Fairy Lights in Femtoseconds: Aerial and Volumetric Graphics Rendered by Focused Femtosecond Laser Combined with Computational Holographic Fields

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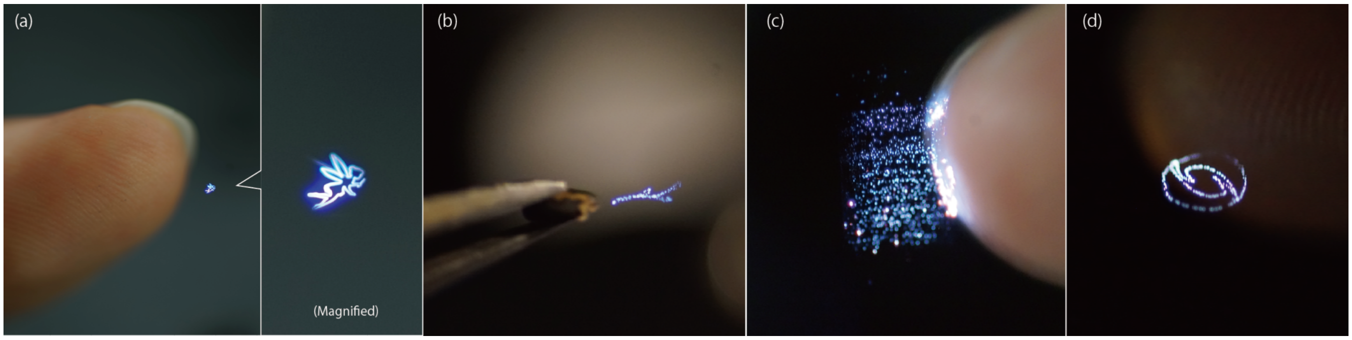

Figure 1: *Application images of Fairy Lights in Femtoseconds, aerial and volumetric graphics in air rendered by femtosecond lasers. (a) A "fairy" flying in front of a finger. (b) A "sprout" coming out from a seed. (c) Interference between a point cloud and a finger. (d) The SIGGRAPH logo.*

We envision a laser-induced plasma technology in general applications for public use. If laser-induced plasma aerial images were made available, many useful applications such as spatial aerial AR, aerial user interfaces, volumetric images could be produced. This would be a highly effective display for the expression of three-dimensional information. Volumetric expression has considerable merit because the content scale corresponds to the human body; therefore, this technology could be usefully applied to wearable materials and spatial user interactions. Further, laser focusing technology can add an additional dimension to conventional projection technology, which is designed for surface mapping, while laser focusing technology is capable of volumetric mapping. This technology can be effectively used in real-world-oriented user interfaces.

High-intensity lasers are used to generate voxels in air (Figure 2). The basic concept was demonstrated using a nanosecond laser and a rendering speed was 100 dot/sec [Kimura et al. 2006]. Later, adoption of a femtosecond (100 fs) laser and 1,000 dot/sec was achieved [Saito et al. 2008]. The color of voxels was bluish white because of plasma emission.

In this study, we use femtosecond lasers with pulse width of 30-100 fs and rendering speed of 1,000 dot/sec, and 269 fs and 200,000 dot/sec, to explore the design space of laser-plasma vlumetric display. Femtsecond lasers generate calmer and safer plasma than nanosecond lasers, which can be incorporated into our daily lives. A galvano mirror and a varifocal lens are used to manipulate the laser beam. In addition, a spatial light modulator (SLM) is used to produce various spatial distributions of light based on interference.

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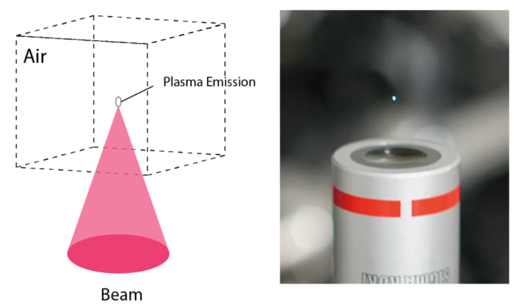

Figure 2: *Plasma induced by focused femtosecond laser.*

A liquid crystal SLM (LCSLM) is used in this study, which contains a nematic liquid crystal layer. The molecule directions within this layer are controlled by electrodes, i.e., pixels, and the phase of light ray reflected by each pixel is modulated according to the direction of the liquid crystal molecule. In other words, this device acts as an optical phased array.

Figure 1 shows example images rendered in air by a femtosecond laser. While the instantaneous intensity is sufficiently high to induce a plasma in air, the time-average intensity of a femtosecond laser is so weak that a user can instantaneously touch the plasma images with a finger. The damage on the skin is negligible.

References

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