논 문
19～6～3

Holography에 의한 화상정보의 전송

Holographic Information Transmittance of Photographic Images

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〔ABSTRACT〕

Up to the present information processing has been studied in the field of radar and electical communication. However, recently photographic images have been sent and received a laser communication system.

This paper is an attempt to discuss a method of information transmittance accomplished by holography. The results of experiment show that two-dimensional photographic images at the output appear with spots and when the degree of intensity of the images produced reach a frequency plane to move towards 40—60μ, they show a finer effect.

1. Introduction

Let the two beams of the object and of the reference project on a photographic plate simultaneously, and after we reconstruct a wave-plane from the recorded photographic plate, as a result, holography[1] can be obtained from the object. This process was attempted by Gabor[2] in 1948, and it produced an epoch-making development, a new method[3]-[5] in creating laser light. Holography produces making-image, record of and reconstruction of a wave-plane, information transformation, information compression, color three-dimensional image, and it applies to magnification increase, to three-dimensional color TV, and to optical memory, also it can optically transmit an information transmittance.[6]-[7]

Information transmittance by means of the optical method, which was attempted by O'neil[8] in 1956, and which introduced Fourier transform to the making-image theory of the optical system, and which eliminates, chooses, changes and specific range of frequency in the input signal of the filter circuit in the electrical communication system. The principle of holography is to transmit only the signal at the circuit including the signal and the noise, and is dealt with only by the optical method, and it tries to produce a clearer photographic image.

This paper is an attempt to discuss that the electrical communication system produces linear information transmittance, while the information transmittance by holography transmits two-dimensional photographic images by Fourier transform hologram.[9]

2. Theory

The principle of transmittance on photographic images by means of holography was originally studied in the field of radar and communication systems.[10] However, recently the principle has led to transmittance of two-dimensional photographic images by utilizing the coherent optical system by using laser light in the field of optics.

Now we use photographic images in which the signal and the noise are mixed simultaneously by the object, and we illuminate beams of a coherent laser to the double diffraction optical system (Fig. 1), and we seek out only the signal; the necessary information made by filtering. The filter must act

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at a frequency plane in which S/N becomes a maximum value; a rate of the signal and the noise of information. Consequently the function[8]-[11] of the filter is

$$H(u,v)=C\frac{S^*(u,v)}{N(u,v)} \quad \cdots\cdots(1)$$

where C is a constant, $S^*(u,v)$ is a complex conjugate spectrum of the known signal, and $N(u,v)$ is the spectrum density of the optical noise.

In addition, when the electrical power of the noise and wave-form of the signal is first shown with Eq. (2):

$$Z(\omega)=S(\omega)^* e^{-i\omega t_0}. \quad \cdots\cdots(2)$$

When the relationship of Eq. (2) is formed, the output power to the noise rate appears at its maximum. The filter which we need and which transmits the information best operates according to Eq. (2).

The complex value showed with the effect of transmittance like Eq. (1). or Eq. (2). Consequently it is impossible that we use an ordinary photograpic plate which influences only to the intensity absolute square(amplitude). Vander Lugt and Lowenthal[11]-[12] use the modified Mach-Zehnder interferometer and make up the optical filter[13] by the holographic principle.

That is, $S^*(u,v)$ is the spectrum of the signal, it can record on a hologram the characteristics of the amplitude and the phase which continue to change as a general complex function. We put the optical signal $S(x,y)$ on the P_1 plane of Fig. 1, and when we make up a hologram on the P_2 plane, the signal is filtered. At that moment, the Fourier-spectrum $S(u,v)$ appears on P_2 plane; the 2nd focus plane of lens L_1 Therefore the optical signal and reference beam $e^i(bu+cv)$ are recrded at the same time.

The transmission rate $\tau(u,v)$ (the amplitude of hologram on space frequency plane) is shown in Eq. (3):

$$\begin{aligned}\tau(u,v)&=|S(u,v)+e^{i(bu+cv)}|^2\\ &=|S(u,v)|^2+1+S(u,v)^i e^{(bu+cv)}\\ &\quad +S^*(u,v)e^{i(bu+cv)} \quad \cdots\cdots(3)\end{aligned}$$

Here b and c show the respective distance of reference beam interval with $S(x,y)$, and the fourth term of Eq. (3) has abilities as the filter of $S(x,y)$.

We put the filter on P_2 of Fig. 1, differently from the above experiment, with the filter function $N(u,v)$ in proportion to the projected beam $N(u,v)$ and when it performs the development processing of $\Gamma=2$, the transmission rate in proportion to $1/N(u,v)$ becomes the amplitude filter. When we duplicate it with $\tau(u,v)$, it is equivalent to Eq. (1). Namely the filter function is

$$H(u,v)=\frac{A(u,v)}{N(u,v)}+\frac{S(u,v)}{N(u,v)}e^{i(bu+cv)}+\frac{S^*(u,v)}{N(u,v)}e^{i(bu+cv)} \cdots(4)$$

where $|S(u,v)|^2+1=(A(u,v.)$

When we put the filter made by such a process upon the hologram on P_2 plane of Fig. 1, because on this plane the spectrum $F(u,v)$ of $O(x,y)$, the inverse of the projected beam becomes Fourier transform. Therefore the photographic image appears at the output plane with Eq. (5):

$$\begin{aligned}O'(x',y')&=\iint_{-\infty}^{\infty}F(u,v)H(u,v)e^{i(ux'+vy)}dudv\\ &=\iint_{-\infty}^{\infty}F(u,v)\frac{A(u,v)}{N(u,v)}e^{i(ux'+vy')}dudv \quad \cdots\cdots(5-1)\\ &+\iint_{-\infty}^{\infty}F(u,v)\frac{S(u,v)}{N(u,v)}e^{i\{(x'-b)u+(y'-c)v\}}dudv \quad \cdots\cdots(5-3)\\ &+\iint_{-\infty}^{\infty}F(u,v)\frac{S^*(u,v)}{N(u,v)}e^{i\{(x'+b)u+(y'+c)v\}}dudv \quad \cdots\cdots(5-3)\end{aligned}$$

Like the object $O(x,y)$ at the centre of X,Y' a photographic image of Eq. (5—1) appears with zero-order. Eq. (5—2) is the pattern at the centre of $X'=b$, $Y'=c$. Convolusion of the signal and the object appears at 1st-order. Eq. (5—3) is the pattern at the centre of $X'=-b$, $Y'=-c$ and crosscorrelation of the siganl and the object.

The photographic image of the (−) 1st-order is transmitted with the spots.

Namely, we put the specific photographic images on the P_1 plane, after making up the filter P_2 plane, and we eliminate the specific photographic image on P_1 plane. We put the optical photographic images instead of specific images, and we intercept the reference beam and lighten the object beam. When it contains the optical photographic image, the photographic image is transmitted with the spots on P_3 plane of the output.

3. Experimental Approach

The entire schematic diagram is shown in Fig. 1, and the practical apparatus shown in Fig. 2.

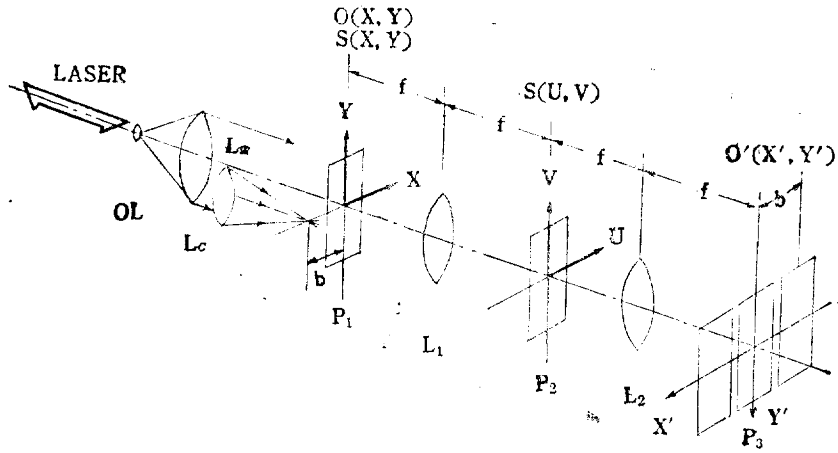


Fig. 1. Information transmittance processing system.

In Fig. 1, when the laser (LD—719, He-Ne Laser wave length 6328 Å, Nippon Tenki K. K)beam is lightened, and it makes up parallel beams, which makes up partial reference beams at L_R (condenser lens making of reference beam,), and which equips the 2nd focus of the lens appearing at the P_1 plane. At the same time we insert specific photographic images at the P_1 plane, and we lighten the reference beam and the object beam. Two beams pass lens L_1, and they reach the P_2 plane; the 2nd focus of lens, on which we put photographic plate (specific photographic plate for the hologram), and they record specific photographic images. In this case, the development processing is solved by using the specific solution. This recorded photographic plate simultaneously uses the reference beam and the object beam by hologram. Subsequently we intercept the laser beam of L_R and exchange an optical photographic image at P_1 plane. It is lightened by the object beam, at this moment, it passes by hologram(filter)

at P_2 plane, through lens L_2, and through lens L_2 which are equipped to let the 1st focus appear on P_2 plane, it reaches P_2 'plane, the 2nd focus of lens L_2. At this time, an optical photographic image appears at part zero-order. If any specific photographic image is beamed on an optical photographic one at (−) the 1st-order part, it appears with the spots. At (+) 1st-order it appears with the unnecessary noise.

Next, in order to examine how photographic information transmits well, we put a pinhole of 1mm at part of the spots, after it passes by, and then we added a photo-tube (RCA-tube.)

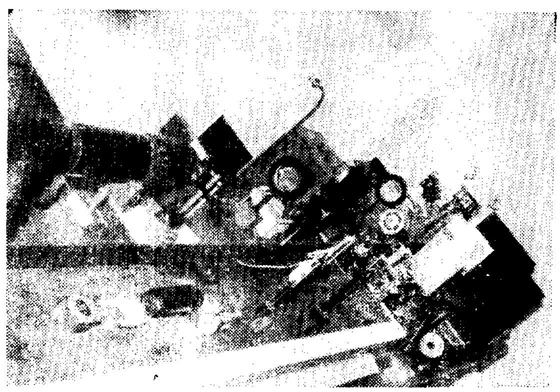
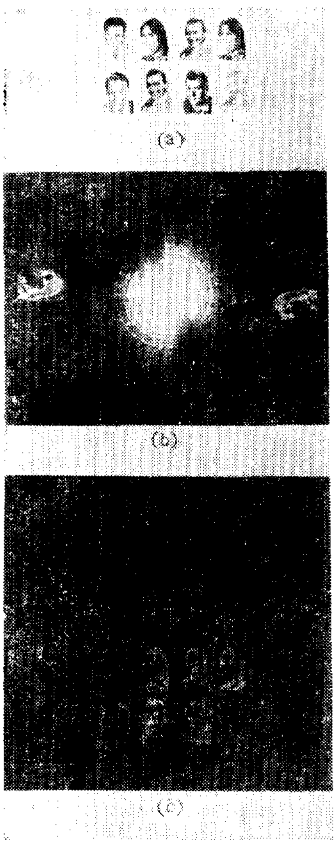


Fig. 2. Photograph of the experimental apparatus for information trasmittance.

We connet aphoto-tube with micro-micro ammenter(Takeda Riken Model TR-16S), to determine the strong and weak degree (effect of transmittance.) Making up hologram at P_1 plane by the same specific photographic images for three times, and after transferring P_2 plane towards the optical axis and perpendicularity, we examine the result.

4. Results

(a) Fig. (3) is the optical photograph inserted on P_1 plane of the input plane. (b) is the woman on the upper left; a specific photographic image at (a). After intercepting the object beam, we project only reference beam, and (b) is the impulse response appearing at P_3 plane, and the photographic image of the woman appears at both sides.



(a). object(including a particular woman)
(b). impulse response on output.
(c). result

Fig. 3. Transmittance resulting from an information processing of a particular woman.

(c) inserts the specific photographic image(woman) in (a) at P_1 plane, and after making up a hologram at P_2 plane, we eliminate the specific photographic image at P_1 plane. We put the optical photographic image(8 photos of men and women) at the very place instead of it. We intercept the reference beam, the optical photographic image is projected, and then (c) is an image which wecan watch at P_3 plane. That is, (c) is the optical photograph of (a), appearing at zero-order, and because, at (−)1st, the filter is the woman, it is only spots that transmit at the place of (−b, −c) at the central point.

The following table 1. shows

Table 1. Measurement Values for Movement of Frequency Plane.

〔A〕		〔B〕		〔C〕	
Displacements of frequency plane(μ)	Current of ammeter($1\times 10^3\mu$A	Displacements of frequency plane(μ)	Current of ammeter($1\times 10^3\mu$A)	Displacements of frequency plane(μ)	Current of ammeter ($1\times 10^3\mu$A)
0	0.218	0	0.159	0	0.241
5	0.245	10	0.194	5	0.361
10	0.271	20	0.278	10	0.472
15	0.355	30	0.412	15	0.569
20	0.449	40	0.532	20	0.648
25	0.512	50	0.608	25	0.712
30	0.585	60	0.680	30	0.768
35	0.675	70	0.648	35	0.799
40	0.765	80	0.564	40	0.796
45	0.838	90	0.431	45	0.788
50	0.872	100	0.264	50	0.756
55	0.891	110	0.182	55	0.698
60	0.899	120	0.145	60	0.600
65	0.881	130	0.129	65	0.488
70	0.835	140	0.129	70	0.411
75	0.768	150	0.148	75	0.345
80	0.699	160	0.147	80	0.271
85	0.619	170	0.129	85	0.234
90	0.521	180	0.111	90	0.209
95	0.400	190	0.091	95	0.182
100	0.340			100	0.176
105	0.299			105	0.155
110	0.265			110	0.151
115	0.225			115	0.151
120	0.201			120	0.159
125	0.198			125	0.168

the results from measuring the spots by micro-micro ammenter as transfering P_2 plane (space frequnc plane) towards the optical axis and perpendicular direction. The graph of table 1, is Fig. 4. On this graph, [A][B][C] respectively shows the experiment by different way on the same object.

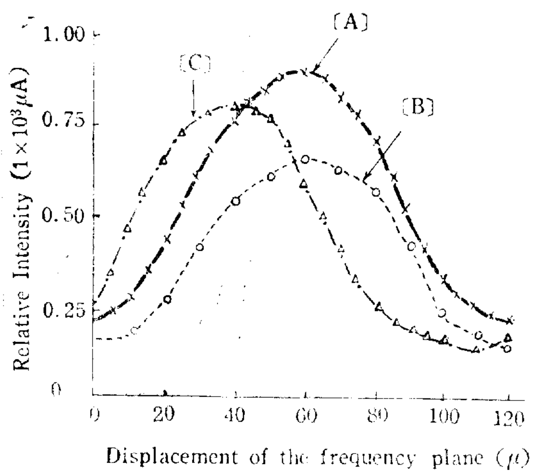


Fig. 4. Variation of spot intensity due to displacement of the frequencyplane.

5. Conclusion

As compared with the electrical communication system, the effect of an information transmittance by holography is two dimensional, and Fourier transform is easily achieved by the effect. In the same time, the efftec can respectively exchange the amplitude or the phase, and it can easily make up the product. In other words, the effect makes up the hologram by a specific photographic image at the input, and it changes the specific photographic image into an optical photographic image. Like (c) of Fig. 3, the information of specific photo-graphic image appears with the spots at the output. As a result, the photographic image is transmitted at least. Fig. 4 indicates to us that when we displace the frequency plane (40-60μ), the effect of transmittance is much better than before.

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