Personalized Hologram

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Abstract

A personalized holographic stereogram printing system has been developed. The system consists of an image processing PC, a system control device and a desktop one-step holographic stereogram printer. It takes less than 90 seconds including file-loading time to obtain a horizontal-parallax-only hologram image 30mm × 22.4mm on photopolymer film. Since our holographic stereogram printer is designed for easy operation under non-laboratory conditions, an anti-vibration table or a dark room is not required. The system is capable of producing not only reflection type holograms but also edge-lit type holograms by making a small change to the printer head. As applications of the edge-lit hologram, we propose a 360 degrees viewable cylindrical hologram and a compact edge-lit hologram viewer.

The system can be applied to many applications such as portraiture, computer graphics, identification, computer aided design, visualization, medical imaging and so on. We will also describe about the consumer applications that will enable us to easily put our personalized contents into the hologram via the Internet.

Introduction

As computer graphic technologies evolve, there are increasing opportunities for dealing with three-dimensional data. Holographic stereograms have been known as promising media for the visualization of such three dimensional image data for over two decades. Until recently, most of commercialized holograms are made by a two-step holography method. Because a two-step hologram is made by copying a master hologram, it is commercially difficult to make just one hologram. On the other hand, a one-step method, which records a hologram directly on a holographic material, is a suitable method to realize a hologram printing system that can easily print only one hologram. With recent improvement of dry-process photopolymer materials, high-resolution spatial light modulators, compact high-power laser light sources and computing power, we could make a prototype of a desk-top high-speed holographic stereogram printer designed for easy operation under non-laboratory conditions in 1998 by using the one-step method. The prototype could produce a horizontal-parallax-only Lippman holographic stereogram. We also succeeded to develop an edge-lit type holographic stereogram printer in 1999. Those systems used a specially developed image processing hardware as an image processor and a DV format videotape as an image storage device. Recently, we replaced those hardware and videotape by a PC.

This paper will present an outline of the development of our holographic stereogram printing system including recent improvements towards easy access to customized hologram printing. We call the holographic stereogram printed with this system ‘Personalized Hologram”, because it becomes easy to put personalized contents into holographic hardcopy

Hologram Printing System

Our holographic stereogram printing system consists of an image processor, a system control device and a desktop one-step holographic stereogram printer. The block diagram and the specifications of our system are shown in Fig.1 and Table 1 respectively. The system control device controls the sequential printing process as follows. After a processed image for an individual elemental hologram is sent to the LCD in the printer, a corresponding elemental hologram is recorded by opening a shutter in the printer and the photopolymer film is jogged to the next elemental hologram position. After the vibration of the jogged film has decayed, the next elemental hologram is recorded and the process loops through sequentially. We formally used a special image processing hardware and a videotape as the image processor. We recently replaced them by Windows PC. Because of this replacement, sending data to the print system through network became possible. A source image file and a parameter file are sent to the PC together. The source image could be a series of still images or a short movie in a movie file format. The parameter file contains the number of frames of the motion file, parameters for image processing, the ID number of the image file and so on. If the source image is a parallax image and the parameter file contains appropriate information, the resulting hologram will be a three dimensional portrait, similar to the portrait system we presented in 1998.This image processing PC can reconstruct a temporary image for exposure based on a pair of input image source and parameter files stored in memory. Because of the easy handling and processing, we used the DuPont photopolymer film HRF800 as our hologram recording media. Print time for a 22.4mm x 30mm size hologram takes less than 90 seconds including file-loading time, with each elemental hologram having an exposure time of 1/16 sec.

Table 1 Specifications of the hologram printing system

Printing Image Size	22.4mm(h) × 30mm(v)
Viewing Angle	60deg(h) × 40deg(v)
Element Hologram Size	0.2mm(width) × 30mm(v)
Printing Speed	90 seconds
Light Source	150mW SHG-YAG Laser
Recording Wavelength	532nm
Printer Size	700mm × 500mm × 300mm

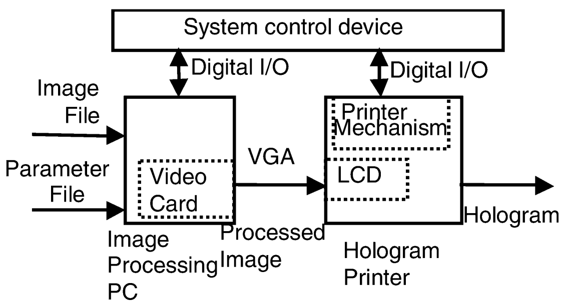

Figure 1. Block diagram

Optical System

The optical system of our holographic stereogram printer is schematically shown in Fig. 2. We used a 150mW SHG-YAG laser with 532nm wavelength as the light source. Because we have used a thin film as our recording media and hologram recording is very sensitive to vibration, film stabilization during hologram exposure was a crucial point for our system. So the mechanical head was designed to minimize the vibration by attaching a stable rigid optical element to the film at the exposing area. By this head mechanism, the vibration decay time was shortened drastically.

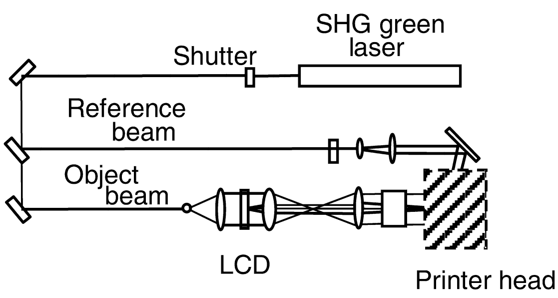

Figure 2. Optical system

This optical system can print not only a reflection type (or Lippman type) holographic stereogram but also an edge-lit type holographic stereogram by making a small change to the printer head and the reference beam path. Fig.3 and Fig.4 show the comparison between the reflection type and the edge-lit type head. In case of the reflection type head, an optical element is pressed onto the film in order to keep the hologram film rigid during exposure of an elemental hologram. On the other hand, a glass block is pressed onto the hologram film and an index matching fluid is supplied between the glass block and the hologram film for the edge-lit type head. A reference beam for the edge-lit hologram was introduced from the edge of the glass block. The size of this optical system is only about 700mm × 500mm × 300mm including the vibration isolation table.

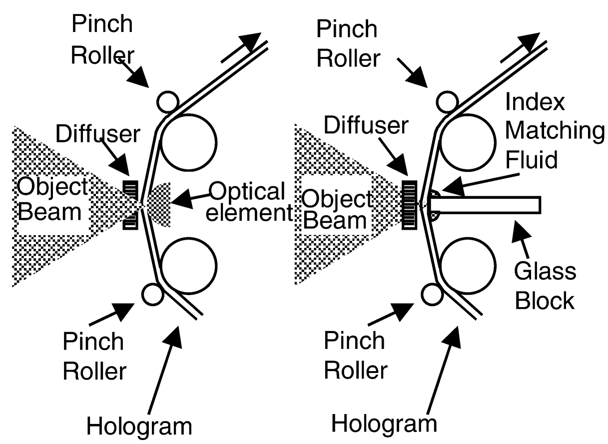

Figure 3. Reflection type head Figure 4. Edge-lit type head

Edge-Lit Hologram Viewer

We also developed a viewer for the edge-lit hologram. This viewer consists of a 35mm × 25mm × 20mm glass block and a 3.5V LED. We found that the brightness of an LED is bright enough to illuminate this size of edge-lit hologram. A small button type battery can be used for the LED power source. The illumination light from the LED is collimated at the mirror on top of the glass block and illuminates the holographic stereogram. The holographic stereogram and the glass block were laminated with optical adhesive (Fig.5).

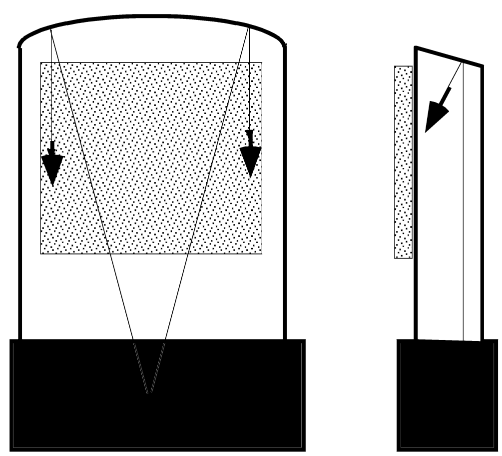

Figure 5. Edge-lit hologram viewer

Figure 6. Hologram image reconstructed from the viewer

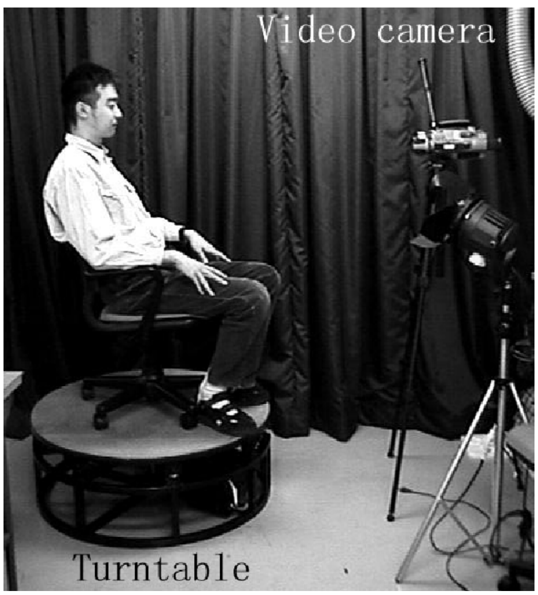

Figure 7. A turntable type image-capturing camera

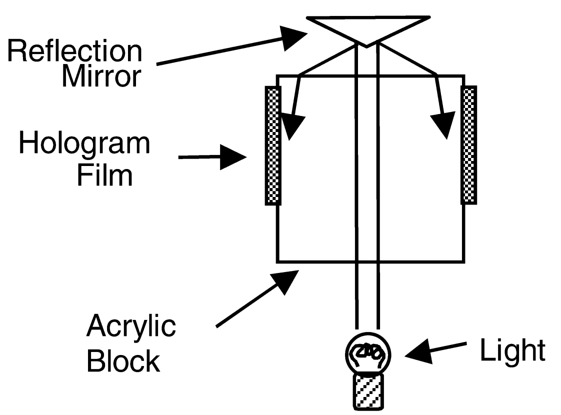

Figure 8. Cross section of a cylindrical edge-lit hologram viewer

We show a reconstructed image of the edge-lit hologram with this viewer in Fig.6. The image quality is adequate from the viewpoint of uniformity, resolution and brightness. By using a turntable type image-capturing camera, our edge-lit holographic stereogram printer can be applied to a cylindrical format (Fig.7). A cylindrical viewer is needed for reconstructing the cylindrical edge-lit holographic stereogram. Fig.8 is a cross sectional figure of the cylindrical viewer. We could see the reconstructed image from 360 degrees around.

Applications

Our system can be applied to many fields. We would like to show some applications below.

Applications for Three Dimensional Image

We developed a parallax image capturing camera system in 1998. As we presented then, our system becomes a three-dimensional portrait system if used with the camera system. In the camera system, parallax images could be captured with a moving video camera in 5 seconds. While the parallax images are being captured, they can be monitored by the subject person from his sitting position by means of a half mirror (Fig.9).

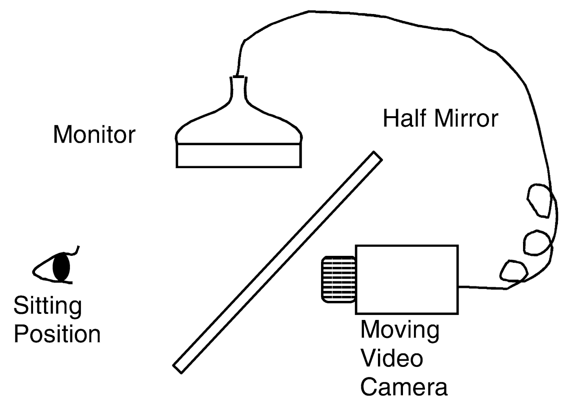

Figure 9. Monitor and Half Mirror

The resulting hologram can express not only three dimensional image but also 5 seconds of slow movement by changing viewing position. We demonstrated this portrait system for 5 months at Sony's entertainment center Metreon in San Francisco in 1999, which was quite popular. The high reliability of the system was also proved through this demonstration. In addition, in the latest implementation, the image data is sent from the camera to the printer via network, enabling the camera to be installed in a variety of locations, which data can be sent to a printing center.

Applications for Two Dimensional Image

Although three-dimensional reality is not shown, a simple short movie or multiple still images can be used as the hologram contents. Any type of differences in images other than parallax can be chosen to be seen from each different viewer eye position. In such cases, horizontal parallax causes image confusion because the right and left eyes see images that differ by more than just parallax. One of the solutions would be "vertical-parallax-only". It is easy to keep the illumination condition with the self-contained light-source hologram like the edge-lit viewer presented in this paper. Fig.10 is one of the photo entertainment applications from a 2 dimensional image. Customers can send a picture and its "Zoom In" area information. The image processing PC can automatically reconstruct a movie of "Zoom out" to "Zoom in", and a motion hardcopy can be easily printed with the system. In this case, it is necessary to send just small 2 dimensional image data instead of huge movie data. It may be an advantage if it is networked.

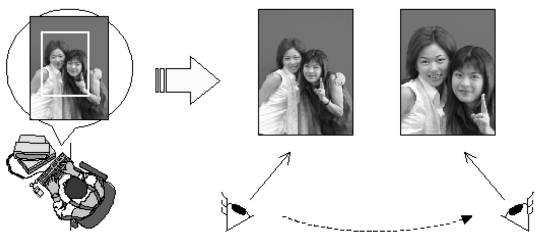

Figure 10. A zooming hologram

Conclusions

We developed a personalized holographic stereogram printing system. This printing system can print not only a reflection type but also an edge-lit type horizontal-parallax-only hologram image 30mm × 22.4mm on photopolymer film. We also developed both a flat type and a cylindrical type viewer for edge-lit holograms. Because an illumination light has been built into the viewer, a good image quality can always be enjoyed without dependence on the external illumination condition. We described consumer application examples. Those examples show that we can easily put personalized contents into the hologram by using our system. The printing function of our system can easily be applied to many other fields, including computer aided design, computer art graphics, visualization, medical imaging, identification and so on.

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Biography

Nobuhiro Kihara received his M.S degree in Physics from the Tokyo University at Tokyo, Japan in 1989. Since 1989 he has worked in the Research Center at Sony Corporation in Tokyo, Japan. In 1994, he stayed at the Media Laboratory in MIT as a research affiliate. His work has primarily focused on diffraction optics and holographic stereogram.