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# Trends of Research & Development of 3-D Display Technologies in Japan

Toshio Honda

Chiba University, Faculty of Engineering, Department of Image Science
and
Leader of Advanced 3-D Telecommunication Project,
Telecommunication Advancement Organization of Japan (TAO)

Abstract

In the presentation, I introduce outlines of the present reseaches and developments of 3-D display technologies tried in some organizations in Japan. The presentations are limited to hardware technologies and also the 3-D display methods of moving images.

## 1.Introduction

Many kinds of images can be easily dealt by computer systems according to the development of information processing technologies ( computer, memory, communication channel and computer peripherals ). Making and processing of ( virtual ) 3-D object are used in some areas, for example, virtual reality (VR), computer aided design (CAD), medical area (using CT images) and simulations in many scientific and engineering areas. As a result, the needs of th stereoscopic or 3-dimensional image display are increasing.

Another view is 3-D television. The standard of broadcast television in Japan is NTSC standard, same as Korea. New TV standard called "Hi-Vision" has been determined and broadcasted already in Japan. And as one of next TV systems, stereoscopic or 3-dimensional television system is expected.

By above mentioned backgrounds, research and development for 3-D images have started in recent several years by non-profit organizations, universities and private campanies.

Here, I introduce the recent researches concerning to 3-D display technologies by classifying the methods. The classification is 1.binocular stereoscopic display, 2.several viewing-points display, 3.many viewing-points display and 4.holographic display.

## 2.Binocular Stereoscopic Display

The principle of this method is as follows. One image taken (or will be viewed) from right direction is seen only by the right eye of the observer and another image taken (or will be viewed) from left direction is seen only by the left eye of the observer. These two images have parallax each other.

The topics of this method are two. One is the Head Mound Display (HMD) like a goggle. HMD is considered to be one of the key devices in movable virtual reality (VR) systems. For this purpose, light and compact devices using aspherical optics have been developed by Canon Co . and Olympus Co .. Both are see-through type.

Another is a parallax barrier type. Usually for this type, lenticular lens sheet is used for image separation. This type is frequently used for static image display, for example, picture postcard at sightseeing place. For video display, the liquid crystal panel ( LCP ) is attached by lenticular lens sheet. The display system in which the checkered pattern mask is used has developed by Canon Co.

The type using parallax barrier has been developed by Sanyo Electoric Co. called as " image splitter " type . This system needs no glass but the eye position is limited to narrow space, The panel size is about 12 inches.

The large screen projection type has been developed with eye position-tracking by ATR Visual Communication Laboratory . The image of LCP is projected on a large lenticular lens sheet.

The information quantity is just twice as the usual 2-D display. So, there are some commercially available closed-systems.

## 3. Several Viewing-points Display

Several images which are taken at few degree interval separation, are displayed only to the directions corresponding to the taken angles. The principle of this method is same as parallax varieer or lenticular lens sheet used in binocular stereoscopic method.

This method enables that the 3D images can be looked at according as the observer moves a little left and right. Two approaches have been tried.

### 3.1.Projection to Lenticular-screen Type

This 3D display system has been developed in NHK Science & Technical Lab. . The number of viewing-points is eight, and the display screen size is 50 inches diagonal. Two video projectors project four images, respectively to the lenticular-screen. The projector is for High Definition TV format ( HDTV or Hi-Vision ) and LCP projection type.

3.2. Diffractive Optics attached to Liquid Crystal Panel Type

This display system has been developed by Toppan Printing Co. . The principle of this method is shown in Fig.1. This figure shows the case that the number of the viewing-points is four. The light-bundle diffracted from one diffractive optical element ( DOE ) is emitted to the direction of the left-eye of the observer, for example. Then the light-bundle diffracted from the next DOE is emitted to that of the right-eye of the observer. Inventors call this DOE " Grating Image ". The LCP should have many pixels, the number of which is that of one image multiplied by the number of viewing-points. Full color 3D video display has been realized with 40mm x 40mm display size with nine viewing-points.

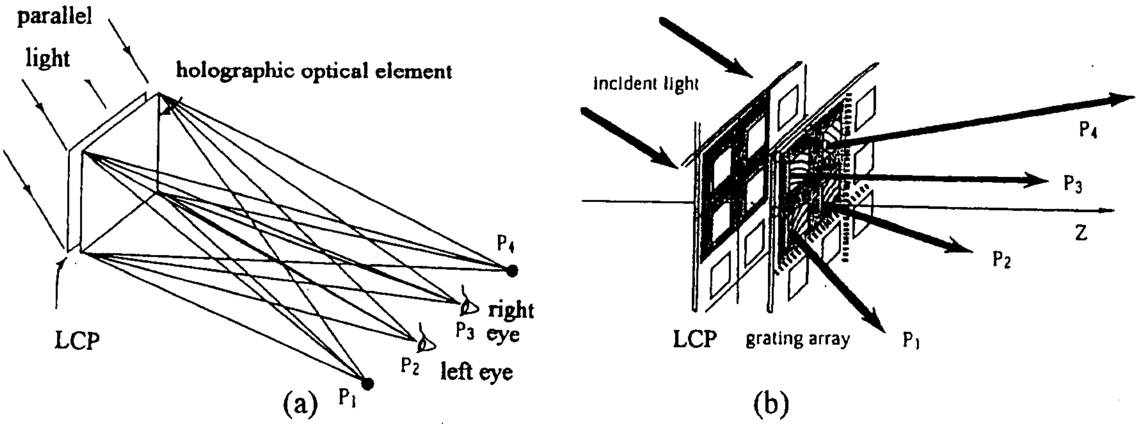


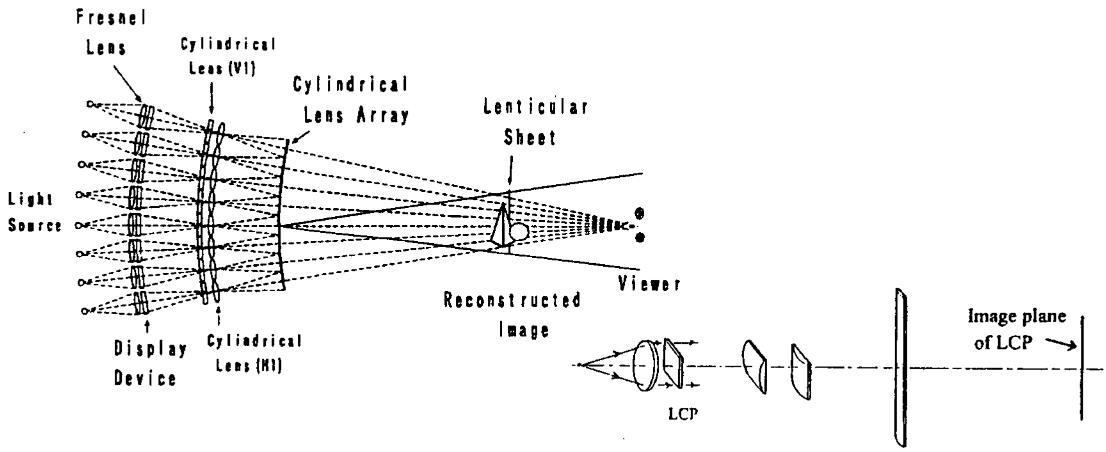

Fig.1. 3D video display system of Diffractive Optics attached to liquid crystal panel
(a) schematic figure of the system,
(b) magnified parts of each pixel and the directions of diffracted light bundles

4.Many Viewing-points Display

This method is what an observer can see more natural 3D video image by doing the separation angle of the interval of next viewing-point narrower, and increasing viewing-points images more. This realization is impossible by extending above-mentioned methods. New two methods has been researched in TAO 3-D Project.

4.1.Projection by Anamorphic Optics Method

This is realized by aligning horizontally special anamorphic optical units like a fan, as shown in Fig.2 (a). The number of the optical unit equals to that of viewing-points. The unit is narrow to horizontal direction and long to vertical one. Using anamorphic optical elements, the lateral magnifications to horizontal direction and vertical one of the projected image can be controled independently. One optical unit is shown schematicvcally in Fig.2 (b). The 3D display system has been constructed with 106 viewing-points and 260mm diagonal diplay size, by using special LCPs having high-resolution and big pixel number.




(a) (b)

Fig.2. The 3D display system using an array of anamorphic optical units
(a) aligning of the units like fan, (b) schematic figure of one optical unit

4.2. Scanning of Focused Light-source Array ( FLA ) Method

This display system has many point light-sources, and narrow light beams from every sources are focused to one point by aligning at narrow intervals like a fan. And, the focused point is raster-scanned by mechanical galvano-mirrors. The light-sources are intensity modulated synclonously with the scanning. One of FLA optics is shown in Fig.3(a), and aligned FLA is shown in Fig.3(b) and the schematic raster scan of FLA is shown in Fig.3(c).

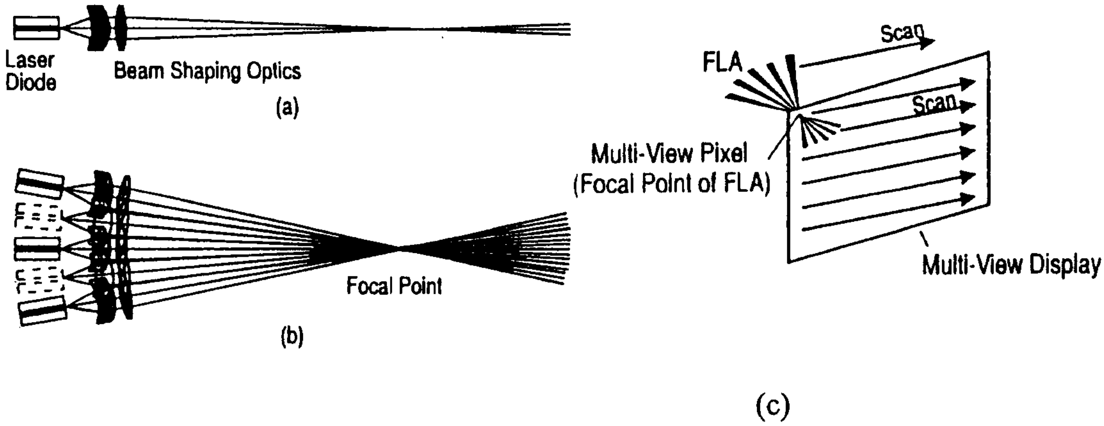



Fig.3 schematic figure of the scanning FLA method. (a) one unit of FLA optics
(b) alignment of the unit, (c) raster scanning of FLA

The principle of 3D diplay is mentioned in the case of one-point object. In Fig.4 (a), first let's consider the FLA is positioned at a point A. Then, one unit source, light beam from which enters to the left eye of the observer, emits light and all other sources except the unit do not emit light. Next, the FLA moves at point B, only one unit source, light beam from which enters to the right eye of the observer, emits light. If the speed of the move is high, the observer recognizes the point image at the position I shown in Fig.4. When the

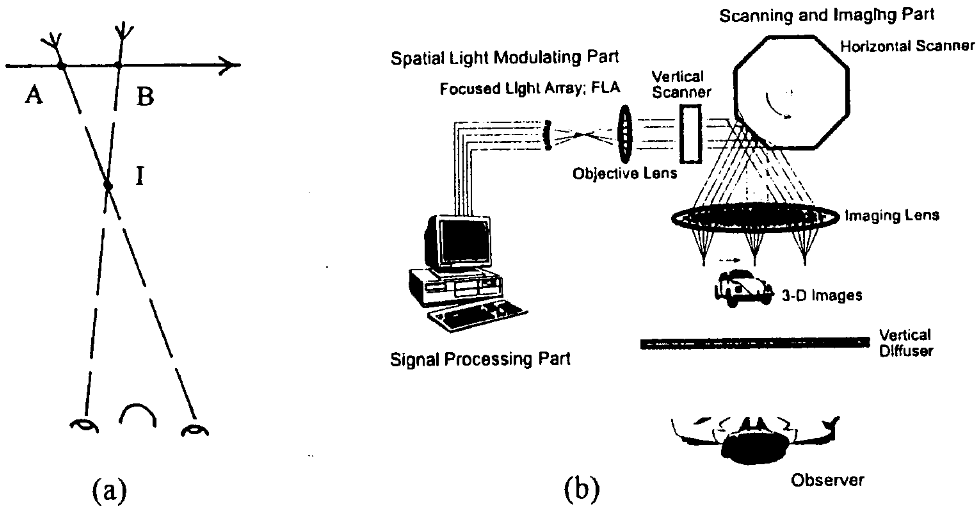



Fig.4 principle of 3D display and schematic figure of the FLA system
(a) figure for explaining the principle of 3D display
(b) shematic diagram of the display configulation

FLA is at the intermediate position of A and B, the emission is controled so as the similar condition is satisfied. As a result, if the observer moves a little left and right, he looks at the bright point I naturally.

45 viewing-points 3D display system has been developed with 220mm diagonal size display area. The system is compact size and can be moved easily.

## 5. Holographic video Display

Holographic display is said to be one of ideal 3D image display methods. Static 3D image display by thes method has been successfully developed using high-resolution recording materials like silver-halide, photo-polymer and dichromated-gelatine. And white-light reconstruction type hologram like rainbow hologram and Lippman hologram are used in almost display hologram.

But, the extension to video system of holographic display is very diffcult, in both input side and output ( display ) side. First, the research of display side has been tried. The drive-signal can be made by computing the interference pattern. The computing has been researched by many researchers as computer generated hologram ( CGH ). And, holographic video display is positioned as one of 3D displays of virtual object made by CAD (computer aided design ) system.

The device for the hologram should have a function of spatial amplitude or phase modulation of laser light. First, acousto-optical modulator has been tried as one-dimensional modulator . Here, I report the use of liquid crystal panel as the modulator.

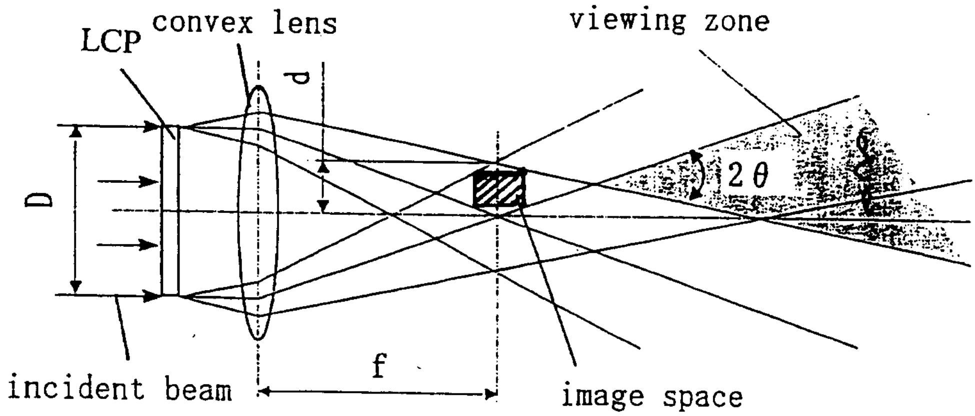



Fig.5. schematic figure of optical set-up for holographic display using LCP

Optical system is shown in Fig.5 in the case of 3D image display, so called Fourier Transform hologram configuration. The viewing angle shown $2\theta$ in the figure is important for the display. In this configuration, the LCP which has very small pixel size and very large panel size is inevitable for the display with large image size and wide viewing angle.

3D project in TAO has using the special LCPs for this purpose in co-operation with Citizen Watch Co.. The specification of the panel is that pixel pitch is 28 x 56 micro meter, panel size is 90 x 54 mm. By jointing several above-mentioned panels optically using half-mirror combiner, equivalent panel size can be widened. This configuration is shown in Fig.6 . By this, the display has been realized with about 200 mm diagonal image size and about 6 degree viewing angle. But the system is now a bread-board model and very large.

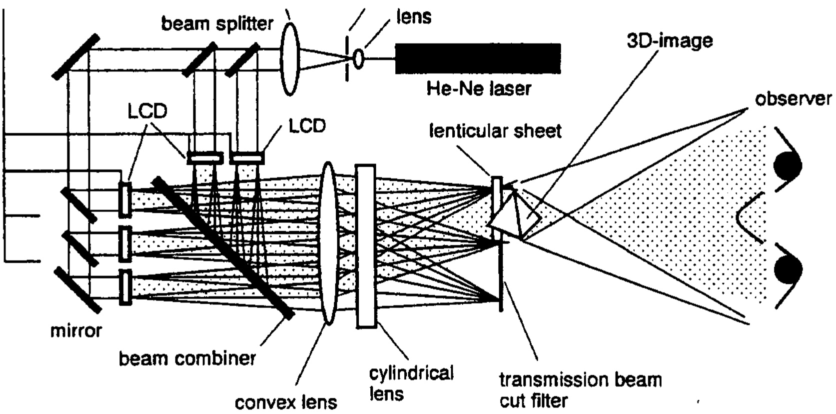



Fig.6. shematic diagram of holographic display combining 5 LCPs by half mirror

6.Finally

I introduced the trends of researches od 3D video display in Japan, in very short space. And only the out-line of each research was mentioned. If you want to know about some researches deeper, please read references and contact to each persons or groups.

Reference

1. Shoichi Yamazaki; Super Compact HMD with Sight Line Input, KOGAKU, 25, p.2-7, (1996), in Japanese