“INSIDE_OUT”
June 27-28, 2003

BY
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THESIS SHOW DOCUMENTATION
Submitted as partial fulfillment of the requirements
for the degree of Master of Fine Arts in Electronic Visualization
in the Graduate College of the
University of Illinois at Chicago, 2003

Chicago, Illinois

Dedicated to *Irina Poulos*, closest friend and soul sister and to my high-school art teachers, the faithfully departed *Vassilis Haros* and *Eleni Papadimitriou* and to *Liz Tenny*, wherever she may be.

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AKNOWLEDGMENTS

Kang Sun and Geoffrey Baum for developing the optical tracking software and interfacing it with the CAVE libraries. Geoffrey Baum for dealing with every other little-thing-that-became-a-big-thing-quickly, night-rides to Home Depot and putting up with me. Dave Pape, Alex Hill, Javier Girado and Geoffrey Baum for development of the YG library and YG nodes that saved me endless time. Greg Dawe for space engineering. Alan Verlo, Patrick Hallihan, Lance Long, Allan Spale and Gene Ostrovsky for fulfilling every technical request I could ever think of. Maxine Brown and Tom Defanti for always putting a smile on my face. Alan Verlo for feeding me chocolate and listening with patience. Joe Reitzer for audio composition and engineering. My brother, Dimitri for getting me started with the audio. Anna Seeto for her motherly instinct, for providing with food and directory assistance. Robynne Gravenhorst for showing up at the right time at the right place and for her ability to pull people together. Franz Fischnaller for providing food for thought.

Special thanks to my thesis committee: Drew Browning for taking time away from his sabbatical to be Chair and for all the moral support over the years. Marta Huszar for her incredible art direction, conceptual support, friendship and honesty. Dan Sandin for giving me the opportunity to do this project, technical assistance, shifting needs to accomodate mine and for being Dan Sandin.

To my mother and father who provided me with financial support and motivation during difficult times. To Marcus Thiebaux who forced me to stand still and focus, for being here even when there and for holding my hand.

To my friends who thankfully are too many to list, yet they are all so close to my heart, for always picking up the phone and for caring.

TABLE OF CONTENTS

“Of all the arts, dance would seem the least likely to accede to the vagaries of rapid change and the relentless advances of this modern technology. Dance, the art of human movement, on the surface appears non-technologically inclined. It is the self-sufficient art.”
Judith A. Gray

1. INTRODUCTION

I grew up as an aspiring ballet dancer who was turned off by the required physical discipline and quickly distracted by the visual arts and technology. I continued practicing dance in other forms such as traditional folk, modern and Latin. My most significant influence in dance is my childhood friend, Irina Poulos currently a student choreographer at NYC Tisch School of the Arts, originally trained in ballet. My master’s thesis project “INSIDE_OUT” is the culmination of more than thirteen years of being a dance “voyeur” and an amateur performer. During the last two years, I have studied the possibilities of combining technology and dance and its historic evolution and I have experimented with my resources to a great extent. This paper outlines my research findings, how they fueled my efforts in the production of my MFA thesis show and my resulting observations from this experience.

2. THE EVOLUTION OF THE RELATIONSHIP OF DANCE AND TECHNOLOGY

Since the first attempts to computerize dance notation (such as Labanotation) in the 1970’s, it was conceived that dance and technology could compliment each other. Just because dance seems to be a self-sufficient art, it doesn’t mean that one couldn’t ‘accessorize’, expand and experiment, as Judith Gray would put it. Initial attempts to design computer-based dancers happened at Simon Frasier University with an ellipsoid body figure and at the Royal College of Art with a sphere-based model that could cast shadows. The pivotal moment for embracing a project like the above may have been the New York Institute’s 1983 ‘elegant dancer’ created for Twyla Tharp’s video choreography “Catherine Wheel”. The development of computerized notation systems for dance has since opened the door for endless choreography experiments. Alice Trexler and Ronald Thornton notably used the first motion detection systems at Tufts University for cross-disciplinary purposes.[1]

One of the first notation systems to become computerized is Labanotation, which was conceived by Rudolf Laban in 1928. The system involves a shorthand system that requires training for interpretation but also allows for some room for improvisation by the dancer. This system has been developed so much that any type of movement can be mapped using it. Giving the dancer freedom to interpret a given choreography is a method that allows for more interesting experimentation and it expands the possible use of a notation system.

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[1] Gray, Judith A. Editor. **Dance Technology: Current Applications and Future Trends.** National Dance Association. 1989.

[2] Calvert, Thomas W. **Toward a Language for Human Movement.** In Dance Technology: Current Applications and Future Trends**.** Edited by Judith A. Gray. National Dance Association. 1989.

For one thing, it makes the notation more useful for dance that is not body-designed such as ballet and it allows for a more modern performance style. Moving away from classical ballet composition and embracing “dance for dance’s sake” is a trend that many arts disciplines have followed during the Avant-Garde movement and following deconstructivism. It seems that making the effort to break down movement and map it gave rise to interests in isolation of movement, decentralization and unconventional ways of reaching balance. This is one of the founding concepts for my project given my frustration with the rigidness of ballet. I originally conceived “Energy Composer” as an application that might somehow enable users to change a fixed choreography into something more dynamic with input from isolated gestures into space.

In the late 1990’s, a new piece of software for dance notation started being developed called “Life Forms”. It has become so popular that it is used extensively for human motion animation in combination with various motion capture technologies. I experimented with this software in the summer of 2001 for “La Boîte”, a networked CAVE™ [i] environment where users were invited to see short dance performances on virtual video screens. The users could also try to imitate the isolated and repetitive movements of virtual dancers in the dance studio who were created in part with “Life Forms”. I had hoped to incorporate visitor traces of a performance and to populate the environment with dancing avatars but a project by Josephine Anstey (PAAPAB) did just that.

My approach with motion capture files in the CAVE proved very frustrating due vendor inconsistencies within the motion capture file format I had chosen (Biovision BVH format). The project was prepared for ARS Electronica 2001 in Linz as part of “ALIVE ON THE GRID” and was featured in the catalog but not completed in time for the festival. In the end, I felt that my project symbolized feeling like an outsider in the dance arena and perpetuated virtual voyeurism and immobility. My ballet training frustration had surfaced again since the virtual dancers were somewhat dismembered, headless and armless creatures repeating an exercise over and over again.

My research into successes with dance and technology pioneers led me to Merce Cunningham. His vision of making dance focuses on the motion itself, not an illustration of a particular concept. His methods are somewhat radical but nevertheless proven. He believes in the independence of dance from sound. He choreographs movement alone and his music composers’ works independently of the choreography. Both music and dance come together for the show. His collaborations with John Cage produced works such as ‘Points in Space’, one of the first dance works designed for the camera view and not for the stage. This particular work assumes no fixed center point in stage and the piece has continuous flow without a traditional start, mid-point and ending. This concept of choreographing movement on stage in a way that every point in space receives attention and ignoring a center is something I took into great consideration for the design of my display application and its functionality. I started thinking of an environment in which there are no hierarchies and structures are loose.

Cunningham’s ability to produce choreography that seemed entirely random intrigued me. He improvises in order to find the movement phrases he is interested in, experiments with their execution and their interpolation and then choreographs. After leaving Martha Graham and starting to develop his own style of choreography, his audience could not believe that the dancers were indeed following a set, strict choreography and were not improvising on stage during the performances. People failed to understand that the range of motion and on-stage positioning Cunningham used would not have worked without much practice and perfection. Phrases originated in improvisation but were executed in the final performance in a strict schedule. What would happen if one would expose dancers to a familiar environment containing random variables with a somewhat known pattern? My hope was that this would allow the dancers to work with a set of fixed movement phrases, yet still result to a unique choreography in each performance.

Motion capture data is commonly used in dance projects to produce 3D animations as additional partners. Such projects are abundant in the Dance and Technology shows organized by Georgia Tech that started in 1994. One of their projects in 1996-featured choreography by David Parsons using animated dancers and virtual costumes through real-time optical motion tracking and projected animation of costumes onto the dancers. Cunningham’s 1999 project “Biped” (see Figure 1. Merce Cunningham's Biped (1999) with virtual dancer backdrop) was a stunning mix of the choreography of real dancers and ethereal dance creatures choreographed using Life Forms and output on gauze screens. The virtual dancers merely contributed in the choreography as additional bodies coming in an out of the stage and added another dimension and depth to the show. “Biped” has been so far the most ‘elegant’ show produced using technology for choreography and no other such project has picked up as much publicity as this one.

Perhaps the most common way to track motion is by analyzing captured images. Computerized image processing technology has been possible since the 1960's and the explosion of video in the last three decades after that has yielded many memorable dance performances. The focus of image-based tracking systems seems to be real-time image processing and interpretation of the dance, often times using color maps. This kind of work is still popular today especially with the increased affordability of digital video cameras. A very popular system that does just this is the VNS (Very Nervous System) created by David Rokeby and used by Todd Winkler.

Post-processing or performing real-time image processing of dance performances has expanded the possibilities of staging in recent days. Video projections are being used as background, filler and to supply the real dancers with more 'partnering' possibilities. Isadora created by TroikaTronix is a graphic programming environment for real-time manipulation of images, video, graphics and sound created for dance projects for Troika Ranch (see Figure 2. Reine Rien, with choreography by Dawn Stoppiello and music/media by Mark Coniglio). In Ohio State's Interactive Performance Series 2002 Think Tank Report, Birringer's summarizing report notes the frustration expressed by people such as Dawn Stoppiello of Troika Ranch and Kent de Spain who wondered "where is the work that has gotten media attention and why does it seem that all performances were always in beta-release aesthetically?". Since I shared the same sentiments, I decided to start with the design of the show aesthetics and finalize the technology closer to the show.

My previous attempt to pursue my interests combining dance and technology were never completed because they lacked the most important component: a physical connection with dance itself. The available tethered tracking systems did not permit for a project that allowed the user to move around too much. Even the wireless tracking system by Intersense did not have enough range in the CAVE. A more practical problem was that one could not slip and fall through the very expensive back-projected CAVE walls. Fortunately, my research lab received funding for optical tracking research, which resulted in my not worrying about walls or wires anymore, even though the range of a tracked space was approximately the size of a CAVE. Without walls, this felt like a much larger space and encouraged the production of “INSIDE_OUT”.

3. MFA SHOW DESCRIPTION

"INSIDE_OUT" took place June 27th and 28th, 2003 at the Electronic Visualization Laboratory (EVL) at the University of Illinois at Chicago (UIC) as part of the requirement of the MFA degree in Electronic Visualization. The event consisted of a physical installation of a performance space in EVL's AccessGrid (AG)[iii] room and ICE lab. EVL's AG room was completely transformed into a dance stage featuring a passive stereo display backdrop (see Figure 4. Stage view from audience seating and Figure 3. Upstage view). Members of the Anatomical Theatre dance company performed live as part of the event. The dancers movements affected the aural and visual outcome of the application projected on the passive stereo screen[iv]. The performers' movement data was collected via an optical tracking system (developed by Kang Sun and Geoffrey Baum) and sent to the "Energy Composer" application that processed the data and responded in real-time (developed by myself using Ygdrasil[v]). Each performer was given ten minutes to improvise on stage and then invited the public (one at a time) to participate and experiment with the application. The ICE lab served as a waiting room and featured a GeoWall[vi] screen that was networked with the application in the AG room and showed the dancer's avatar live in the application space. One plasma screen showed live video of the stage and another displayed a matrix of video loops from the dance rehearsals. A four-tile display system contained show credits, performer bios and brief descriptions of the software and hardware technology used for the show. Multiple video streams of the event's aspects were broadcast live over the AccessGrid network and Boston University's AG node connected and watched the event on opening night.

4. THESIS SHOW GOALS AND CONCEPT

"INSIDE_OUT" combined the physical space with the virtual space because it consisted of an equal amount of physical set design and virtual application design. My interest in this originates with a group project/show[vii] I participated in as an undergraduate for which our group created a motion platform that was real-time controlled by keyboard and complimented a simple animation projected onto a video monitor. This combination of a physical piece and a screen into another world was in the back of my mind for a long time. My previous training as a traditional artist left me always wanting something more out of this project than just a virtual world.

My hope was to "flip the table" on VR that had been done traditionally at EVL for the past ten years because virtual navigation was disabled and application response depended upon physical exploration of the space. The title for the show originates with this concept. Instead of the having the user navigate virtually within the environment through a wand or spaceball, he/she has to physically navigate the environment and explore the full space in order to have an experience. This was taken a step further conceptually because the AG room passive stereo display’s view was that of the user’s perspective from inside the world looking out because the head was being tracked. Robynne Gravenhorst (artistic director of the dance company) explained this to the audience by telling them to imagine the display showing what a camera on the dancer’s head would see. This was different from the ICE lab/waiting room view, which was a view of the guest facing the dancer avatar in the virtual world; it was a view from the outside looking in.

The main goal of the show was to create a multi-modal interactive performance space with emphasis on exploring movement and giving the user motivation to move around as much as possible into the space. The driving application had to be adaptable to the complex needs of an expert user (i.e. dancer) and responsive enough to satisfy experimental usage by a novice (i.e. show guest). In my mind, this combined EVL's more recent tradition of allowing guest interaction during events with a forgotten, yet resurfacing tradition of performance art from the days of real-time analog video manipulation.

The passive stereo display was not the show's main attraction, yet served a more dynamic role than a backdrop. This was not to say that a backdrop is not as important as the rest of the experience but it was meant to be integrated weighing in as much as the performances and the audio experience. My thoughts on using VR as a backdrop was that people were going to move less if they were fixated at the graphics; they would have to learn the geography of the space by depending on the audio feedback first and then learn to combine the outcome with the visuals. My observations about this are detailed in the summarizing statement of this paper.

5. SHOW COMPONENTS

a. Stage design

The staging area included a custom designed floor that fluoresced under UV light and consisted of foam tiles to provide comfort for the performances (see Figure 6. Foam tiles painted with stencils under UV light). The tiles withstood rehearsals and two nights of performances. Opaque black curtains covered the upstage area and sides of the stage and hid lab equipment and other aesthetic problems since the space was not designed for such use. The view of the front of the stage was slightly obstructed by four panels of transparent curtains, white in the corners of the stage and black in the middle with large gaps in between.

The white curtains in the two front corners of the stage provided additional illumination in the room since no other lights but the ceiling UV lights could be used for the performances. The overall bluish white environment that served as the foundation for the environment would have pleased Bernard Castel, a Jesuit who constructed his music-color instrument believing that “a base note, (which we call C), rendered a firm, tonic color serving as a foundation for all colors, and that was blue.”[3] Overall, the dramatic atmosphere I achieved with the set design helped view the project as something much more experimental than what visitors may have expected.

The obstruction by the curtains served both as a way to stop the audience from getting on stage at an inappropriate time and also motivated them to move around so they can see better. Poking through

[3] Milicevic, Mladen. **Experimental/Abstract Film and Synaesthetic Phenomena 1725-1970**. (http://myweb.lmu.edu/mmilicevic/pers/exp-film.html)

the curtains and hiding behind corners obliged people to become curious “voyeurs” yet in a quick twist of fate they were eventually invited to participate if they desired. Many were surprised to be invited on the stage and even more were surprised to hear how it all worked. I was pleased to observe the interleaving of the spectacle of the dancers, followed by the demystification of the stage and then the spectacle of the guests interacting with the application.

b. <u>The relationship of the stage and the display application</u>

Ultraviolet (black) light was used to satisfy the needs of the tracking system blocking out everything but the fluorescent markers and inspired me to experiment with a wide range of fluorescent products. I designed a monochromatic floor that consisted of random arrangements of type by using stencils and white fluorescent paint in different opacities. I varied letter spacing and line spacing of the letterforms and left enough negative space to create a feeling of density and scarcity throughout the space. The stencils were hung randomly from the ceiling and laid out on the floor’s ‘out-of-tracking’ areas to enforce the idea of positive/negative space and to provide some illumination since they glowed under the UV lights.

The random arrangement of the white letterforms (glowing slightly blue) was duplicated in the display application in three dimensions so that the physical and the virtual space were linked aesthetically. It is important to note that my aesthetics for the entire piece originated with the creation of the floors. I wanted to create a design that showed movement and represented some kind of flow without explicitly writing down instructions and adding one more visual for the user to be fixated on. After throwing out several designs, I decided that there was nothing that captured the essence of my intent more than simple letterforms, especially stencils. This lent the piece an abstract and industrial look but maintained certain elegance. The random layout satisfied my need of creating a non-hierarchical design and reminisced of Cunningham's "Points in Space". Instead of using dancers, I used letterforms to activate various locations in space and used them as my base "molecules" for filling the application volume in three dimensions.

c. Virtual environment choreography and aesthetics (Energy Composer)

I wanted the visuals and audio of the piece to create the illusion of a seductive yet uncomfortable space. Since the letters on the floors did not spell out any words except by chance, I recorded my own voice blurting out twenty-six phonemes and tweaked their base key to provide variation. This proved especially frustrating since I am not quite a native speaker of English and I have problems annunciating properly. The base environment for the virtual application became an orchestrated chaos of faded letters that blurted out their phonetic sound and highlighted briefly as they were touched. The hollow boxes and disconnected phonemes left something to be desired.

The theme extending the interactivity design was pulled from a classic choreographic improvisation where the dancer is invited to imagine themselves in a comfort zone, "a circle of about two feet in diameter. It might be a place of fun, whereas the outside area is one

[4] Milicevic, Mladen. -.
[5] Blom, Lynne Anne. Chaplin, L. Tarin. **The Intimate Act of Choreography**. University of Pittsburgh Press. 1992.

of drudgery, or the place is a relaxation area whereas outside there is tension. But you are allowed to stay there only five to ten seconds and then you must leave. It is a place to recharge..."[7] My concept of the comfort zone was stretched a little further by wanting to create an uncertainty as to which areas were supposed to be comforting; this was meant to be assessed differently by each user.

The performers were instructed to imagine themselves in a damp place, a dream where they are trying to speak but can't spell out any words. They had to battle the space delicately, tempted by colorful and playful melody carriers that hinted the existence of another place. These carriers moved randomly within designated spaces and if the performer intersected with them they enlarged, animated and eventually reduced to original size and floated away. These objects were designed to contrast the base monochromatic bluish-white of the environment and the voice-based aural experience.

Historically, Isaac Newton was the first to produce non-linear, spherical representations of color space[8] and publicized his thoughts on music and color correlations. In Optics he proposed “a strict correspondence between the seven colors of the rainbow and the seven notes of the musical scale: increasing frequencies of light oscillations in the spectrum (from red to violet) correspond to increasing frequencies of sound oscillation in the diatonic major scale.”[9] As a tribute to him, the letters A through G were selected to represent the octave without sharps or minors and I made personal

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[7] Blom, Lynne Anne. -.
[8] Newton, I. **Color Circles**, Nature Feb 10, 1870.
[9] Tchouvileva, Tatiana. Caglioti, Giuseppe. **Colored music: Historic background and perspectives**. (http://www.aedo-to.com/eng/library/mc4/storia.html)

decisions on the associations between each color and letterform. I discovered that even color/letter synaesthetes associate different colors to each letterform so I imagined myself as a synaesthete. For example, I imagined the letter A to be red because I find the color red is so dominant. Multiple concentric rings animated around these letters to hint of Newton’s design of color space.

The next step was to visualize what would happen when one entered the comfort zone. I produced abstract color/form animations by looking into Paul Klee’s notebook collections which I have studied since I was a child. I was also heavily influenced by Oskar Fischinger’s animation collections and his selections of musical instruments. I attempted making animations with pictures of representations of color but the result was completely flat. While producing these animations, I tried to imagine what kind of musical instruments and rhythm would complement them. For example, the yellow comfort zone is a lively composition of violins combined with a visual of fast-swirling yellow lines; the purple comfort zone is a dark purple looming cloud containing the most bass and slowest audio of all the comfort zones. I provided my audio composer with instructions on desired musical instruments and tempos and together we produced seven mixes of melodies and ambience for each zone. In addition to the above, I designed an additional set of audio triggers arranged as interleaved vertical and horizontal thin slices each ten feet wide and deep, or tall and deep accordingly. For this I composed a fairly continuous loop of metallic ‘sweep-like’ sounds shifting from A to G. This produced a discreet aural feedback while someone was moving on stage (even by small increments) and sounded as if they were tingling glass chimes to promote the feeling of a fragile ambience one was located in ‘empty’ space.

Before rehearsal time, I discussed with the dance company the positioning of the zones. Positioning was critical so that the entire tracked space could be activated and so that only two melody containers could mix aurally at the same time due to their proximity. The position of each zone was justified by its color value, tempo and tonal range. (see Figure 9. "Energy Composer" invisible system of triggers/movement planes for melody containers. Top view and Figure 10. "Energy Composer" invisible system of triggers/movement planes for melody containers. Perspective view):

- Red and yellow were positioned at arms reach (5.8 feet), upstage and downstage so that they could be heard while standing up stretching. These containers moved on the horizontal plane, parallel to the stage in a random fashion but in opposite directions. The melody for the yellow container consisted of fast string instruments (violins, etc), while red contained a more dramatic composition with a dominant piano; their loudness and dominance justified their positioning above everything.
- Orange and green were positioned mid-level at 3.3 feet, closer to the center of the stage and diagonal of each other. This way one had to either bend halfway or stand tall on knees to find them. Green and orange were of the same color value and contained the exact same mid-fast composition with different instruments: green consisted of earthy, mid-tone drum instruments that reminisced of Africa; orange consisted of a more Asian collection of

instruments with a higher pitch. These zones were the hardest for the guests to find because they did not seem to want to bend their spine or knees to get their heads to the right level.

- Blue was positioned half a foot off the ground on the left corner of upstage and contained a bass, dramatic loop. Purple was positioned diagonally opposite of blue, downstage to the right, at zero feet off the ground and contained a majestic collection of large drum instruments. Both of these had to reached by crawling low on the floor and utilized the speaker sub-woofer heavily. Surprisingly, it was quite easy to get people to sit on the floor and put their head very low to activate these sounds.
- Cyan was positioned in the center of the stage and moved from 0 to 6 feet in a random fashion. This zone tempted with a short loop of piano keys and contained the sound of a tropical thunderstorm when inside. One could remain in this zone by moving up and down in the center of the stage. Cyan was positioned this way to symbolize the behavior of the water element. This was the easiest zone to find but not as easy to stay in unless one was willing to guess direction of movement.
- In the remaining two 'quiet areas' one could hear the distinctness of the 'glass chimes' while moving their hands and could also hear a breathing sound as if the whole environment was always alive; a reminder that if we stand still, we can hear our breathing. We used these quiet zones as start/stop areas for the performances by scripting thirty seconds of in/out time of the breathing being the loudest ambient audio. The dancers choreographed this, each in their own style as their way of

reaching that dream or meditation state that enabled to look for their comfort zone.

Overall, this arrangement of zones successfully motivated guests to move quite a lot even if they were more mechanical in their motions. Even the dance company members seemed to have favorites based on their preference of audio or color animation. Most important is that even though I positioned a zone in the center of the stage, there was no perceived center of stage in my opinion.

6. TECHNICAL DATA

a. Tracking system

Two stereo cameras made by Point Grey Research tracked three fluorescent markers (head and two wrists) worn by the person on the stage. The markers position data were calculated by two computers (one for the head, one for two wrists) running a tracking daemon. The display computer ran a tracking daemon that collected that data and communicated with the "Energy Composer" application. The software that performed all the tracking data collection and processing was written by Kang Sun and Geoffrey Baum on top of libraries provided by the camera manufacturer, Intel's Open Computer Vision (Open CV) libraries and VRCO's TrackD code.

Tracking materials were hand-painted and sewn by myself and my show crew volunteers and involved an expensive and tedious process of looking for fluorescent colors that were bright and distinct enough to provide good tracking. Our final selections of paint were fluorescent yellow, orange (Wal-Mart craft fabric paint) and red (Roscoe fluorescent scenic paint) (See Figure 7. Tracking materials and Figure 8. Robynne Gravenhorst of the Anatomical Theatre wearing three markers used: orange for head, yellow and pink for wrists)

b. Display application

"Energy Composer" was developed with Ygdrasil (YG)[xii] and consisted of the following main scripts:

i. "A-to-z" phoneme distributor script containing the stenciled letterforms that moved randomly within specified volumes. These letters were transparent and their opacity increased briefly upon intersection with the user’s hands to create the illusion of highlighting in space. This script also contained the references to the audio files corresponding to each letter. (See Figure 11. Top view of the "Energy Composer" application in the CAVE simulator.)

ii. “A-to-G” distributor script containing the floating comfort zones, randomly moving within specified regions. These spherical objects enlarged to enclose the user and animated (see Figure 12. Red animation in full bloom and Figure 13. Orange animation in full bloom) upon intersection with the user’s hands. Upon an exit event they reduced to original size and their corresponding color animation faded away.

iii. A file containing a system of audio triggers that shifts the ambient soundtrack from A to G as the user moves their hands across the space.

iv. A timeout script that faded out the introductory audio (breathing) and gave the performer thirty seconds to get ready, then ten minutes to improvise and another thirty seconds to close their performance.

7. CONCLUSIONS/OBSERVATIONS

Approximately one hundred and fifty people attended the event, thirty of which interacted with the application time permitting. The application proved to be both complex enough for the expert users and provided enough feedback for the guests to enjoy (see Figure 16. Audience guest in the Violet comfort zone). The waiting room provided relief in-between performances although many were hesitant to enter the room. Technical difficulties prevented the guests in the waiting room from seeing the actual animations from displaying properly when the user was enclosed in their comfort zone.

In addition, the poor quality of the passive stereo display in the AG room obscured the vividness of many of the animations but no other display was available for the project. The display's off-center positioning that was part of the AccessGrid room setup had not been originally positioned to be used with tracking in this way. Because of this, the view displayed a 'not-so-exciting angle' and narrow view of the environment and the projection data coordinates had to be recalculated with the combined efforts by Geoffrey Baum and Todd Margolis.

Members of the Anatomical Theatre responded to the environment with their own unique style and invented distinct movements in search for their comfort zone. The resulting compilation of movements from just two rehearsals and two performances is impressive (see Figure 14. LeAnn Vancil of the Anatomical Theatre while in the Blue comfort zone and Figure 15. Lyndsae Rinio of the Anatomical Theatre while in the Yellow comfort zone.) The choreography lacked a more involved dialogue with the display visuals due to the lack of additional rehearsals and the dance company's inexperience with virtual reality. A more complex choreography could have been achieved had they spent more time with the application in order to develop relationships with the comfort zones and the base environment. It is possible however that the spontaneity of the performers' movements would have been lost with more rehearsals.

My last observation is that those who paid attention first to the aural environment rather than the visual environment developed a much better understanding of the space. This perhaps was because of the strange angle of the visuals and the level of comfort one had to develop with the tracking requirements. My heightened perception of sound even in low frequencies is a bias against evaluating the results of this phenomenon. Some of us respond quicker to vision, others to sound. A future implementation of this project may be able to evaluate this issue further.

8. FIGURES

Figure 1. Merce Cunningham's Biped (1999) with virtual dancer backdrop

Figure 2. Reine Rien, with choreography by Dawn Stoppiello and music/media by Mark Coniglio

Figure 3. Upstage view

Figure 4. Stage view from audience seating

Figure 5. ICE lab as waiting room setup. From left: GeoWall screen with dancer's avatar, plasma with video archive, 4-tile display with credits, plasma with live video stream

Figure 6. Foam tiles painted with stencils under UV light

Figure 7. Tracking materials preparation

Figure 8. Robynne Gravenhorst of the Anatomical Theatre wearing three markers used: orange for head, yellow and pink for wrists to maintain a consistently trackable volume from different angles

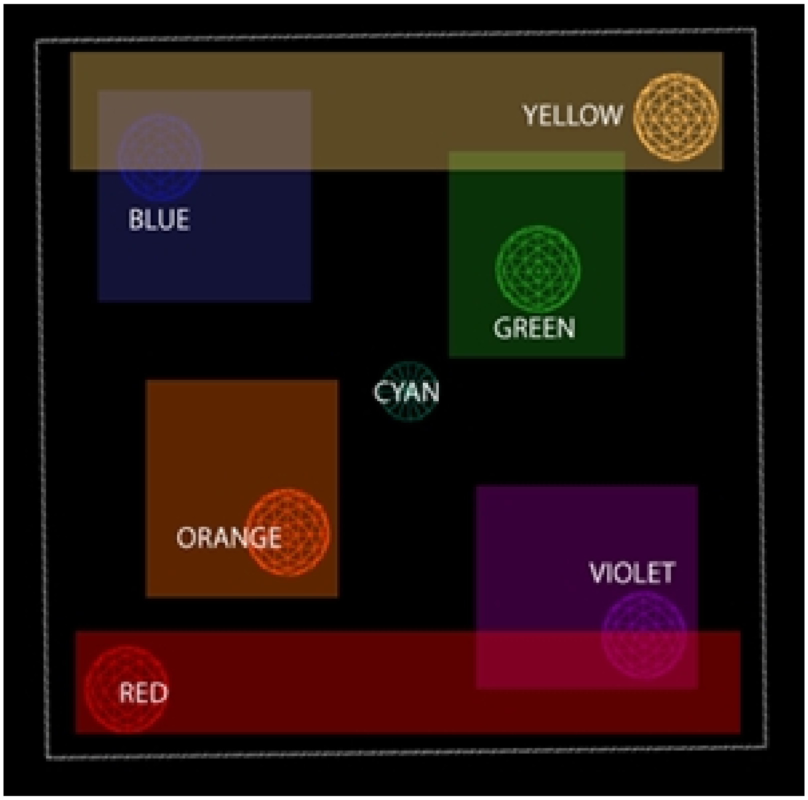

Figure 9. "Energy Composer" invisible system of triggers/movement planes for melody containers. Top view

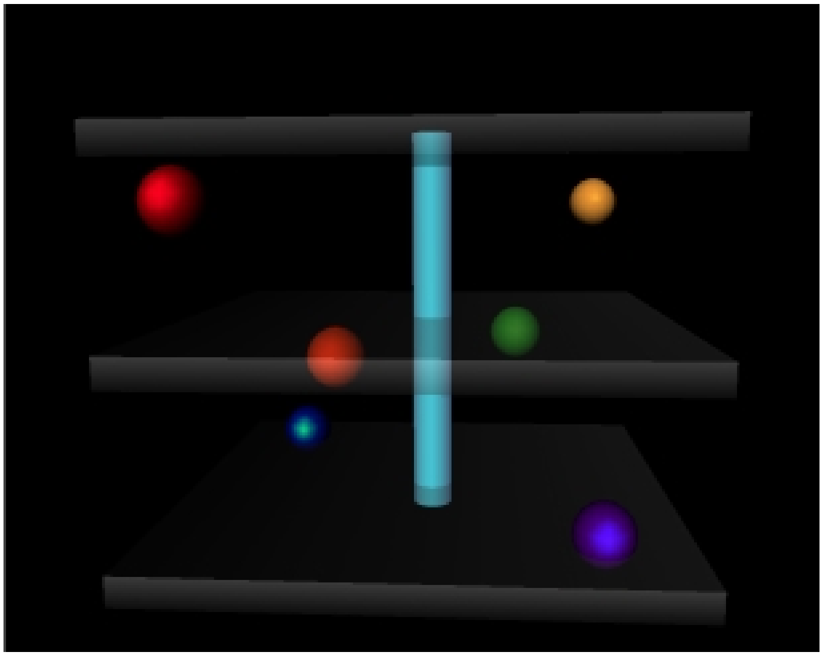

Figure 10. "Energy Composer" invisible system of triggers/movement planes for melody containers. Perspective view

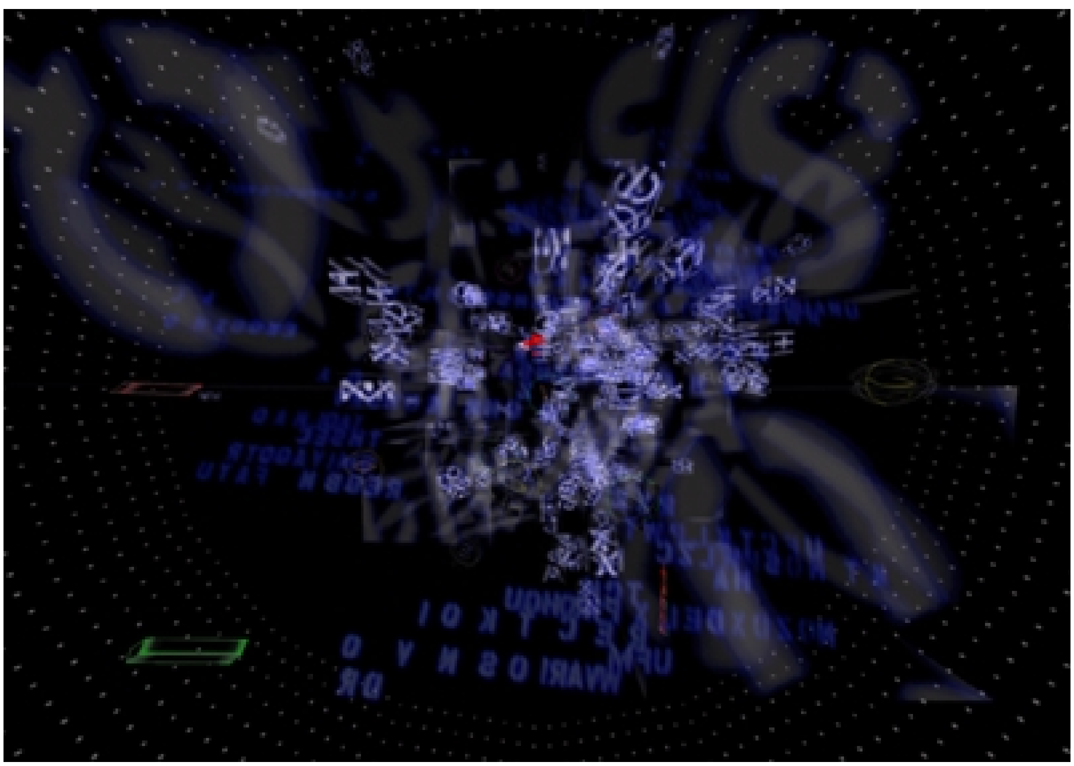

Figure 11. Top view of the "Energy Composer" application in the CAVE simulator

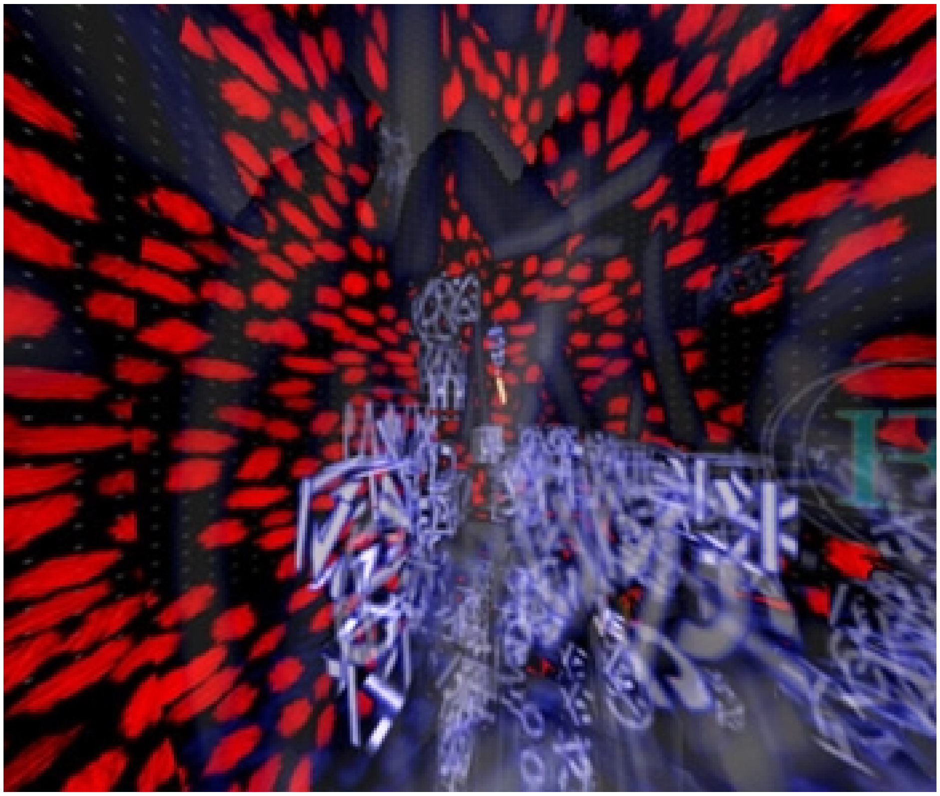

Figure 12. Red animation in full bloom

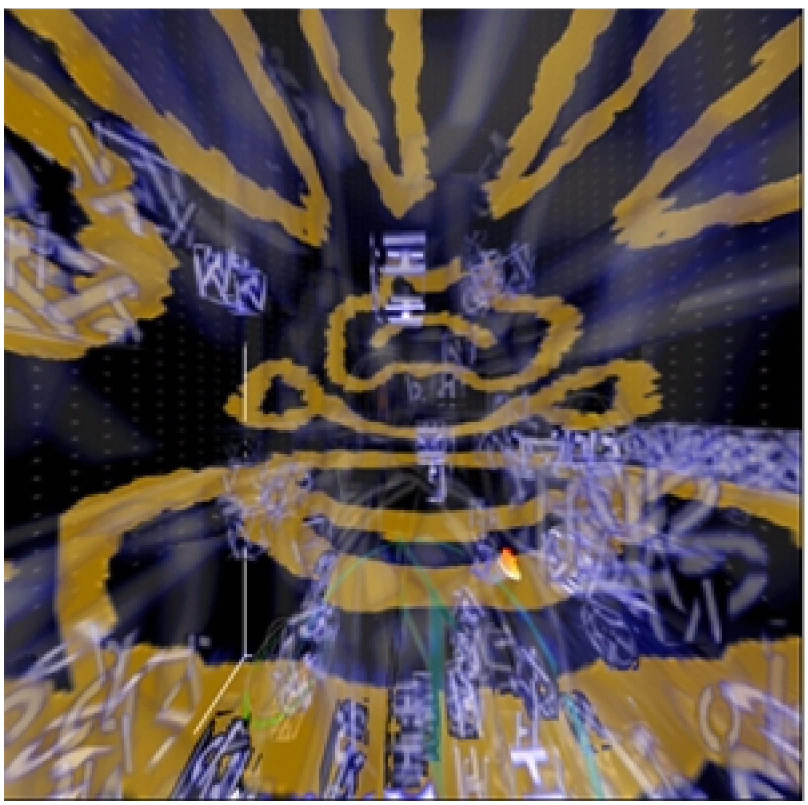

Figure 13. Orange animation in full bloom

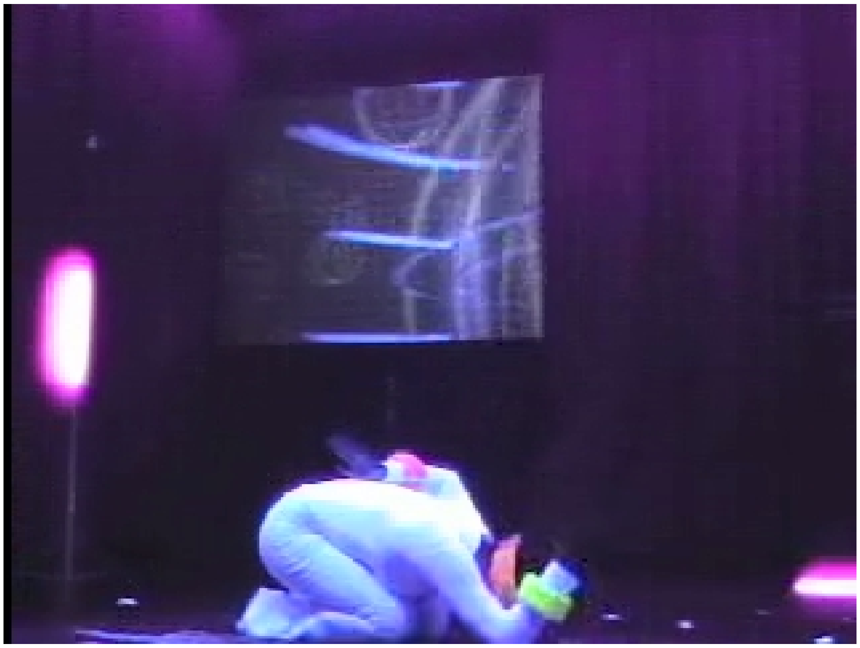

Figure 14. LeAnn Vancil of the Anatomical Theatre while in the Blue comfort zone

Figure 15. Lyndsae Rinio of the Anatomical Theatre while in the Yellow comfort zone

Figure 16. Audience guest in the Violet comfort zone

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10. ENDNOTES

[i] Virtual reality can be defined as the wide-field presentation of computer-generated, multi-sensory information which tracks a user in real time. In addition to the more well-known modes of virtual reality, head-mounted displays and binocular omni-oriented monitor (BOOM) displays - the Electronic Visualization Laboratory (EVL) at the University of Illinois at Chicago (UIC) introduced a third mode in 1992: a room constructed of large screens on which graphics are projected onto three walls and the floor. Specifically, the CAVE™ as installed at EVL, is a theater 10x10x9 feet, made up of three rear-projected screens for walls and a reflective projection for the floor (the software could support a 6 wall CAVE.) The CAVE library software synchronizes all the devices and calculates the correct perspective for each wall.

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[iii] The AG is a collection of computing resources (computers, network, software, etc.) that enable "human interaction across the grid". The AG design goal is "group to group communication". This can scale from informal interactions to more formal interactions such as seminars, training, collaborative work sessions, and distributed meetings across multiple remote sites. EVL became an Access Grid (AG) node site in 2000.

[iv] The C-Wall is a high-quality, tracked, circularly polarized passive stereo wall, which could also be adapted to active stereo using Mirage DLP projectors. It is a site-specific, configurable installation (rear or front projection) with a component set similar to that of the GeoWall, but at a higher price point. It functions as a one-wall CAVE in terms of performance and compatibility with CAVE library software.

[v] Ygdrasil is a framework developed by Dave Pape as a tool for creating networked virtual environments. It is focused on building the behaviors of virtual objects from re-usable components, and on sharing the state of an environment through a distributed scene graph mechanism. It is presently being used in the construction of several artistic and educational applications. Ygdrasil is built in C++, around SGI's IRIS Performer visual simulation toolkit and the CAVERNsoft G2 library. CAVERNsoft is a C++ toolkit for building collaborative networked applications or logistical networking applications.

[vi] The GeoWall, is low-cost, non-tracked, passive-stereo system that allows distributed audiences to view and interact with 3D immersive content. While it can be applied to many applications, the Geoscience community immediately saw its potential for supporting Earth Science curricula in the classroom and in geological fieldwork, and created a consortium to deploy this technology to its members; hence, the name GeoWall.

[vii] AD409 Electronic Media Events with Drew Browning in Spring of 1997.

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[xii] YG was developed by Dave Pape at EVL and utilizes CAVE libraries and SGI OpenGL Performer. The random path movement node was written by Javier Girado and an additional node for more natural avatar movement was provided by Geoffrey Baum.