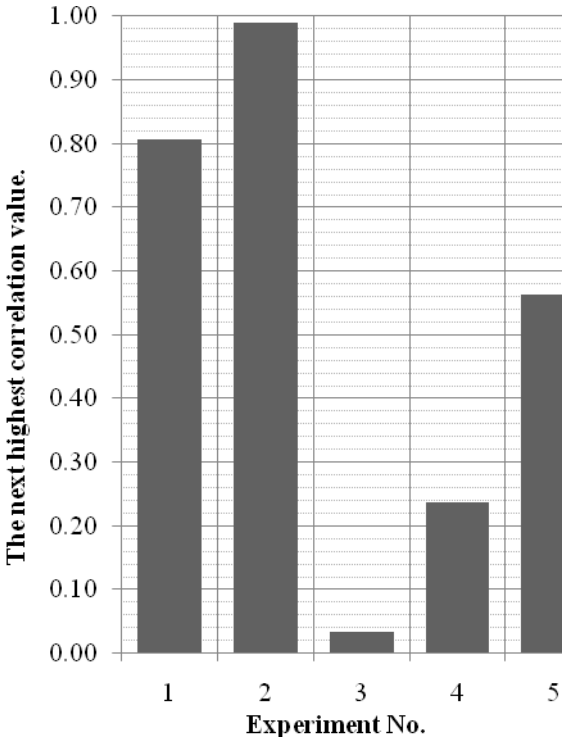

Fig.4. Combination of image groups and correlation value

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. Need to choose the optimal combination of correlation, it is possible to identify self and others using the image correlation value.

Using a combination of autocorrelation can be obtained. Good results are obtained using these combinations.

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

REFERENCES

[1]N.Komatsu, K.Tanaka (2004), Digital-watermarking technology, The Institute of Image Electronics Engineers of JAPAN (in Japanese).

[2]T.Yatagai, (2004), Optical Computing, Kyoritu Shuppan Ltd (in Japanese).

[3]Z.Kiyasu (1983), The Hadamard matrix and its application, IEICE (in Japanese).