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Improvement by the image processing of the certification of a reconstructed image from Computer-Generated Hologram picked up by digital watermark

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ABSTRACT: Computer Generated Hologram (CGH) is made for three dimensional image of a virtual object that difficult to illuminate laser light directly. Even if this CGH deteriorate, it has characteristic that reconstruct is possible. This is a characteristic called the multiplexing that Fourier transform has. This characteristic is paid attention for the purpose of embedding this CGH as digital watermark because it is necessary to deteriorate this CGH. The purpose of this study is to make a computer authenticate CGH which we embedded it as digital watermark and took it out and regenerated. The method of the certification is Phase Only Correlation (POC). This study succeeded in improving the value of this evaluation.

1. INTRODUCTION

Computer Generated Hologram [1]~[3] (CGH) is made for three dimensional image of a virtual object that difficult to illuminate laser light directly. We uses dislocation model of CGH that be made relatively easily because it takes time to reconstruct three dimensional image even if use the fast algorithm. This dislocation model of CGH is demanded by calculating to Fraunhofer diffraction namely disintegration Fourier Transform. Even if this CGH deteriorate, it has characteristic that reconstruct is possible. This characteristic is paid attention for the purpose of embedding this CGH as digital watermark because it is necessary to deteriorate this CGH. This technique is used for the purpose of copyright protecting for digital image The digital watermark to use in this study is a frequency domain type. This technique has the characteristic that the SN ratio of an original image and an embedded image is higher. But this technique has a weak point. When the image which was made by this technique deteriorated, the embedded image not can be taken out. For example, it is the deterioration such as the weighted average filter. Therefore, we do not consider the deterioration of the image which was made by this technique in this study. The purpose of this study is to make a computer authenticate CGH which we embedded it as digital watermark and took it out and regenerated. The method of the certification is Phase Only Correlation (POC). POC is technique in consideration of only the form of the image. This method that pay attention to form includes a fault. It is that a correlation of O and similar form such as Q rises. This study tried improvement by doing image processing before taking the correlation of reconstruct image and original image to improve.

2. METHOD

2.1 MAKING Computer-Generated Hologram

The section explains the principle of the Fourier transform type hologram to use in this paper. For original image f(x,y), we perform a calculation equivalent to Fraunhofer diffraction namely disintegration Fourier Transform. The coordinate system of the original image defines it as (x,y). The coordinate system on the hologram side defines it as (u,v). When we perform this calculation, spectrum information is concentrated in the low frequency domain when we apply it for an original image. It is common to put random phase on original image f(x,y) to distribute this spectrum information for a frequency domain uniformly. Random phase ϕ (x.y) is random numbers of 0 - 2π. In other words, we regard a phase ingredient as important generated complex number information. Therefore, the computer hologram of the Fourier transform type is made by the following expressions.

$$F(u,v) = \frac{1}{\sqrt{N^2}} \sum_{m=0}^{N-1} \sum_{n=0}^{N-1} f(m,n) \phi(x,y) \cdot \exp\left\{ -j \frac{2\pi(mu+nv)}{N} \right\} \quad (2.1.1)$$

In addition, We perform this processing because it is known that gradation characteristics are compatible with the resolution of the reconstruct image by making F(u,v) 2 value by the following methods[4].

$$F'(u,v) \begin{cases} +1 & (\pi/2 \le |\arg F_S(u,v)|) \\ -1 & (otherwise) \end{cases} \quad (2.1.2)$$

$$F_S(u,v) = \frac{F(u,v)}{\max|\ \mathrm{Re}[F(u,v)]\ |} \quad (2.1.3)$$

Show the concrete processing result in the next section.

2.2 DIGITAL WATERMARK

This section explain frequency domain embedding type digital watermark to use in this paper. The frequency ingredient embedding type is the digital watermark which paid attention to that a high frequency ingredient of the Fourier transform is hard to look like human eyes. This

method can embed CGH as digital watermark without affecting an original image more markedly than the masking type[5]. The information that is embedded by this method is poor at attack of compression father. But, the attack to the image after having embedded it does not consider it in this paper. Because we take first priority whether the certification of the reconstruct image is possible, in this paper use this method. Show below the processing results.

Fig.2.2.1
Original image

Fig 2.2.2
Embedded image
frequency ingredient

Fig 2.2.3
Embedded image
masking type

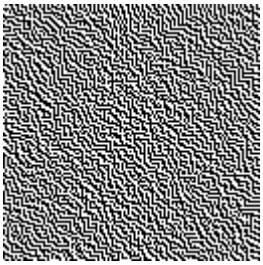

Fig 2.2.4
CGH
original

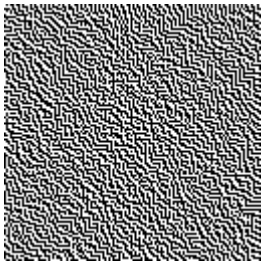

Fig 2.2.5
CGH
picked up

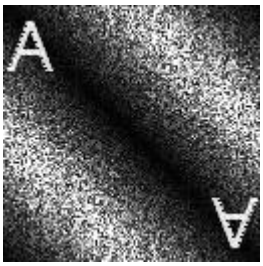

Fig 2.2.6
Reconstructed image
by original CGH

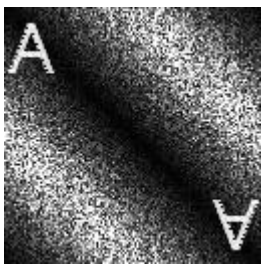

Fig 2.2.7
Reconstructed image
by picked up CGH

This study use the spectrum of the imaginary number to be born in the middle of this processing as a compound key. This is to suppress the deterioration of the image

2.3 PHASE-ONLY CORRELATION

Phase-Only Correlation [6] is a method to calculate a correlation that is made to do normalization to 1 of a provided amplitude ingredient by Fourier transform. Therefore, the method is not affected by the brightness value of the image. In other words the method was pay attention to the shape of the object in the image to compare only the phase ingredient of the image. show below a definition of Phase-Only Correlation.

Two images were put with f(x,y) and g(x,y) each.DFT is Fourier transform, they are as follows.

$$F\ (u,v) = DFT\left[f(x,y)\right] \tag{2.2.1}$$

$$G\ (u,v) = DFT\left[g(x,y)\right] \tag{2.2.1}$$

Phase information and amplitude information was expressed as follows. The amplitude ingredient was regarded as 1

$$F(u,v) = A_F(u,v)\exp(j\,\theta_F(u,v)) \tag{2.2.1}$$

$$G(u,v) = A_G(u,v)\exp(j\,\theta_G(u,v)) \tag{2.2.1}$$

Phase-Only Correlation was defined as follows

$$PH(u,v) = IDFT\left[\frac{F^*(u,v)G(u,v)}{\left|F^*(u,v)G(u,v)\right|}\right] \tag{2.2.1}$$

$F^*(u,v)$ This function is complex conjugate.

2.4 THE IMAGE PROCESSING

1. The pixel level of the image is made a 2 level.(The threshold is 128.)
2. When the value of the attention pixel is clearly higher than the value of the pixel of the circumference, the value of the attention pixel is changed to 0.
3. The image is processed by raster operation until the change of the image disappears.
4. The image is processed by the Laplacian filter. The outline of the letter is extracted in this way.
5. The image which was processed to division into four is used in only a left upper part.

Show below the processing results.

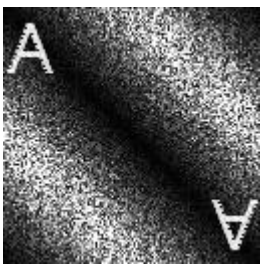

Fig 2.3.1
Before processing

Fig 2.3.2
After processing

3. EXPERIMENT METHOD

1. Prepare the128*128 following images of "A" – "Z" form of the P-Gothic.
2. CGH which was made by a source image is embedded as digital watermark.
3. The embedded image is taken out. The image taken out is reconstructed.
4. The evaluation level by POC of the reconstruct image which nothing is made is compared with the correlative value by POC of the processed reconstruct image.
5. This study assumes the image which showed the highest correlative price a certification image.

4. RESULT

Show below the experiment results. It was revealed that original image and processed reconstruct image became highest. Characteristic examples of the correlative value by POC are "C" that is changed 0.087792897 to 0.150123, "E" that is changed 0.0532826 to 0.107673,"F" that is changed 0.0532826 to 0.094749.

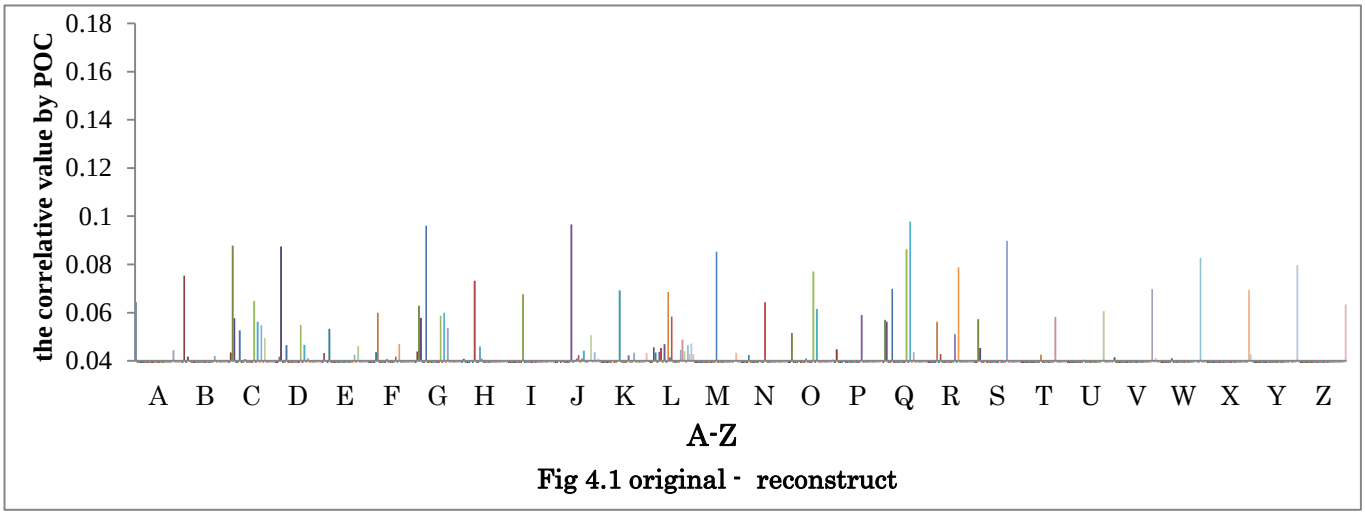

Fig 4.1 original - reconstruct

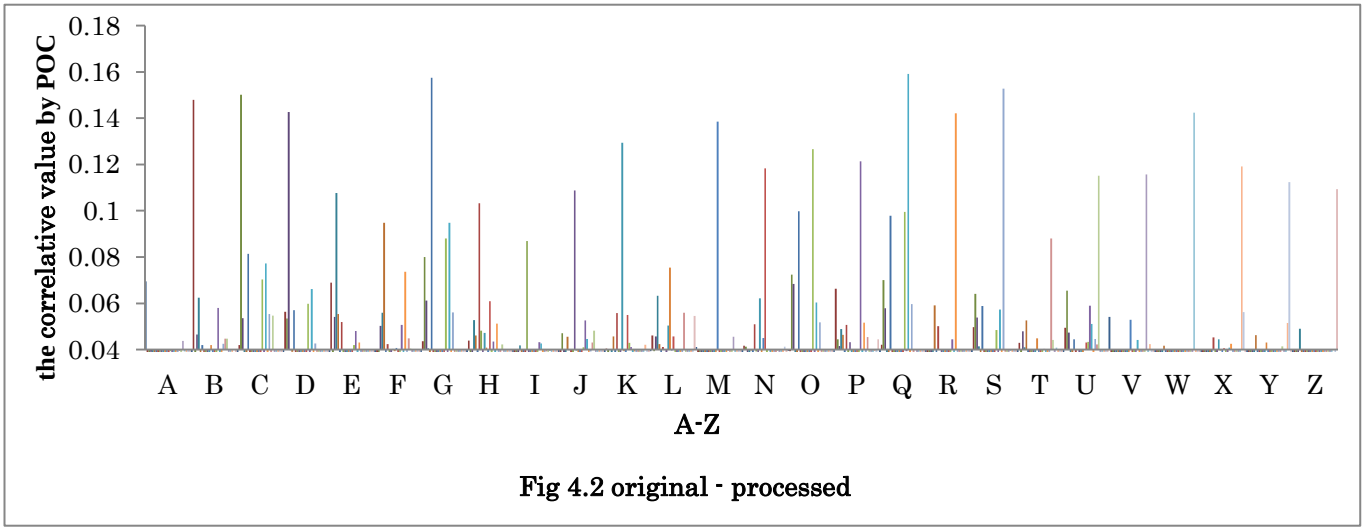

Fig 4.2 original - processed

5. CONSIDERATION

The correlative value by POC improved generally by performing the image processing that paid attention to an outline. The correlative values of character "E" and "F" improved very much. This improvement is able to authenticate it easily by computer. However, the correlative value such as character "A", "I" and "L" did not improve very much. It becomes the future problem to improve these values.

6. REFERENCES

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