An Exploration of Holography via Creation of Various Holograms

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1 Introduction

When talking about holograms, most people think of the three-dimensional image that is projected from a device since this is how it is being depicted in popular media. However, hologram is the complete opposite of this notion. A hologram is, in simple terms, an two-dimensional image with depth. It records the interference patterns formed between a light source of constant wavelength and a light source of the same wavelength is reflected from an object. There are two main types of holograms: reflection and transmission. In this experiment, both types of holograms were created. Further explorations were made by creating diffraction grating using holography, two-channel transmission and reflection holograms, and copying hologram.

1.1 History

Before diving into the experiment, it is interesting to discuss the history behind it. Dennis Gabor, a Hungarian-British physicists, discovered electron holography, holographs constructed with electron waves, when he was trying to improve electron microscopes. However, the first optical holograms that is of a 3D objects were constructed independently by Yuri Denisyuk, a scientist in Soviet Union, and Emmett Leith and Juris Upatnieks at the University of Michigan. Denisyuk constructed a different arrangement, where the reference and the object beams were opposite but remained incident to the emulsion. His arrangement led to what is now called reflection or Denisyuk's hologram.

Leith and Juris were unaware of Denisyuk's work. Leith and Juris were working on developing advanced radar imaging system. Having read Gabor's work, Leith and Juris knew the issues with spurious image, later known to be an aliasing artifact, as mentioned by Gabor. In an effort to reduce the aliasing artifact, Leith and Juris changed the arrangement by offsetting the source or reference beam through the usage of a prism. The prism will deflect the reference beam such that the reference beam and the object beam will still interefere at the the holographic plate. Since Leigth and Juris were working under security, their works couldn't be published for a while, and thus, could not be reached to Gabor or Denisyuk,

1.2 Transmission and Reflection Hologram

Two types of holograms were constructed in this experiment: transmission and reflection. The between these two types is the location of the recording medium with respect to the object and reference beam. In transmission hologram, the object and reference beams are facing the recording medium at the same side. This allows for greater flexibility with arrangement, such as the usages of multiple mirrors. Because of the flexibility, transmission hologram can have a wider viewing image than that of reflection Hologram.

In reflection hologram, the object and reference beams are facing the recording medium on opposite side. In other words, the reference beam and the object beam are propagating towards each other. One advantage of reflection hologram is that it can be viewed using a white light source. This is because of Bragg's angle, which allows viewing with sources of partially filtered white light. With the fringe plane almost parallel to that of the recording medium, Bragg diffraction is the main factor for image formation.

2 Setup

The plates, films, and developer agents were obtained from a small company, known as Integraf. The holographic plates and films were model PFG-01 and PFG-03. The chemical kits used to developed these two models were JD2 and JD4 respectively.

For transmission hologram, a diode that produced a stable and divergent beam beam of 3.0 mW. The diode is mounted on a long post, with a clamp holding the diode in place. The diode is mounted at an angle such that the beam illuminates both the plate and the object. The plate and the object are placed 45 degree relative to each other, with the emulsion side, the side of which the hologram is being encoded, of the plate or film facing towards the object. A cardboard box is placed in front of the beam so the beam doesn't hit the plate before exposure, similar to that of a shutter. The setup can be seen in figure 1. A green safety light is turned on with all other sources of light in the room turned off. All noises should be minimized, as noises influence the development of hologram. After 10 seconds of waiting to minimized vibrations, the plate or film is taken out of a drawer and carefully placed in position without light source touching the medium. After 5 seconds, the cardboard box was removed. The recording medium were exposed to about 30 seconds before gently placing the cardboard box in front of the beam. The plate or film is developed in the chemicals with the emulsion side facing up. The plate and film is dry in a dark room.

For reflection hologram, the arrangement is changed such that the diode is facing the object head on. The plate or the film will be placed in front of the object in between the object and the diode, with the emulsion side facing towards the object. The arrangement can be seen in figure 2. The process of developing the hologram follows that of the transmission hologram, as stated above. The only difference is that the exposure time is reduced to 10 seconds.

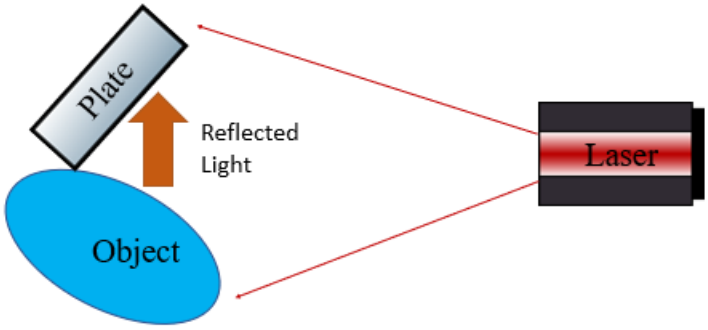

Figure 1: Transmission Hologram Setup. The cardboard box will be placed in between the diode and the plate and object. The box will block the all of the light coming from the diode towards the object and the plate

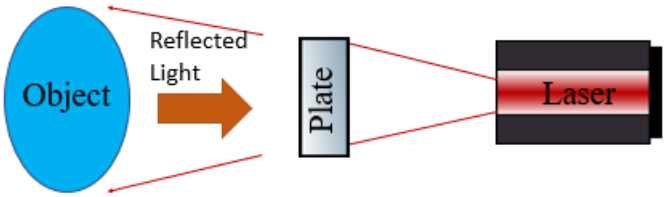

Figure 2: Reflection Hologram Arrangement. The cardboard box will be placed in between the diode and the plate such that the box block all light coming from the diode onto the plate.

3 Results and Discussion

Several holograms of each type were created successfully. Various objects, ranging from coins to small action figures, were encoded onto holographic plates and films.

Further exploration can be done with the successful creation of multiple holograms. The creation of dual-channel holograms were in the works but could not be completed by the end of the projects. Essentially, we were trying to encode two different images onto the same plate or film by rotating the recording medium itself. Further work can be explored in attempting to construct an hologram of another hologram using the same wavelength.