HOLOGRAMS: Our Habitation

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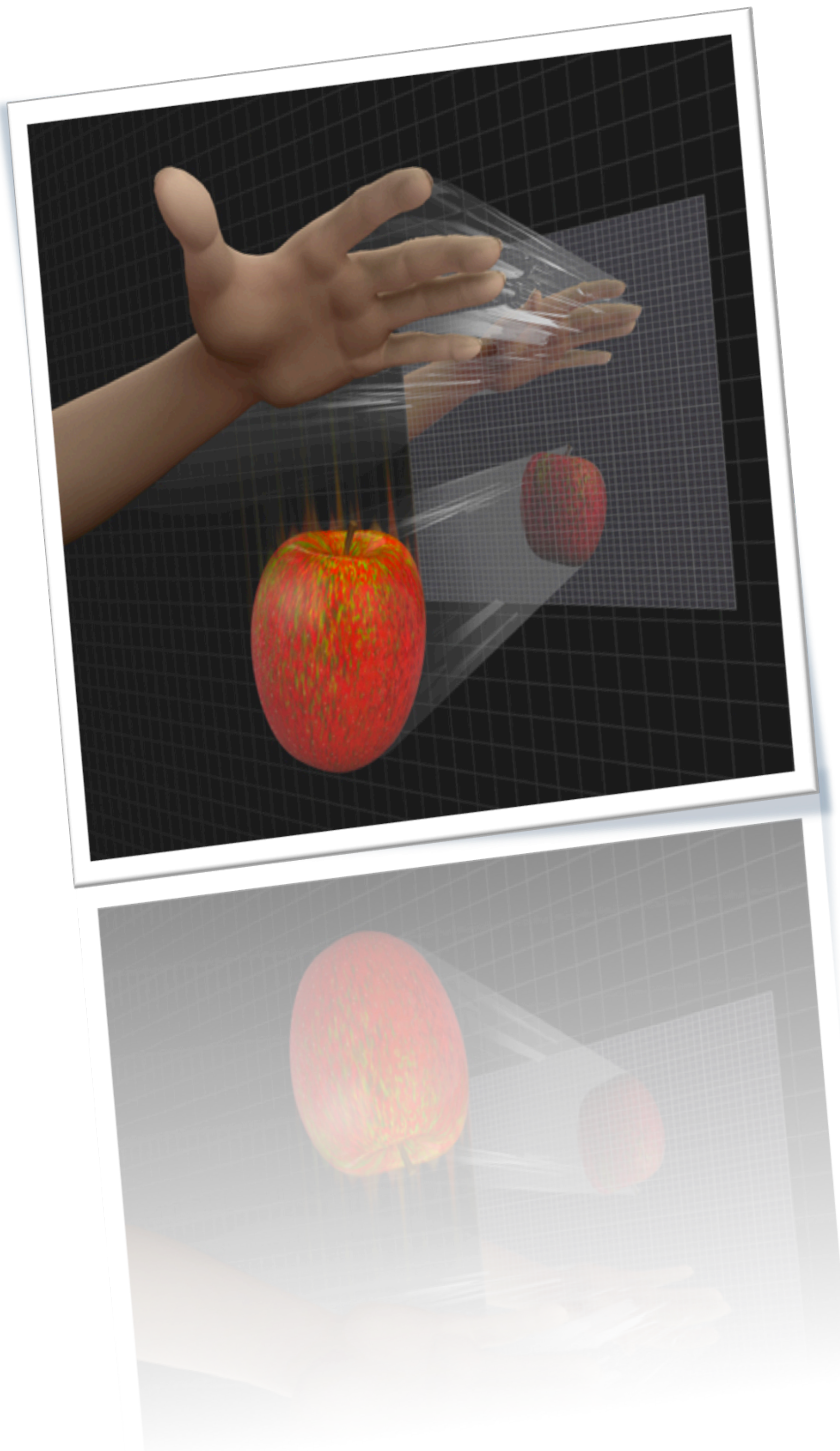
Freiberger, Marianne. "A Holographic Universe." Cartoon. Plus Magazine. 1 July 2009. Web. 11 May 2012. <http://plus.maths.org/issue51/features/maldacena/HologramIllustration_small.jpg>.



Contemporarily holography is a field of science heavily studied by a wide range of researchers and enthusiasts in diverse disciplines. "The proper viewing of a hologram is an eerie and mystical experience. No curious person can fail to ask for an explanation." (1) Scientist delight in cognizance of theoretical colloquy of this disquisitional modern day art-form, as well as the possible uses and implementation for veritable societal use. "People put a lot of comfort and faith in [holograms], but it's really the emperor's new cloths. They are dual purpose, for display and for security, and people forget the display end of it," (2) said Jeff Allen, a pioneer and artist in holography. Several studies are continually being conducted regarding the relevancy of the field of holograms. In particular the University of Arizona offers a full gamut of holographic study; "Researchers at the University of Arizona are very intent on creating holographic videos in real-time." (3) And companies have intention to implement holograms into their product line when technology becomes available.

Today holograms are used in a number of ways. One of the most common uses of holography is the essentially failed security feature in major credit cards. In an effort to discourage or totally prevent forgery of credit cards, major card companies like Visa and Mastercard believed holographic security prints on plastic would be the answer. Visa and Mastercard reported a loss of two million dollars in 1993 from falsified credit cards, which lead to exploration in security enhancements. Robert Lee, head of Electron Beam Lithography department in Australia's Commonwealth Scientific and Industrial Research Organization (CSIRO), invented the technology trade named Exelgram. Though providing a new obstacle to expose and deter counterfeiters the design only made counterfeiting harder, not impossible. Criminals eventually found that holograms aren't particularly hard to produce.

In addition to effectuation of holograms are also used a security measure in currency. In an article called "Fooling the Forgers", from Science Spectra (2000), "The percentage of counterfeit US$100 bills circulating in Europe often exceeds 80 percent." (4) Lee claims that optically variable devices (OVD) is the only way to prevent this crime. The details on Exelgram OVDs' remain confidential for security reason, but the technology has been purchased by a growing number of organizations. In essence, Exelgrams function by printing thousands of microscopic tracks. Placed under the light the OVD different images when held at different angles. The images produced can use up to nine colors, capable of changing with every angle. In 1997 the Hungarian National bank issued new banknotes encompassed with the technology. American Express developed Euro traveler's check expecting a 30 percent decrease in counterfeit related losses; the losses dropped by nearly 90%.

As an experiment to gauge hologram contrivance, Texan researchers and law enforcement initiated an observation of Special Weapons and Tactics Teams (SWAT) tactical utilization of geospatial holograms. The goal was to decide if holograms should be regularly incorporated in establishing a geographical reference to provide a clearer picture of the potentially environment as oppose to a two-dimensional map. The study conducted called for controls and creation of holographic maps. Trained law enforcement agents were instructed to locate an objective in a dark maze at a local laser tag facility. The control group was timed using a normal 2D map renders. Whereas the pilot group used the 3D holographic geometric map render. Digital mapping services like Google Maps have been enhancing SWAT tactical decisions in regards to wayfinding. Tactical planning, collaboration, and responsiveness, are all focuses that must be addressed before SWAT will incorporate holographic design into their métier.

"Seven SWAT members found that route planning was easy with the geospatial hologram and four members found that route planning was more difficult with the [2D] paper maps."(5)

While seven out of the eight SWAT participants agreed that holograms are beneficial, five SWAT members believe a conventional 2D map are also valuable. The comparison of times in finding the hidden object albeit existent is intelligible from the standpoint of true efficiency. The concerns are real and well warranted. Some of the worries include the expense of the technology, visibility in different light and, most concerning, is the time it takes to produce geospatial holograms. "Current holographic technology does not allow instant hologram generation." (5) Though the final analysis concludes that there are no real notable difference between the 3D map and the 2D map (from a quantitative point-of-view), the qualitative data support the push for use of geospatial holograms for SWAT missions.

The beauty of true holographic images is it allows any user to view a 3D scene from any perspective, with out any form of eyewear. Meaning the perspective of an object can be viewed upon in a single frame. Today's holograms are able to encode scenes viable from over one million different angles. SWAT participant 5 said, "It was like looking down at the maze." (5) The problem in the SWAT simulation was less an issue of functionality but more an issue of producing a holographic image in a timely fashion. Currently SWAT teams use other technologies to know the ground that they may be entering (i.e. aerial picture taken via helicopter, or satellites images.)

Beyond security or defense tactical use, hologram theory may be integral explanation to the design of the universe itself. Physicist, Leonard Susskind, and Nobel prizewinner, Gerard 't Hooft, postulate affirmatively in the theory of the universe being a hologram. Marcus Chown, author of "Quantum Theory Cannot Hurt You," presents an intriguing exposé on the unusual discoveries made by German based gravitational wave detector, GEO600. The GEO600 has been monitoring the ripples in space-time caused by neutrons stars and black holes since 2002. German team members became perplexed over interfering noises being identified by their elaborate and sensitive detector. American physicist, Craig Hogan, approached the German team with an exegetical hypothesis as to why this is occurring. Hogan believes the GEO600, within its sensitive structure, may have extended to areas of space-time outside of the smooth continuums and scenarios once described by Albert Einstein. "If the GEO600 result is what I suspect it is, then we are all living in a giant cosmic hologram," claims Hogan. (6)

To believe that the universe may be constructed of interfering light patterns was an idea generated out of perpetuated by Susskind and 't Hooft in the 1990s. Meaning ones life experience takes place on a very distant 2 dimensional, projected through space-time giving the illusion of a three dimensional world in a four dimensional environment. (The fourth dimension is expressed as moving time.) A popular contemporary, cartoon aired on Cartoon Network, illustrates the first four dimensions in a clear tongue-and-cheek fashion. The main character invents a bubble blower capable of blow two, three, and four-dimensional bubbles. Imagining a 2D bubble emitting a 1D shadow, then naturally a 3D bubble emits a 2D shadow. A 4D bubble in theory then emits a 3D shadow, an enigma and comically paradoxical proposition. In theory generating a black hole that devours every thing in its negative gravitational pull. Susskind, 't Hooft, and Stephen Hawking all inspired by Jacob Bekenstein work with black holes at Hebrew University, Jerusalem, Israel.

"If space-time is a grainy hologram, then you can think of the universe as a sphere whose outer surface is papered in Planck length-sized squares, each containing one bit of information." (6)

Named after the founder, German physicist Max Planck, a Planck is the natural normalized unit for describing universe constants. "Or to put it another way, a holographic universe is blurry," says Hogan. Karsten Danzmann of the Max Planck Institute for Gravitational Physics sent a plot of noise being detected to Hogan. "Incredibly I discovered that the experience was picking up unexpected noise…it looked exactly the same as my prediction," says Hogan. Even with a growing mound of information it is still far too early to conclude and confirm any of theory or assertion regarding the construct of the universe. A confirmation would completely remap the entire approach to quantum theory. Craig Hogan levels, "There could still be a mundane source of noise."(6)

The general consumer has not been forgotten in this arcane field known as holography. In fact a great deal of consideration for the average person has been the focal point of visionaries in the field. Pop culture science fiction like "Star Wars" has endorsed and represented holographic use in society as a humble technological wave of the future. A BBC special in 2011 describes a holographic television becoming a reality, available at the end of the year 2012. Computer Company, IBM provides literature referencing holographic data storage. The sophistication of optics coming out of World War II played a huge role in the engineering field, contributing to the study of camera's and lenses. The origin of holograms has humble beginnings dating back to the 1890's when French physicist, Gabriel Lippmann, invented color photography.

Lippmann's efforts, however, were not entirely appreciated right away. Lippmann received the Nobel Prize in 1908 with little interest from the average person. By coincidence, Dutch physicist Frits Zernike also received little attention for his concept of phase-contrast microscopy. Zernike's technique awarded him the Nobel Prize in 1953, but was also mildly regarded. Both these discoveries combined have made way in inspiring Dennis Gabo "a creative engineer at ease with mathematical physics but with no background in optics." (9). Gabo's goal was to make specimens under a microscope more visible which he was able to do with the use of an electronic beam recorded on photographic film. He first coined the term "hologram," with Greek roots meaning "whole drawing". Although incredibly unique and innovative, Gabor's concept posed as impractical filled with fundamental flaws at the time. His concept required the use of a monochromatic electron beam that could maintain a constant electron source. Light lasers would not be invented until 1960.

Next a grad student by the name of Yuri Denisyuk would gain fascination in Gabor's work. Denisyuk's concept was to capture a scene like the human eye would capture one, in full parallatic display. Denisyuk was discredited by others in his field at the time based on his results or lack there of, although he was able to produce "wave photographs". Coming out of the University of Michigan, was young electrical engineer Emmett Leith, who performed classified researcher for the United States military. Merging mathematical postulates concerning optical physics, Leith and his team was able to create enough theory to classify a new applied science. "Military security prevented publication." (9)

"Holography really did not shrink in the 1955-62 period as one would erroneously conclude from the open literature. In a manner of speaking, it went underground," (9) Leith writes.

1961, Juris Upatnieks came up with a way to make Gabor's theories into a reality as he demonstrated ways of encoding / decoding transparent image information in a two step hologram process. Using overlapping images and applying communication theory, Upatnieks was the first to introduce the use of interference patterns; two images overlaid and cancelling out at specific points. 1963 the laser became available only to aid Leith and Upatnieks. Even though the theory was ironclad, the images that were produced from this assembly of research put into practice "amazed all who saw it" (9).

"Holography innovations go on behind the scenes, rather than in the limelight, to develop new applications, and innovations." (9)

Hologram enthusiast Kip Siegel is a physicist who founded Conductron. Siegel hyped and promised employees / shareholders / potential investors that the United States would soon be the only country with holographic television and cinema. Today we still live without these accoutrements although. What remains however is the faith that holographic moving display is a consumer reality. In the 1970's Star Wars and Star Trek alike give a simply impossible vision of holographic use but help propel the concept by entertaining viewers around the world. One decade later, low cost methods of printing holograms on film (as well as foil), became available. This process also allowed from image prints of all colors of the rainbow, providing alternative modus operands to marketing, and anti-counterfeiting companies.

Far more important than receiving messages from Princess Lea, holograms have the potential to serve in the medical field. "Surgeons at different locations around the world could use the technique to observe in three dimensions, in real time, and to participate in the surgical procedure." (9) Pairing a red, green, and blue laser allows the production of full color images. As of now we have the technology to display holographic images that refresh every two seconds. "A 50Hz nanosecond pulsed laser is used to write the holographic pixels. Multicolored holographic 3D images are produced by using angular multiplexing, and the full parallax display employs spatial multiplexing." (10).

Television sets today change 24-30 frames to the second the displays having refresh rates of either 48Hz or 72Hz (divisible of 24). Even though the human eye is capable of detection of over 30 frames per second, many find such speed in television to be unnecessary and disorienting. Perhaps the nature of holograms would rewrite the opinion on this matter as well. Holograms being intrinsically three-dimensional differ from 3D movies in the sense that it does not require any type of special eyewear. The projected image that one sees in a hologram is literally holding a 3-dimentional value in 3D space. Complex mathematics goes into how holographic images work on a detailed fashion. The general makeup of a hologram can be understood by examining a small facet of general optics.

Lets take an apple in reality for example. In reality, we see an apple hanging in the grocery store mental awareness of the somewhat spherical object is an apple. The human mind has built up association. The apple is refracting and reflecting color aimed at the iris. (The iris of the human eye is a lot like the iris of a camera.) It adjusts and the image is captured into the retina. The retina takes the image and sends it through the optic chiasma and eventually reaches the visual cortex, where the brain receives and decodes its message. When we see a picture, our eyes adjust to color values and our brain uses its ability to associate images to give us a meaning of the picture.

A movie is a reel of several pictures in sequence moving quickly to give us the illusion of movement. Similarly a 3D movie has the same effect, as a movie however the still image we view in each frame is a compilation of feed from two separate cameras. Holographs differ immensely from 3D motion pictures. 3D images are optical illusions generated by two overlapping images slightly offset in two different colors or tones (occasionally red and blue) representing a stereographic field. When wearing the proper eyewear, the brain interprets the viewing plane as one image in an almost crossed eyed fashion.

Without the eyewear, no 3D image will be produced. Even though something may appear to be 3D reaching in front of you, one would never be able to grab a point. The BBC news report makes note of the belief that extended 3D imagery can cause headaches. 3D is not recommended for children under the age of three. The reason for this is that the eye and brain must work incredibly hard to construe this complex image. Holograms have an entirely different mechanism for producing realistic 3D. Typically done by shining two intercepting lasers at an emulsion of a sinusoidal wave pattern, the two lasers are divergent of one original beam constructed with the principal that their intensities must be equivalent and synchronized. The reflection bouncing off the image builds a 3D image. This is explained by a concept called cancelation.

What are holograms? Holograms are products of holography capable of displaying objects and environments in three-dimensions, unassisted with eyewear. They can be computer generated, captured by still cameras, or even the use of the digital holographic camera ‘eHoloCam’. “Holographic cinematography has previously been demonstrated.”(10) So far holograms are considered to be one of the more reliable measures of safeguarding against duplications of precious documents or notes in both printing and scanning. Leaving room for further research and development may be essential if we are ever to understand greater the meaning of life, as we pursue happiness and other worthwhile endeavors.

Work Cited:

1. Kasper, J. E., and S. A. Feller. The Complete Book of Holograms: How They Work and How to Make Them. New York: Wiley, 1987. Print.
2. "Who's Behaving Badly?." Communications Of The ACM 50.4 (2007): 13-14. Academic Search Complete. Web. 11 May 2012
3. Nguyen, Chuong. "Holographic Telecommuting to Become Reality Thanks to U. of Arizona." Ubergizmo. Ubergizmo, 03 Nov. 2010. Web. 11 May 2012. <http://www.ubergizmo.com/2010/11/holographic-telecommuting-to-become-reality-thanks-to-u-of-arizona/>.
4. "Fooling The Forgers." Science Spectra 20 (2000): 19. Academic Search Complete. Web. 11 May 2012.

5. Terry Nichols, et al. "Investigating Geospatial Holograms For Special Weapons And Tactics Teams." Cartographic Perspectives 63 (2009): 5-19. Academic Search Complete. Web. 11 May 2012.
6. Chown, Marcus. "All The World's A Hologram. (Cover Story)." New Scientist 201.2691 (2009): 24. MasterFILE Premier. Web. 11 May 2012.
7. "The Real You - Adventure Time." Wikia. Wikia, 14 Feb. 2011. Web. 11 May 2012. <http://adventuretime.wikia.com/wiki/The_Real_You>.
8. "Holographic Television - the New 3D?" BBC News. BBC. Bbc.co.uk. BBC News, 11 Feb. 2011. Web. 11 May 2012. <http://news.bbc.co.uk/2/hi/programmes/click_online/9393762.stm>.
9. Johnston, Sean F. "Whatever Became Of Holography?." American Scientist 99.6 (2011): 482-489. Academic Search Complete. Web. 11 May 2012.
10. N. Peyghambarian, et al. "Holographic Three-Dimensional Telepresence Using Large-Area Photorefractive Polymer." Nature 468.7320 (2010): 80-83. Academic Search Complete. Web. 11 May 2012.
11. Carnoy, David. "Six Things You Need to Know about 120Hz LCD TVs." CNET. CNET, 25 Oct. 2007. Web. 11 May 2012. <http://reviews.cnet.com/4520-6449_7-6792632-1.html>.
12. "History Of Lasers." About.com Inventors. Web. 11 May 2012. <http://inventors.about.com/od/lstartinventions/a/laser.htm>.
13. "Planck Units." Wikipedia. Wikimedia Foundation, 05 Sept. 2012. Web. 11 May 2012. <http://en.wikipedia.org/wiki/Planck_units>.
14. "Retina." Wikipedia. Wikimedia Foundation, 05 Sept. 2012. Web. 11 May 2012. <http://en.wikipedia.org/wiki/Retina>.
15. "The Word of Notch." At What HZ Does the Eye See? :. Web. 11 May 2012. <http://notch.tumblr.com/post/134701406/at-what-hz-does-the-eye-see>.
16. "Think Research." IBM Research: Overview. Web. 11 May 2012. <http://domino.research.ibm.com/comm/wwwr_thinkresearch.nsf/pages/storage297.html>.
17. Burns, N M, and J Watson. "A Study Of Focus Metrics And Their Application To Automated Focusing Of Inline Transmission Holograms." Imaging Science Journal 59.2 (2011): 90-99. Academic Search Complete. Web. 11 May 2012.
18. Sharma, A. K., D. P. Chhachhia, and A. K. Aggarwal. "Moiré Pattern Encoded Extended Fractional Fourier Transform Security Hologram." Journal Of Modern Optics 55.3 (2008): 351-359. Academic Search Complete. Web. 11 May 2012.

Further Reading:

1. Amos, Jonathan. "Hologram Messaging Coming of Age." BBC News. BBC, 11 Apr. 2010. Web. 11 May 2012. <http://www.bbc.co.uk/news/science-environment-11685582>.
2. "Holography." Wikipedia. Wikimedia Foundation, 05 Nov. 2012. Web. 11 May 2012. <http://en.wikipedia.org/wiki/Holography>.