Dot Character Display Using a Negative-Film Diffraction Grating Matrix

Mikio Mimura, Atsuya Ishida and Kouichi Hayakawa

Department of Applied Physics, Faculty of Engineering, Osaka City University, Sumiyoshi-ku, Osaka, 558 Japan
(Received July 25, 1996; Accepted August 19, 1996)

A diffraction grating matrix made of negative film is applied to display dot characters. Using an X-Y plotter of a personal computer, a multiple grating pattern is plotted in a matrix form. The photograph of the pattern is the negative-film diffraction grating matrix. When a laser light illuminates the grating matrix, the diffracted light displays a dot character. Several alphabetic characters are displayed in this way.

Key words: diffraction, grating matrix, negative film, X-Y plotter, dot character

A simple diffraction grating can be produced photographically: a pattern drawn by an X-Y plotter of a personal computer on a large scale is reduced by taking a picture of it. Creating a diffraction grating in this way is instructive for students in a science course. Five spectrum lines of a mercury lamp were separated by such a simple diffraction grating.13 In this short note, a dot character display is attempted using these gratings. The diffraction angle $\theta$ of the light is expressed by the following formula,

$$d\sin\theta = m\lambda,$$

where $d$ is the line interval, $\lambda$ is the wavelength of the light, and $m$ is the order of diffraction. By adjusting the line interval and the direction of the line, the light beam can be pointed in any direction. If multiple gratings are used, multiple light beams running different directions are created. By collecting them to the focal plane of a lens, a dot character is displayed. Characters have also been displayed using a computer generated binary Fraunhofer hologram.9 Compared to such computer generated hologram, the calculation for the character display in the present grating matrix method is very easy.

The basic concept of the present method is shown in Fig. 1. A dot character "A" composed of 16 dots is to be displayed. The point $(x_0, y_0)$ shows the position of the 0-th order light. To direct the light beam of the first order diffraction to the position $(x_i, y_i)$, the angle of the lines of the grating should be:

$$\varphi = \arctan \frac{x_i - x_0}{y_i - y_0},$$

and the line interval should be:

$$d = \frac{\text{const.}}{\sqrt{(x_i - x_0)^2 + (y_i - y_0)^2}}.$$

Figure 2 shows a schematic drawing of the 4×4 grating matrix to display the character "A." The pattern is plotted on A4 size paper using an X-Y plotter with a pen of 0.25 mm thickness. The size of the pattern is 160×160 mm. The lines in each grating have the angle $\varphi = -20\degree$ and the line interval $d = 0.5-0.75$ mm, which are calculated by the previous formulae. A photograph of the pattern is taken with a camera (Olympus OM-4) using a lens with a focal length of 28 mm. The film is Minicopy (Fuji). The reduction rate is 0.024, which means that the size of the grating matrix is 3.8×3.8 mm.

Figure 3 shows the experimental setup for the display of a dot character. A He-Ne laser light beam passing through a beam expander illuminates the grating matrix. The diffracted light is collected by a lens of 200 mm focal length, and is focused on a screen. The diffraction pattern.
saturation level of the CCD. Second order light spots are also observed, the intensity of which is about 2/3 that of the first order light. The characters of "OSAKA" displayed in this way are shown in Fig. 5.

The dots in characters thus displayed can be placed at any position, which is in contrast to the usual dot character where each dot is placed at a fixed position. The ability to guide the light beam to any position in the present method may be applied to the optical interconnection.\textsuperscript{3)} Although to turn the beam on or off would require the combination of the grating matrix and a liquid crystal panel.

Acknowledgment

Part of this work was supported by SHIMAZU CORPORATION.

References