Laser produced 3D Display in the air

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1 Key Points

We have used laser produced plasma technology to make a flashpoint in the air. We have greatly improved the brightness, contrast, and production distance of the plasma by optimizing the laser beams. Using laser plasma, we have been the first to succeed in displaying "real 3D images" in a space where there is nothing but air.

2 Synopsis

We have succeeded in the experimental fabrication of a device displaying "real 3D images" which consist of dot arrays in space where there is nothing but air.

Most of the 3D displays reported until now draw pseudo-3D images on 2D planes by utilizing the human binocular disparity. However, many problems occur, e.g., the limitation of the visual field, and the physiological displeasure due to the misidentification of virtual images.

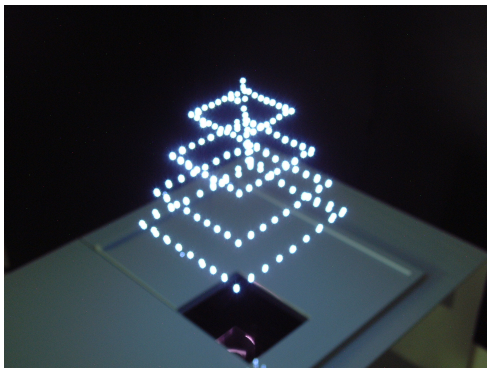

Figure 1: A 3D-object displayed using a 3D-image spatial drawing device we have developed.

The device we have developed utilizes the plasma emission phenomenon near the focal point of focused laser light. By controlling the position of the focal point in the direction of the x-, y-, and z-axes, we have succeeded in displaying real 3D-images constructed by dot arrays in air (3D-space).

3 Background of our Research Work

Our living space is three-dimensional, and all the things which exist therein are also three-dimensional objects. Of course there is an abundant amount of information on 3D-images on the Internet, but we hardly ever see "real 3D-images" reproduced from this electronic information. This is because we have no electronic devices enabling us to display real 3D-images.

In fact, some 3D-displays enabling us to deal with 3D objects have been reported, but most of them display pseudo-3D objects on 2D devices by utilizing the human binocular disparity, inducing many problems which it is essential to rectify, e.g., the limitation of the visual field, and the physiological displeasure due to the misidentification of virtual images.

4 History of Research Work

Taro Uchiyama and Burton Inc. noticed a phenomenon that, when laser beams are strongly focused, air plasma emission can be induced only near the focal point. Thereby, they succeeded in the experimental fabrication of a device displaying 2D-images in the air, which are constructed from dot arrays produced using a technique combining a laser light source and galvanometric mirrors. To further form 3D-images in the air, the scanning of the focal point in the depth direction along the laser optical axis is essential. However, for such a purpose, the quality of the laser and the technique for varying the position of the focal point must be improved, and thus as yet there are no 3D display devices.

5 Details of Research Work

We have succeeded in a spatial display of "real 3D images" consisting of dot arrays using a device which is made by additionally incorporating a linear motor system and a high-quality and brightness infrared pulse laser into the 2D display device mentioned above.

The linear motor system enables the position of the laser focal point to be varied by high-speed scanning of a lens set on the motor orbit. Incorporation of this system makes the image scanning in the direction of the z-axis possible. For scanning in the x and y axis directions, conventional galvanometric mirrors are used.

The laser light source we used in this work is a high-quality and high-brightness infrared pulsed laser (repetition frequency of pulse: approximately 100 Hz), by which plasma production can be more precisely controlled, enabling brighter and higher contrast image drawing. In addition, the distance between the device and drawing points can be greatly extended (several meters).

The emission time of the laser pulse light is on the order of a nano-second (10^{-9} sec). Our device uses 1 pulse for each dot to that the human eye can recognize plasma emission by utilizing the after-image effect, and enables a 100 dot/sec display.

By synchronizing these pulses and controlling them with software, our device can draw any 3D objects in air.