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RESEARCH ARTICLE

PRODUCTION OF HOLOGRAMS THROUGH LASER- PLASMA INTERACTION WITH APPLICATIONS

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Abstract

This review paper covers extensive research on the production of holograms through laser plasma interaction. The concept involves production of plasma trails through femtosecond laser pulse and capturing them through charged coupled device. This particular paper also revolves around the procedure and principle of Touchable holography. It lays emphasis on tactile display that is the primary requirement for touchable holography and also throws light on hand tracking and applications of the same.

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Introduction:-

Through everyday life, increasing application of holography will soon find the way. With the help of holograms nowadays most stunning 3D images and movies are being created. The creation of computer-generated holograms has resulted in artificial holograms which are made by the means of numerical methods in which recorded and reconstructed image is delivered to the computer. But due to the high cost, they have become impractical for many applications. However, 3D display will become a common substitute in the near future with the decrease in computer hardware cost. In the field of Biology, IT, Medicine, Communication, Security, Architecture and stuffing, holography has found its vast application. To provide a realistic image to support special eyewear making a holographic three-dimensional display is one of the most interesting applications of holography. By using large area photo refractive polymer and very high deflection productivity and excellent three-dimensional holographic telepresence system has been made to provide better user interaction. For remarkable 3D information recording and display, updatable holography has proved as the most significant technique. The following topics will cover a theoretical and practical study on forming 3D images by utilization or application of holography.

Generation Of Plasma Trails

Plasma Trails

The femtosecond pulse laser is an ultrashort laser beam having time duration in the order of 10^{-15} second. Due to their property of having broadband optical spectrum and high power, femtosecond laser pulses are used in creating plasma trails. When the laser pulse incidents on a material or is focused in air, it excites the species (electrons) present inside the material or gases (air) and plasma trails are formed. The probe pulse on the other hand after having a variable delay passes through the excited species and monitors its spectral lines in excited state [1].

The probe pulse is generally used to monitors the spectral lines of materials in both excited as well as ground state and to establish comparison between them.

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Charged Coupled Device

A charge coupled device stores and displays data of an image through a sensitive-integrated circuit. It converts each pixel in an image into an electrical charge. The intensity of this electrical charge is related to a color in the color spectrum. The underlying principle of charge coupled device is photoelectric effect. The upper plate of CCD is made up of silicon which has a great tendency to lose electrons. When a photon strikes the silicon plate, the electron excites and becomes free to move. Meanwhile, capacitor is placed below the silicon plate to store these free electrons. This silicon plate and capacitor sandwich is miniaturized in an integrated circuit which collectively known as a pixel. A CCD consists of many such pixels. When the shutter is closed, the voltage across the capacitors denotes the no. of electrons the capacitor collected. This information is guided to the computer. Filters are used for colored images.

Holographic Footage Of Laser-Plasma Interaction

Principle

The production of holograms through laser plasma interaction begins when a Ti-Sapphire laser amplifier functioning at 800nm wavelength splits into two with an energy and pulse width of 2mJ and 150 fs FWHM respectively. The pump beam having a major share of energy which is approximately equal to 1.5mJ, is focused with an achromatism lens (F=5cm) after a flexible delay. The highest power of the pump pulse is 10GW which is six times more than critical power of 1.8GW of self-focusing in air. The plasma trail produced is captured by the probe pulse that spreads in a path perpendicular to the pump beam. The probe pulse after recording the plasma trail passes through two lenses of focal length F1 and F2 that magnifies the images by factor $F1 \cdot F2$ before meeting CCD. We capture a hologram which is an in-line [Gabor] with the help of CCD camera which is due to the interference amid the diffraction of the plasma dispersal and the probe beam [1].

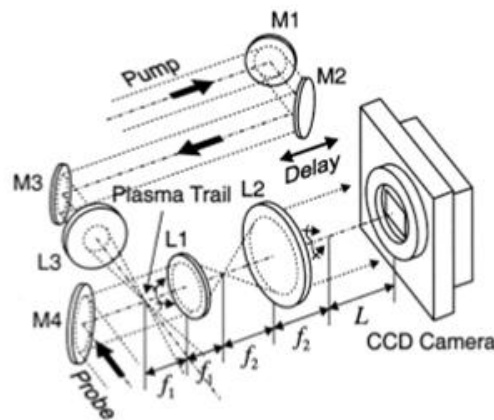


Figure 1:- An intense femtosecond laser pulse is focused by L3 and leaves a Plasma Trail.

Transmission Holography

1. In the process to make a transmission holograph, an experiment is performed. In this experiment, setups of two kinds are used for, first is off-axis solo beam and second is split beam arrangement which has been shown in figure 2 and 3, respectively. To record holograms usually the coherent laser sources are used but by using small coherence light sources, it is also possible to record the hologram.[2]
2. To get the desired result, the strength of the reference wave must be greater than the object wave which is a mandatory factor in diffraction efficiency. Hence, 4 ratio 1 relation was being used for this experiment. The coherence length of the source laser should be greater than the path difference between the reference wave and the object wave. The Silver halide emulsion plate is used as a holographic plate which is illuminated by continuous wave lasers. Some more specifications of the plate or the typical grain size is 40 nm and 7 micrometers is the emulsion thickness with refractive index of 1.61 and silver halides mass per unit area is 2.7 gram per centimeters cube. [2]
3. Helium-neon laser of 1.5 megawatt is used as a source laser and the object can be any. If the object preferred for recording is very large or very small or even translucent, the observer must use the recommended procedures to obtain its holography. Now to perform the exposure procedure the plate is detached from its place and exposed in green safe light.[2]
4. This procedure includes two main steps which are developing and bleaching over the previous processes that mainly comprises three steps emerging, bleaching and fixing. The pictures are visible in the exact red colour of

the Helium neon laser. The simulated image is ortho-scopic in nature and is formed behind the plate while the real or actual image is pseudo-scopic and is constructed in anterior of the plate. The Hologram is illuminated with the reference wave which is conjugated to obtain the real image of the object.[2]

5. Now the Hologram that is reconstructed is coloured but mostly have homochromatic images. In order to capture and reconstruct a hologram which is in 3D shape as well as is multicolored, we at least need 3 laser wavelengths to produce them.[2]

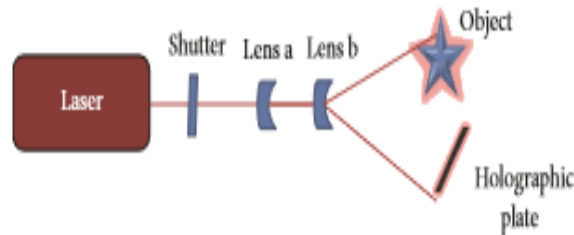


Figure 2:- Off-axis single beam setup.

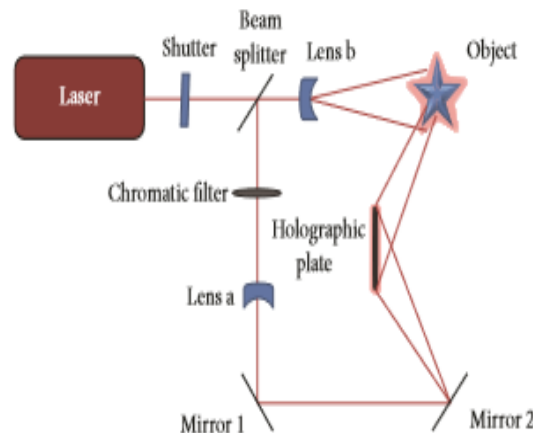


Figure 3:- Split-beam setup.

Touchable holography

In science fiction movies for several decades mid-air presentations, which show moving images in space which are free have been extensively shown and have attracted a number of audiences across the globe. Recently, in the arena of digital Signage and home-based TV, they are fascinating to audiences as promising Technology where many types of holographic displays are developed and proposed. A virtual object which is hovering can be easily seen by the observer but the extraordinary experience is shattered the moment when the observer reaches for it and he feels no sensation on his hand. The primary requirement to the airborne image in 3D free space is tactile feedback which is one of the biggest issues for scientists. The tactile sensation requires the observer's interaction by nature and appearance of holographic images is depressed by the presence of a stimulator in the workspace. This raises the urgency of some type of Remote-Control label tactile sensation. In this particular section of this report how tactile display can lead to tactile sensation is thoroughly discussed paving way for a very new kind of technology which is known as touchable holography.[3]

Principle

By utilizing or using a concave mirror a floating image from an LCD is provided by holographic display. 30 cm far from the area of the display, the projected image is formed. In order to touch the projected image, the observer can get close to the image and can try to sense it with the help of his hands. Without tactile sensation, it is very obvious that the observer's fingers will pass through the projected image.[3]

Tactile Display

1. The tactile sensation on the observer's hand is provided by an airborne ultrasound text-style display. The nonlinear phenomenon of ultrasound along with acoustic radiation pressure is the guiding principle for this textile display.

$P = \alpha E$, where E is the energy density of the sound and α here is a constant usually ranging from 1 to 2 which highly depends on the reflection coefficient at the surface of the object and P represents the acoustic radiation pressure. The propagation of the ultrasound is in the same direction where the acoustic radiation pressure is acting.[3]

2. Hence, we can say that the object is being pushed by the ultrasound. The equation stated above suggests that the wave field synthesis can be used or utilised to cut through the spatial distribution of the pressure. The observer can sense the tactile sensation on their bare hand. When the ultrasound is being radiated by the tactile display in free space with no direct contact.[3]
3. 324 ultrasound transducers have been installed in the recent version of prototype with resonant frequency of 40 kilohertz to generate 1 focal point and to move it in three dimensions, the phase delay and amplitude of the respective transducers are controlled individually. Sufficient vibrations of 1 kilo hertz can be produced by using this prototype.[3]

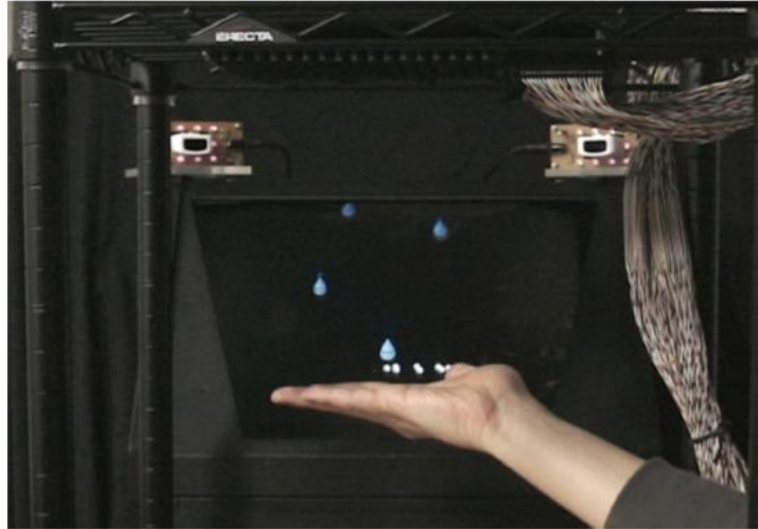


Figure 3:- Developed interaction system. An aerial imaging system, a non-contact tactile display, and a Wiimote-based hand-tracking system are combined.

Hand Tracking

For the hand tracking system Wiimote which is an infrared camera is used for this purpose, just for simplicity, as there are many camera-based as well as pointer less hand tracking systems that are in fashion these days. The observer's middle finger is attached with a retro reflective marker which is illuminated by IR LED. The 3D position of the finger is sensed by the two Wiimotes. The user or observer can handle or control the virtual image which is floating with their bare hands by using or considering this hand tracking system.[3]

Applications

This particular Technology enables visual as well as Tactile sensation to be refreshed based on the data which is digitally provided. Hence the developed system can produce various virtual objects. From video games to 3D CADs, this system has found its vast application. For instance, a demo has been provided. In this demo the user's palm is hit by the raindrops and he can feel the textile sensation which is formed by the ultrasound. In another demo the virtual creature crawling on his Palm can be easily seen and felt by him.

Conclusion:-

Many projects such as Voxels, which are interactive, three dimensional holograms made up of tiny points of light plasma have been created by researchers at Digital Nature Group by using laser-plasma interaction. Femtosecond lasers with resolution up to 2 million dots per second are used for accomplishing fairy lights This project is completely harmless to the observer or the experimentalist as the bursting of Plasma is so rapid that touching them won't burn him or her. From retrieving lost database to improve surveillance , the concept behind the technology which is presented in this paper has many potential to revolutionarise the virtual world.

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