THE FAR DARK SHORE: SCULPTURAL DEPTH AND RELIEF IN DIGITAL STEREOSCOPIC VIDEO AND COMPOSITED STEREOSCOPIC COMPUTER GRAPHICS

JD PIRTLE
2008 HONORS THESIS, BACHELOR OF FINE ARTS
CENTER FOR DIGITAL ART AND EXPERIMENTAL MEDIA (DXARTS)
UNIVERSITY OF WASHINGTON

ABSTRACT

The depth and relief present in stereoscopic art are sculptural qualities similar to those found in dioramas. Unlike traditional sculpture, projected stereoscopy does not adapt to the viewer's movement or position without the additional aid of external systems, such as motion tracking. However, the phenomena of depth and relief in stereoscopic digital media are powerful and important tools for artists to explore and utilize. This paper details the methodology and research involved in the creation of a digital stereoscopic video composited with stereoscopic computer graphics, entitled The Far Dark Shore. Created with Maya 3d modeling/animation software and a high-definition (HD) stereoscopic camera apparatus, The Far Dark Shore is the product of a year-long cycle of research concerning the implications of digital media attaining the power and relief of sculpture. With the intent to present the piece in a gallery setting, research has also been centered on the exploration of the space that exists in stereoscopy—the space behind the screen, the space existing at the screen plane, and the space between the screen plane and the viewer. The Far Dark Shore features a dancer portraying a young woman encountering her mortality through her relationship with orchid blossoms.

INTRODUCTION

Stereoscopic art created and viewed with digital processes represents an unprecedented opportunity for artists to work in a dynamic and underused medium. Stereoscopic techniques give artists the power to realize their work in much the same way painters, photographers, and filmmakers do, with the additional qualities of depth and relief. The visceral qualities of sculpture make it a very engaging medium. Whether it is a complex bas-relief or a bust on a podium, sculptural forms engage the viewer in a way that is impossible in 2d art; sculpture has a reality that can never exist in a painting or photograph because it lives in the same plane as the viewer. When we view 2d art, we are merely gazing through a window into another realm; when we are confronted with sculptural art, we encounter an entity that occupies that same space as we do. 3d immersive environments such as holography, stereoscopic video and photographic sculpture have sculptural qualities and depth that can be used to heighten artistic experiences and portray a portion of the world we perceive through the gift of our binocular visual system [1]. True sculpture adapts as the viewer moves through space around it. Although this effect is not possible in stereoscopic art projected on a surface, digital stereoscopic techniques have pushed the medium beyond the limitations often cited by its detractors [2]. While projected stereoscopic art does not adapt to the viewer's movement, sculptural qualities are present.

WHY STEREOSCOPY?

Humans have enjoyed an epic relationship with 2d art. Beginning with the first depictions of life by early humans on cave walls, art in the form of painting, illustration, photography and motion pictures have been realized on a flat surface. Humans visually perceive our world through an amazingly complex ocular system that employs binocular vision to give us a sense of depth. Our visual world is dominated by 2d rectilinear objects; computer monitors, paintings, photographs, television and cinema lack depth. We are a species who perceives the glory of our world in three dimensions, yet in a majority of our art we portray this 3d sense of life through flattened media.

Artists of the Renaissance developed techniques, such as linear perspective, in an attempt to add depth paintings. Linear perspective, Trompe-l'œil, and other systems meant to create the illusion of depth are only representations [3]. We hear people describe figures in paintings as “real” or “life-like.” Though they don’t often realize it, they are at least subconsciously aware of the gap and discontinuity that exists between themselves and the surface plane of the 2d art they are describing. They are two different worlds.

Stereoscopic art can take many forms. Synthetic stereoscopy utilizes computer graphics captured with virtual cameras to realize 3d models and animation. Stereo video and photography employ a dual-camera approach to approximate binocular vision. Though stereoscopy has drawn the attention of artists sporadically since its invention nearly 170 years ago, stereoscopic art remains in obscurity in an age rife with advanced digital imaging, digital video techniques and emerging media. Stereopsis, the phenomenon of perceiving depth through our miraculous binocular vision, is enjoyed by most but understood by few. Although we spend our waking hours enjoying a 3d world made possible by stereopsis, we have come to accept planar, or 2d, art as the standard for a majority of the art and entertainment we experience [4]. Many thousands of artists and scientists have pushed photography, motion pictures, and 2d animation to their present state. Unfortunately, there are relatively few pioneers and devotees of stereoscopic cinema and animation. Although adequate research is available on the history and techniques of various forms of stereoscopic art, there is an utter lack of examples of a practical workflow suited to today's broad range of digital techniques and practices.

HOW STEREOSCOPY WORKS

Stereoscopic vision in humans and apes is made possible by the binocular nature of our eyes. Our brain utilizes the data gathered by our eyes, which on average are separated by 65mm, and combines the slightly different images we see into one image that contains depth information [5]. At this point, it is important to make a clear distinction between stereopsis and stereoscopy. Stereopsis (literally "solid seeing") is depth sense made possible by binocular vision [8]. Stereoscopy is a broad term that includes any technique in which three-dimensional information (specifically depth information provided by binocular vision) is recorded and presented in a two-dimensional format [6]. Recent advances in digital technology have made this technique more accessible to artists and researchers in many fields, including telepresence and teleoperation. While there are many techniques with which an artist may create and display stereoscopic art, the method with which I am working uses a digital

3d projector and Liquid Crystal Display shutter glasses. The digital projector, which uses Digital Light Processing technology, displays an interleaved stream of left and right images at 120 frames per second. The glasses are synchronized with this stream and block images so that the right eye only sees the right image and the left eye only sees the left [7].

A BRIEF HISTORY OF STEREOSCOPY

Sir Charles Wheatstone invented stereoscopy in 1833. Following Wheatstone's successful creation of a stereoscope that used mirrors to view two separate images in 3d, Sir David Brewster invented a stereoscopic viewer that used cards with homologous images (right and left) printed side by side [9]. This form of stereoscope peaked in popularity during the last decade of the nineteenth century, but soon disappeared into antiquity in the face of new printing techniques for illustrations in books and the invention of photography [10]. Since then, many have tried to popularize stereoscopy through photography, anaglyphs (a technique in which two colors, usually red and blue, are offset printed and viewed through glasses with one blue and one red lens) and motion pictures. Despite their efforts, stereoscopy has seen many periods of brief interest only to fade once again into an obscure novelty.

STATE OF THE ART

Digital imaging has brought stereoscopy to life once more. New digital projectors, such as the InFocus DepthQ, have made it possible to project stereoscopic video, computer animation and photographs from one projector. Major media companies have embraced these new digital techniques and another mainstream stereoscopic resurgence is underway. With the proliferation of inexpensive high-definition televisions and DVD players, consumers are increasingly interested in viewing movies at home; box office dynamos like James Cameron are shifting their focus toward 3d in an effort to lure an audience back into theaters. A large number of theaters in North America, China and Japan are currently installing large 3d systems as consumer interest grows. As high-grossing production companies, movie studios, directors and producers continue to create mainstream movies in 3d, consumer knowledge and interest will continue to grow—an interest that will hopefully resonate in the arts. As 3d systems for classrooms, homes and theaters become more affordable, artists and researchers will have a growing number of opportunities to create and distribute stereoscopic work. These developments in mainstream media and entertainment signal a renewed interest in stereoscopy, but unlike previous eras, digital tools that make it possible to conceive stereoscopic art in a relatively inexpensive way are available to artists.

There are essentially two types of professionals currently working in the field of 3d. The first and largest group consists of artists, technologists and scientists conducting applied research for military and commercial customers. The never-ending quest for military supremacy has driven 3d to new heights, much as it has for digital computer graphics for the last six decades. Commercial interest in 3d has brought many high quality experiences (e.g. IMAX) to consumers throughout the world.

The second and much smaller group working in 3d is made up of artists, technologists and scientists conducting pure research that is meant to create and inform fine art. Many research institutions engage in 3d art research, yet the medium is obscure and adolescent when compared to most artistic media. The potential of stereoscopic art cannot be overstated—there are myriad directions one might take in 3d art provided ample research is conducted, a vocabulary is defined and a methodology is devised.

The research conducted before, during and after creating The Far Dark Shore would not have been possible without the work done by Vibeke Sorensen, Lenny Lipton and Harold Layer. For over three decades, Vikebe Sorensen has been experimenting with computer vision and electronic visualization. In addition to the large body of research published on the subject of computer art, she has created groundbreaking work in stereoscopy, in pieces such as Maya and Fish and Chips. Lenny Lipton is a stereographer and author of Foundations of the Stereo Cinema: A Study in Depth, from which a great deal of technical information that informed the video portion of The Far Dark Shore was taken. Harold Layer, Professor Emeritus at San Francisco State University, has authored numerous papers on the subject of stereoscopy in fine art and greatly influenced this entire project.

RESEARCH FOCUS

My research project, entitled The Far Dark Shore, is a stereoscopic video with composited stereoscopic computer graphics. Created with AutoDesk Maya [11] and a high-definition (HD) stereoscopic camera apparatus (fig. 5), The Far Dark Shore is the experimental result of research and practice that has been focused on the creation of an environment in which I can describe the cycle of innocence, adversity and acceptance that occurs in human life. This arc might occur in the space of moments or in the duration of a long life. The duration of childhood can be defined simply by the moment in which one recognizes the universality of human pain, suffering and terror— at that moment we enter the adult world. As we recognize our mortality, we are transformed by that knowledge. Throughout adolescence and adulthood, the quality and tone of life is defined by how we deal with this adversity, and what is left when that adversity has passed. Concurrent to the development of this thematic framework, I began to wonder what the best and most effective way to convey the universality and power of this human condition. Ideation led in many directions, from rear projection on sculptural fabric to single-channel video. The Far Dark Shore began as a vision of a solitary woman seated on the ground with pink blossoms falling to the ground all around her. This vision expanded, and the narrative that developed from this primary hallucination became the framework for the cycle of innocence, sorrow and wisdom that I wished to portray. The quest for how to create and present my vision was resolved after the completion of a period of research in synthetic stereoscopic modeling and animation. I had the opportunity to conduct research in stereoscopic video due to the fact that the Center for Digital Arts and Experimental Media at the University of Washington had recently acquired a stereoscopic high-definition camera rig (fig. 5), which is rare among academic institutions.

I intended to composite synthetic stereoscopic computer graphics and stereoscopic video. Though there is significant research in each field, there is very little in the way of artistic precedence for the combination of the two. The resulting technical questions became: How do I combine these two stereoscopic elements in a visually appealing manner? What workflow will make this process possible? How should I explore the severely underused and overlooked concept of binocular parallax to punctuate aspects of my piece? [12]

The major research questions of this project are:

a) What are the implications when digital media, such as film and computer animation, attain the power and relief of sculpture?
b) Exploring the space that exists in stereoscopy—the space behind the screen, the space existing at the screen plane and the space between the screen plane and the viewer. How can I mitigate and exploit these spaces?

CHOREOGRAPHY, DIRECTION, AND COSTUME DESIGN

While modeling elements in Maya, generating storyboards, and establishing a thematic framework for The Far Dark Shore, I began the process of finding a dancer with whom to collaborate. After sending out several calls for dancers with acting experience, I interviewed seven candidates, choosing

Heather McKee for the role. Ms. McKee is a University of Washington dance B.F.A. candidate and has acting experience. My vision since the beginning was that the creative process between the dancer and myself would be collaborative. Based on the thematic framework, storyboards and rough computer models, Ms. McKee and I began developing a composed improvisation that would combine interpretive dance and movement-based acting. Ms. McKee would perform over a surface of black material in a dark environment to facilitate the luma and color keying [13] that was necessary to remove evidence of her environment, leaving a void in which to place the computer graphics elements of the piece.

Developing the choreography of the piece began with an analysis of the thematic framework and storyboards. Ms. McKee and I created a framework of movement and dramatic motivation for each of the seven scenes that made up the piece. Since she would be performing with computer graphics elements that would be added later in post-processing, cues were addressed at the shoot through a fairly complicated process of directing. A basic coordinate system was established verbally before each shoot to give Ms. McKee the general location, velocity and trajectory of the major computer graphics elements to be added in post-processing (fig. 7).

The creation of the appropriate costume came from adapting thematic elements of the project. The type of dress that was necessary was a simple gown that would be difficult to place in a specific time period, would be long enough to surround the dancer in a seated position, and short enough so as not to impede her performance in an upright position. The final version combined the best aspects of three different dresses.

Another important costume element was the fabric that would create the illusion of a long dress, the skirt of which would radiate out around the dancer, defining the plane on which she sat. We would be using several fans to create enough circulation of air to move the dancer's hair and garments—this element of the video shoot was crucial to the process of matching the movement of the computer graphics blossoms that would later be composited in the video, so numerous fabrics were tested to get the proper results.

RESEARCH TRAJECTORY AND WORKFLOW

My intent via The Far Dark Shore is to place the dancer and the viewer in the same space. 2d art often has an underlying feeling of protected voyeurism. The viewer, while often absorbed with the content of the work, is subconsciously aware of an invisible and persistent barrier between themselves and the art. Inherent in time-based 2d art is the subconscious feeling that the events and emotions portrayed are a slice of the past. A large part of the power of sculpture comes from the strong feeling of immediacy combined with the experience of occupying the same dimension as the work. The woman and the blossoms in The Far Dark Shore inhabit the same environment as the viewer. As in 2d video, the screen plane is an impediment to 3d composition. No matter how the work is composed, there is a certain degree of conscious awareness of the presence of a rectilinear boundary. In The Far Dark Shore, this boundary is an opening connecting the woman and the viewer. By placing the woman in a void and projecting the video on a blank wall, I am attempting to downplay the effects of the screen. The viewer should be at one end of a vague, rectangular room, opposite of the figure of the dancer, who seems to occupy a rather large void.

The issue of the proper workflow for each stage of this project is a central topic of my research and therefore will be covered in detail in this section.

Technically, using the stereoscopic video rig was an enormous artistic challenge. There is very little research published about the process of shooting and editing stereoscopic video with this type of apparatus. Many commercial companies utilize a similar stereoscopic rig in their 3d productions, but do not publicly release results of their research or practice. Few, if any, academic institutions have access to this type of equipment or experience in this paradigm. Having just created and implemented a graduate-level studio art class in stereoscopic cinema, DXARTS has taken the first step toward establishing a methodology and precedent in this area of arts research. Because I was conducting the inaugural video shoot with this new apparatus, large portions of the compositional and methodological decisions made during the process were based on the documentation of researchers working with other types of stereoscopic film/video/still rigs. All scenes from The Far Dark Shore were shot using a 2.5" interaxial [14] distance between the cameras, which corresponds to the average human interocular distance. This decision was based on the principle that any subsequent shoots would use the results of the initial shoot as a baseline from which to work. A major impediment to the shooting process is the lack of any reliable monitoring systems for the stereoscopic video system. Two video monitors were used for the right and left cameras, but were only useful as a means to focus the cameras. There is no 3d feedback in the system. What this means is that the results of the shoot had to be minimally processed (clips captured, arranged in After Effects, and exported) before being viewed on a 3d projector.

The custom stereoscopic video apparatus used to shoot The Far Dark Shore makes it possible to record video with two Canon XH-G1 high definition video cameras simultaneously. The right camera is mounted horizontally and can be moved to the right or left using a dial, adjusting the interaxial distance of the cameras. Due to the size of the cameras, the left camera is mounted vertically and uses a 45°-beam splitter to reconcile this orientation to horizontal shooting. This system makes it possible to attain very small interaxial distances, as low as zero inches.

Two editing processes were necessary to prepare the video and computer graphics aspects of my piece for the final edit, in which the two would be combined. The first process consisted of capturing the raw footage from the right and left cameras from the stereoscopic camera rig. Once the desired clips were captured, trimmed and labeled in Final Cut Pro [15], these clips were then imported into After Effects [16], where the final video edit would be undertaken. In After Effects I aligned right and left video clips, color corrected, added transitions and keyed any unwanted elements. The keying process was fairly involved, using multiple garbage mattes [17] and luma keys to remove undesired artifacts from the video shoot, primarily the mat on which the dancer was performing, reflections on the floor and light leakages from the background.

Due to faults in the stereo video camera rig and a lack of real time feedback, an exhaustive parallax correction process was necessary before the final video edit could be rendered. The shoot involved a mix of long, medium and close-up shots, and it was necessary to adjust the parallax of the video in After Effects by moving the right video layer up, down, right or left. Many compositional decisions were made at this point. With a seated subject filmed using a long shot, too large a parallax can give the viewer the illusion that the vertical trunk of a subject's body is tilted forward at a 45° angle. For close-ups, too large a parallax can cause a painful divergence of the eyes as the viewer's brain tries to reconcile the image. Once all of the parallax adjustments were made, the final video aspect edit was then rendered from After Effects and added to a second After Effects composition. In this new composition, I composited the computer graphics and the final stereo video edit.

The computer graphics portion of the piece was create in Maya (fig. 1), implementing a virtual stereo camera rig tuned to match the specifications of the Canon XH-G1 cameras used in the stereoscopic video rig. Over a period of several days, the final computer graphics were rendered frame-by-frame as Wavefront RLAs [18] on nine computers. The RLA format stores RGB, Alpha, and Z channel information [19], which makes it ideal for compositing when depth is to be used or manipulated. Once the RLA sequence for each virtual camera was imported into After Effects, I duplicated the right and left sequences in order to have a right front, right back, left front and left back (fig. 3). This orientation is necessary in order to implement Depth Matte effect [20] in After Effects. This effect makes a slice in the Z information, making it possible to place some computer graphics behind the dancer and some in front. By placing the dancer (video aspect) between two layers of computer graphics and using the Depth Matte effect, blossoms would pass in front of and behind the dancer (fig. 8).

Once the general blocking of the computer graphics was completed, it was necessary to apply noise, blur and color correction effects to the computer graphics layers in After Effects in order to best match them with the video, as computer graphics tend to have a sharp edge that isn't present in video. A black sticker had been applied to the dancer's hand during the video shoot; I was able to use this dot for motion tracking in After Effects to aid in matching certain aspects of the video and computer graphics (fig. 4). Transitions were added to the computer graphics layers in After Effects to match the video layer. The last adjustments made to the final video were to tune the parallax of the computer graphics layers to match the changes made to the video layers.

Though I initially intended to explore the phenomenon of binocular parallax, the aesthetic concerns of the piece greatly limited experimentation in this area, particularly the necessity to match the parallax of both the video and the computer graphics. It is now clear that careful compositional considerations and planning would be necessary prior to any stereoscopic video shoot in order to experiment with binocular parallax.

In order to properly exploit the sense of space, depth, and relief made possible by stereoscopy, one must carefully weigh the following compositional questions:

a) What is the scale of the piece? What scale best serves the piece? The compositional issues to be addressed differ based on the size of the environment (which could vary from a small laptop computer display to large cinematic screens).

b) In what type of environment will the piece be viewed? The type of environment in which the final work will be viewed affects compositional, methodological and thematic issues (such as duration and scale). The viewer approaches the piece differently based on how they encounter it. While a typical viewer may feel comfortable sitting for extended viewing in a theater, the same viewer may react differently to a gallery setting, in which they are asked to stand while viewing.

An equally important set of compositional questions must be thoroughly answered to mitigate the harsh or unpleasant effects that are common to stereoscopic art:

a) How do figures, objects, etc. interact with the edge of the screen? Often the depth or relief of stereoscopy is ruined by proximity to the edge of the screen.

b) What are the boundaries of comfortable viewing in terms of parallax?

The experience of viewing the piece could be ruined without careful consideration and understanding of optical phenomena, such as accommodative convergence.

CONCLUSIONS

The Far Dark Shore demonstrates that stereoscopic media, specifically digital video and computer graphics, can be combined in a manner that is both visually appealing and subtle. The depth and relief of the figure and the blossoms is an excellent example of the rather large difference in 3d and 2d media. Stereoscopic art is not 2d art made 3d—it is a separate artistic discipline that demands an entirely different methodology, workflow and vocabulary. The artist working with stereoscopic techniques is at odds with technical issues, clichés, and public ignorance.

The first major research question centered on the implications of digital media attaining the power and relief of sculpture. The figure of the dancer in The Far Dark Shore appears to be a 3-dimensional being occupying a void in the wall. The blossoms have volume individually, and certainly they coalesce to form a ring or halo that has depth and relief. Beyond natural depth cues such as perspective, occlusion and relative size, stereoscopy gives the artist the power to create the illusion of depth on a grand scale. Along with this illusion of depth comes the ability to make objects and environments appear to have a dimensionality that is impossible in any 2d medium. A simple video of a figure moving from background to foreground becomes a moving sculpture rather than a flattened, shaped plane as in 2d video or computer graphics. These phenomena greatly alter the basic compositional decisions an artist must make when working in this medium.

The second major research question involved the space created by stereoscopy.   The type and scope of this space depends on the presentation method. In handheld stereoscopes, the space tends to give the feeling of looking through a peephole or periscope. In a theater setting, the viewer is consistently reminded of the dislocation between what is happening on the screen and what is occurring in the space around them, due to stadium seating and the other architectural components present in a theater. My goal was to place the viewer, the dancer and the blossoms in the same space. This was partially successful; projecting on a bare wall served to remove the screen from the viewer's conscious or subconscious mind, yet the presence of a projector on a stand in front of the viewer was a presence that could not be ignored. Based on careful consideration of my piece as it is currently situated in the gallery, the ideal way to present my piece would have been rear projected on a clean surface—this arrangement would remove significant distracting artifice (with the exception of the LCD glasses) from the experience.

Based on observations by a variety of viewers (some with a great deal of experience with stereoscopy, and some with little or none), this medium tends to have a feeling of immediacy that 2d video lacks. I theorize that this effect is due to several factors:

1) The viewer is constantly re-engaging with the work. The feeling that what the viewer is seeing is "real" or that the events are occurring "now" is reinforced at regular intervals, especially during scene transitions or parallax changes.

2) The lack of depth in 2d video has become so ubiquitous as to seem normal. It is no wonder that viewers often have a feeling of surprise or disbelief when they initially encounter stereoscopic art. In this way, cultural ideas about film and video may transform the experience made possible by stereoscopy. 2d art and entertainment have distorted our collective expectations.

This phenomenon could become commonplace as stereoscopic display systems evolve into autostereoscopic [21] systems, ending the novelty of 3d and helping to make it a mainstream medium. The immediacy that one feels when watching 3d art is directly related to the viewer's recognition of a familiar experience—visually experiencing something in all three dimensions. While this is an everyday occurrence we, as viewers, have learned to accept video and computer art as two-dimensional.

The choice of displaying The Far Dark Shore in a small gallery setting meant that the overall scale of the projection was necessarily also small, approximately 7' X 5.25'. Since the environment of the piece is actually quite large (the woman occupies a fairly large void defined by blossoms falling at significant distances behind her), the potential impact of a work of this nature would be greatly increased through larger overall scale of the presentation of the work. Ideally, viewers would encounter the figure of the dancer in at least a 1:1 ratio, significantly heightening the experience.

Subsequent research involving stereoscopy led me to the theory that a figure filmed stereoscopically might attain certain sculptural qualities that could be described as being analogous to a Bas-relief. This is evident in The Far Dark Shore, as the dancer's performance is not simply a video of a dance performance. Once the dance is choreographed and performed and the video composed and shot, the results are something greater than the two parts. Every aspect of the dancer's physique and costume becomes an object of great relief. The results are very different than what they would be with a similarly shot 2d video.

To use motion picture or digital video jargon to examine and describe stereoscopic video is ineffective and facile; as with all new forms of artistic expression, novel terminology and metrics must be developed to encompass the output of the artists and technologists working in this medium. Despite the relative age of stereoscopy, stereography or the process of composing artwork specifically to be created and displayed stereoscopically, remain burgeoning fields. Future research conducted by artists at institutions like DXARTS, which have invested resources into stereoscopic art, will determine whether stereoscopy as an arts medium has any future, or is fated to once again fade into obscurity.

SUMMARY OF CONTRIBUTIONS

1. Completed research project that combines dance performance and computer graphics, captured stereoscopically, and conducted investigation of the overall impact of the final piece as digital, sculptural media.
2. Successfully merged stereoscopic computer graphics and stereoscopic digital video. (Merged parallax, motion capture, stylistically uniform).
3. Carried out first shoot with stereoscopic camera rig, documented results, and informed consequent shoots.
4. Contributed unique data to the overall body of research being conducted by graduate-level Stereoscopic Cinema class at the University of Washington, populated wiki, and contributed to workflow.
5. Created new virtual stereoscopic camera rig in Maya that successfully replicates the Canon XH-G1 cameras in the stereoscopic high-definition camera rig.
6. Directed and choreographed dance performance designed specifically for stereoscopic video shoot.

DIAGRAMS AND SCREENSHOTS

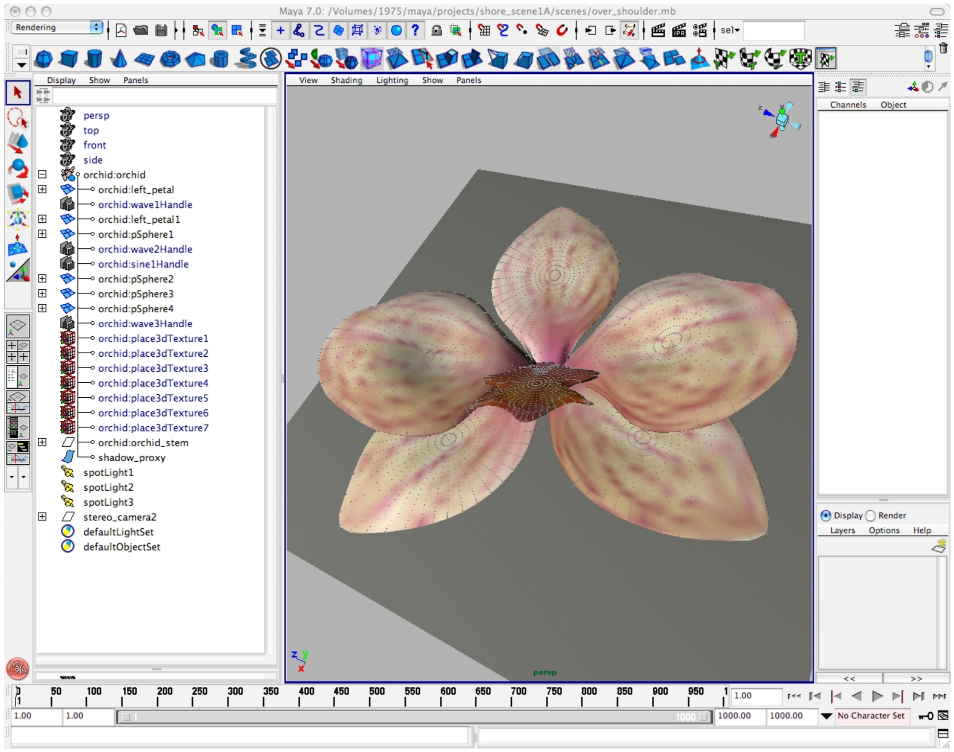

FIG. 1. Detail of Blossom Model in Maya

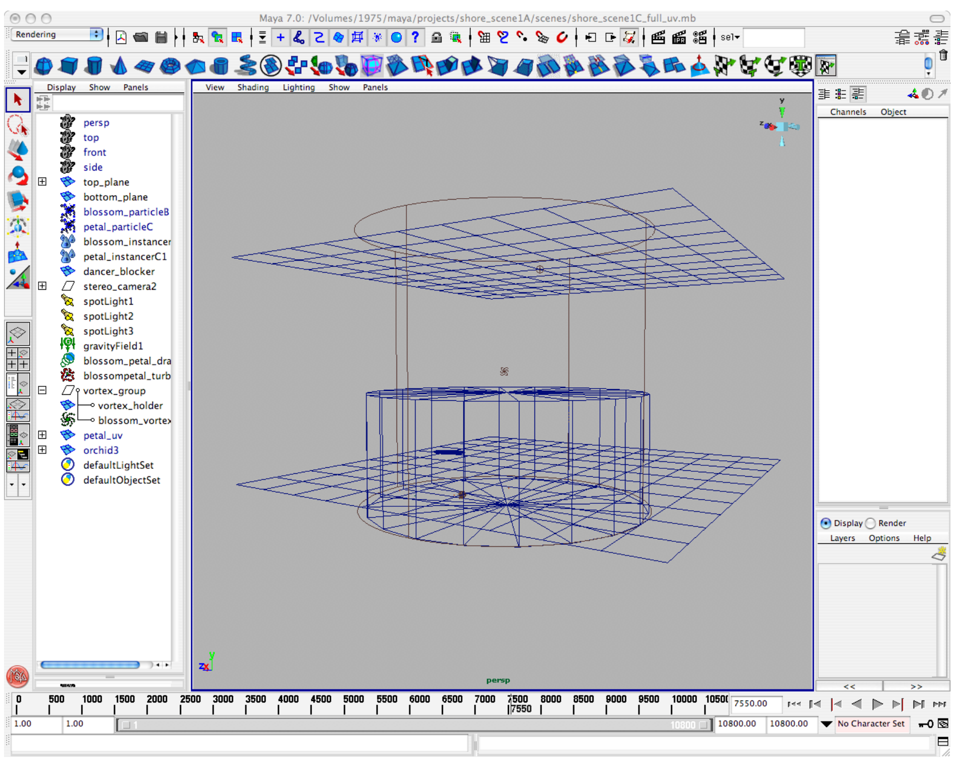

FIG. 2. Detail of computer graphics environment in Maya

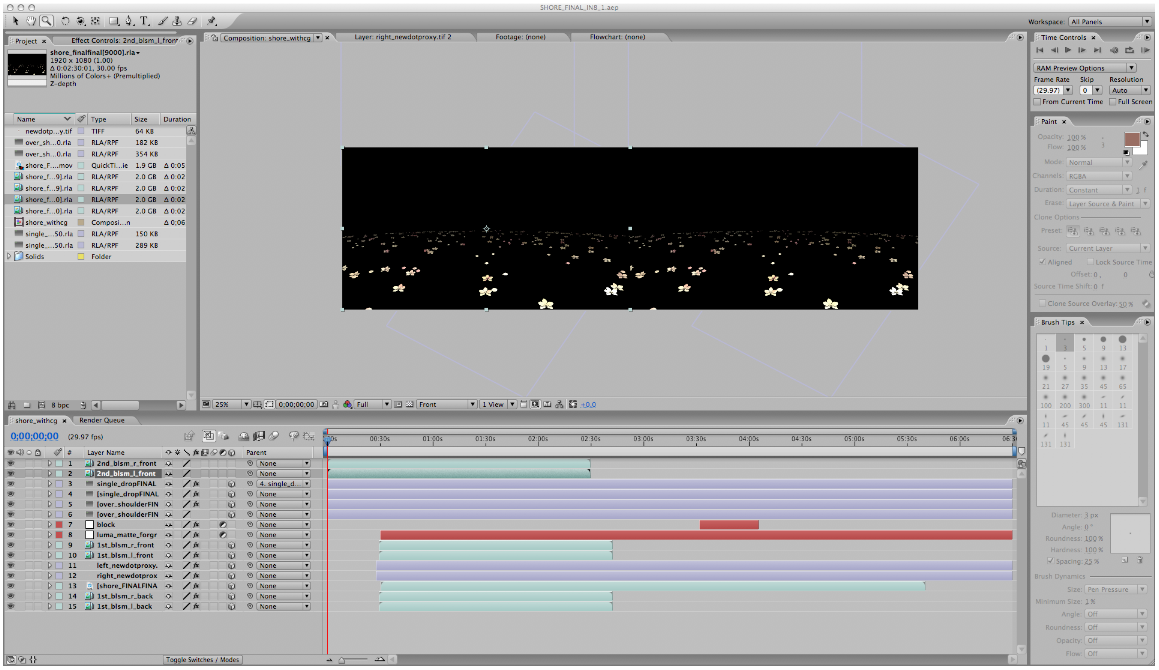

FIG. 3. Compositing Computer Graphics in After Effects

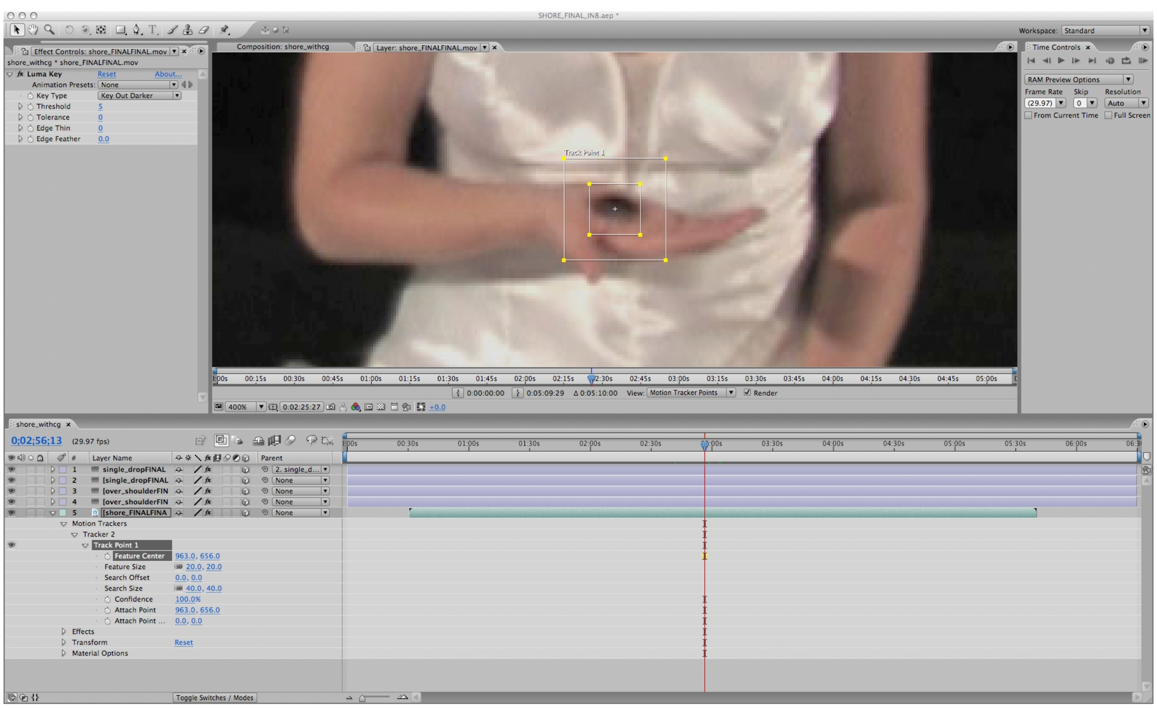

FIG. 4. Motion Tracking in After Effects

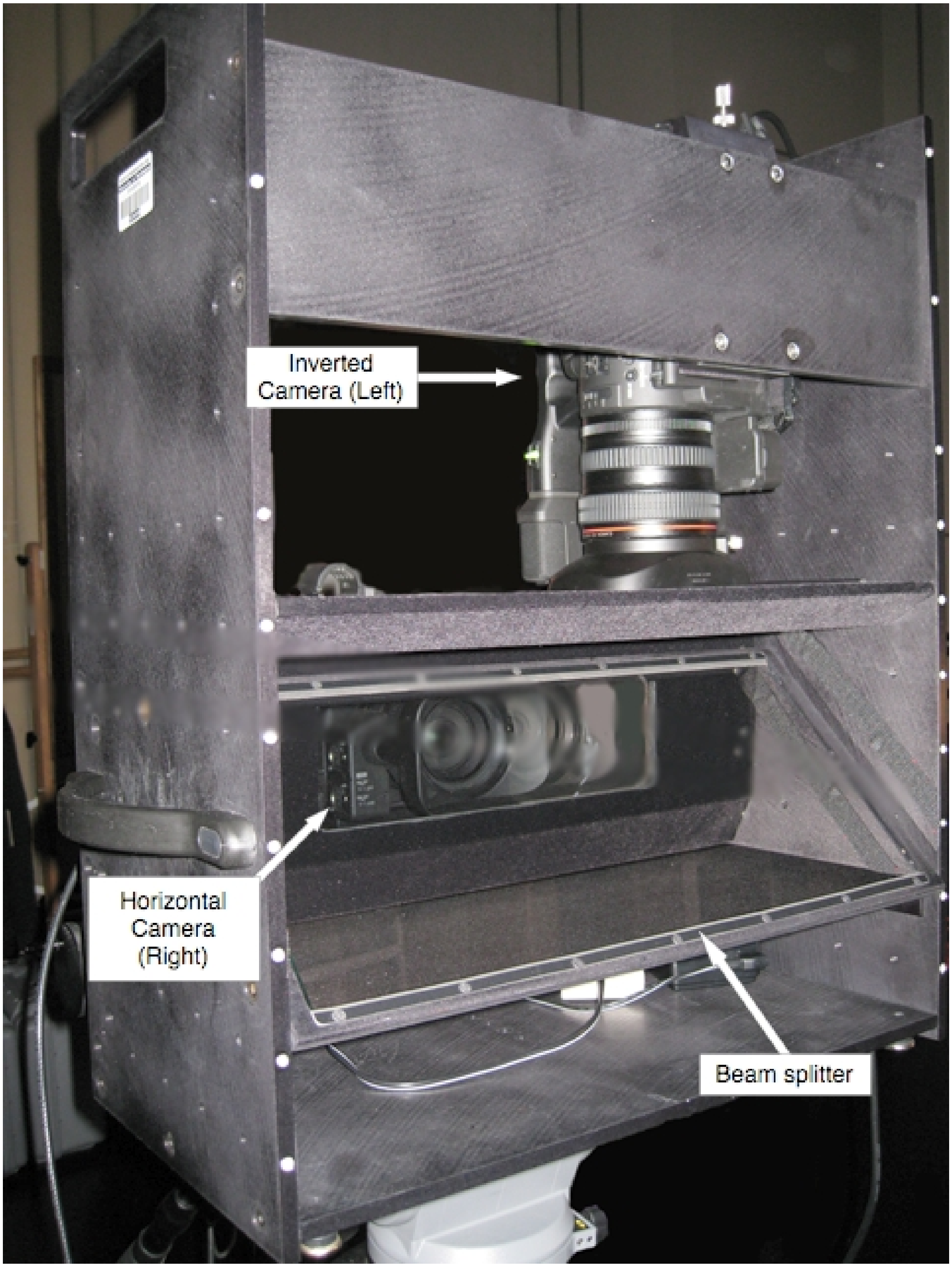

FIG. 5. Stereoscopic High Definition Video Rig

FIG. 6. 2d still frame from scene one

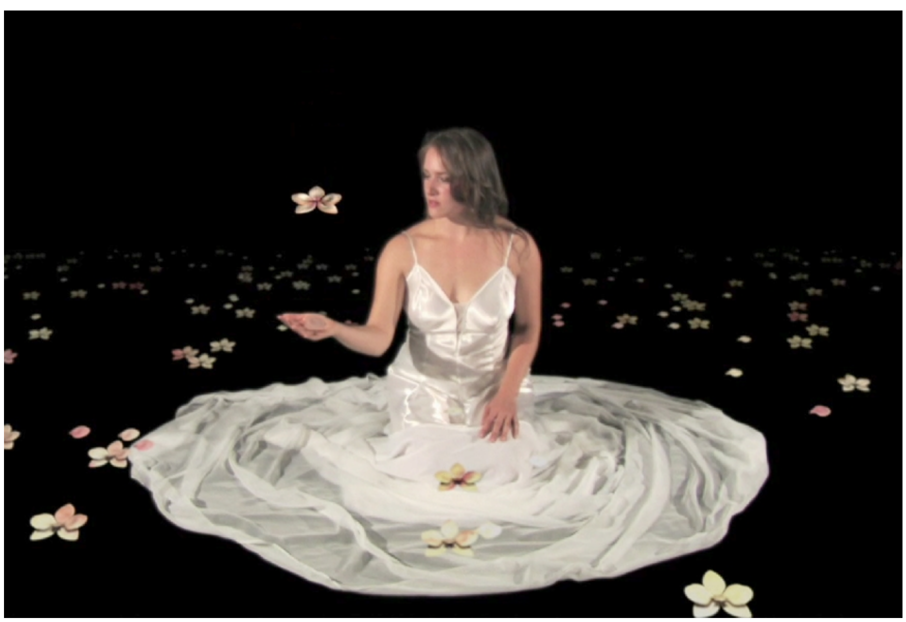

FIG. 7. 2d still frame from scene two

FIG. 8. 2d still frame from scene four

FIG. 9. 2d still frame from scene five

FIG. 10. 2d still frame from scene six

REFERENCES AND NOTES

1. Vibeke Sorensen; Robert Russett, Computer Stereographics: The Coalescence of Virtual Space and Artistic Expression, Leonardo, Vol. 32, No. 1. (1999) p. 3.

2. Glenn Biegon, Stereoscopic Synergy: Twin-Relief Sculpture and Painting, Leonardo, Vol. 38, No. 2 (April 2005) p. 4.

3. Vibeke Sorensen; Robert Russett, Computer Stereographics: The Coalescence of Virtual Space and Artistic Expression, Leonardo, Vol. 32, No. 1. (1999) p. 3.

4. Lenny Lipton, Foundations of the Stereoscopic cinema : A Study in Depth, New York : Van Nostrand Reinhold (1982) p. 54.

5. Exploring Stereo Images: A Changing Awareness of Space in the Fine Arts. Harold A. Layer, Leonardo, Vol. 4, No. 3. (Summer, 1971), p. 5.

6. Lenny Lipton, Foundations of the Stereoscopic cinema : A Study in Depth, New York : Van Nostrand Reinhold (1982) p. 45.

7. Edward J. Wegman; Jürgen Symanzik, Immersive Projection Technology for Visual Data Mining, Journal of Computational and Graphical Statistics, Vol. 11, No. 1. (Mar. 2002) p.165)

8. Lenny Lipton, Foundations of the Stereoscopic cinema : A Study in Depth, New York : Van Nostrand Reinhold (1982) p. 54.

9. Lenny Lipton, Foundations of the Stereoscopic cinema : A Study in Depth, New York : Van Nostrand Reinhold (1982) p. 25.

10. Harold A. Layer, Holographic and Stereoscopic Space: New Research Directions, Leonardo, Vol. 22, No. 3/4, Holography as an Art Medium: Special Double Issue. (1989) p. 2.

11. Autodesk Maya is 3d modeling, animation, effects, and rendering software.

12. Changing the camera base between homologous images (to cause either hyperstereoscopy or hypostereoscopy) to reveal hidden spatial relief and stereoscopic information. Exploring Stereo Images: A Changing Awareness of Space in the Fine Arts. Harold A. Layer, Leonardo, Vol. 4, No. 3. (Summer, 1971), p. 5.

13. The Luma Key in Adobe After Effects is a compositing tool that creates transparency for darker values in the image, leaving brighter colors opaque. The Color Key effect keys (removes) out all image pixels that are similar to a specified key color.

14. The term interaxial refers to the distance between the centers of two cameras.

15. Final Cut Pro is a digital nonlinear video-editing suite.

16. Adobe After Effects is a motion graphic design and visual effects software

17. A garbage matte is a technique used in video editing to remove parts of an image that keying effects cannot remove.

18. Wavefront RLAs (Run-Length Encoded Version A) is an image file format.

19. 32-bit graphics systems contain four 8-bit channels. Three for red, green, and blue (RGB), and one Alpha (or mask) channel, which specify the order of channels that are overlaid. The z channel is one of three channels (x,y, and z) in computer graphics that contains 3d information. The z channel provides information about depth.

20. The Depth Matte effect in Adobe After Effects reads the depth information in a 3d image and slices the image anywhere along the z-axis.

21. Autostereoscopic systems are any system in which one may view stereoscopic media without the aid of glasses or other external artifice.

BIBLIOGRAPHY

Glenn Biegon, Stereoscopic Synergy: Twin-Relief Sculpture and Painting, Leonardo, Vol. 38, No. 2 (April 2005) pp. 92-100.

David W. Brisson, Visually Scanning 4-Dimensional Objects with the Aid of Hyperstereograms in Color Leonardo, Vol. 13, No. 4. (Autumn, 1980) pp. 310-312.

Harold A. Layer, Exploring Stereo Images: A Changing Awareness of Space in the Fine Arts, Leonardo, Vol. 4, No. 3. (Summer, 1971) pp. 233-238.

Harold A. Layer, Holographic and Stereoscopic Space: New Research Directions, Leonardo, Vol. 22, No. 3/4, Holography as an Art Medium: Special Double Issue. (1989) pp. 411-413.

Lenny Lipton, Foundations of the Stereoscopic cinema : A Study in Depth, New York : Van Nostrand Reinhold (1982).

Robert Mallary, Spatial-Synesthetic Art through 3-D Projection: The Requirements of a Computer-Based Supermedium, Leonardo, Vol. 23, No. 1 (1990) pp. 3-16.

W. R. Sears, On Stereoscopic Painting, Leonardo, Vol. 8, No. 1. (Winter, 1975) p. 91.

A. T. Smith; N. E. Scott-Samuel, Stereoscopic and Contrast-Defined Motion in Human Vision, Proceedings: Biological Sciences, Vol. 265, No. 1405 (Aug. 22, 1998) pp. 1573-1581.

Vibeke Sorensen; Robert Russett, Computer Stereographics: The Coalescence of Virtual Space and Artistic Expression, Leonardo, Vol. 32, No. 1. (1999) pp. 41-48.

Edward J. Wegman; Jürgen Symanzik, Immersive Projection Technology for Visual Data Mining, Journal of Computational and Graphical Statistics, Vol. 11, No. 1. (Mar. 2002) pp. 163-188.