Spinning-disc 3D Television

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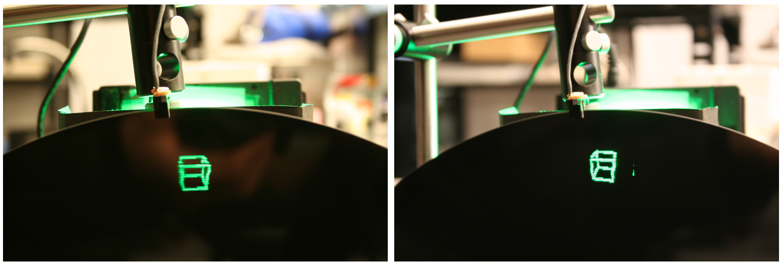

Figure 1: *Image of Spinning-disc 3D Television(Left), Looking from another angle(Right)*

1 Executive Summary

In this work, we have incorporated a novel LED-projection technology into the simple structure of a spinning-disc television. In order to display a 3D image, we have replaced the conventionally used light bulbs with an LED array. With the aid of this technology, users can view different images from different viewing angles.

2 Project Overview

The transmission of three-dimensional (3D) images can be used to create the visual experience of people and objects at remote locations sharing the same spatiotemporal space. In other words, 3D image transmission technology can eliminate the boundary between spatial and temporal domains. Our ultimate goal is to develop an image display technology that can eliminate the distance between two spaces so that users perceive the 3D presence of an object.

Toward this goal, we have previously developed TWISTER[Tanaka et al. 2002] and Seelinder[Endo et al. 2005] to realize an autostereoscopic display without the need for wearing any special equipment. The present work extends the abovementioned prototypes toward reconstructing a more natural 3D "presence" of objects. The first spinning-disc television system was publicly demonstrated by J. L. Baird in 1926[Tiltman 1933]. This system realized the spatial transmission of two-dimensional visual information. Baird was also the first to invent a stereoscopic display that employed the same method. The attractiveness of this method lies in the fact that the resulting reconstructed images are sufficiently realistic for the user to perceive the presence of an object. In this work, we have incorporated a novel LED-projection technology into the classical structure of the spinning-disc television. In this system, the light rays around an object are first acquired. Each of these light rays is then projected in order to reconstruct the motion parallax and the binocular stereopsis. The system can use this process to acquire, reconstruct, or even deform volumetric visual information at a remote location. The visual experience provided by this system can overcome spatial and temporal distances, thereby enabling the convergence of the entire on the same visual plane.

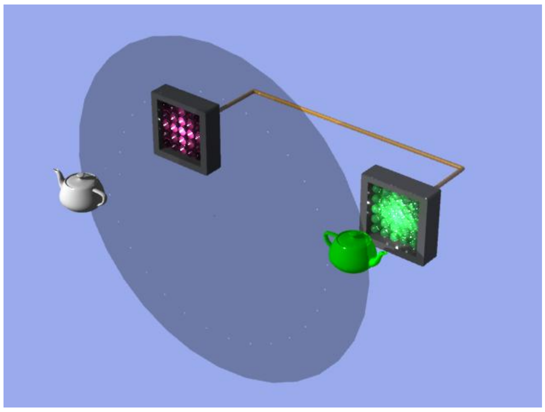

Figure 2: *Diagrammatic illustration*

3 Vision

A spinning-disc 3D television can improve 2D image display. This system displays not only a flat image but also one that is in spatial motion without the user having to wear any special glasses. People can view the correct 3D video image from their individual viewing positions.

This system will be used for installation art work. In the future, this system might serve as the foundation for the development of 3D display systems.

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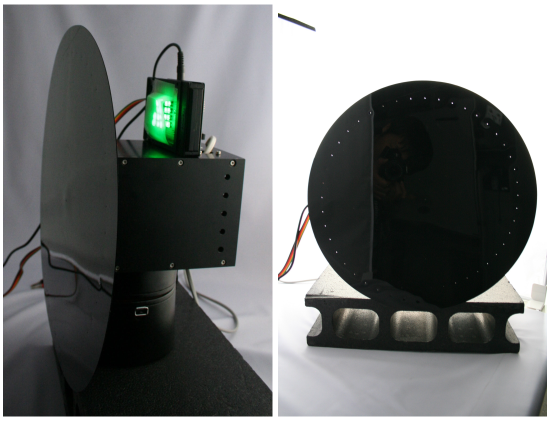

Figure 3: *Implementation of the system*

4 Technical Innovation

The system displays multiple images based on the viewer's line of sight. It can display both horizontal and vertical parallax. Currently, the system can display twenty monocolor images simultaneously. Plans are currently underway to develop this system further so that it displays eight by eight full-color images. The system can capture the images by the camera part. In addition, it can display moving images. Figure 2 show a diagrammatic illustration of the system.

This system comprises three components:

- spinning disc with holes
- LED array for displaying multiple images
- photo diode array for capturing multiple images

The spinning disc, also known as the Nipkow disc, controls the rays of light, which pass through its hole. The rotating disk has holes arranged in a spiral formation around its circumference. The light that passes through the holes as the disk rotates produces a raster scanning pattern with a rectangular area. As a result, the disc can convert the time-line light intensity from a scene for image capture or convert an image from the time-line light intensity for image display.

The LED array can display multiple images simultaneously. The conventional Nipkow disc employs only a single bulb, and it can display only a single image. In this new system, however, each LED element displays different images and an observer can view different LED elements through the hole in the disc.

The photodiode array captures different images by the same method as that employed by the LED array. Conventionally, the photodiode array employs only a single light detector, which is placed behind the disc. In our system, however, each viewing direction has a separate light detector array.

With the aid of these components, the system can display multiple parallax images.

4.1 System Configuration

We have developed a prototype display system (see Figure 3). This prototype system has a 380-mm-diameter Nipkow disc with 45 holes. It has twenty LEDs placed behind the disc, and the observer can view twenty different images from his/her viewing position. The screen resolution is 45 $\times$ 45 pixels (see Figure 1). The frame rate is up to 20 frames per second (fps), and the screen size is 25 mm $\times$ 25 mm.

The Siggraph version will have a larger disc and higher resolution. In this system, the LED array will have a 64-pixel resolution and the observer can view 64 images. The photo sensor array will also have a 64-pixel resolution, similar to the LEDs.

Therefore, 64 different images can be captured and displayed. The frame rate of this system will be up to 30 fps.

5 Context

Thus far, many systems that can suitably realize stereoscopic and multiple parallax displays have been proposed. Among stereoscopic systems are several varieties of head-mounted displays (HMDs)[Sutherland 1968] and immersive multi-display units such as CAVE[Cruz-Neira et al. 1993]. These systems require the observer to wear special glasses for stereopsis. However, observers would find it more convenient to view a display without wearing special glasses. In order to circumvent this problem, parallax barriers and lenticular lenses have been used in a number of systems. We developed TWISTER[Tanaka et al. 2002], an immersive autostereoscopic display. This system works as a cylindrical display by rotating 36 display units around the observer while preserving the time-varying patterns. Each of these display units contains two LED arrays, one vertical 1D array for each eye, and a thin barrier. The units rotate at a speed of about 100 revolutions per minute (rpm), and the controller synchronizes the display update to create an effective frame rate of 60 fps. With this system, the observer can view a stereoscopic image in 360° without wearing special glasses. We also developed Seelinder[Endo et al. 2005], a cylindrical rotating display with a parallax barrier. With this system, the observer can view 3D images from 360° without wearing special glasses. Next, we examine the possibility of realizing a flat-panel-type multiple-parallax image display. Many types of flat stereoscopic display systems that do not require the observer to wear glasses are available[HAMAGISHI et al. 1996]. These systems display multiple images along multiple directions. Therefore, an observer can view stereoscopic images. However, in this system, there is a trade-off between the number of directions and the resolution. If the system displays a horizontal and vertical parallax image simultaneously, the resolution decreases significantly. The spinning-disc television was invented by J. L. Baird almost 80 years ago in 1925. Baird conducted a public experiment of the system in 1926. The spinning disc is also known as the Nipkow disc. We found that the spinning disc can be employed in a system to display multiple parallax images. We therefore extended its application to 3D television.

6 User Experience

We will install a disc that is approximately 2.5 feet in diameter along with an LED array. All the components will be covered with transparent safety shields. The observer will be able to view computer graphics and camera images. Each image would move and alter the scene automatically, and each observer would require about one or two minutes to complete this procedure.

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