Collaborative virtual environments art exhibition

Margaret Dolinsky[*a], Josephine Anstey[b], Dave E. Pape[b],
Julieta C. Aguilera[c], Helen-Nicole Kostis[c], Daria Tsoupikova[c], Daniel J. Sandin[c]
[a]Indiana University H.R. Hope School of Fine Arts 1201 East 7th St. Bloomington, IN. USA 47405
[b]University of Buffalo, 248A Center for the Arts, Buffalo, NY. USA 14260
[c]University of Illinois at Chicago, 851 S. Morgan St. Rm. 1120 SEO, Chicago, IL. USA 60607

ABSTRACT

This panel presentation will exhibit artwork developed in CAVEs and discuss how art methodologies enhance the science of VR through collaboration, interaction and aesthetics. Artists and scientists work alongside one another to expand scientific research and artistic expression and are motivated by exhibiting collaborative virtual environments. Looking towards the arts, such as painting and sculpture, computer graphics captures a visual tradition. Virtual reality expands this tradition to not only what we face, but to what surrounds us and even what responds to our body and its gestures. Art making that once was isolated to the static frame and an optimal point of view is now out and about, in fully immersive mode within CAVEs. Art knowledge is a guide to how the aesthetics of 2D and 3D worlds affect, transform, and influence the social, intellectual and physical condition of the human body through attention to psychology, spiritual thinking, education, and cognition. The psychological interacts with the physical in the virtual in such a way that each facilitates, enhances and extends the other, culminating in a "go together" world. Attention to sharing art experience across high-speed networks introduces a dimension of liveliness and aliveness when we "become virtual" in real time with others.

Keywords: Virtual reality, Distributed/network graphics, MultiMedia Information Systems, CAVE, Fine arts

1. INTRODUCTION

Collaborative virtual environments or virtual reality (VR) is VR over the network. In this collaborative virtual environment art exhibition artwork is shared across CAVE sites. Exhibitions of the CAVE as a visual medium have developed over the last ten years for conferences such as SIGGRAPH,[1]SuperComputing[2] and IGRID,[3] among others. These venues often focused on the emerging technology and innovations by showcasing applications not only in math, physics and science but also art, humanities and cultural heritage. The science of VR lies in its software programming and computer hardware but its language and experiences are developed through the visual, cognitive, kinesthetic and proprioceptive realms of the body and mind. Art tradition informs the VR experience through emphasis on visual quality and experiential conceptualization of sensorial communication, visual metaphors and navigation strategies.[4] At last year's SPIE conference, collaborative virtual environment art was part of a panel. This year, the tradition has continued and expanded to include more words from a selection of the participating artists and scientists.

In this paper, we will explain dynamics in VR collaboration including recent exhibition venues and address a selection of the specific works in words and images. But perhaps more importantly we will position the arts within the science of virtual reality to explain how the arts inform "the engineering reality of virtual reality." The next section, VR collaboration is presented by Josephine Anstey who will describe the experience of remote navigators in VR art worlds and in particular the disco theater in the VR art of "PAAPAB." Writing on the computing power of distributed network graphics is Dave Pape with the VR selection ""Kites Flying In and Out of Space." Afterwards, a discussion of perceptual shifts in VR and "Beat Box," a playground of audio sequencers for sound collaboration will briefly introduced. Then we turn to more didactic rhetoric that briefly outlines the investigations of art into theory for practice. Julieta Aguilera discusses how art informs VR as a medium but how VR art is unique in comparison to a painting which

[*] dolinsky@indiana.edu, phone 1 812 855 5171; fax 1 812 855 7498; dolinsky.fa.indiana.edu

is viewed from a single vantage point: VR is a location to be lived. This brings on challenges for the VR artist developer who can no longer control the point of view. In this time based medium, unlike film, the view frame is constantly shifting according to the perspective of the navigator and with each occasion of the performance. The physical realities of the CAVE as it houses the body informs the work of Helen-Nicole Kostis who writes on the fluidity of expression that occurs in the action-reaction dialogue between the body and its physical space. As the body moves, the eyes seek what is familiar in order to identify its location and access the situation perceptually and cognitively. This dynamic is emphasized in the art and words of Daria Tsoupikova in her section on "Seeking the Familiar in VR." Tsoupikova believes that the rich tradition of 2D and 3D art history informs the visual composition for VR space.

2. VR COLLABORATION

In the last few years a flexible group of collaborators has been making networked VR art projects for display in CAVE or CAVE-like systems. The group's first exhibition was at the 2001 Ars Electronica Festival and most recently we exhibited V_Hive at the SVR Virtual Worlds Festival in Brazil, October 2004. The exhibits have typically been networked between four to eight locations in the US, Europe and South America.

Collaborative VR adds life to virtual environments that might otherwise seem empty and possibly sterile. All the applications in the V_Hive suite of art projects can run in stand-alone mode, a default position that is vital in the face of the problems that can occur when participants, continents apart, are sharing large and complex virtual worlds over very varied networks. However, the real fun begins when you are part of a group exploring the virtual worlds, listening to artists in different locations explain their ideas, and experiencing their visions directly. Typically remotely located users introduce themselves in Confluxus, a world between worlds which holds all the worlds; mini-globes each representing a different art project, swirling with images and fixed into a glowing 3D grid. Once the users choose which VE to visit, you can see their avatars cluster around a spinning globe. Then each in turn winks out of existence, until you follow and find them dancing, making music, or spraying each other with particle systems inside one of the art VEs.

Figure 1. V_Hive at the SVR Virtual Worlds Festival in Brazil, October 2004.

At each remote location, the participant "driving" the VR experience is wearing a tracking system. Typically they will have a tracking sensor on their heads and on one or two hands. This simple tracking system is immensely effective in imparting a sense of life to the avatar - the virtual representation of that person - as it appears in the virtual world and to all the other participants. During our recent networked exhibition at SVR in Brazil, one participant in Buffalo was most impressed by the sense of co-presence evoked by being able to see the small, natural movements of the avatars, as they stood around talking, looking at each other, running over to show each other objects, pointing, gesticulating. Groups in different locations made the pieces in V_Hive and the avatars are all different, they range from a smoothly curved abstraction that evokes ideas of whales and water-eroded rocks, to green robots, to Norse Gods. Many researchers suggest that a photo-realistic level of detail is necessary in order for people to feel immersed in a believable world.[5] Others suggest that more abstract representations leave the participant's imagination room to fill in details more richly.[6] Others argue that "realism" is not only, or mainly, about how things look in a virtual world, but how they move and respond.[7] Our shared VR spaces indicate that a more abstract avatar, coupled with natural body language, often reads as a living "person" better than the photo-realistic (but never really human) humanoid.

One of the applications in V_Hive is PAAPAB made by Josephine Anstey, Dave Pape and Dan Neveu at the University at Buffalo. It is a dance-floor environment populated not only by remote participants but by life-size dancing characters. In a previous work, the Thing Growing,[8] the authors had used the tracking system to capture motion, save it to files, and play it back to animate computer-controlled characters. This process gives the characters the same naturally alive feel as the avatars of real people. During the production of that piece, they noted how much fun the motion capture process was; since they had set up a recording environment that allowed the recorder to watch the character in real time, play back, rerecord etc. The PAAPAB environment jumped off from that point.

The environment consists of a dance floor with three semi-transparent platforms suspended above it. On the largest platform are four interactive recording booths, each with a different kind of character in it. When the user gets close to the booth, she is automatically positioned about 8 feet from the character and facing it. A voice tells her to get ready to record, this is reinforced by similar text on the booth. The voice starts a count down, and at "three" the booth text changes to "Recording" and the user's movements are recorded. After 15 seconds the recording stops, the voice and text inform the user that the character is now playing back the recording, and the user can watch what she has done. Finally the data is saved and the character leaps down from the translucent platform onto the dance-floor dancing all the way. Another character appears in its place, and the recording can begin again. Meanwhile the dance-floor holds traces of the last 40 users who have recorded motion; characters all dancing to a variety of techno-beats. The users can go down to the dance floor, dance among these characters, and also dance with each other.

The application is light-hearted, but raises some interesting issues. Watching your own very idiosyncratic movements mapped onto another being can be pleasurably narcissistic. Is there also pleasure in controlling that remote body? Users can choose from a variety of character styles: one is dragon-like; one has wings which ripple; one is a skeleton with a human face; one is an abstracted sex-kitten. Does the choices reveal something about what kinds of other bodies each user is comfortable inhabiting? The virtual and real are also conflated and intermingled. Some of the models used for the characters are also used as avatars, all the beings are moving realistically, so it can be challenging to figure out who is real and who is not. Finally PAAPAB allows a kind of social interaction based in the body to be shared, virtually, across the network.

There were some challenges and choices involved in making a real-time, networked motion-capture environment. Although the controller we use has buttons we don't use them to stop and start the recordings. Instead we made the recording booths as automated as possible so that it was easy for first time VR users. This automation included triggering the booth's response to the user based on proximity and then positioning the user facing the character - as many users would take so long maneuvering into position they would miss the recording window. Our animation system also had to take into account that people at different locations had different numbers of tracking sensors. We made a virtue of this necessity and programmed it so we can animate more body parts than we have sensors, by mapping all the body parts to the sensors available but then adding suitable offsets and delays to some of the parts. We ended up making two versions of the system that saves the motion capture data and shares it among the different locations. One, for use on faster networks, streams the animation data for all 40 characters over the network. The other allows each location to save any avatar's tracking data into a file locally. The Ygdrasil authoring system was used for all the V_Hive applications and we benefited from the well-defined user model in making this application. As well as handling the issues above, the model makes it easy to enforce that one user is controlling a character at any one time.

3. KITES FLYING IN AND OUT OF SPACE

"Kites Flying In and Out of Space" is a virtualization of the physical kites created by the artist Jackie Matisse. They are dynamic linear kites with very long tails, sometimes 35 to 49 feet in length, with various abstract patterns on their tails and heads. The lines Matisse draws are not physical tracery, but rather are trajectories in the sense that a "bee" line shows the direction or motion of an object in space. Such lines exist so long as the mind embraces them as an idea or concept.

Because the motion and trajectories of the kites are a core element of Matisse's work, simulating this in the virtual kites has been the focus of our work. Realistic animations of cloth and cloth-like objects can be generated using a mass-spring physics system.[9]

The "Kites Flying" environment was previously implemented, using a mass-spring model, for iGrid 2002, an international testbed event for grid-computing applications.[10] In that case, the simulation was free to consume large amounts of computational resources. 12 kites were simulated, each one comprising approximately 250-point masses and 900 springs. Each kite ran on a dedicated processor (at one of four different computing centers), and used roughly 1.1-megabits/second network bandwidth from each simulation computer to the VR display system.

Significant computing power and network bandwidth are often not readily available for art shows, and so our goal has been to decrease the requirements of "Kites Flying", potentially to something that can run well on a single, standalone PC. Reduced computing requirements were important for the most recent showing of the kites, in the V_Hive exhibition in Sao Paulo, for two reasons. First, V_Hive was a group show, and so the kites' simulation had to share the computer with several other pieces. Second, the network bandwidth available between the United States and Sao Paulo was extremely limited. The V_Hive show also added the component of being a networked virtual environment -- the previous version of the kites, although using networked computers for the simulation was a single user environment; all data was transmitted to just one VR display.

For the V_Hive version, we reduced the simulation of each kite from a complete 2-dimensional mesh of 250 points to just a single string of 20 points, connected by 19 springs. This string was treated as a skeleton for the kite, from which the rendered mesh was generated on each frame. Although the fine details of the kites' motions are lost in this approach, the gross movement -- the lines and trajectories drawn by the kites -- are very similar to that of the more complex simulation. With this reduced model, we were able to simulate five kites, running the simulation on the same computer as the graphics (and all the other pieces in V_Hive).

To eliminate any large bandwidth requirements, we chose to run the kite simulations independently on each participating VR system. In other words, there was no master simulation to guarantee that all participants saw exactly the same results; the only data that was shared was the positions of the heads of the kites (which participants could grab and move about). From past experience with other complex, highly dynamic networked virtual worlds, we believe that this sort of "cheating" is acceptable. The different participants do not know exactly what the others are seeing, so as long as the virtual objects behave roughly the same way on each VR display, people will believe that they are identical, and the illusion of a shared world is not broken.

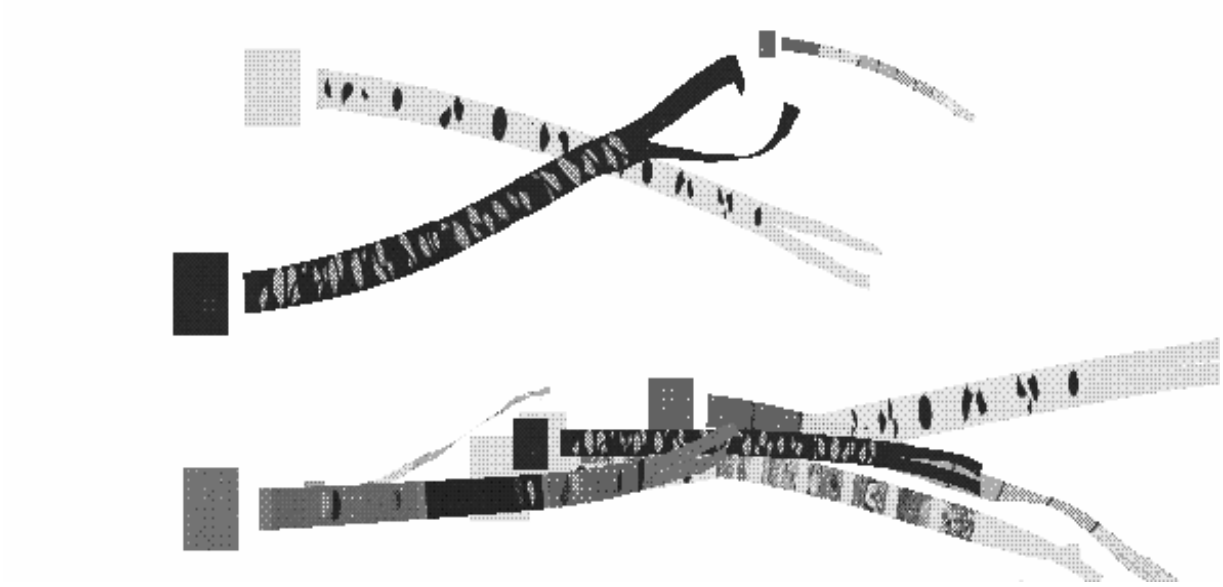

Figure 2. The virtual kites.

4. PERCEPTUAL SHIFTS

CAVE art is a predominately visual and kinesthetic form of 3D computer graphics that reacts to the viewer-participant as she manipulates her head, hand and body movements. The CAVE offers a psychological proximity whereby the participant is physically located inside the art, however the final piece cannot be realized without an active engagement to form and shape it. For the active participant in the CAVE, the boundaries begin to blur between the self, the virtual environment and where the real world is. Reality is determined by the participant and updated by the computer as code, screens, mirrors and projections mediate the negotiation between the two within the artwork.

There is a historical tradition in art towards the desire for altering perception and promoting a perceptual shift for the viewer. A perceptual shift is a cognitive recognition of having experienced something extra-marginal, on the boundaries of normal awareness, outside of conditioned attenuation. Often times these experiences of perceptual shift are promoted by creative activity, as outlined in Csikszentmihaly's idea of flow.[11] Flow can occur through such endeavors as playing surrealistic games or solving a jigsaw puzzle. Other times a perceptual shift is the motivation for the viewer in visiting art works such as trompe l'oeil, Cubism, Cornell boxes, labyrinth gardens and Brecht's political theater.

These devices for wonderment are enchanting and have a magical quality that involves specific interaction unique to the type of device and its functions. Once the participant realizes her or his role within that interaction relationship, exploration begins and opens up possibilities for cognitive and perceptual shifts. Creating such art pieces as "Beat Box" is an attempt to shape perceptual possibilities for decision making and acting within virtual environments.

Figure 3. "Beat Box." Interactively placing sounds at an interval or head on a audio sequencer.

"Beat Box" is an environment of audio sequencers and drum machines for sound collaboration. The art imagery explores the concepts of gesture, voice and dialogue as they resonate one to the other through bodies, instruments, sounds and avatars in real time VR graphics. The gestures and movements of the navigator's body ignites the movement of musical instruments and avatars.

Each audio sequencer is an instrument made up of a series of graphical heads. Each head is a placeholder for sounds and sound selections designated by an navigator. As the sequencer plays, a head represents an interval in the sequence. Moving across the instrument, each head expands in turn to figuratively expel its voice and call out a sound. Three audio sequencers control, respectively, percussion, ambient and bass sounds. The drums are interactively played by "hitting" them with the navigational wand. This provides the most immediate feedback for the navigator's gestures and is an expressive movement for remote sites as they see one another's avatars in action.

"Beat Box" can be enjoyed through a variety of heights and vantage points to see the environment. But more importantly it was created as a challenge to "work" at play in VR. The selection of sounds occurs by pressing the first button on the navigation wand. This allows a new sound to be active. The active sound is then attached to an interval by approaching a head and pressing the second wand button. The attachment of the sound gives the interval a voice made up of that sound. Sounds are updated in real time across the network. Initial attempts to network such an audio intense piece were difficult – the network messages lagged so that the audio and the graphics did not always synchronize. Performance on the IGrid infrastructure was smoother and "Beat Box" was shared across five collaborative CAVE sites: IUB AVL, UIC EVL, NCSA IL, UB and SARA in Holland.[12]

5. VR AS ART MEDIUM AND LOCATION

For the past century or so, exceptional human works have been not just admired by their creativity, but cornered into the term "art" and then distilled to mostly visual works, most specifically oil paintings. Any oil painting can be called "art" whatever it is today. Most sculpture, photography and film, can be fearlessly called art as well, without much debate. More so, any object inside a gallery is definitely art, no matter what. For some reason, the human capacity to perceive creativity in human-made objects has been replaced in the popular media with the mere recognition of a medium or location. Yet mediums like oil paintings, which were to be windows to other realities, available in important buildings centuries ago, do not mean the same for society as they did before. Today we have electronic windows, and virtual spaces.

But how do medium and location relate to us? For many years, we humans have not changed much: we still have the same number of limbs and senses. What has changed is the world we design around ourselves, and how we designate what surrounds us, the time we spend with each other and our constructions, and with each other through our constructions. No wonder media and medium have the same language root, as they mean ways of communicating.

There are many challenges in understanding how different mediums and crafts, which are chosen to express significant issues, have a prelude purpose in our experience of the world today. Also, the idea that art-driven endeavors are a finite historical construction, related to mediums of the past, has become a strategy for product consumption. This is how today, art galleries are filled with artifacts more related to journalism or art criticism rather than creation per se, which instead of addressing novel observations that come out of our contemporary surroundings and ways of life, limit themselves to be the platform for opinions of current technologies and their consequences. It is important that our interdisciplinary communities understand all this, so we can tune up to work together.

Another aspect that needs to be investigated through public discourse is to do with the concept of dynamic works that are not a one-time events but rather are performances. Looking back to painting and sculpture, real time computer graphics take on the visual tradition and expand to not only what we face, but what surrounds us, and respond to our body gestures: art making that has been isolated into a static snapshot for the past century, is now out and about, in fully immersive mode within CAVE virtual worlds. VR worlds exist in fresh instances of the original art whenever they are performed.

For example, VR challenges us to explore what a window to another reality is, or what a virtual presence can say, even if does not have material decay or physical constraints to express something. More so, virtual worlds exist in the present, and depend on our actions. In the creation of virtual worlds, one may borrow from film craft, but change the eye of the filmmaker to the eye of the navigator. One may also take into account the possibility of multidimensional architecture, where spaces are malleable and move beyond three dimensions. As a result, the art medium and its multiple locations of virtual and physical worlds work together to form a new type of symbolic dialogue for art and science.

6. VR AND PHYSICAL REALITY

6.1 Fluid functions and the body

The instantiation of new realities and new worlds is a fascination of many artists working with VR. In contrast, the replication of everyday existence and the cloning of "reality" are not a personal goal or favorite. The simulation of identifiable realities is also not interesting to many VR artists. It is the uniqueness of VR as a medium that calls for the creation of new, synthetic, realities, where the space "becomes" the place. That uniqueness along with the combination of virtual and physical realities and the discourse that is generated by their coexistence inside a dialogical context brings new dimensions awaiting to be explored. It is a challenge for VR architects to represent realities in order to confront users with paradoxes in worlds that are not "typical", where rules that do not follow the functions of common reality govern.

Richard Brown believes that artists can use new technologies to give people experiences of alternative space-time frameworks, physical experiences impossible in the real world, "free of the Cartesian Prison".[13] Objects, spaces, bodies, movements, situations, and rules that were once thought to have a "boxed" identity and behavior can now occupy character and personality, power and control, or even exhibit fluidity in their manners. Virtual worlds are spaces where the occupation of architecture is being reused and transformed. Artists, researchers, and engineers combine multiple disciplines to become a new kind of creators, what we call "architects" of this "other" kind of space.

The architect of a virtual world is finally free of the "tyranny of function."[14] In these multi-dimensional spaces new rules can govern, rules that define gravity, interactivity, architectures resulting from the spatial relations of objects, and animate/inanimate behaviors. The architecture can be crossing definite borders. These borders can collapse and coalesce in non-linear time. The architecture is liquid and metamorphic. "It is an architecture that breathes, pulses, leaps as one form and lands as another."[15]

Figure 4. "Animagina" CAVE art.

An impetus for creating virtual reality lies on the ability to turn things around. Concepts can be reversed, as the public can become private and the small can be metamorphosed to large, a 2D image can be morphed or extruded to a 3D object and the opaque can become transparent and vice-versa. All this is happening in a user-centered perspective world where our bodies are an instrument. Experiences of gravity, speed, interaction, and basic existential necessities, such as light, heat, water, and the elimination or the surcharge of them, are absent in the physical sense. There exists the

capacity to traverse environments quickly or slowly, fly in space, cross walls and barriers and interact with or touch objects in a manner never before possible. There are no restrictions imposed on an architect and simultaneously the participant is liberated from any restrictions through the freedom of the architects. This freedom can be perceived as the freedom of the creative mind, but, because at the end we are what we make or what we make is what we will become, at the same time it can generate consciousness of the worlds being formed. In virtual worlds "there is both a fluidity and speed of movement that are more akin to dreams than waking life." [16]

6.2 The body, physical, and virtual acquaintances

Being in a virtual world the physical body occupies the virtual and physical worlds simultaneously, actions have consequences, albeit different ones, in both worlds.[17] Immersed in a virtual world the participant loses track of time and space and questions the relationship with the physical one and the balance between these realities. The formation of new rules and archetypes, and the creation of hybrid realities is a personal fascination of the author and of many artists. As Jeffrey Shaw has suggested "the most fascinating aspects of life in our era do not lie in things limited to the real world or some fixation with imaginary worlds, but are found instead in the creation of imaginary spaces of dialogue with the bodily experiences of history and its real spaces. In other words, Shaw emphasizes the creativity of the border region where one foot rests in the real world and the other in the world of fantasy."[18] The personal fascination thought, does not reside solely reside in the borderline experience of physical and virtual, but also in the investigation of our perception of the connection between virtual and physical objects and spaces and in the way the human brain creates the associations between them. The interest extends also to the behavioral psychology of participants and architects towards the virtual and the physical universes.

Extending the dialogue of one participant with a virtual universe to a multiple-client universe, the experience transcends and multiplies these dialogical situations. It takes them to a multi-layered level. Incorporating telepresence – "a technology for a person to be present *in some form* in a distant place"[19] – in virtual reality, we create tele-immersive experiences. Physicality and kinesthetic information are being transmitted through the participants' virtual representations – the avatars – where the communication and meeting over distance through a virtual world, becomes a reality. Participants enter a virtual world through a portal, connect with remote sites and set a rendezvous to a specific location/world. They can talk, listen, and respond. Voice is not disembodied. When the physical arm is extended the virtual one follows. Gesture and gaze follow the physical movements. Hybrid identities are being multiplied or become layered.

Virtual and physical interact in such a way that the one enhances, extends, or functions as an aiding prosthesis to the other, culminating in a "go together" world. Their interaction forms new ontological totalities and holistic universes, and is much more than just a series of human-computer interactions.

6.3 Virtual and common reality

The immersion in virtual spaces enhances our understanding of our physical body's relationship with the world and of our everyday existence. Through immersion and telepresence we better understand how our world functions, how we function, and which are the rules that seem transparent or are taken for granted in our common reality. The creation of imaginative spaces not only gives us the opportunity to experience an "other" type of "being" in the world, but it also represents our everyday existence in this world, as the space is now both of real and virtual nature. "The city is now composed of a synthetic space-time."[20]

7. SEEKING THE FAMILIAR IN VR

The technical and aesthetic evolution into the production of Virtual Reality (VR) environments follows principles based upon the history of 2D and 3D art. Among those visually composing principles are balance, color, repetition and rhythm.

In order to have a visually pleasing image the overall scale and the proportion of each element needs to be balanced. One can think of a rule of proportion such as the golden section, which is a ratio approximately 1:1.62. The ancient Greeks discovered that many natural objects, such as pine cones, flowers and animal shells are designed according to this proportion. The connection of this number in natural phenomena and its role in aesthetics is explained by recent discoveries in dynamical systems theory.

Color theory describes the use of color to achieve unity and harmony to an image, which communicates a mood and can even affect spiritual thinking. Or color can force the eye and mind to focus on a specific element in an image; this element can be placed in the composition so it contrasts in color or brightness with other elements. Color can manipulate our perception and cognition because our eyes respond to various wavelengths of light, which communicate through various nerve impulses to the brain. When you view a Hokusai woodblock of a *Great Wave* you are lead from the eyes to the brain in a certain direction through the dynamics of balance and appropriate amounts of positive and negative spaces (contrast in color, brightness, proportion, and scale), which allows your vision to flow evenly over the image.

Another principle is the one of repetition and rhythm. By connecting multiple elements through the same properties of color and proportions, one can effectively highlight the connective relationships. Gestalt theory of perception developed by psychologists states that humans tend to seek consistencies among visual elements, which helps to comprehend and interpret sensory information. Our cognitive skills are based on the fact that we seek the familiar in the unknown to learn and understand new environments. That is why until 20th century art was mostly preoccupied with visualization of the world and the body according their visible surface features.

Besides art history, these principles affect all aspects of culture including: medicine, education, entertainment, propaganda, advertising and theology. In theology, for example, there is a whole discussion about the status of the material objects in relation to human spirituality, perception in relation to faith and trust, architectural space in relation to our memory and mind, symbols and icons in relation to our cognition, religious practices in relation to the human body and psychology. Psychologists use color to communicate to the human mind, rhythm and repetition of eye movements to heal consequences of traumatic experiences.[21] Sound and musical compositions speak to senses, which can transform human beliefs. Leonardo da Vinci and Gino Severini researched the synthesis between music and color. Paul Klee stated that color may be managed through a general theory of composition in the same way that sound is managed through the framework of musical theory.

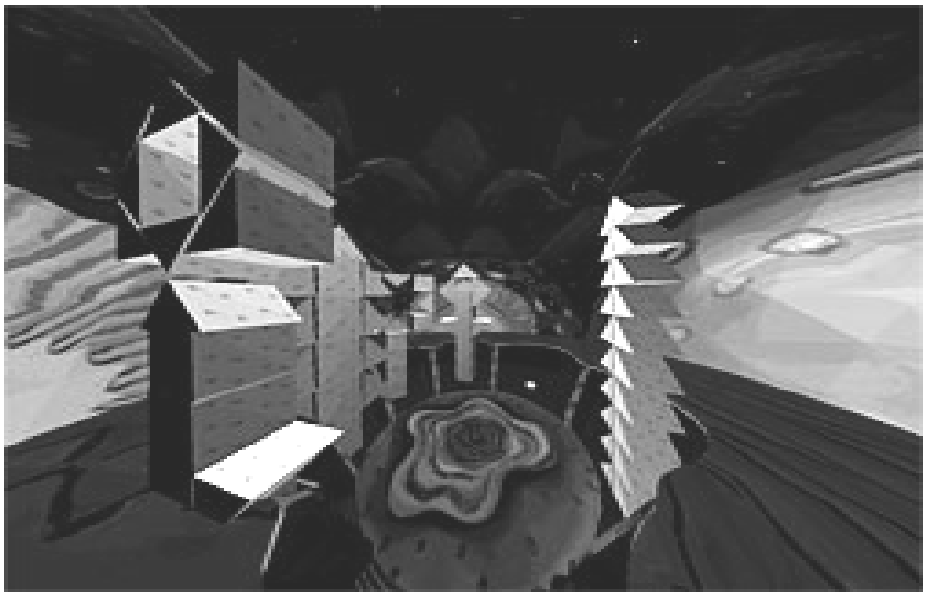

Figure 5. CAVE Art still from “Rutopia.”

Since our learning of the new depends on recognition of familiar patterns, artists until the last century used recognizable patterns through the visible appearance of things (natural elements, human body, industrial objects) to expressively communicate ideas. In art therapy, education and psychology creative expression is used to analyze and evaluate our

perception of the world and ourselves. Propaganda, advertising, and marketing employ compositional and color emphasis to force the eye to focus on selected elements. Recognizable subjects such as violence, erotica, and fast speed are common entertainment themes in Hollywood films and in computer games. We are continually discussing their affect upon psychological, emotional and physical concentration. For example: what is the rise of the level of adrenalin in our body through visual excitement?

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In the virtual reality environments those principles are affected by changes in real time and by interactive manipulations of the user in addition to their traditional 2D and 3D functions. These new requirements affect the creative process. One technical component is the small file size of those objects and the speed of the navigator in an environment of real time interaction. Another new requirement for a new aesthetic is based upon their physical and psychological influence on the human body inside the virtual reality world.

The latest development in our electronic revolution is one of telecommunications and global networking, where Virtual Reality through computerization is an arts pioneer. In this new space there is a possibility for creation of interactive, intelligent environments such as dynamic architecture and self-organized interfaces. Instead of literally following the replication of the natural phenomena based on our intuitive comprehension through common experience, artists now create new conceptions of reality and identity.

These new conceptions expanded traditional aesthetic principles of art making into other dimensions in depth and time. Cognitive and time-based, they require new poetics, or new principles of aesthetics. It is an excitingly area for experimentation and unleashed creativity. There are no limitations of material properties so common to design, sculpture, painting and other traditional arts. There are no limitations of space, time or intended audience such as sculpture installation, a dance recital or film theatre. Through network connections artists can collaborate on the projects from different sides of the globe in real time. Space and time can be manipulated interactively and remotely through the network while participant's physical faculties and emotions can be forced to share common sensational experiences across the globe.

Composition, balance, color, repetition and rhythm principles expand into new dimensions in VR and require more planning, work, development time, testing, and evaluation. For example, to force the eye to focus on a specific element in a 2-D image, this element can be placed in the composition so it contrasts in color or brightness with other elements. It is a difficult task to achieve even in the restricted width and height of a 2-D image. In a VR project, besides the addition of depth dimension, elements should be placed effectively in a timeline sequence, and may have several forms and textures to be changed by collaborative interactivity. However, the time-based moving image requires less detailed artwork because the human eye tends to loose concentration on details in the moving image proportionally to its speed. Looking at the fast changing images on the screen, we seek the familiar and common artistic features to understand the overall art style. Thus, each individual moving image must follow the overall style guidelines while permitting a lower level of details.

In interactive projects however, both venues of development (time-based style driven and individual composition driven) collide because the element can be static while it waits for the user commands, before it is animated through interaction. The color or compositional emphasis in the VR environment should be placed not only in three dimensions: depth, width and height, but also into a certain moment in the project timeline. This adds a need to control its impact range on a time-based sequence. This effect can be orchestrated to control the communicative power of the project and requires a variety of skills from the artist.

Our visual system is capable of achieving sharp focus in approximately a 2 degree arc of vision and a moderately sharp focus in an approximately a 10 degree arc of vision. Beyond that, vision is very sensitive to motion and can discriminate light from dark but has a much lower visual acuity. Thus traditional artistic 2-D and 3-D objects can be completely inside the sharp focus of vision when we direct an eye on it, the focus is objective and depends on the user's gaze. In immersed VR environment; however, the single user is not able to see the whole environment around him with sharp focus, so the focus is subjective and depends on the direction of the gaze of each individual user. VR artists can use those characteristics to avoid rendering unnecessary level of details, increase efficiency of the application, and to manipulate user's field of vision.

Recent research in Neuroaesthetics explains the connection between mind, consciousness, body's symbolic language and art through the complex neurofunctional mechanism of human nervous systems. Art project "can increase the quantity and interconnectedness of dendritic arborization in a specific cortical region" which broadens the opportunities for VR art and its effect on human perception, emotional, and spiritual states.[22]

7. CONCLUSIONS

The painting may be a frozen moment in time, the film may be a fixed story in a linear time but collaborative VR is an ongoing movement in real time in real locations across the networks. Finished graphical works such as animation and film do not capture the human element of unpredictable circumstance found in VR collaborative art. The gestures and expressions that are captured during these moments are unique and cannot be programmed or anticipated. They depend on the emotional and mental contact that occurs when people are collaborating with one another over the ethereal medium of the internet.

Collaborative virtual environments extend traditional art medium and computer graphics into experiential, sensorial time based performance phenomena. VR art presents a view that changes with the navigator's perspective and performance episode. VR art is informed by traditional art and film aesthetics and theories but must be augmented by mathematics, science, software and hardware in order to develop the powerful visuals and experiential phenomena that can be creatively accessed for perceptual and cognitive awareness.

Our experience of the world is an interpretation based on the strategies that we develop for making decisions about what to focus on. This notion holds true for discovering a CAVE world: Although the CAVE may simply be projection arts, it still requires an interpretation of a confrontation within the real world.

One question that comes up after these considerations is: how could we differentiate human constructions that are more mundane or functional, and human constructions that are more interesting and gratuitous within VR. In order to answer this question, we need to move beyond ordinary notions of art. As previously explained, the idea that art can be stated by a medium or location is not enough. VR may point to a need to reformulate what the meanings of medium and location are or can be. The use of Virtual Reality as a medium, that is, as real-time, immersive computer graphics and as a location - simultaneously in data space and in real world space - is but a necessary challenge to cultural development.

ACKNOWLEDGMENTS

We would like to acknowledge all those who were involved in the production of the artworks that on exhibition at the SPIE EI 2005 conference: "Beat Box" was designed by Margaret Dolinsky with Edward Dambik, Nicholas J. Bradley, Adam Schweigert, and Craig Strubing at Indiana University Bloomington Advanced Visualization Laboratory (AVL) and the HR Hope School of Fine Arts. "Animagina" was created by Julieta Aguilera, Helen-Nicole Kostis, Seung Kang, and Tina Shah at the University of Illinois at Chicago Electronic Visualization Laboratory (EVL) where Daria Tsoupikova designed "Rutopia" and Todd Margolis created "Confluxus." Co-Director of EVL Daniel Sandin presented "Looking For Water" with Laurie Spiegel and gives thanks to Dick Ainsworth and Tom DeFanti. "PAAPAB" was made by Josephine Anstey, Dave Pape and Dan Neveu at the University at Buffalo. "Kites" was presented by Dave Pape with thanks to the artist Jackie Matisse, Ray Kass, Tom Coffin, Shalini Venkataraman, and Jason Leigh. Everyone gives special thanks to Daniel Sandin, Dave Pape, Helen Kostis and Alex Hill for their technical expertise and motivation.

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