International Journal of Internet, Broadcasting and Communication Vol.12 No.4 128-136 (2020)
http://dx.doi.org/10.7236/IJIBC.2020.12.4.128

IJIBC 20-4-16

A Feasibility Study on the Lifelong Education Program of Holography Using Simple Hologram Making Tools

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Abstract

In this paper, we presented a simple hologram recording set for learners to broaden their program choices and experience holographic techniques with lifelong education programs. In order to obtain quality 3D images, the quality of light sources and recording mediums, which are the main elements of hologram recording, must be good. In addition, due to the characteristics of the hologram, the ambient vibrations shall be minimized for accurate interference pattern recording. The simple hologram recording set presented in this paper has not significantly restricted in space and location, and anyone can easily experience it at a reasonable price compared to the existing hologram production method. Also, it can make two different type of hologram (transmission and reflection) for providing easy access to recording and reconstruction of the hologram. Experiments have shown that holographic manufacturing practices are a very useful way to educate the public on optics and photonics technologies.

Keywords: *Holography, Hologram Making Tools, Kits, Hologram, Education*

1. Introduction

Human beings are born and raised as social animals and play a role as a member of society through education, learning and training. The expansion of computers and mobile devices and the development of the Internet give human creativity and economic advantages to devote to self-development. Also, the size of the economy and advances in medical technology are prolonging the average human life span. Therefore, the increase in human leisure time is often applied to learn and train not only to improve hobbies and specialties but also to

Manuscript Received: August. 28, 2020 / Revised: September. 5, 2020 / Accepted: September. 9, 2020
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find employment and skills. According to Article 2 of the Lifelong Education Act, lifelong education is defined as "all forms of systematic educational activities, including education supplemental education, adult basic and literacy education, vocational ability improvement education, liberal arts education, cultural and arts education, and civic participation education, excluding regular education courses in schools." Lifelong education is education that is done through human life education and lifewide education. Paul Lengland said that vertical education such as infant, boyhood, youth, adult, adult, and seniority, which means cradle to grave, and integrated education with horizontal education such as home education, school education, and social education are needed [1].

Recent breakthroughs in imaging technology can almost record information of any object in nature as a two-dimensional plane image through a camera lens. It is also integrated with high-tech technologies so that it can feel real in augmented reality and virtual reality. In order to watch current 3D or Virtual Reality (VR) images, auxiliary tools such as glasses for 3D and Head Mounted Display (HMD) are needed, respectively. Wearing a device can cause dizziness and discomfort. Holography is a technology that can eliminate such discomfort and produce real-world 3D images in space and see them with both eyes.

For hologram education, laser, holographic recording medium, vibration absorption table, and optical elements such as lenses, mirrors, and space filters are needed. There shall also be a separate laboratory with curtains ready to block the light. In order to have a perfect laboratory, there are economic constraints. Therefore, there are few places where people who first know the hologram can experience the hologram record. Holographic education is occasionally conducted but is often limited to one session and not continuous due to the absence of a place. Although there are kits that can experience holograms online in Korea, most of them are for pseudo-holograms. It is not a kit that can record real 3D images based on optical technology.

Overseas, two manufacturers have developed and marketed holographic kits [2,3]. In Portugal, a pilot study was conducted to evaluate holography as a strategy for education and training in optics. In order to expand the study, a school network called "Holonet" was established. The laboratory of the University of Aveiro in Portugal has been led by the development of holographic systems and educational materials, and for the first time it has started as an official school education [4-6]. In Korea, however, hologram education has yet to take place during regular or non-regular education. Therefore, in this paper, a simple hologram recording set is proposed that can utilize holography as a school education or as a lifelong education program for the general public. Experiments using the hologram recording set was conducted, and the results showed that quality holograms can be produced using simple tools.

2. Holography Technology

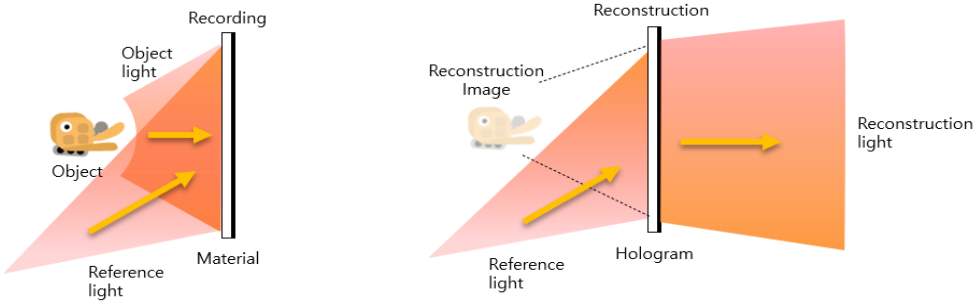
2.1 Holography Trends

The theory of holography was first published in 1948 by Dennis Gabor, who won the Nobel Prize in Physics in 1971, while studying ways to improve the resolution of electron microscopes [7]. The holography is a technique that can record things as they are using the diffraction and interference of light. One laser light is separated, one is used as a reference light reflected from the mirror, and the other is used as an object light by examining the object directly. These two lights interfere with each other, so that the interference pattern is recorded in the holographic recording material, which is called a hologram. Holography technology was developed before lasers were invented. Gabor recorded the hologram using filtered light by passing mercury lamp light through the pinhole. The recording images of this time were very blurry and therefore did not attract much attention. When lasers were invented in the 1960s, holography technology capable of recording 3D images of objects made a breakthrough [8].

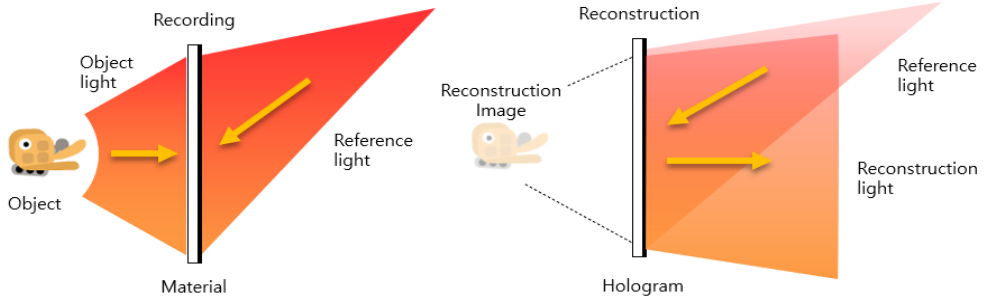
Unlike photographs that can only record the average intensity of light for a viewpoint, holograms can record all visible viewpoints using light interference techniques. It is possible to record both the phase representing the distance between an object and the observer's eye, and the amplitude representing the intensity. That is, it can record all the information that is reflected from an object. Therefore, it is possible to acquire a three-dimensional image rather than a flat two-dimensional image, such as a photograph [9]. Holograms are actively applied to entertainment fields, such as arts and performances, restoration of cultural assets, and the forgery and tampering mark of credit cards and identification cards [10, 11]. Also, with the advent of the 5G era recently, applications such as virtual reality, self-driving cars, medical services, and education are expected.

2.2 Types of Hologram

For hologram recording, a laser light source with good coherent is generally used. The laser beam is divided into two beams using a beam splitter. One is the light coming from the object you want to record, and the other is the light directed to the holographic recording material. Record on the material the interference pattern in which the two lights intersect [10]. Holograms can be divided into transmission and reflection holograms, as shown in Figure 1. As shown in Figure 1(a), the recording of a transmission hologram is accompanied by a reference beam and an object beam in the same direction. For reconstruction, project a laser beam behind the recorded hologram. Observe the recorded image produced by the laser beam transmitting forward from behind the hologram. As shown in Figure 1(b), the recording of a reflection hologram involves the reference light and the object light on the recording material in opposite directions. For reconstruction, the general white light in front of the hologram is required. It is possible to observe the reflected image recorded in the hologram.



(a) Recording and reconstruction of transmission hologram



(b) Recording and reconstruction of reflection hologram

Figure 1. Types of hologram

3. Experiment with a Simple Hologram Recording Set

Generally, holograms are manufactured in laboratories with expensive optical elements, including optical table. In this paper, a simple holographic recording set was produced where all learners can record high quality holograms anywhere other than a limited place without economic burden. Silver halide plate was used for hologram recording material. A reflection and transmission hologram were successfully produced using a simplified hologram recording set. Location of objects for recording high quality holograms, distance between object and laser light source, and time spent on hologram recording were optimized. The visual differences between reconstructed hologram images and photographs were also analyzed.

3.1 Components of a Simple Hologram Recording Set

monochromatic light source, recording material, developer and bleacher are important factors for recording hologram. also, for high-quality educational hologram, it should be considered that monochromatic light source with the same wavelength and phase relationship, a recording material with high sensitivity, and an environmentally friendly developer and bleacher. Table 1 shows the key components of holographic recording set.

Table 1. Key components of a simple holographic recording set

Laser Diode	Recording material	Developer, Bleacher
		

3.1.1 Laser Diode Light Source

The laser light source used in this tool is a Class IIIa diode laser classified by the International Electrotechnical Commission (IEC). It is a laser diode (LD), which meets single longitudinal mode (SLM) and is low power with less than 5 mW. Direct exposure to laser light is a potential hazard, but there is little risk if handled through safety training [12]. Laser diodes use the stimulated emission of photons within a semiconductor. The advantages of laser diode are long-lived and highly reliable. It is also small, lightweight, with low power consumption, and can be mass produced, making it cheaper. The laser diode used in this paper does not require special optical table, only setting for hologram recording is required at the normal table.

3.1.2 Hologram Recording Material

In order to produce high quality holograms, a good quality hologram recording material must be selected There are three representative types of holographic recording materials: silver halide, dichromic gelatin (DCG), and photopolymer. The greatest advantage of silver halide over two different photosensitive materials is that they are more than 1,000 times more sensitive. Silver halide is used by using a wet process and is coated on film or glass plate. The main characteristics of silver halide materials marketed for the manufacture of color holograms are shown in Table 2 [13].

Ultimate Holography's UH08 is an environmentally friendly, harmless, and highly sensitive silver halide material [14]. In order for students and the public to easily record the hologram, the following conditions of

the recording medium are required.

First, iso-panchromatic photosensitive emulsion with high resolution, capable of recording all wavelength bands 440 to 700 nm.

Second, it can be recorded with a low power light source laser of 20 mW. Third, do not use harmful chemicals in humans that have been applied to traditional holographic recording.

Table 2. Commercial silver halide holographic recording materials

Recording material	Optical reaction bandwidth (nm)	Resolution(lines/mm)	Grain size(nm)
U08[1]	**440-700**	10,000	8
PFG-03CN[2]	**435-665**	6,000	9
PFG-03C[3]	**450-700**	6,000	10
BB-PAN[4]	**440-650**	6,000	10

[1] Ultimate Holography [2] Sfera-S Ltd, [3] Slavich, [4] Colour Holographic Ltd.

3.1.3 Developer and Bleacher

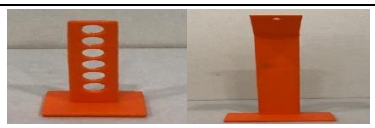
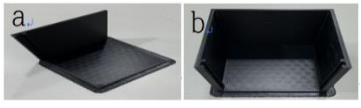
One of the most important factors in holographic emulsifiers is the absence of harmful chemicals. Ultimate holography developed environmentally friendly photosensitive agents using products from the food industry. There are two-step for development processing using it. First, it is holographic development with 4 to 6 min. Dilute 1:10 at a temperature of 20-25 degrees. Secondly, it is holographic bleaching with 3.5 min. temperature of bleacher is 20-25 degrees. Table 3 illustrates the development process using ultimate holography's recording material.

Table 3. Development processing of basic Ultimate Holography's recording material

Processing step	Time (min)
Holographic development using UH developer (20~25° C, dilution rate 1:10)	4 to 6
Water cleaning	0.5
Holographic bleaching using UH bleacher (20~25° C)	3.5 (or until transparent)
Water cleaning 1	3
Water cleaning 2(Kodak Photo-Flo)	1
Drying	20

Table 4. shows other components used in simple holographic recording sets. Supporter that made with formboard or 3D printing and recording material assistance have two different type transmission and reflection. Cooling clip is heat sink of LD. Power supply is used with 3V normal battery. Shutter blocks and exposes LD light and vibration buffer is a sponge for relieving vibration. Recording object is reflective material. Recording material storage box use for protecting recoding material from light.

Table 4. Other components used in simple holographic recording sets

Items	Picture	Features and conditions
Supporter		Making with formboard or 3D printing a: transmission, b: reflection
Cooling clip		Heat sink of LD
Power supply		Normal battery(3V)
Shutter		A device that blocks and exposes LD light.
Vibrating buffer		Vibration relief sponge
Recording material assistance		Recording setup assistance a: transmission, b: reflection
Recording object		Reflective material
Recording material storage box		Complete block of light

3.2 Hologram Recording Experiment

3.2.1 Reflection Type Hologram

For the recording of a reflective hologram, place the object behind the recording medium and light the red LD in front of the recording medium. Approximately 7 seconds were applied from the hologram recording start point LD ON to the recording end point LD OFF. As shown in Figure 2, reconstruction is possible with white light in front of the recorded hologram. You can check the reconstructed image of the hologram in front of the recorded hologram.

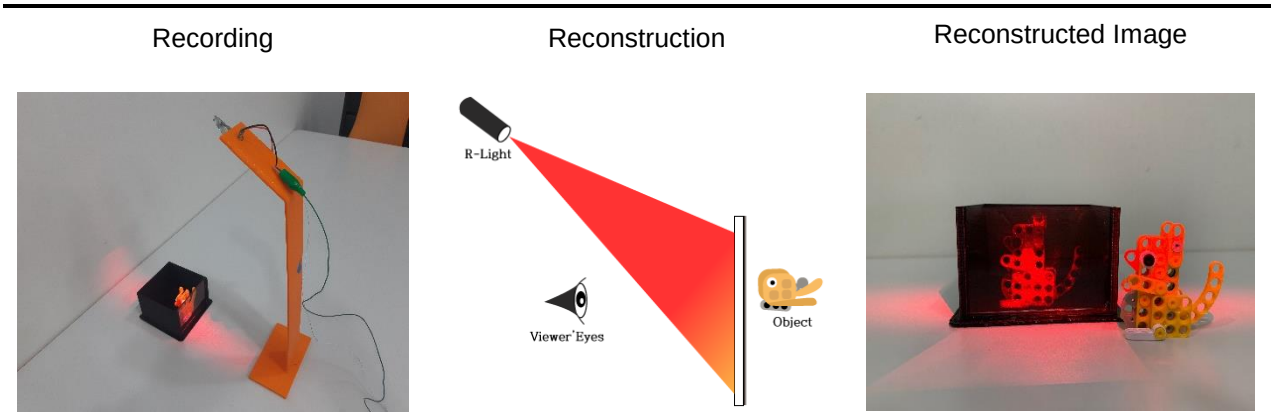


Figure 2. Recording and reconstruction of reflection hologram

3.2.2 Transmission Type Hologram

For the recording transmission holograms, place the object in front of the recording medium. The recording time was approximately 7 seconds, like the reflection type. LD light at the time of recording should be used for the reconstruction of the transmission hologram as shown in Figure 3. Illuminate the LD behind the recorded transmission hologram. When this light passes through the hologram and the eye is placed on the passing light, it is possible to observe a recorded hologram image that appears behind the hologram.

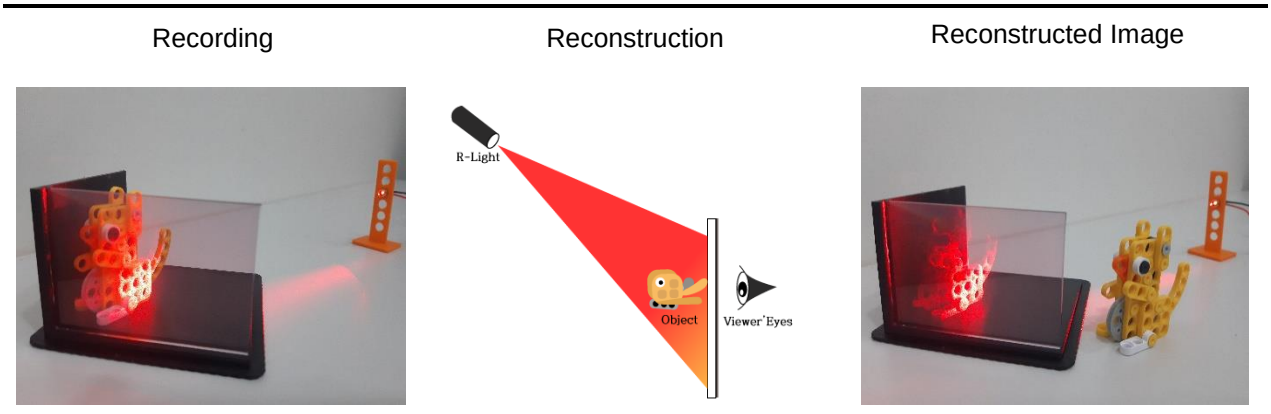


Figure 3. Recording and reconstruction of transmission hologram

4. Hologram Recording Experiment Results

A measure of how much light source was involved in the regeneration image when reconstructing the recorded hologram is called diffraction efficiency. A high degree of diffraction efficiency means that a high-resolution regenerated image is acquired. High diffraction efficiency is the most important factor in holographic production. In addition, when the holographic recording is complete with the same optical layout and wavelength, the regenerated image is represented in the original position where the object was located. If the optical layout is different and the wavelength of the regenerative light changes, the position of the regenerated image changes. Therefore, identifying where the replay image is represented is a very important process to consider when creating a hologram [13].

The results of the experiment using a simple holographic recording set formed in this paper are shown in Table 5. The diffraction efficiency was measured at more than 15% and the exposure time was less than 10 seconds and the distance taken was around 25 cm. The holographic recording and reconstruction experiment with holographic recording sets showed that the recording time took approximately 20 minutes overall. It took 10 seconds to get the laser on and off, six minutes to stir up the developer, nine minutes to stir up the bleach and five other minutes. The results of the experiment confirmed that in order to obtain high quality 3D images, the quality of light sources and recording medium, which are the main elements of hologram recording, must be good. Also, due to the characteristics of the hologram affected by the waves, vibration around the set should be minimized for accurate interference pattern recording.

Table 5. Experimental results of a simple holographic recording set

Parameter	Unit	Results
Image quality (diffraction efficiency)	%	≥ 15%
Recording time (exposure time)	second	< 10
Hologram color	mono/color	red
Laser Diode	mW	5
Recording distance	cm	25

5. Conclusion

In this paper, we carried out the study of holography in order to satisfy the educational needs of the general public and the convergence talent education in the rapidly changing field of education. For this purpose, we created a simple hologram recording set which can make two different type of hologram (transmission and reflection) for providing easy access to recording and reconstruction of the hologram. Experiments on holographic recording and reconstruction enabled the production of high-quality holograms. The simple hologram set created in this paper has not significantly restricted in space and location, and anyone can easily experience it at a reasonable price compared to the existing hologram production method. It will be an effective tool for learning holographic experiences, which have not been taught smoothly in regular and non-regular courses. We also look forward to the creation of many creative and artistic works through the opportunity to freely record holograms wherever we want.

Acknowledgement

"This research was supported by the MSIT(Ministry of Science and ICT), Korea, under the ITRC(Information Technology Research Center) support program(IITP-2020-0-01846) supervised by the IITP(Institute of Information & Communications Technology Planning & Evaluation)"

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