Special Effects Techniques for Integral Holograms

Sharon A. McCormack
Holography
P. O. Box 38
White Salmon, WA 98672

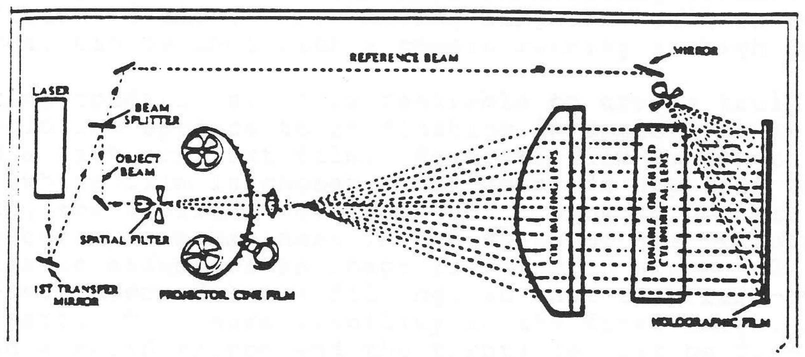
Abstract

Integral holography is the integration of multiple exposures of motion picture film that have been translated into holographic form. Because integral holograms are formed from motion picture film, there are no limits on the subject matter. All of the cinema and video techniques known today can be utilized to record and mix imagery.

Introduction

In 1877 Edward Muybridge made a wager with the Governor of California about whether a running horse's feet are all off the ground at the same time. In the process of documenting this, Muybridge devised a unique sequential photographic setup, which captured all of the horse's feet off the ground. Unwittingly, he also laid the foundation for the first true motion pictures. In much the same way, integral holography may be the predecessor of three-dimensional motion pictures of the future.

Integral holograms are a wonderful form of holography because, unlike other forms which are limited to the laboratory environment, integral holograms make it possible to record living things in motion, outdoor scenes, computer graphic imagery, and virtually anything that can be recorded on movie film. I have designed and built a printer which has a reel to reel film drive which allows producing three dimensional films of any length. These films may be displayed in a cylindrical or flat format.



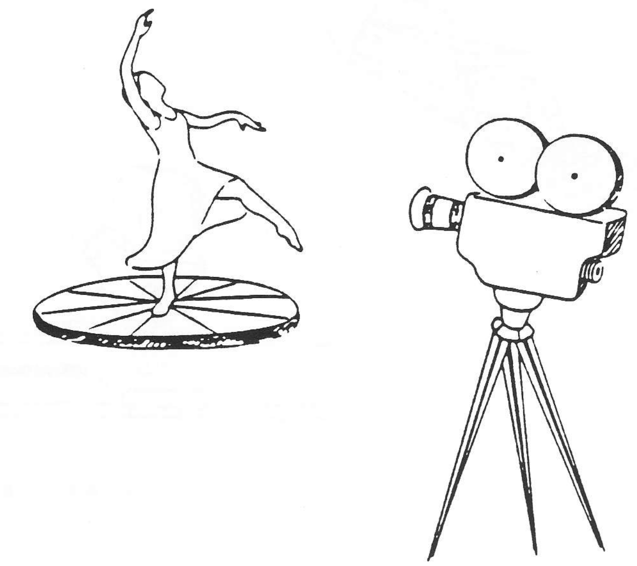
Integral Holographic Printer

Another innovation is computer control which enables me to change the various parameters during printing such as: exposure time, holographic film spacing, ratio of holograms to movie frames printed, settling time and beam ratio. Testing, which was once a time-consuming process, is made simple and more efficient by the computer controls which precisely alter recording parameters. Image information storage is also facilitated by the computer. Image printing parameters stored in the computer make the printing process empirical for the first time.

A number of techniques will be discussed for creating special-effects that are commonly used in film and video production, and which can be utilized for creating three dimensional effects in integral holograms.

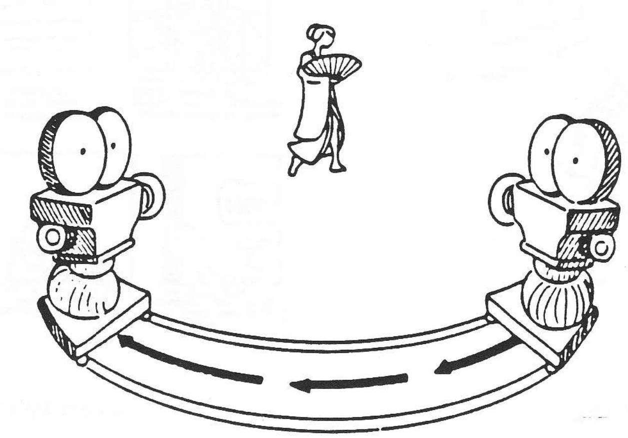
When an integral hologram is made, we are, in a sense, making a mini-movie, and similarly to making a movie, we would start with a creative idea. A creative idea in film is developed by the use of a story-board. Story-boards are necessary in the case of choreography, costume and set design. A linear story-board is typically used in films and, because some integral holograms are cylindrical, a story-board in the round is often used. It is most desirable to use a circular story-board in the case of a 360 degree hologram because it insures that the beginning and end of the sequence will appear smooth and continuous.

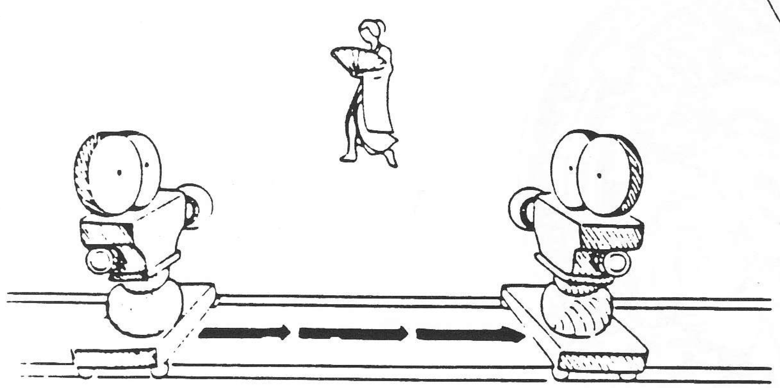
Integrals have traditionally been filmed of a rotating subject with movement being optional. The product shot need not be in motion. A hologram of a person would ususally contain some motion.



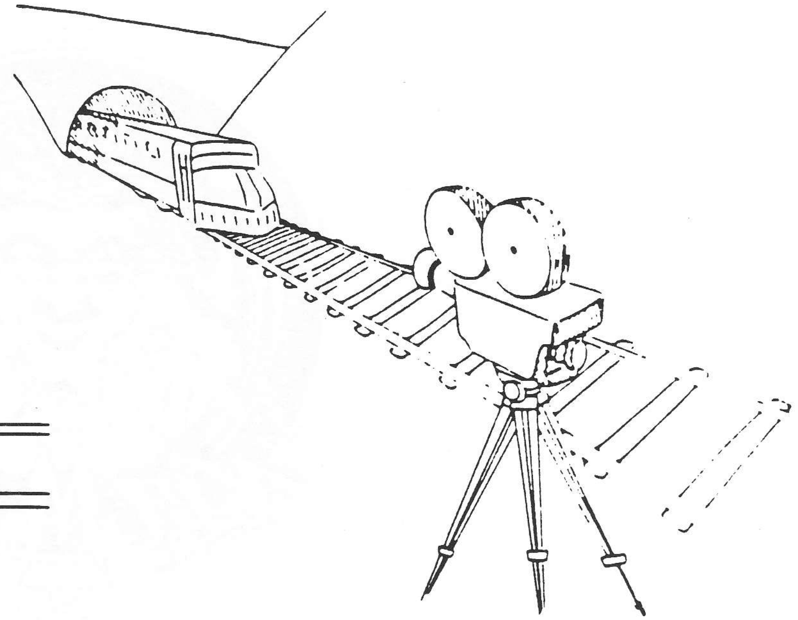
Normally, filming takes place with a stationary camera, the subject centered on a rotating turntable, the camera running at 24 frames per second, and the turntable taking 45 seconds to complete one rotation. It is necessary for the subject to move in slow motion, so as to have enough fill-in frames to minimize distortion, much like cell animation. The resulting distortion would be a staircasing effect, or a smearing effect, if there were insufficient frames. Fast-moving subjects, such as horses running, birds flying, or ocean waves, can be shot with a camera running at high speed.

For studio filming conditions, it is desirable to have a truly black background, so the imagery on the hologram appears to be floating in space. It is desirable to have a full tonal range and a high contrast film. Reversal film is generally used in printing. Typically, black and white film is chosen. The color is supplied from the diffraction of the light illuminating the finished hologram. If the background is overexposed, it will be evident in the hologram as a haziness in the shape of the cylindrical lens aperture. This lessens the dramatic effect of an image floating in space. It is also important to choose a pin-registered camera for the filming, so that the frame-by-frame lineup in the hologram will be perfect. To insure stability in the final image, it is necessary to have the camera mounted on a solid tripod and the turntable must be free from jitter.



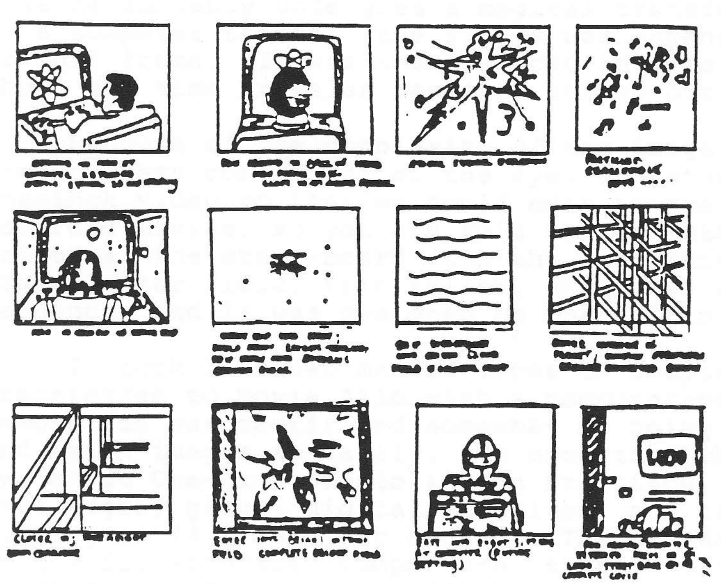


Filming with linear track

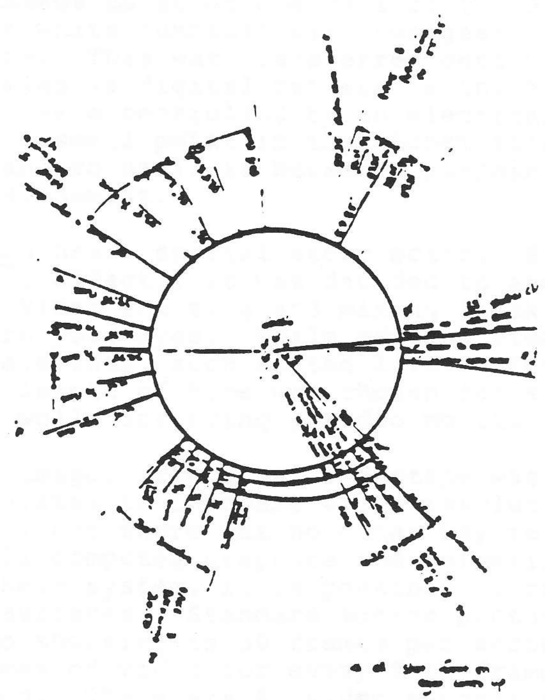


Filming with stationary camera

In addition to the traditional method of turntable filming for integral holograms, it is also possible to use a track to move in an arc around the subject, or to use a linear track to travel horizontally in front of the subject, or shoot from a single, stationary camera position, at an angle, to achieve parallax. These techniques can produce effects such as a train coming at the viewer, or ocean waves breaking toward you, or a person walking toward you.



Traditional linear storyboard



360° storyboard

I will now discuss the creation of 'Time Man', the computer generated S.P.I.E. logo, and some new work.

Time man is an integral hologram that tells a story of an alchemist and his artifact-filled lab, who sniffs a potion and is blasted into the starry universe. Time-man was a commissioned work for a Cupertino, California restaurant called Eli McFly's. This hologram measures 2 feet in height and 3 feet in diameter. In this holographic stereogram, the lab scene was shot on a rotating turntable with one-inch video. I was thus able to preview the action as it would be recorded and transferred to the hologram. Elements such as the speed of rotation, the speed of the alchemist's motion and the objects in the set were previewed on the video monitor and precisely timed with the holographic transfer in mind. The lab section makes up about one half of the 360° image. A time traveler was then filmed (myself in a white jumpsuit with headgear, resembling a skydiver), also shot on a rotating stage. This was transferred onto video. The special effects emanating from the alchemist's eyes (a digital pattern making him look like he suddenly undergoes a magical transformation) were controlled by an electronic pen on a computer tablet: the figure was expanded from a small point in the alchemist's face to full frame. It was then reduced in size across an arc until it became a pinpoint. Thus, the time traveler seems to spring out of the alchemist.

Because of the complexity of the image, Time man has a special story-board. Since we wanted beams coming out of the eyes and other special effects, it was decided to shoot in one-inch video so that we could edit in real time. Video shooting and mixing is akin to polaroid movies, so you are able to see things before your eyes. While editing video, we looked at the story-board with the different scene elements, such as the live action, digital star field, free faller, and laser eyes. A length of time was chosen for each sequence, and it was designed on the editing system while observing a video monitor.

It took 14 video master tapes to complete this image. The final videotape was transferred to movie film with a computer-enhanced system to increase video resolution. Resolution was sacrificed somewhat by going to video, but there was no other way to mix and match images so easily. We used the Dubner CBGII computer graphics and animation system at One-Pass Studio in San Francisco. With their system, it is possible to create soft edges, glows, digital dissolves, and textured surfaces. Standard motion picture filming is 24 frames per second. The standard video shooting is 30 frames per second, so in the film-to-video comparison, there are five frames of video for every four frames of movie film. Time man is 100½ holographic inches long. There are 67 video seconds at 30 frames per second, or 2,010 frames. We printed each frame twice, so there are 4,020 holograms.

Sequences from Time Man

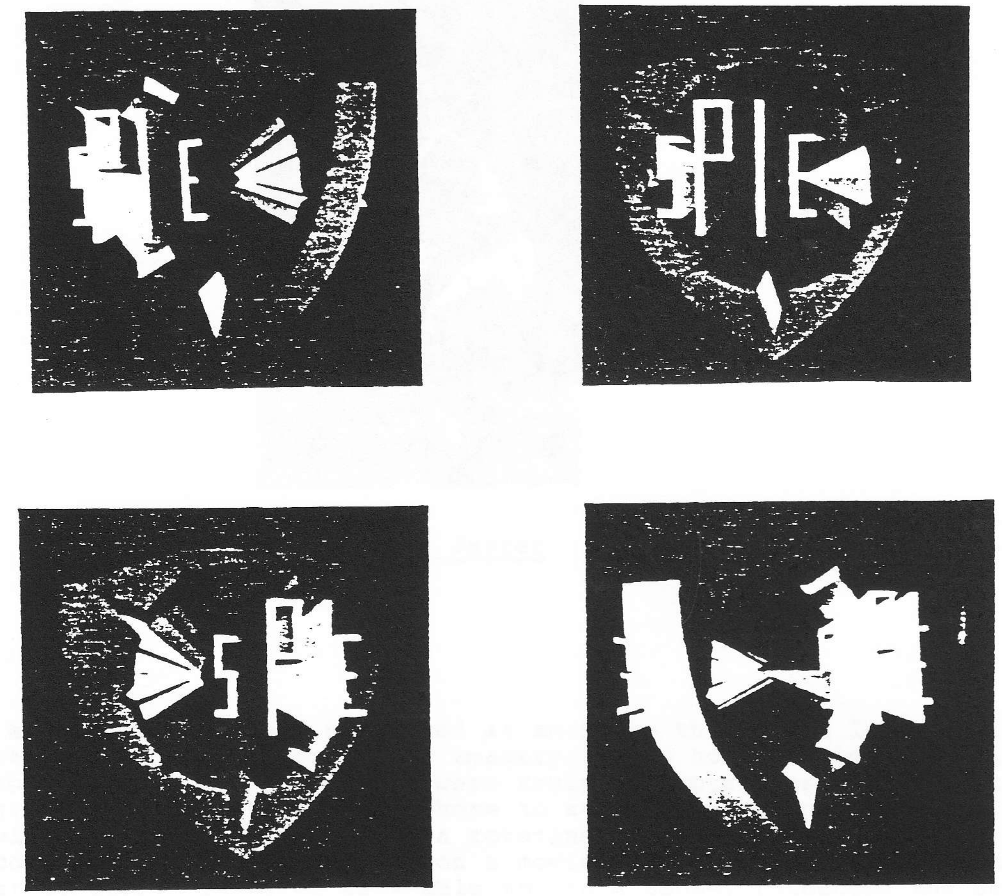
Computer Graphics

As computer graphic imagery evolves, its ability to synthesize a realistic-looking image increases. It is this ability that has led to the growth of three dimensional perspective and, more recently, three dimensional perspective with rotation. A few very advanced and costly systems have had this ability to rotate in 3-D for a number of years, but it is only now that it is becoming widespread in the marketplace.

Integral holography is a major breakthrough for viewing computer graphics. On a computer monitor one sees a series of two dimensional images which only imitates three dimensional information. The significance of holographic stereograms is that they are the only way to see three dimensional computer graphics in true 3D.

The SPIE Logo

The SPIE logo is an integral hologram produced for the SPIE using a Cubicomp Solid Modeling system. It was decided that the SPIE logo would have to be altered somewhat to translate well into 3 dimensions. The front face of the logo remained almost intact, but the lettering had some liberties taken with it. We decided that a false perspective would make the lettering appear to stretch out into infinity. A reverse of the lettering was done to appear on the reverse side so that the logo would be readable from all angles.



Sequences from SPIE Logo

The Cubicomp is a polygonally-based system. All points of the polygons were entered directly via keyboard into the Cubicomp system. Once a wireframe model was created, the Cubicomp, using its hidden line removal program, makes the wireframe object appear to be a solid with realistic lighting and shadow detail.

The Cubicomp system allows a solid object to be mirrored so the back face of the logo shield is simply a mirror of the front. The Cubicomp also allows for the lighting angle to be set in any direction. The angle picked made the object appear to be top-lit. The lighting angle chosen also had to create interesting shadows on the logo as the object rotated. With the Cubicomp, shading is automatic and dependent on the angle of the light. For instance, if the lighting is from the side, the shading realistically appears on the surfaces of the sides of the object facing away from the light source.

The color scheme for the logo was chosen to translate well into a hologram. For this reason, various shades of gray were chosen as the primary colors which display as multi-colors in the final hologram. The Cubicomp has a palette of over 16 million colors and 65,000 colors can be displayed simultaneously.

Once the model was created, a motion path was chosen for the logo to move on. In video, 30 distinct positions per second can be displayed to produce very fluid motion. In holography, it is desirable to have 2-3 frames per degree. For the 360 degree hologram it was decided to have the animated sequence last 720 frames in a 360 degree rotation.

From The Jester

New work

The Jester is a new work that was conceived as an image that would lend itself to 3-D montage, of live action and computer-generated imagery. This hologram is an advance from Time man, because the computer graphic images were truly 3-D rotations. I did not want to go to video and degrade the resolution, so I chose to stay with motion picture film. The Jester was filmed with motion picture film on a rotating stage with a fixed camera. We took the film and constructed an acetate grid on a moviescope and a matching electronic grid on the computer monitor. Thus, we were able to, in a sense, rotoscope the action from the film with the computer imagery. Another way to do this would be to put frosted acetate on the front of the monitor and project with a single frame projector from the film onto the monitor. I could have transferred the film image to one-inch video, and converted the computer graphics onto videotape by using a Lyon-Lamb or GSI board and video edit all the component images together. Video editing makes image mixing a tactile, controlled, and immediate affair. We opted for the best resolution we could get this time, instead of video editing, and decided against putting all the components onto video. After The Jester was filmed, we then designed three computer graphic forms that the Jester would juggle in the hologram. Each shape would have a different position in the hologram. We filmed each shape separately, and decided that each shape would take on a different color. The color change would be achieved in the printer by changing the reference angle, thereby changing the diffraction angle and the final color.

The benefits that these methods offer to holography encourage a new freedom in the creation of imagery which was never before possible.

Acknowledgments

I want to give special thanks to Michael Leeds, Adolph Esposito, and Gary Leo for their encouragement, enthusiasm, and help, and to Lloyd Cross, my holography teacher, and developer of the first integral holographic printer.

References

1. D. J. Debitetto, "Holographic Panoramic Stereograms Synthesized from White Light Recordings," Applied Optics 8, 1740-1741 (1969).
2. L. Cross, "Multiplex Holography," paper presented at annual meeting of the SPIE, San Diego, Ca. August 1977.
3. S. Benton, "The Mathematical Optics of White-Light Transmission Holograms," Proc. of International Symposium on Display Holography, Vol.1.
4. L. Huff & R. L. Fursek, "Cylindrical Holographic Stereograms," Proc. of International Symposium oif Display Holography, Vol.1.

"Special Effects Techniques for Integral Holograms"

SPIE
Los Angeles
1986

Sharon McCormack Holography • P.O. Box 38 • White Salmon, WA 98672
Studio (509) 493-1334 • FAX (509) 493-4830