APPLICATIONS OF ART AND TECHNOLOGY
FOR ARTISTS AND EDUCATORS
IN HOLOGRAPHY AND VIDEO

A Thesis

Presented in Partial Fulfillment of the Requirements
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ABSTRACT

At the same time our society has become more dependent on technology and as the global competition that exists in science, industry, and business intensifies, there has been a waning interest in science and mathematics by elementary and secondary students in United States schools.

The phenomenon of art as a universal language and children accepting new technology as the norm and a way to fit in with their peers provides the opportunity to reach and teach many through art and technology. Often by the age of ten, youngsters have made judgments about themselves and their abilities. Many think they have no artistic ability if they cannot draw realistically or that science and math is too hard. Some of the abstract concepts we ask students to grasp in mathematics and science become clear when presented during hands-on demonstrations in math and science, through art.

The fact that I am a woman artist using holography and video opens new ways of thinking about art and technology. I plant the seed that maybe you do not have to draw realistically to be good at art. I plant the seed that technology can be used in art. I plant the seed that there is art in technology. I plant the seed that girls, as well as boys, can communicate ideas and excel using technology and art. Of course planting the seed is a good beginning. Teaching holography is where nourishing of the seed produces the bloom.
If technology is the door through which students enter holography, art is the window of expression that allows the students to use holography to create landscapes the mind has envisioned. Without art education, a critical component in the creation process would be missing. Art holds and guides the hand of technology in holography as an art form and is a crucial component for experiencing success in the creative formula. Art taught through holography or holography taught through art, are interchangeable with the end result being knowledge that can be measured, applied, and visually observed.

Holograms are used all over the world for security purposes, in laboratories to perform nondestructive testing, in art galleries to exhibit multicolor and artistic concepts, in electronic circuits, and in computer-generated optical elements. Lasers in barcode scanners are used globally to read information.

In addition to a hologram being made with light waves, a hologram can be made with sound waves and other waves in the electro-magnetic spectrum. Holograms made with X-rays or ultraviolet light can record images of particles smaller than visible light, such as atoms or molecules. Microwave holography detects images deep in space by recording the radio waves they emit. Acoustical holography uses sound waves to see through solid objects. Physicists use holography to record interactions of sub-atomic particles. Optical engineers use holography to make minute measurements; biologists study cells and tissue, and mechanical engineers use holographic interferometry to test for stress and faults in a variety of materials.

These are just some of the holographic innovations and applications being utilized today. Holography's ability to record and reconstruct both light and sound waves makes it a valuable tool for science, industry, education, business, and art.
With availability, ease of use, and education, just like photography, holography will become less marginalized as people see and understand the possibilities of the multiple applications for education that exist in holography. The mindset or preconceived idea that science and technology are hard to understand and not enjoyable can be changed through the art and education inherent in holography.

Much like "art on a cart" holography can be "holography on wheels". While not the ideal way to present holography, a portable presentation method may be instrumental in the initial acceptance of holography as an educational tool. Large numbers of students and teachers can be introduced to the basic concepts, wonder, and possibilities of holography in a presentation that is easily set up, taken down, and transported to a different location. Inexpensive diode lasers are small, easily built or obtained, and safe.

Through education and recognition as an artist using holography and video I seek to demystify the process and promote the voice I have found as an artist and educator using technology.
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CATALOGS

Holographic Transformations - Approaching the Fourth Sequitur. Page 15, Columbus, Ohio, Published by the Department of Physics, the College of Math and Physical Sciences, Ohio State University. November 1999

Some Space Between. Pages 16 – 17, Columbus, Ohio, Published by the Ohio State University College of the Arts, Action Award, Ohio State University December 2001

REVIEWS AND ARTICLES

"Exhibit Shows How Technology Affects Tradition", Picture of "Spirals in Glass", February 3, 2000

Hall, Jacqueline, “Computer Screen Is Their Canvas”, Columbus Dispatch, February, 13, 2000


Mayer, Bill, “Artist Follows Her Heart To Creating Holograms”, Picture of “Faith”, Columbus Dispatch, February 6, 2003,

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CHAPTER 1

INTRODUCTION

Upon receiving my Bachelor of Science degree in Education from Ohio State University, I went through a process of clarifying what was necessary for me to achieve self-satisfaction in my career choice. Feeling strongly that art is a universal language and that art-based curriculum reaches across gender, socioeconomic, and racial strata to reach and teach all children, I began my graduate career in Art Education at Ohio State. Of course talking and writing about art is not creating art, and this became a source of frustration. This frustration, and a chance encounter in the Department of Art with a small poster describing the course Art 455, Beginning Holography, became the catalyst for change. Choosing to take the course Beginning Holography put me on a path of self-discovery, providing me with the artistic means to create and giving me a voice to express my ideas and myself. The Ohio State University is one of the few higher education institutions that offer the opportunity to study holography. This opportunity exists through the forward thinking of the Ohio State University College of the Arts, Department of Art, Art and Technology Program, and the Department of Physics, which is part of the College of Mathematics and Physical Sciences (MAPS).
My graduate career went in another direction as I discovered that I could express myself artistically, and that the art of holography could be used to teach and teach more than just art. My experiences as a Graduate Teaching Associate in the Department of Art's Beginning, Advanced, and Honors Holography courses reinforced and strengthened my vision of the contribution holography and art can make in the teaching environment.

Before my exposure to holography, I seldom thought about the way I see and what that means visually. The slice of life unfolding outside my window is perceived differently by others looking through the same window. But what if the view outside the window was flat, like a photograph, painting, or video? The value of a photograph could express mood, some perspective, and document the scene. The view of a painting could add more information including texture, depth, and an imaginary landscape. The value of a video could reflect what was happening outside the window in real time and would add movement. All the missing information from these two-dimensional mediums is revealed when you look through the window in three-dimensions. Parallax is the missing part of the visual perception process that is revealed when you see in three-dimension. Parallax allows us to see a certain distance around, over, behind, and under objects and helps us perceive depth. As you move, your perspective changes. Using holography I can communicate the way I see, not just what I see. For several years I have been using the tool of holography and video to explore my own realities and comment on traditional art mediums and their subject matter, providing different windows to look through.

The definition of window is an opening for letting in light or air, or for looking through and anything likened to a window in appearance or function. I think of a frame as a window, containing something for me to see out of or into. The metaphor of a window as a frame, containing something to view, is helpful in describing the viewing process in art. The frame defines and concentrates what the viewer is to
see. If you make an opening with your hands and hold the opening in front of your eyes, what you see is framed, helping you to block out information that is not important and concentrate on what is (important). A hologram has been said to be a "window with memories". On or near the apparently blank window (piece of glass) an object was present some time in the past. When a spotlight illuminates the glass, an image is recreated in three dimensions, as if the object had been brought back to the window. Like looking through a partially covered window, you can see an entire image by looking through only part of a hologram. (Yung H. Song and Albert B. Dick, Laser Holography, Thomas Alva Edison Foundation, Inc., p. 6, 1987) The ability to see through windows without preconceived ideas of art may be difficult. Awareness that occurs while looking and learning can expand our view of the world. Through exposure, exchange of ideas, and education our minds evolve. This evolution is fertile ground for changing the mindset of how art is perceived, appreciated, and utilized.

My reality includes bumping up against overt and subtle misogyny, and I have, at times, felt limited and confined by the role society has assigned me because I am a woman. These boundaries are often perceptual in nature and play a part in defining who I am and how I act. The powerlessness and feelings of confinement and worthlessness that one experiences when no one listens to you or discriminates against you, are inclusive of women but can include children, men, the unlovely, the obese, the mentally ill, the poor, the elderly, and those in American culture with skin color other than Caucasian. In our culture this majority of people form the large base of a "pyramid of power". Wealthy Caucasian males flesh out most of the pyramid's small pinnacle. The degree of powerlessness and confinement one feels is related to where one resides within the pyramid. Lamenting the unfair distribution of power and resources that result in discrimination, and then doing nothing, holds no one accountable.

I feel a responsibility to seek and practice fairness. With all the injustice in the world, where then does one begin to make a difference? For me, identifying and
examining issues that have impacted my life and are important to me motivate me to comment artistically on sexism, ageism, discrimination, confinement, children’s rights, and education. Identifying and examining these issues was a starting point in my social responsibility awareness.

The art commonly used in the media and advertising conceals the immense diversity of all but a few in our society. We are bombarded with images dictating how we should look, act, and feel. The distorted “Barbie doll” image that is accepted by many as the standard of beauty in our culture is impossible to obtain or maintain. This unrealistic standard of beauty objectifies women (as sexual objects), contributing to health problems, sexual harassment, disrespect, and helps assign women to less visible, more passive roles.

To become visible, women need to practice reciprocal listening, as well as, having and using their voices. This will provide opportunities to move away from being viewed as passive objects and position women (people) as the makers of their own images.

Using my artistic voice, I try to stimulate ideas and dialogue that will challenge and encourage all that view my art. When I create art, I hope not only to empower viewers but also to comment on, and raise consciousness about certain unfair conditions of being elderly, handicapped, poor, unlovely, female, obese, a child, or not Caucasian. I do not believe you have to “hit one on the head” to get your point across when dealing with issues like sexism that are deeply rooted in our culture. Art can provide a persistent, subtle, or “in your face” comment on social issues in a way that may have more impact than just reading or hearing about an issue. If a person is bombarded with what they do not want to see, they will not look. For example, the feminist movement experienced some backlash after gains, in part because of extremist factions garnering constant negative media attention. Knowing
that you have to first look, see, and think before the desire to act is engaged applies not only to social commentary but also to holography's growing acceptance as an art form and education tool.

Using holography and video I began exploring these issues within the boundaries of time, depth, parallax, and space and how these real or perceived boundaries shape my reality, and how I could use these mediums conceptually. Video deals with the issue of time and captures time moving through space. By playing back a video, I can recreate what happened in real time. Holography allows me to reveal many layers of a sculpture capturing a three-dimensional recreation of the sculpture in real time. There is an element of time moving through three-dimensional space that is perceptual, which changes the viewing of a finished hologram to an intellectual level. Both video and holography are direct mediums offering ways to perceive, process and understand the bits of information that whirl by us on a daily basis.

The pursuit of meaning and understanding of the world we live in is something all humankind has in common. There is a feeling of satisfaction that comes with translating abstract information and ideas into solid form thereby demonstrating in a concrete way, (higher) understanding. For example, a student sketches ideas for an imaginary machine that moves. The student using materials found in the garage creates a working machine out of metal, gears, ironing board, wheels, and batteries. While some at the science fair or art and technology show may scratch their heads as to what category the machine should be judged in, no one disputes that the student has demonstrated understanding of many science, math, and artistic principles. The creative process from concept to implementation is an accomplishment that promotes the self-satisfaction of a job well done and is rewarding. This satisfaction is soothing to the soul and is what art can give to us.
It is through art education that one can see as art, the shifting shapes and undulating patterns of light and dark as the sun passes through clouds, foliage, and then the blinds on the window. Through art education we learn to see and appreciate that art is everywhere, waiting to be discovered and used, thereby enriching our lives.
CHAPTER 2

WHAT IS HOLOGRAPHY?

The terms and theory of hologram and holography are attributed to Hungarian
Physicist Dennis Gabor (1947). The word hologram is derived from the Greek
words “holos” meaning whole or complete and “gram” meaning message or picture.
A hologram is the recording of light waves, at a moment in time, reflected from an
object on high-resolution photosensitive material such as film or glass. Holography
is the process by which the hologram is made.

How Holograms Are Made

To make a hologram, a laser beam is split into two beams with a beam splitter. One
beam, the object beam, illuminates the object(s) in its path and the beam's light
waves are reflected onto the film. The other beam, the reference beam, travels
directly to the film. While the reference beam provides some illumination, objects
placed in its path create a shadow or absence of hologram. The photosensitive
high-resolution emulsion used on the film records the interference pattern from the
two beams falling onto it.
Although the exposure and development of holographic film occurs in the dark, without light there would be no holography. Light is energy that travels through space in a waveform. The crests and troughs of these waves rise and fall at right angles to the direction they are traveling (like waves in the ocean). White light has many different wavelengths, and its phase is random. The light emitted from the laser is one wavelength or coherent light. This means the light waves are “in phase”; all the crests and troughs in the waves travel along together and are the same size. When the coherent wave front from the laser beam meets the wave front from the object at the film plane, an interference pattern results. It is the interference pattern that allows a record to be made of the light reflected from the object.
The interference pattern of the two light waves can be described as a pattern of light and dark lines or fringes. When a crest of a wave interferes (collides) with another crest, the interaction is said to be positive, or constructive interference, resulting in a light area. When a wave crest meets a wave trough, the resulting interaction is negative, or destructive interference, resulting in a dark area. This interference pattern is recorded in the emulsion on the film during exposure.

Figure 2: Two laser light waves meet and create interference pattern

The hologram is developed and processed in a darkroom. To see the hologram that exists within the film, a light source is needed to reconstruct the wave front. The interference pattern recorded on the film focuses the incoming light waves from a light source into a replica of the light waves that were originally reflected from the object onto the film. When the hologram is illuminated, by a spread laser beam or a light directed on the film at the same angle as the original reference beam, the diffracted light is reconstructed producing a three-dimensional image. The reconstruction of the original object’s light wave pattern allows us to see light waves reflecting off the objects or composition exactly as it existed in time at the precise moment the film was exposed.
Displaying Holograms

Sometimes holograms are displayed pseudoscopically. The pseudoscopic view is the real view where the light comes to a focal point in front of the film (in space). The image is turned back to front spatially, turning space inside out. For example, if I press my hand into clay or plaster, I can make a hologram of the handprint relief mold. The pseudoscopic view, when the film is turned front to back and top to bottom, would show the handprint inside out, projecting out in front of the glass. Images can appear to be inches to feet in front of the glass. Often viewers reach out and try to touch holograms, convinced the objects are floating in space. The orthoscopic view of the same hologram is the virtual view with the focal point behind the film plane and front to back orientation. This view would show a three-dimensional imprint of a hand behind the glass.

In art galleries, holograms are often exhibited under a flat piece of glass in a frame mounted on a wall. It feels like you are looking through a window because what you see through the glass frame has depth, volume, perspective, and parallax. When illuminated with daylight or light other than a single spotlight set at the correct angle (original angle at exposure), the framed hologram is visually twodimensional. At best, improper lighting or lighting at the wrong angle, only hints at what is contained in the frame. When holograms are properly lit, they are three-dimensional, however even though the frame has some thickness, it holds a flat piece of glass over the hologram and is perceived as two-dimensional. These two observations of the juxtaposition of the two and three-dimensional aspects of framed holograms in a gallery, have influenced how I display my art. Sometimes, the presentation of the hologram becomes the engine that drives the piece.

I have always been somewhat bothered by holograms in black frames often found hanging in a gallery. When illuminated properly, artistic holograms are impressive
to behold. However lights do burn out, become dim, and are not at the proper angle. When this happens, an artist's work cannot be viewed the way the artist intended. By taking the hologram out of the frame, visually interesting combinations abound. A hologram mounted directly on the wall can recede, as if objects are actually inside the wall. A hologram within a painting, sculpture, or photograph surprises the viewer when discovered, and is visually engaging.

"Thinking outside the frame" led me to experiment with materials I could mount a hologram on or in, and then to create with lighting, shadows and color from the entire piece (the framing, hologram, and sculpture) that would play on the wall, behind the piece and the floor in front of the piece. Experimentation led me to use holograms within paintings, sculptures, photographs, collages, and in and on glass, wood, and stone. This process led me to "thinking outside the piece" and toward installation art. Installation art is sometimes considered site-specific which means the art is created within the space it will be exhibited in as part of the piece's concept. For example, if a gallery has large uncovered windows, I can suspend rainbow and diffraction grating holograms framed in grapevines in front of the windows. In this case, I have used the real windows and ambient light as well as fixed spotlights that fall on the holograms and their frames, as part of my artwork. Once the sun goes down, the spotlights on the holograms reveal the hologram's content while shadows and colors play on the darkened window, floor, and walls. Abstract sculpting with light using rainbow and diffraction grating holograms and shadows from what holds the holograms is an important part of my work. These types of holograms can be used within well-known forms of art or stand alone, colorfully abstract.
Holography in Art

It is ironic that there are no established aesthetic criteria for holography. The criteria for art aesthetics one has learned are applied to other artistic mediums such as painting, sculpture, and photography. The public's general knowledge about art can be a disadvantage when applied to holography. One way to counteract this disadvantage is by demonstrating that there are similarities in holography with the traditional art mediums such as painting, sculpture, and photography. By referring back to earlier forms of art that share a common area of knowledge, the gap between the public's knowledge and expectations of art can be narrowed.

I often use sculptures of mouths, hands, and ears in still life compositions as subject matter for holograms. By providing the viewer with images of familiar objects, I have demonstrated the three-dimensional properties of holograms in a widely known form of art: the still life. These holograms do not confuse the viewer with abstract subject matter, freeing them to interpret for themselves what the still life says to them.
Other examples of connections to earlier art forms are found in Cubism, where subject matter is broken up and reassembled in an abstract form, in Trompe l’oeil, where the style of painting gives the impression of photographic realism with the use of linear perspective, and in seventeenth century Dutch paintings where photo-realism and is used in the technology of camera obscura. These examples demonstrate perspective. The goal of perspective is to show three-dimensions on a two-dimensional surface which is something holography does effortlessly. This perceptual directness happens because of technology.

Using correct technique, I can record an object on film as a hologram. The hologram can be technically flawless but perceived only as documentation. I can make a hologram of a composition of army men figurines (a favorite choice of students if not given guidelines) that technically records the composition exactly as it is. In this case I have documented objects not art. Found objects can be made artistic by altering them in a way that makes them another material the artist uses to communicate. An example of this would be melting the army men or using their shadows within a composition. I could make a hologram of a museum piece, fine jewelry, or my own art that is also an accurate documentation. Even an object that is
art can be recorded technically, but not be considered art. By taking this art object and putting it in a holographic still life that considers content, lighting, mood, emotion, exposure time, and developing techniques, I can create technically excellent holograms that are exhibited in museums and art galleries.

It is the artist, using creative resources, that communicates ideas and emotions to provoke a response from the viewer. Some artists have discovered the resource of the laser and produce wonderfully unique holographic art. Holographic artists from around the world exhibit their work in galleries and museums as well as work and sell commercially.

There are many artists working in holography that have influenced and inspired me. I consider myself fortunate to have met some of them. For many years, the Ohio State University has sponsored Interdisciplinary Research Seminars. In holography these lectures and workshops have brought artists working with and exhibiting holography to Ohio State. This unique opportunity to meet, hear, and see artists at work has enhanced my art and reinforced my vision of holographic applications. The artists that I have met through these seminars have exhibited nationally and internationally. Rebecca Deem creates pulsed laser transmission holographic mixed media art. Deem was a member of the team that created the first pulsed laser portrait of a president (Ronald Reagan) for the Smithsonian Portrait Collection. Fred Unterseher, co-author of Holography Handbook, is a pioneer in optical holography and an Ant Farm member (the art/media collective famous for Cadillac Ranch and Media Burn). Unterseher creates holographic mandalas and yantras that explore light and spatial relationships in kinetic form. Dan Schweitzer's background in theater arts impacted his work in holography. He often used stage-like settings to address the issues of space, time, and color. Schweitzer combined tiny bronze sculptures with rainbow holograms projecting their colorful images in front of the sculpture. Scott Lloyd using common subjects (a penny, saltine crackers, pieces of candy) works in split-beam reflection hologram set-ups. He
creates holograms that play with the idea of transforming preconceptions about
common images and their meanings. Sam Moree also sculpts with light using
rainbow holograms, collage techniques, and sculpture. In his words, "the sculpture
works as a focal point to balance the complex details of the hologram." Moree
came to holography with a background in painting, sculpture, photography, film,
video, and theater.

While thinking about artists that have influenced me, I was struck by the fact that
they are primarily women. At least half of the predominant artists working in
holography are women. Harriet Casdin-Silver, a pioneer in the field of holography
is an installation and holographic artist, believes that the field of holography, unlike
other scientific fields, had not yet developed a strong male hierarchy by the 1960's
and that also coincided with the height of the women's liberation movement. As
women became more confident in their creativity, holography offered a level
playing field of opportunity. Casdin-Silver was the first artist to develop frontal-
projection holograms, the first to explore white light transmission multi-colored
holograms, and the first to exhibit outdoor, solar tracked holograms. Doris Vila is a
holographic artist that creates three-dimensional video and interactive installations
where stories stretch out in space rather than over time. Viewer's bodies trigger
changes in the video and holographic scenes. Vila sometimes projects video onto
holograms. Vila has said she makes holograms of ideas not things. Anna Marie
Nicholson is known for her holographic pulsed laser portraits. She focuses on the
human figure and its ability to express, in gesture, hidden agendas. She thinks of
the body as a thin shield with the body reaching out to escape confinement.
Margaret Benyon, like Casdin-Silver, has been working in holography since the
1960s. In her "Male and Female" series of holograms she combines reflection
holograms with an under painting that can be seen when the hologram's lighting is
turned off. Sally Weber sculpts with light often in large site-specific installations
intended to project color dimensionally into the viewer's space. She often uses the
natural forces of wind, water, and sunlight in her pieces. Weber is interested in the
nature of light and the effect color has on the human psyche. Feminist artist Judy Chicago, a multimedia artist has also influenced me. Chicago’s believes that art can be aesthetically, spiritually, and socially effective. Her use of visual symbols to liberate women from negative attitudes about female anatomy and their own bodies served as a framework for imagery that worked toward reversing the devaluation of females in patriarchal culture.

**Holography in Other Disciplines**

In addition to a hologram being made with light waves, a hologram can be made with sound waves and other waves in the electro-magnetic spectrum. Holograms made with X-rays or ultraviolet light can record images of particles smaller than visible light, such as atoms or molecules. Microwave holography detects images deep in space by recording the radio waves they emit. Acoustical holography uses sound waves to see through solid objects.


Optical engineers use holography to make minute measurements; biologists study cells and tissue, and mechanical engineers use holographic interferometry to test for stress and faults in a variety of materials. Peter Hering, a Professor of Physics at the Institute of Laser Medicine at the University of Dusseldorf, Germany heads a team at Surgical Systems Laboratory that takes three-dimensional measurements using holographic tomography. A holographic image is taken of a patient with a paused
laser system (pulse duration = 20 ns) that contains complete three-dimensional spatial information, which due to the short recording time, is not affected by the object moving. The low energy density of the laser beam allows the recording of patients with their eyes open.

Holograms are used all over the world for security purposes, in laboratories to perform nondestructive testing, in art galleries to exhibit multicolor and artistic concepts, in electronic circuits, and in computer-generated optical elements. Lasers in barcode scanners are used globally to read information. Almost everyone has seen embossed reflection holograms. The silver images or designs are found on credit cards, drivers licenses, magazine covers, concert tickets, and candy wrappers. You can even eat a candy hologram! The candy’s surface is molded into tiny, prism-like ridges. When light strikes the ridges, it is broken into a rainbow of bright iridescent colors that display three-dimensional images. Embossed rolograms are found on wrapping paper, ribbon, and other paper or plastic products. It is becoming more common to see reflection holograms on commercial products such as bookmarks, jewelry, clothing, and even swim goggles.

When you cut a hologram in many pieces, the whole image is contained on each piece. This is because the necessary visual information is contained on each piece of film. This phenomenon has led some to believe that we live in a holographic universe. Michael Talbot debates this philosophical point of view in the book “The Holographic Universe”. University of London physicist David Bohm, a former protégé of Einstein, and Stanford neurophysiologist Karl Pribram believe that the universe itself may be a giant hologram, quite literally a kind of image or construct created, at least in part, by the brain.

**Innovations in Holography**

DuPont Corporation makes a plastic holography film (photo polymer) that can be developed using heat and light. This holographic recording material can record full
color realistic images. Dai Nippon Printing Company of Japan mass produces color holograms, some as large as billboards, using this technology. Sony Corporation has developed a holography-printer-camera system that can make three-dimensional images from a digitized source in minutes. In the future we may see a hologram printer connected to a computer that enables a desktop printer to produce three-dimensional images. At the University of Alabama in Huntsville, researchers are developing the sub-systems of a computerized holographic display. The research focuses on providing control panels for remote driving, training simulators, command and control presentations, however, researchers believe that TV sets with three-dimensional images might be available for as little as $5,000 within the next ten years. Polaroid Corporation scientists have developed a holographic reflector that promises to make color LCDs whiter and brighter. A transmission hologram sits behind an LCD and reflects ambient light to produce a white background. Working independently, NASA's Jet Propulsion Laboratory and IBM have demonstrated the use of holograms to locate and retrieve information without knowing its address in a storage medium, just by knowing some of its content. Marine researchers have developed an undersea holographic camera that generates in-line and off-axis holograms of marine phytoplankton. A computer controlled stage moves either a video camera or a microscope through the images, and the organisms can be measured as they were in their undersea environment. The aircraft industry uses a holographic lens to allow a fighter pilot to see critical cockpit instruments while looking straight ahead at a target.

These are just some of the holographic innovations and applications being utilized today. Holography's ability to record and reconstruct both light and sound waves makes it a valuable tool for science, industry, education, business, and art.

What Holography is not: Photography

Holography and photography do share some of the same nomenclature. Both mediums pay attention to lighting, mood, content, exposure, composition, and use
film, chemistry, safe lights, and the darkroom. Shared nomenclature aside, even the words themselves are similar. The meanings of the words, however, are completely different. The obvious difference is a photograph (picture message) is two-dimensional with the image perceived flat, and a hologram (whole message) is three-dimensional with depth, volume, perspective and different views provided by parallax. It is the difference between seeing your world flat, like a picture or the way you see it, three-dimensionally.

There is a parallel with the history of photography that invites comparison. It was not a surprise invention when Louis Daguerre announced his new process of photography to the world in 1839. A method to record the images created by the camera obscura had been anticipated. The three-dimensional image, visible without a stereoscopic viewer, was also something people envisioned long before the holographic process made it possible. The invention of photography evoked a hostile reaction from artists who thought their livelihood was threatened and that a photograph was a visual image deprived of its soul. Artists using photography as a tool explored photographic cropping, composition, exposure, scale, and developing techniques and discovered and promoted the visual grammar contained within a photograph. Alfred Stieglitz, Laida Ben-Yusuf, Dorthea Lange, and Man Ray are just a few artists whose work began to impact fine art. During this time many photographers tried to establish their medium as a separate means of visual expression, equal to more traditional ones.

Man Ray (1890 – 1976) a painter and photographer in the Dada, Surrealist, and Abstract art movements produced a variety of art ranging from paintings, motion picture films, found objects, mixed media sculpture, poetry, and photography. Man Ray often altered or manipulated the design of the found object giving them provocative titles. In 1918, Man Ray carefully photographed an eggbeater and its shadow. The image suggests the anatomy of a man, capable of stirring things up and was titled "Man". His interest in chance, machines, and conceptual ideas led to
his discovery of the "Rayograph" which later was called a photogram.

Like photography, holography attracts artists from other mediums. Art and artists change and evolve with time, knowledge, and resources. Many artists that began with paint on canvas as their medium embraced photography as another creative outlet and some are now discovering holography's creative potential.

"That window, that vast horizon, those black clouds, that raging sea, are all but a picture...you know that the rays of light, reflected from different bodies, form a picture, and paint the image reflected on all polished surfaces, for instance, on the retina of the eye, on water, and on glass. The elemental spirits have sought to fix these fleeting images: they have composed a subtle matter, very viscous and quick to harden and dry, by means of which a picture is formed in a twinkling of an eye. They coat a piece of canvas with this matter, and hold it in front of the objects they wish to paint. The first effect of this canvas is similar to that of a mirror: one sees there all objects, near and far, the image of which light can transmit. But what a glass cannot do, the canvas by means of its viscous matter, retains the images. The mirror represents the objects faithfully, but retains them not: our canvas shows them with the same exactness, and retains them all. This impression of the image is instantaneous, and the canvas is immediately carried away into some dark place. An hour later the impression is dry, and you have a picture the more valuable in that it cannot be imitated by art or destroyed by time... The correctness of the drawing, the truth of the expression, the stronger or weaker strokes, the gradation of the shades, the rules of perspective, all these we leave to nature, who with a sure and never-failing hand, draws upon our canvases images which deceive the eye." Gaspard Tiphaine de la Roche, Paris, 1769 "The passage above could have been written about photography". (Bentov, S. A. Holography: The Second Decade. Optics News, 1977

During the last fifty years, photographs have been absorbed into the mainstream of art. Photography today is not only presented as a means of illustration but also as a
document and art in itself. Growing pains that photography experienced on the way to being accepted as a valid means of artistic expression are similar to what holography as an art form is experiencing today. These growing pains also include misinformation, mystery, and secrecy.

**Growing Pains**

The mist of misinformation that swirls around holography, and the lack of understanding about the technology required to make a hologram obscures and limits how, when, and where it can be used. Most people have a frame of reference when it comes to holograms. It is not uncommon for a person’s point of reference to be based on the fictional information or misinformation associated with holography. Many movies and television shows have envisioned holographic TV and a myriad of other fantasy (at the present time) applications. “Beam Me Up Scotty” (Star Trek), Princess Leia (Star Wars), and Disney World's fortune-teller in the crystal ball simulated holograms, and the zapping power of lasers may be fictionalized but still function as the point of reference that can spark the desire to learn about holography.

Holography has also suffered from secrecy. In physics, research, and business, developments are kept secret and protected in case they are commercially viable. Many artists after taking the time to master a technique or process are reluctant to share for fear others will have the knowledge and ability to produce the same or similar type of work.

As an artist, I am influenced by my unique life experiences and environment. The fact that others can master the technical aspect of holography should not threaten or intimidate an artist wanting to use the medium. Sharing knowledge fosters an atmosphere conducive to creativity, growth, and learning. Experiencing the work
of others stirs the pot of creative juices and is a resource I use providing inspiration, new ideas, and motivate me to keep learning and expressing myself artistically.

The cloak of mystery, which in the past has been a detriment, is part of holography’s appeal and can be used advantageously. A bit of mystery can be interesting and invites pursuit of a solution. When I say I make holograms with a laser, I get an interested response. While the adults may be somewhat impressed, it is the children and students that usually want to know more by demonstrating an eagerness to embrace learning and using a new technology.
CHAPTER 3

MY ARTISTIC MEDIUMS

Holography

When I think about the path I have taken during my journey through holography, I am struck by the thought that I still feel a sense of wonder and excitement about what I am doing. I entered into holography without a strong background in art, mathematics, science, or technology. I had a few anxious moments when I realized I would be dealing with all four while pursuing holography. This source of anxiety quickly dissipated as I made real life connections to the math, physics, science, and artists being presented through lectures, seminars, and hands-on demonstrations. For me, learning holography through an art-based course was a painless way to learn and apply some basic art and science principles and have fun in the process. The technology of holography is the vehicle I drive to my destination—my art. I had to learn how to drive first, and what a journey it has been!

One of the attributes of holography is that it makes you think. It is impossible to do holography and not think. For example, our idea of right and left is one-dimensional and is determined by arbitrary choice. When you look in a mirror, your left eye in the mirror is actually your right eye (think of yourself as inside the mirror looking out). For me, the most intellectually stimulating part of holography is the problem solving and exploration that happens as I work. Sometimes my work happens by coincidence as I experiment with the medium, learning what I can and cannot do. If I can make a hologram of the inside of an object (not visible to the
naked eye), then I discover I can do a double exposure and have both the inside and outside of the object together on one hologram! The discoveries are ongoing, and the vision of how to use these discoveries put the art in holography. The act of viewing an art hologram is active and thought provoking. The feeling of viewing another dimension with it’s own set of realities draws me in to look around, contemplate, and stay awhile.

In an exhibition of my holograms at Denison University Art Gallery (Granville, Ohio January 18 through February 22, 2002), I displayed a series of holographic human ears of people from ages eight to eighty. The ears are mounted inside glass jars on pedestals. The viewer sees a three-dimensional ear when standing in front of the piece. When the viewer moves around the pedestal, they can see a flat piece of film in an empty jar. Visually the white columns and jars are interesting even when not lit. I stood nearby the “Ear In A Jar Series” during opening night of the exhibition as several people viewed my work. One person first encountered the jar with a side view. She saw nothing and was truly puzzled why an empty jar was in an art gallery. The person she was with was viewing the illuminated front view of the holographic ear image and the dialogue and genuine interest they exchanged as they changed orientation was great fun and rewarding to me as the artist. The concept behind the “Ear In A Jar” series began with wanting to comment on my belief that in our culture, what women, children, and the elderly have to say is not always heard correctly or heard at all. Not being heard is a way people are marginalized, alienated, excluded, and devalued.

If I speak and no one listens, eventually I will feel that what I have to say is of no value and stop trying to communicate. If I speak and no one listens, I have no voice.
Figure: 5 “Eighty Years In A Jar”

One way we communicate is with our hands. This communication is both visual and tactile. When I make a mold of a person’s hands, ears, or mouth, I use an alginate for the mold and white casting stone or clear resin to cast. Looking at the cast hands, ears, and mouths, one cannot discern whether they belong to a person of color, male or female, or their economic status. In essence, I have objectified, called attention to, the person by their body parts that hear, speak, and work. The hologram of my grandmother’s hands, “Vada’s Hands at 94”, invites the viewer to speculate about the person who the hands belong to. Like a road map both worn and well used, the gnarled, fragile, and expressive hands communicate a past, present, and future.

**Video**

My interest in video began before my discovery of holography. For many years I have used a camera as a creative outlet and to document what interested me. I embraced the then new technology of consumer video cameras over twenty years ago. I used the video camera creatively much the same way I used my still camera, however, consumer video cameras were big and heavy. I had to also carry the recorder that held the VHS tape and was tethered to the video camera and battery.
pack. Creative content aside, it took planning, physical energy, and was time consuming to use video. What a difference the advances in digital technology have made! It still takes planning, some physical energy, and is time consuming to work in video, however, the small lightweight, digital video camera I use today affords me far more flexibility, spontaneity, and ease of use that contributes, not subtracts, from the creative process.

Once holography provided me with another perspective when looking through the window, I started thinking of ways I could use the video camera to capture a moment in time and add the third dimension to flat video footage. Remember it is because of parallax your view changes as you move, enabling you to perceive depth perception. A parallax sequence can be made on film or video and be directly converted into a hologram. I had used stereoscopic parallax in making animated multiplex holograms. The holography lab I work in has a 15mw and a 50mw helium-neon (HeNe) laser. Without access to more sophisticated equipment, the process of making animated multiplex holograms involves shooting slides of an object or scene in one degree increments as you move left to right around the object (or move the object in increments). The slides are then placed side-by-side going left to right. When looking at two slides with slightly different views, with the left eye looking at the slide first in sequence, and with the right eye looking at the slightly different slide to the right of the first, the two views merge and become three-dimensional. This is the principle stereoscopes used as early as 1890. Stereoscopes are hand-held devices with two eyepieces for viewing two photographs taken at a slightly different angle, rendering the image three-dimensional. After choosing pairs of slides that demonstrated merged views, I had 12 slides to work with. The film is then masked (blacked out) all except a horizontal slit where the slide is projected onto the film. The horizontal slit is moved after each exposure. Each slide is exposed to the laser and recorded on the film in this horizontal fashion. The resulting hologram has a small range of
movement because only 12 views were used. Sophisticated equipment can produce many more views and result in a three-dimensional dancing ballerina, a smiling Shakespeare, or a 360-degree animation!

Parallax data can be recorded and stored digitally. Television, film, and video are using parallax because a moving camera can convey more realism than a still camera. Motion or temporal parallax gives the viewer three-dimensional clues even if the motion is minuscule and not noticed by the viewer.

Video cameras can be hand held to provide lateral temporal parallax. Motion parallax data can be captured from any side moving or orbiting vehicle such as a car, train, boat, plane, or dolly, that travel in a smooth motion past a scene. Although I did not know what motion parallax was at the time, I began experimenting with making video look three-dimensional, exploring the layers between two or more points.

This exploration led to the creation of “Layerscape”, a video installation in 2001. I used digital video in two ways in this installation. One video was shot with the camera on a tripod secured to the front passenger side window, with the view being what a passenger would see looking out the side window while driving around the perimeter of the city. This can be visualized as a large circle (Route 270 Outer-belt) around the city of Columbus, Ohio. The other video was shot with the camera mounted on a tripod in the front passenger seat, pointing straight ahead. I drove through the approximate middle of Columbus on High Street (Route 23). You can visualize this as the circle bisected. I projected this front passenger view video onto a canvas panel (86”h x 44”w). I found that when I cut a section out of the panel, the video “dropped through” the opening while still projecting around the sides of the opening. I ended up projecting through three panels with different size windows. The combination of motion parallax and the video dropping through the
three layers of panels (four when you add the white wall behind the last panel) have three-dimensional attributes. While the two videos, due to motion parallax, are interesting to look at, I found they have more of an impact when viewed together.

As an installation, "Layerscape" is supposed to be viewed while seated in one of the two chairs placed in front of the three canvas panels that are suspended from the ceiling. When seated, if the viewer looks to the right they see the video taken from the passenger side window of the circular route around Columbus, Ohio. Looking straight ahead the viewer sees the front passenger window view of the passage through the middle of the layers of Columbus neighborhoods. Some viewers have a feeling of motion sickness while viewing this installation and prefer to stand or view from a distance.

Documenting the layers and boundaries of a city became more engaging when viewed as an installation and the only audio consisted of wheels on pavement and ambient traffic noise. In my sixty-minute documentary interview video "Queen Brooks, Passion Inside The Lines", I wanted to give a voice to artist Queen Brooks, not just document her life. Queen speaks of growing up in Columbus, her family,
and her art. Queen’s experiences as an African American girl, woman, mother, daughter, and artist tell a story of strength, vision, compassion, hard work, mentoring, and joy.

This video will be used in a future installation with another documentary interview video I have done, “Karen Negley, Faithful Passion”. Karen speaks of growing up in West Africa and her experiences as a Caucasian American girl/ woman/ mother/ daughter/ nurse/ and pastor’s wife.
CHAPTER 4

HOLOGRAPHY AS AN ART EDUCATION TOOL

It is easy for me to say that holography can be a player in art and education but implementing a plan to use holography as a vehicle to educate will take perseverance and exposure. Through education and recognition as an artist using holography and video I seek to demystify the process and promote the voice I have found as an artist and educator using technology.

You do not need art education to look at a hologram. It is what it is—a three-dimensional image. The nature of the image, as opposed to its interpretation, cannot be misunderstood. Unlike the painted illusion, it is not dependent on suggestion and variable subjective responses. In our culture a sophisticated awareness of three dimensions is undeveloped. The situation could be compared with that of early movie patrons who were disturbed by parts of bodies cut off by the edge of the screen. (Leonardo, Vol. 6, no.1, p.3, 1973) While one does not need to be educated in art to look at a hologram, it is through art education the viewer learns to appreciate, understand, and evaluate what they see.

Children, like sculptures, are molded with reality, fantasy, desires, and immediate gratification. Children accept new media as the norm and are intrigued by technology. This willingness to embrace technology creates an ideal environment to teach holography, which is, at first glance perceived as science. Once the science or technology is grasped, the applications of holography are discovered.
Because children accept new technology as the norm, they risk becoming social misfits if they do not participate, such as watching the right television show, playing the "cool" "in" video and computer games, and using the latest electronic devices. In these virtual dialogue windows, communication with others gives way to communication through and with objects. Does being "wired" promote isolation of our youth and squelch creativity? Perhaps it is in the best interest of our culture to explore ways to encourage children to drive the technology rather than be driven by the technology.

The phenomenon of art as a universal language and children accepting new technology as the norm and a way to fit in with their peers provide the opportunity to reach and teach many through art and technology. Often by the age of ten, youngsters have made judgments about themselves and their abilities. Many think they have no artistic ability if they cannot draw realistically or that science and math is too hard.

When I gave a visiting artist talk about holography to three fifth grade classes at Liberty Elementary School in Worthington Ohio, I received immediate, enthusiastic feedback. I had the attention of everyone from the moment I mention that I use a laser to make holograms. The bits of science (properties of light, optics, and waves) and math (angles) I presented in my lecture were immediately absorbed as another connection and reinforcement of what the children are learning in school. The fact that I am a woman artist using holography opens new ways of thinking about art and technology. I plant the seed that maybe you do not have to draw realistically to be good at art. I plant the seed that technology can be used in art. I plant the seed that girls, as well as boys, can communicate ideas and excel using technology and art. Of course planting the seed is a good beginning. Teaching holography is where nourishing of the seed produces the bloom.
For the youthful contemporary culture of electronic equipment, video games, music CD's, videos, the past may have negative value. Holography may have to be fully integrated into our culture before artists use it regularly, and it is not "through being invented yet.  

(Boston, MA, Interview in *Holography News*, vol. 11, No 2, April 1997)

The artistic grammar of holography is easily communicated and learned. Concept, materials, tone, value, lighting, composition, shape, texture, volume, and presentation are introduced once technical proficiency is achieved. As an educator and artist, the balance between art and technology is my tool and inspiration. This balance is achieved through the use of technology, concept, and art when one has the means to express opinions, communicate, and contribute to the world. I think of the hologram I create as a balance between art and technology. The layers of reality that exist within the hologram challenge traditional concepts of art and inspire me to help others see art in holography and the technology in art. A balance between being an educator and artist is teaching through art. Some of the abstract concepts we ask children / students to grasp in mathematics and science become clear when presented during hands-on demonstrations in math and science, through art. My aspiration is to open new windows of expression and opportunity, embracing the balance between art and technology.
CHAPTER 5

BRINGING HOLOGRAPHY TO STUDENTS

Ideally, as part of the art and science curriculum, someday every school will have a room that is used as a holography lab. The amount of money needed to set up a lab contributes to a mindset “the glass is half empty”. While it is true that labs in a college setting use more expensive and sophisticated equipment, portable systems using low wattage diode lasers are inexpensive, accessible, and safe.

Imagine if you will: It is the beginning of a new school year and your students have walked into a room containing chairs, tables, a sink in the corner, and a black board. Around the room, like little windows, black frames recede into the stark white walls, seemingly empty. You flip the switch to the track lights that illuminate what the frames contain, and welcome your students to the world of holography. Within minutes your students are out of their seats doing the “holo-dance”. The holo-dance can be described as the movements one makes while viewing a hologram. Because of the three-dimensional properties of the hologram, viewers move their heads and bodies up, down, and sideways to see around and behind the objects in the hologram. Sometimes arm movements are involved when hands reach out to touch the empty space in front of a hologram.

You have what every teacher desires, a class of students wanting to learn and the tools that will help them apply what they learn. When you mention that they will be making holograms with a laser, the students are eager to begin. Holography is the tool you will use to teach science, math, and problem solving. through art.
As time passes and basic information is gained, it is time to set up the table where holograms will be made. The laser will need to be built or secured, optics set up, and a dark room organized. These processes take time, cooperation, and problem solving. By the time students are making holograms, many skills and much learning has been acquired and applied.

Once the technical processes have been mastered, the students will have the tools necessary to create. If technology is the door through which students enter holography, art is the window of expression that allows the students to use holography to create landscapes the mind has envisioned. Without art education, a critical component in the creation process would be missing. Art holds and guides the hand of technology in holography as an art form and is a crucial component for experiencing success in the creative formula. Art taught through holography or holography taught through art, are interchangeable with the end result being knowledge that can be measured, applied, and visually observed.

I have imagined the ideal setting for teaching art and holography in a room with access to a sink. Much like “art on a cart” holography can be “holography on wheels”. While not the ideal way to present holography, a portable presentation method may be instrumental in the initial acceptance of holography as an educational tool. Large numbers of students and teachers can be introduced to the basic concepts, wonder, and possibilities of holography in a presentation that is easily set up, taken down, and transported to a different location.

Tung H. Jeong and Albert B. Dick’s booklet published by the Thomas Alva Edison Foundation, Laser Holography – Experiments You Can Do...From Edison, 1987 provides a variety of projects and scientific experiments that students can perform easily in a classroom. These experiments engage the student’s curiosity and encourage them to seek and study the techniques and scientific principles at higher levels. Frank DeFreitas in Shoebox Holography, 1999 has a step-by-step guide to
making holograms with an inexpensive diode laser pointer that could also be used in a classroom setting. Students can sometimes obtain a free laser from the scanners grocery stores throw away.

If it is so easy, fun, and inexpensive, why aren’t more teachers and artists using holography to create and teach? I believe holography will become less marginalized as more people see and understand the possibilities of the multiple applications for education that exist in holography. With understanding, availability, and ease of use, just like photography, holography will blossom and grow. The mindset or preconceived idea that science and technology are hard to understand and not enjoyable can be changed through the art and education inherent in holography.
CHAPTER 6

CONCLUSION

How much do we miss by not seeing? I almost passed by that little poster for the Department of Art course Beginning Holography that was competing for space on a wall crowded with other announcements. I am grateful I did see the poster and took a chance on something I knew nothing about. Researching, experimenting, and applying what I learned as a Graduate Teaching Associate in Ohio State University's Department of Art, Art and Technology Program did put me on a path of self-discovery, and provided me with the artistic means to create which has equipped me to succeed and give back to the world I live in. Holography opened my eyes and mind to another way of creating with and utilizing the universal language of art to teach. As our society has become more dependent on technology and the global competition that exists in science, industry, and business has intensified, there has been a waning interest in science and mathematics by elementary and secondary students in United States schools. Holography stands poised as a comprehensive and accessible resource available to generate interest in art, technology, and science. Art taught through holography or holography taught through art may be interchangeable, however the end result is applicable knowledge that contributes to understanding the world we live in.
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