DOCUMENT RESUME

ED 391 494 IR 017 647

AUTHOR Layng, Jacqueline M.
TITLE The Creation and Varied Applications of Educational Holograms.
PUB DATE [95]
NOTE 10p.; In: Eyes on the Future: Converging Images, Ideas, and Instruction. Selected Readings from the Annual Conference of the International Visual Literacy Association (27th, Chicago, IL, October 18-22, 1995); see IR 017 629.
PUB TYPE Guides - Non-Classroom Use (055) -- Speeches/Conference Papers (150)

EDRS PRICE MF01/PC01 Plus Postage.
DESCRIPTORS *Educational Media; *Futures (of Society); *Holography; Lasers; Measurement Equipment; Photographic Equipment; *Production Techniques; Technological Advancement; *Three Dimensional Aids; Visual Arts
IDENTIFIERS Precision Optics; *Technological Methods; Visual Imagery

ABSTRACT

The potential of holograms has been left virtually untapped in the field of education. A hologram can be described as a three-dimensional photographic record of the interference pattern of two superimposed beams of coherent light. Holography requires: (1) high-resolution film; (2) a laser, often a red-beamed helium neon laser; (3) optical components, including positive and negative lenses, mirrors which redirect light, beamsplitters which create the two superimposed beams, and the film plate holder; and (4) the isolation table, which stabilizes the other components and saves them from vibration. Setups vary according to whether the recording process involves a one-beam transmission or a two-beam transmission. Film processing is very similar to photography but requires pyrogallic acid, sodium carbonate, potassium dichromate, and concentrated sulfuric acid. After the film is developed, it is imperative that the film plate be correctly illuminated to produce a three-dimensional image. Holography has helped advance the arts through the production of popular commercial and fine art images and the study of visual design. It has also made a difference in how scientists and manufacturers gather information about changes in materials and products by allowing them to make extremely precise measurements not possible by any other means. Some museums can even offer three-dimensional replicas of priceless antiques too fragile for public display by using holograms. Holography has even moved into more commercial and educational areas like supermarket bar code scanners, computer data storage, X-rays, microscopy, television, and medicine. For example, medical students can have the opportunity to work on holographic organs before cutting into an actual body. Someday holographic television may implement artificial intelligence in education, by staging recreations of important events, for example. Holograms often depend on the aid of other technologies to accomplish their purpose, and scientists have had trouble increasing the hologram's size while still maintaining a quality image, but even so, the potential of this technology looks enormous. (Contains 17 references.) (BEW)

The Creation and Varied Applications of Educational Holograms

by Jacqueline M. Layng

Introduction

Holograms are an exciting technology developed years ago but becoming increasingly popular today. Although most people have come in contact with a hologram, their potential has been left virtually untapped, particularly in the field of education. In order to understand the potential of holograms to the field, it is first important to understand the technology behind them as well as their present and future applications.

Hologram Technology

"A hologram is a photographic record of the interference pattern of two superimposed beams of coherent light, one directly from the source and the other reflected or scattered from a physical object" (Kasper & Feller, 1987, p. v). Dennis Gabor invented holography in the late 1940s and named it "hologram," which means whole record. In other words, a hologram is a three dimensional recorded image that is assembled in a very unique way. Although holography is similar to photography, the only equipment the two share is the use of emulsion to record images. The film required in holography is typically of higher resolution from, 2,500 to 5,000 lines per millimeter. This higher resolution is important to insure the quality of the image recorded.

There are two kinds of film, "the Agfa-Gevaert 8E75 HD NAH glass plate, which has an emulsion coating on one side of the glass, and flexible acetate-backed film" (Lovine, 1990, p. 45). The glass plate is more popular with holographers because it does not bend or require special attention to keep the film rigidly in place as needed with plastic film. The other tools that make a holographic image possible are lasers, optical mounts, mirrors, lenses, beamsplitters and an isolation table.

Lasers

There are many different types of lasers, but the helium neon (HeNe) laser that produces a red beam has been the main one used in holography. It is the color of the laser that determines the emulsion used for recording. In recent years different types of lasers such as "rainbow" and others have been utilized to create various kinds of holograms. The importance of the laser to holography cannot be overstated because, in order to create a holographic image, coherent light must be utilized. Coherent light is a synchronized pure source of energy that has the precision required to record holographic images. It is for this reason a hologram cannot be created through ordinary light like a photograph.

> "Individual units of light from the object and from the reference light meet, and in varying degrees, interact positively and negatively. Where they meet more negatively, little or no light is recorded, and where they meet more positively, light is recorded in the holographic film" (Lloyd, 1993, p. 378).

This is how a hologram is recorded and why the laser is such an integral part of the entire process.

There are five different classifications of lasers that are accessible to human beings during normal operation used in holography (Lovine, 1990, p. 29). Class I lasers cannot under normal conditions emit any hazardous levels of light and are ½ millwatt or less in power. Class II lasers do not exceed one milliwatt of output power but can cause retinal damage if one stares into the beam for a long period. Class IIIA lasers contain output power between one to five milliwatts. Most HeNe lasers are produced in this class. Class IIIB has an output power between five to five hundred milliwatts and must not exceed five hundred milliwatts. This laser can produce accidental injury if viewed directly. Class IV exceeds power limits of Class IIIB and produces a hazardous direct or reflected beam (Unterseher, Hansen & Schlesinger, 1982, p. 100).

Optical Components

Optical components or lenses and beam splitters are also imperative to the creation of holographic images "The key purpose of the lens in holography is to spread the laser beam" (Lovine, 1990. p. 31). This is accomplished through the use of positive and negative lenses which split the laser beam in different ways. Mirrors are also used to redirect light on the table to correctly capture the image. Beam splitters divide the beam of light into two well-defined beams and consist of a piece of glass with parallel faces. These beams are the reference and reflected light that create the recorded image or hologram.

The most commonly used mirrors are flat or plane mirrors, that are a must in holography, to redirect the reference and object beams several times between laser and film (Heckman, 1986, p. 202). Although holography has been called "lensless photography," lenses do serve an important purpose in the holographic process.

> "An unspread laser beam is far too narrow to illuminate anything but the smallest objects. The most useful lens is a simple diverging one similar to the end piece of a microscope. This widens the object beam so its light reaches the whole viable surface of the subject to be holographed" (Heckman, 1986, p. 203).

The third optical mount that makes holography possible is the beamsplitter, which divides the laser into the reference and object beams. A beamsplitter allows a holographer to divide laser light into many different intensities which ensures that the interference between object and reference waves is properly recorded into the emulsion (Heckman, 1986, p. 203).

The final and fourth type of optical mount required to record a hologram is the film plate holder which does just what its name claims, securely holds the film in place. Therefore, lenses widen the laser beam while the mirrors redirect it and the beamsplitters divide it, weakening or strengthening the reference as well as object beams to capture the three-dimensional image on the emulsion held in place by the film plate holder.

Isolation Table

The final piece of equipment required to record three-dimensional images is an isolation table.

> "Stability is essential to producing holograms. The isolation table stabilizes the components placed on it and isolates them from vibration. Since the surface of the isolation table supports all of the components and subject, the impact of vibration cannot be overemphasized. Vibration so slight that is imperceivable to our senses can prevent the hologram from forming clearly." (Lovine, 1990. p. 17).

It is evident that noise or any interference will hinder producing a viable image. The environment must be pure and the conditions near perfection to create a high quality hologram. The table must be placed correctly and a interferometer (measurement instrument) utilized to graphically display any vibration in the area or on the table.

Recording Process

The entire recording procedure must take place in a near totally dark room for the image to form on the emulsion. The amount of time an object is exposed in holography is determined by a light meter just as in regular photography, except the exposure charts reflect the individual medium's optimum exposure environment. The table is set up in a specific way to record an image and this setup varies with the kind of laser beam utilized.

For example, a one-beam transmission hologram shoots the laser through a lens which also serves as a beamsplitter sending the beam to a mirror and to the object. These beams bounce off the object and mirror toward the film plate recording the image through the interference between the two beams (Kasper & Feller, 1985, p. 106). There are various other items that are used to direct the beams or limit the amount of light falling in any one area that are called filters and cards.

A two-beam transmission hologram is similar to a one-beam transmission but utilizes a beamsplitter to divide the beam before entering the lenses, sending one beam directly through one lens to a mirror then off the film plate and a second beam to a mirror which reflects it through another lens off the object to the film plate. There are other methods, such as one-beam and two-beam reflection, that utilize several beamsplitters and/or mirrors to redirect the reference and object beams to record from two different directions. "With reflection holography, a laser beam is spread evenly onto a piece of holographic film with a concave diverging lens" (Schlegel, 1986, p. 23). There are multiple set ups using the various optical mounts to create different holograms Nonetheless, when a hologram is recorded, information about the object is stored everywhere on the film plate (Unterseher, Hansen & Schlesinger, 1982, p. 356)

Film Processing

If this equipment is utilized correctly an image will have been recorded on the emulsion, but the process to create a hologram will have been only partially completed. The film must be developed and properly illuminated to produce a holographic object. There are basically four chemicals required to develop transmission and reflection holograms. These are: pyrogallic acid, sodium carbonate, potassium dichromate and sulfuric acid (concentrated). The process of developing is very similar to that of photography. The film plate is put through several chemical washes and dried.

The washes consist of a developer, stop bath, fixer, hypo-clear, photo flo and bleach which is used to improve the diffraction efficiency of the hologram (Unterseher, Hansen & Schlesinger, 1982, p. 56). The amount of time the emulsion should be washed in each bath varies due to the type of emulsion and the kind of transmission utilized when recording the object. The general process for single/split beam holography is, "develop - D19 for 15% dark by eye, stop for one minute, fix for three to five minutes, rinse three to five minutes, hypo clear two to five minutes, rinse two to five minutes, bleach until pink, rinse two to five minutes, photo flo briefly and squeegee" (Unterseher, Hansen & Schlesinger, 1982, p. 140). It is important to remember that the emulsion must be completely dried before illuminating the film plate.

Illuminating the Image

It is imperative that the film plate be correctly illuminated to produce a three dimensional image. There are two types of illumination and each hologram requires its own type. White light reflection is viewable in white light and it is best to illuminate this hologram with a point light source such as the sun. "Reflection holograms work something like a mirror, so the hologram is viewed from the same side as the light" (Lovine, 1990, p. 77). Transmission holograms need a monochromatic light or laser for viewing. In this type of hologram, the light must pass through the film, so observation takes place on the opposite side of the light source. "To produce the holographic image, all you have to do is to process the hologram and then place it back in the original reference beam" (Saxby, 1988, p. 42). It is in utilizing a replica of the reference beam to illuminate the film plate that a virtual image of the object is created occupying the precise space of the original object. Hence, the process used in recording the image is somewhat duplicated in the process of displaying the image.

Hologram Market

The holography, which is complicated and at times confusing, is being replicated continually all over the world. Holograms have proven to be quite useful in society and have found a "home" in the market place. Currently, holograms can be found on food boxes, magazine tip-ins, credit cards, magazine covers, labels (for security reasons), book covers, tickets and currency. They appear to sell products at a faster pace and reduce fraud by making it difficult to reproduce illegal credit cards and currency (Kluepfel & Ross, 1991, p. 7).

The majority of holograms are called rainbow holograms, and "have been made easily printable via embossing the images on plastic" (Brand, 1988, p. 84). However, the hologram image is still difficult to duplicate for fraudulent purposes. The original uses of holograms fell in the area of the arts and has only recently branched out into the commercial market. The applications of this incredible tool appear to be limitless and as new ground is being broken the opportunities for other fields working with this tool are also increasing.

Hologram Applications

Three general applications of holography have emerged since the mid-1960s. These fields are: "display holography (popular commercial and fine art images), holographic non-destructive testing of materials (technology of holometry) and holographic optical elements (Museum of Holography)" (Lloyd, 1993, p. 377). A fourth application of educational holography is currently evolving utilizing the hologram's ability to take three-dimensional ways of thinking to another dimension of presentation, representation and conceptualization. "Until two decades ago, holography was strictly the domain of research scientists working in heavily funded research and development programs" (Sanders, 1993, p. 7). Now, two broad areas of significance in the fourth application of holography are the expanding educational roles and exploring holography conceptually to restructure critical assumptions within as well as between the disciplines of the arts and sciences. In discussing the varied applications of holography this paper will first focus on the general applications which aid learning and knowledge acquisition and then look at the direct uses of this technology in the field of education.

Holography has helped advance the arts through the study of visual design and has made a difference in how scientists gather information about changes in materials and products. Museums use holograms to make exact three dimensional recordings of priceless antiques, fine art and rare archeological specimens too fragile for public display; while, manufacturers in the air and space industry use holographic non-destructive testing (interferometry) to make extremely precise measurements not possible by other means. For example, "An airplane structure can be recorded before and after flight in order to find abnormal deformations indicating areas at which there is a risk of future failures" (Abramson, 1981, p. 324).

New and innovative developments in the field of holography that have been and are affecting the field of education include: holographic elements used in super market bar code scanners, holographic computer data storage, X-ray holography, microscopy, television and advanced biomedical as well as topograpnical imaging techniques. Bar code scanners have been adopted all over the world, and laser scanners have come to be used in various situations, such as libraries.

Computer data storage has recently been developed, "a holographic device that could store 1,000 times more data than today's computers and retrieve the data 100 to 1,000 times faster" (Rockford Register Star, August 30, 1994, p. 4A). Holography is many different things, "the ability of artists to be sculptors of light, allowing scientists to be students of "transholography" which addresses elusive, complex issues involving time-reversal and possibly allowing the contents of the Library of Congress to be holographically recorded into a volume that will fit on a spoon" (Lloyd, 1993, p. 384).

It is difficult to believe such things are possible but they are being developed. The field of holography has moved beyond the fields of art and science to include the fields of business and education. For example, "Researchers at Stanford University have demonstrated a prototype storage device that uses holographic technology to store computer data. The device would allow massive amounts of data to be stored in an area the size of two sugar cubes" (Rockford Register Star, August 30, 1994, p.4A). This development will most likely have great effects on the field of artificial intelligence, telecommunication, and virtual reality. The increased storage should expand the development of speed and accuracy in delivering telecommunications and virtual reality. Imagine transporting large graphics over the Internet in a fraction of the time it takes today. These improvements aided by holography could be the answer to the power and space requirements needed to optimally develop artificial intelligence. Computers that act and react as humans without constant assistance from humans and with the ability to process information fully may well be possible through the use of holographic technology.

These are the high-end users of holography, which are utilizing this tool to increase knowledge and improve society. The field of science invented holography and has been the most consistent developer of the tool. Holography has been an important tool in the research of matter and, with every new innovation, the hologram becomes a more valuable instrument of science. Art has also benefitted from working with holograms by uncovering detailed information on light and using this information in other areas to increase creativity as well as knowledge. Education has been a part of the development of holography and there is a strong need to apply the technology to education.

The educational applications for formal and informal environments have just begun to be tapped and the future appears to be a vast and open field of opportunities. Holograms can be used to inform students, "in ways print and electronic media can never comparably approach (precise size replication of objects in length, width, depth with parallax, and options for demonstrating motion)" (Lloyd, 1993, p. 377). There are also the practical uses of holograms to aid students in conceptualizing whole objects that could not be experienced first hand.

Mass-produced holograms have proven to be of great interest and have sold millions of magazines as well as other products. The most viable and widely produced holograms have been embossed on plastic or silver stickers. These holograms are inexpensive and have an ability to motivate people's interest in various subjects (Kluepfel & Ross, 1991, p. 64). Although not all the holograms are of high quality, there is a potential for putting these same holograms to work positively in education.

A teacher utilizing these holograms could stimulate interest in science and explaining the procedure in hologram development can still yield exciting results. The simple discussion of what makes a hologram would raise multiple questions on this subject and more. Most students are curious to know how and why things work, especially if they appear high tech. (Lloyd, 1993, p. 382). Students making their own holograms can produce a wide variety of investigations on lighting, the color of objects and the commonalities between the arts and the sciences. According to R. Scott Lloyd, "Several schools are taking advantage of learning from existing, mass produced holograms and are making their own in the classroom. This is where the discovery in the arts and sciences can truly soar" (1993, p. 382).

As society continues to move forward in the "age of information", more and more information is being visually gleaned from the world. It is becoming imperative that education aid learning through an interactive environment using various technologies. Holography has been and is continuing to be an important technological tool in the field of education. Microscopic holography allows the student of science to record an object in a short amount of time and "transient objects can be examined at leisure and in full three dimensions" (Caulfield, 1970, p. 123).

Furthermore, the present use of holograms in the field of medicine is giving students the ability to work on holographic organs before cutting into actual bodies (Brand, 1988, p. 90). A perfect example of virtual reality in action is Snapshot X-ray holography. It displays particular promise for a safer and more effective X-ray by allowing doctors as well as medical students to focus on particular areas of the body with complete three-dimensional information (Solem & Baldwin, 1982, p. 229). These are present uses in the field of medical education and actual proof of how holography is merging with other technologies such as virtual reality. The future holds great promise for these types of applications in other areas of education.

According to Ronald Schlegel in 1986 "A GTE laboratory developed a room size prototype holographic television and in the not-to-distant future a full color-holographic television should be available on the market" (p. 24). This would be the merging of artificial intelligence, virtual reality and holography to create a full-sized virtual environment that processes information like humans. Basically, it will be Star Trek: The Next Generation's holodeck incarnate. Imagine a classroom that brings the civil war to life with the students actively participating as key historical figures. The artificial intelligence would be the brain of the entire operation, storing, retrieving, and creating an infinite number of scenarios for the participants. Virtual reality would be the scenarios come to life using holographic images to create a three-dimensional environment which interacts with the participants. Each technology would interact with one another to create this environment, an environment that could exist without all three technological components. All of these various applications play a role in the field of education.

Holograms have opened up a whole new frontier for humans to strive to understand and control. This technology gives artists and scientists a special tool to aid them in understanding the world. Several positive applications have been discussed and the area is still relatively untouched. The future holds the most important key to the field of holography. Imagine using a holophone that sends three dimensional images of people into homes so they can share information. Holograms could be used to adorn drab office blocks and industrial estates; they could be used to provide panoramic views of exotic locations in air terminals and restaurants or a hologram of a police car could be planted near a busy street to slow down traffic (Wenyon, 1985, p. 131). All of these applications would require the aid of other technologies such as telecommunications, artificial intelligence and virtual reality. Perhaps, these holograms will be transported over phone lines by a computer utilizing artificial intelligence to create these various virtual environments.

There are several future challenges to using holography in education. The field has a consistent problem with increasing the size of holograms and maintaining a quality image. True color has also been an elusive element that developers need to control to evolve towards "real life" holograms. Although moving holograms do exist, there is a need to work on increasing the series of movements as well as the ability to transmit quality images over other media Here artificial intelligence could prove to be the greatest help to holography by allowing the computer to solve these human limitations. Holograms do have certain limitations at this time, but, as researchers continue to work on solving the problems, it becomes apparent that holograms are here to stay.

In fact, some of the most useful discoveries in the field have come through collaborations between two or more technologies such as the laser in the holographic process and recently the development of computer holograms. This particular area appears to have been drawing a great deal of attention. One example of a computer hologram is "medical imaging".

> "X-ray-like data from CAT scanners and MRI machines are assembled in 3D images of the body. Instead of a slice at a time you get a whole transparent body. You peer into a person's abdomen, peeking around a bone or an organ for an anomaly" (Brand, 1988, p. 90).

Positive outcomes through the use of computer holograms are another area just beginning to be analyzed. Overall, the hologram seems to be quite a technological advancement for society. As Schlegel states, "Holography and the laser truly have unlimited potential" (1986, p. 24). This technology continues to affect a multitude of fields, in particular telecommunications, artificial intelligence, virtual reality and computers.

References

Abramson, N. (1981). *The Making and evaluation of holograms*. London, England: Academic Press.

Beelingham, Washington: SPIE- The International Society for Optical Engineering.

Brand, S. (1988). *The Media lab*. New York: Penguin Books.

Caulfield, H.J. (1970). *The application of holography*. New York: Wiley-Interscience.

Heckman, P. (1986). *The Magic of holography*. New York: Atheneum.

Holography used to store data. (1994, August). *Rockford Register Star*. p. 4A.

Kasper, J. & Feller, S. (1985). *The Hologram book*. Englewood Cliffs, NJ: Prentice-Hall, Inc.

Kasper, J. & Feller, S. (1987). *The Complete book of holograms*. New York: Wiley Science Editions.

Kluepfel, B. & Ross, F. (Eds.). (1991). *Holography market place* (3rd ed.). Berkeley, CA: Ross Books.

Lloyd, R.S. (1993). An Introduction to educational holography. In R. Braden, & J.C. Baca, & D. Beauchamp (Eds.). *Art, Science & Visual Literacy* (pp. 377-385). Blacksburg, VA: The International Visual Literacy Association.

Lovine, J. (1990). *Homemade Holograms: The Complete guide to inexpensive do-it-yourself holography*. Blue Ridge Summit, PA: TAB Books.

Sanders, M. (1993, February). Low cost technology: For technology education. *The Technology Teacher*. pp. 7-11.

Saxby, G. (1988). *Practical holography*. New York: Prentice Hall.

Schlegel, R. (1986 May/June). Laser Holography: High tech with high potential for learning activities. *The Technology Teacher*. pp. 23-26.

Solem, J. & Baldwin, G. (1982, October). Microholography of living organisms. *Science*. pp. 229-35.

Unterseher, F, Hansen, J & Schlesinger, B. (1982). *Holography handbook: making holograms the easy way*. Berkeley, CA: Ross Books.

Wenyon, M. (1985). *Understanding holography*. New York: ARCO Publishing, Inc.