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전자계산기 홀로그램을 이용한 레이저 주사장치
Laser Scanner Using Computer Generated Hologram

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요 약

전자계산기 홀로그램을 이용한 Over-filled 주사장치를 구성하고 주사특성을 측정하였다. 그 결과 주사거리는 40cm 정도이고, 100 μm 정도의 해상도를 가지며, 회전면의 흔들림에 대해서도 안정함을 보여 주었다.

1. Introduction

Holographic laser scanning system has been developed to replace the polygonal mirror scanner which is expensive and requires high rotational stability. Holographic scanner operating in transmission type is free from beam misplacement due to facet wobble intrinsically.[1]

Olof Bringdahl and Wai-Hon Lee presented the laser scanner using CGH (Computer Generated Hologram).[2] But it had many problems such as short scan length (6 Cm), large focal length (3.75 m), and low resolvable elements per scan (320 N/scan). Most of these problems are due to the limitation of the size and the resolution of the plotter to draw CGH and to the under-filled scanning method. (Fig.1.) From

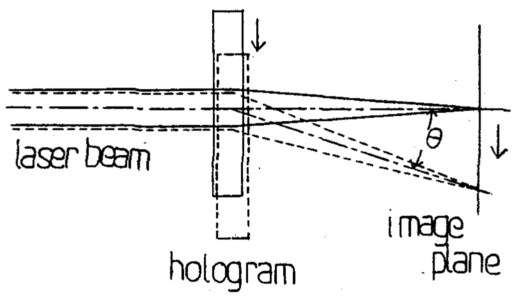

Fig.1. Under-filled scanning

Fig.1, to obtain a large scan length , the maximum deflection angle (θ) must be large , therefore the minimum[2] grating period becomes very small, so that the grating can hardly be made by present systems of plotting and lithography.

In this paper to overcome these problems, the over-filled scanning method , which is used to reduce fly-back time or retrace time in polygonal and other facet scanners, was used.

2. Over-filled CGH scanner

In Fig.2, a small part of laser beam diverging through the large angle θ is incident on the holographic lens L fixed along the round of the drum and is focused on the image plane I. As the drum rotates , the focused spot scans the image plane I. The function of the hologram plate is only to focus the laser beam, therefore the design of the hologram for the over-filled scanning becomes easier than for the under-filled scanning in which both the focusing and the deflection of laser beam must be considered simultaneously. For sufficiently large radius R , the scan length $l = R \times \theta$ can be large.

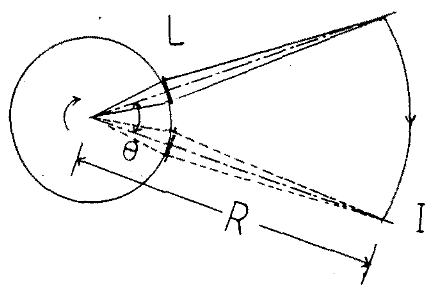

Fig.2. Over-filled scanning

The whole schematic diagram of this over-filled scanner is shown in Fig. 3. The slit S was used to separate the desired first order beam from the beams of other diffraction orders. In experiment the circumference of the drum was devided into 16 parts and the holographic plate was fixed on each part around the drum. The radius of the drum was 10 Cm and the distance between the hologram plate and the image plane ,or the back focal length of the holographic lens was 90 Cm. Therefore the scan length is given by

$$L_s \simeq 100 \times (2 \times \pi)/16 \simeq 40 \ (\mathrm{Cm}).$$

Fig.4 shows the experimental set-up for this scanner.

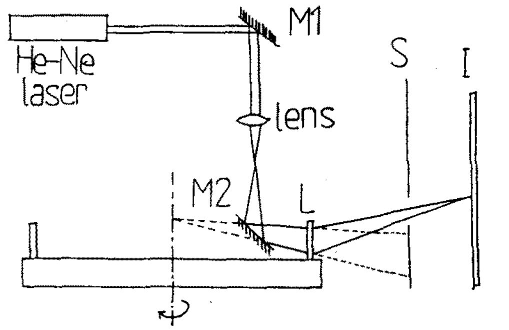

Fig.3. Whole schematic diagram of over-filled scanner

3. Fabrication of Hologram

In Fig.5 , the front and back focal length of the holographic lens were designed to be 10 Cm and 90 Cm , respectively. The phase difference between O and O′ through the free space is given by

$$\phi(x,y) = \frac{2\pi}{\lambda}\left((r^2 + 10^2)^{1/2} + (r^2 + 90^2)^{1/2}\right)$$

$$r = (x^2 + y^2)^{1/2}, \quad \lambda = 633 \ (\mathrm{nm})$$

and is compensated by the hologram plate. Therefore the hologram function becomes $\phi(x,y)$. Wai-Hon Lee published that the relation between a grating pattern and the corresponding hologram function $\phi(x,y)$ [3] is given by

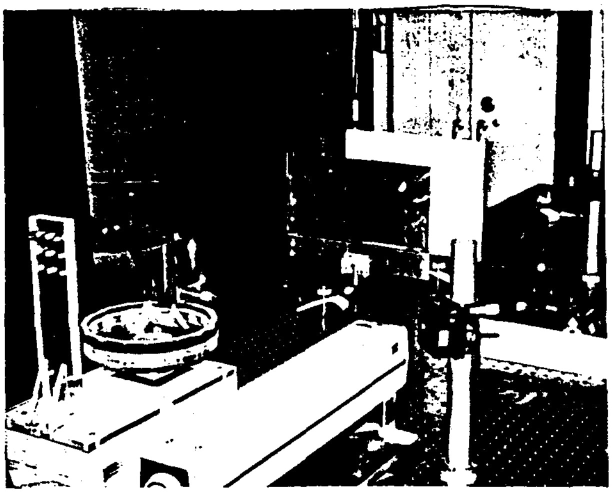

Fig.4. Experimental set-up of the over-filled scanner

$\phi(x,y) = 2n\pi$, n --- integer .

Therefore the grating pattern of this holographic lens is given by

$$\frac{2\pi}{\lambda}\left((r^2 + 10^2)^{1/2} + (r^2 + 90^2)^{1/2}\right) = 2n\pi, \quad n \text{ --- integer.}$$

From this equation the grating pattern is a set of concentric circles therefore the accuracy of drawing can be very high. In experiment the grating pattern was drawn using IBM computer and Calcomp plotter , then this pattern was photoreduced to 1/112th of its original size (Table.1) on a HRP plate. To make many such holograms and raise the diffraction efficiency the grating pattern on the HRP plate was exposed on photo-resist coated on a slide glass.

In the finally produced hologram , the minimum grating period was about 8 um and the diameter of holographic lens was about 6.5 mm. Therefore by Rayleigh criterion the spot size of the laser beam on the image plane is

$$W \simeq \lambda \frac{f}{D} \simeq 95\ \mu m$$

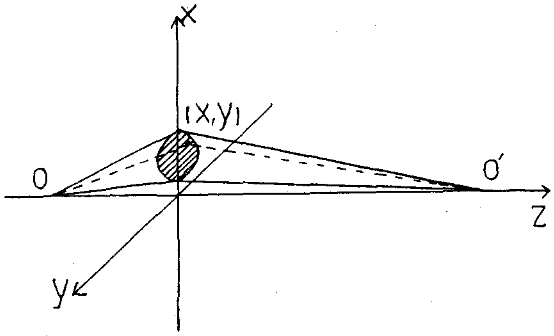

Fig.5. Formation of the hologram function

Table 1. Original pattern drawn by Calcomp plotter

Diameter	76 (Cm)
Number of gratings	405
Minimum grating period	0.9 (mm)
Width of line	0.3 (mm)

4. Experimental Results

Fig.6 shows the pattern of the scan lines exposed on Agfa-Gevaert 10E75 photographic plate . Measuring by microscope , even when the scan line was exposed 30 times , the line width was about 100 μm . This result also proves that this over-filled scanner of transmission type is stable to facet wobble.

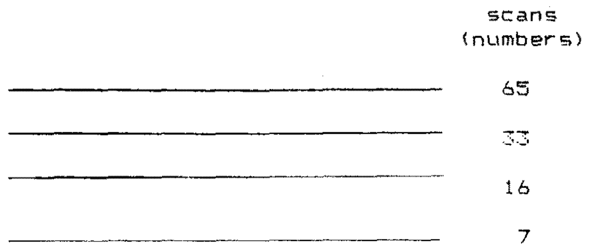

Fig.6. Photographs of the scan line pattern for each specified number of times of scanning exposed on Agfa-Gevaert 10E75 photographic plate.

5. Conclusion

To overcome the problems for under-filled CGH scanner, the over-filled CGH scanning method was proposed. Experimental results shows that the over-filled CGH scanner has high resolution (100 μm), large scan length (40 Cm), and low sentitivity to facet wobble.

References

1. Charles J. Kramer, " Holographic laser scanner for nonimpact printing," Laser Focus, 17, pp 70-82 June 1981.
2. Olof Bryngdahl and Wai-Hon Lee, " Laser beam scanning using computer-generated hologram, " Appl.Opt., 14, 183 (1976).
3. Wai-Hon Lee, " Binary synthetic hologram," Appl.Opt., 13, 1677(1974).