On Creating Virtual Reality Stories And Interactive Experiences

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Abstract

After 10 years of research in Virtual Environments, interactive real time Virtual Reality systems are now available that even support highly immersive, interactive presentations for large audiences. Following the single-user head mounted technology of the early days, multi channel stereo projection systems are now applied in nearly all application domains, complemented with spatial auditory rendering, and prepared for haptic and olfactory sensation. The paper discusses the application of interactive digital storytelling as a means for future education, entertainment, product presentation and event based marketing. We will introduce the process of creating, developing, installing and operating digital stories. We will also communicate experience from applying those stories in different public scenarios in the past 3 years. Several examples of story-type applications with different goals will be presented, and the suitability of VR displays will be discussed. GMD's Virtual Reality Framework for distributed applications, called AVANGO, is introduced, along with an outlook for storytelling in terms of both technology and content.

***Key words**: Virtual Reality, projection systems, interaction, simulation*

1. INTRODUCTION

Virtual Reality has been considered an innovation in man machine communication, allowing the user to communicate more intuitively and directly through an interface that addresses all five human senses and understands human communication and interaction metaphors. Since the early days VR has been explored as an expressive tool to create realistic virtual worlds and to immerse humans in fascinating synthetic audio-visual experiences. Today, VR techniques are fairly well introduced in the design construction and production processes, and used to visualize complex CAD geometry or flow phenomena. Occasionally, VR installations can even be found in museums or other public places like trade shows and exhibitions.

The extensive use of computer animation in recent Hollywood productions shows the extent to which computer graphics can contribute to storytelling. Enabling this technology to be real time and interactive would allow personal participation in the story—as an observer defining an individual view or as a participant activating alternative scenarios or having a unpredicted impact in the story. On the other side, desk top computer games today document the advances in real-time interactive scenarios but with compromises in addressing the human senses. In this paper we discuss storytelling by comparing the aims and needs. We introduce AVANGO, our Virtual Environment software framework, and its extensions for storytelling. The CyberStage, a CAVE-like display system, is also described and a number of recently developed audio-visual experiences for the CyberStage are presented. The stories range from a service oriented production for a particular company to exploratory self-experience installations.

2. INTERACTIVE DIGITAL STORYTELLING

Digital storytelling first of all refers to the technological aspect that content is provided and can be accessed in digital format. From there we define interactive digital storytelling as a form of "story" that can be explored in different directions. The reader/user can line up sequences from a very complex pool of story fragments and environments. He can create his own individual path through it—and the accompanying story from it. Immersive virtual environments are currently the most sophisticated medium for experiencing hybrid narrative content as described above. VR systems seem to be most interesting for the education and entertainment industry where the technology might offer a new way of perceiving, experiencing and handling content of any kind.

While common desktop computer systems force users to adapt their working behavior to multipurpose input and output devices, like keyboard and monitor, modern virtual reality display systems adapt to the users traditional workspace to function as an interface to computer aided work. This is also interesting in the field of theatre and cinema, where planning, presentation and management of single productions requires a well integrated set of tools in order to save valuable resources without compromising creativity. Vice versa, the virtual space more and more becomes a medium for entertainment and culture of itself, but still lacks the necessary tools to author narrative virtual environments.

Technically, real time presentation and simulation is required, where real time is defined as a system in which the user is not aware that a computer is processing his interaction and behavior. Real world phenomena have to be presented in a way that provides the illusion of realism. These are basic requirements for the runtime system, the control and operating software, and the algorithms for interpretation and simulation—a real challenge for machines and networks. To create a digital story today is very exhausting, as authoring tools for creative teams are not available. Despite the high technology the storyboards are still developed in the traditional way—imagination of creative people sketched as key scenes on paper. Animation, interaction, audible and visual effects are described verbally and written down. Colors and lighting effects are derived from the drawings. With this information, designers and modelers apply tools from computer animation to create geometry, modify and import real world images and movies as textures, define object morphing and animation paths etc. The challenge is to transfer as much functionality as possibly from the animation package to the VE runtime system. Background music is sometimes composed according to the animation, and audible effects are recorded and digitized. Haptic and olfactory effects can be made accessible by simulation modules. Each item, every piece of geometry, each sound, must be pre-prepared to be finally stitched together by programming the run time system, a tedious task that defines actions and reactions, controls timing and integrates a zoo of peripheral I/O devices to a sensational installation. In our lab, programming is based on the AVANGO VE framework, which supports a number of effects and simulations. Programming a story is done by scripting object behavior, presentation characteristics, navigation and interaction techniques.

3. AVANGO - A FRAMEWORK FOR DISTRIBUTED VIRTUAL ENVIRONMENTS

The AVANGO system [1] has been under development at GMD since 1996. It serves as a common system platform for nearly all research and development activities in the GMD Virtual Environments group. AVANGO provides programmers with the concept of a shared scene-graph, accessible from all processes in a distributed application. Each process owns a local copy of the scene graph and state information, which is kept synchronized. Our object-oriented framework allows the creation of application specific classes, which inherit distribution properties. In addition the shared scene-graph is augmented with a distributed data flow graph. This provides the same evaluation characteristics in distributed applications as in stand-alone applications, and effectively supports the development of distributed interactive applications. We focus on high-end, real-time, virtual environments like CAVEs [2] and Workbenches [3], in contrast to similar systems like Repo-3D.

AVANGO combines the familiar programming model of existing stand-alone toolkits with built-in support for data distribution that is almost transparent to the application developer. It uses the C++ programming language to define two categories of object classes—nodes and sensors. Nodes provide an object-oriented scene-graph API that allows the representation and rendering of complex geometry. Sensors provide an interface to the real world that imports external device data into an application.

All AVANGO objects are field containers, representing object state information as a collection of fields. AVANGO objects support a generic streaming interface, which allows objects and state information to be written to a stream and the subsequent reconstruction of the object from a stream. This interface is one of the basic building blocks used for the implementation of object distribution.

Connections between fields are used in AVANGO to build a data flow graph orthogonal to the scene graph. The data flow graph provides a way to specify behavior and enable interactive applications.

To maximize performance we chose to base the AVANGO framework on SGI Performer which handles advanced rendering tasks like culling, level-of-detail switching and communication with the graphics hardware. Whenever the underlying hardware allows, Performer utilizes multiple processors and multiple graphics pipelines.

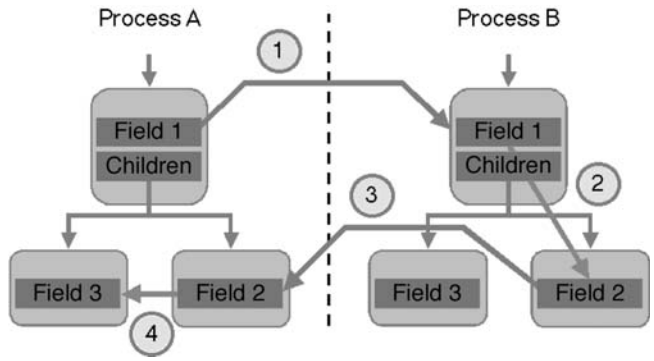

Figure 1: Event distribution in AVANGO scene graph structures

In addition to the C++ API, AVANGO features a complete language binding to an interpreted language called Scheme, which is descended from Algol and Lisp. It is a high-level language supporting operations on structured data such as strings, lists and vectors. All high-level AVANGO objects can be created and manipulated from the general purpose Scheme program.

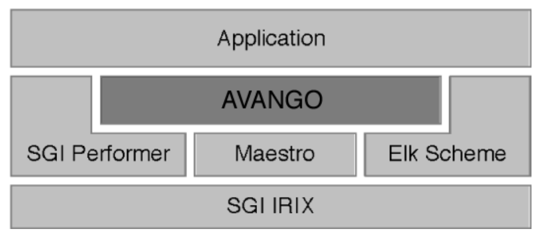

Figure 2: AVANGO system overview

The AVANGO scripting interface suggests a dual approach to application development. Complex and performance critical functionality is implemented in C++ by subclassing and extending existing AVANGO classes. The application itself is then just a collection of Scheme scripts which instantiate the desired AVANGO objects, call methods on them, set field values and define relationships between them. Scripts can be written, tested and debugged while the application is running. This leads to very short turnaround times in the development cycle and provides a very powerful environment for rapid application prototyping.

3.1 Distribution

The main goal driving the design of distribution in AVANGO was to make the development of distributed applications as simple as the development of stand-alone applications. The application programmer should be allowed to concentrate on the application itself, while AVANGO provides the infrastructure to make that application distributed. To achieve this degree of network transparency requires the concept of distribution to be an integral part of the object model in AVANGO.

The high bandwidth requirements during object access for rendering necessitates that each object exists in the local memory of the rendering process. For this reason the distribution support in AVANGO is based on object replication and the distributed shared memory model.

The ability to replicate the entire scene graph, paired with the state transfer to joining members, effectively solves the problem of database duplication. New members can join an existing distribution group at any time, and will immediately receive a local copy of the scene graph constructed so far in the distribution group. As a consequence the application programmers do not need to concern themselves with distribution details. They can take the scene graph for granted on a per-process level, and concentrate on the semantics of their distributed applications.

3.2 The Sound Server

The sound server [4] runs on any SGI machine and supports all kinds of audio interfaces, including 8-channel ADAT compatible sound output devices. The sound server is based on IRCAM's Max/FTS real-time sound processing system [5,6] originally built for computer music applications. FTS is an extensible signal-processing kernel that provides the low-level modules required to build sophisticated sound synthesis and processing applications. Max is a graphical programming environment used to interactively build FTS programs. Max also allows the control and monitoring of states in a signal-processing program running in FTS. The spatialisation algorithms in the sound server are partly based on IRCAM's Spatialisateur toolkit [7] developed in Max/FTS. The higher level sound server software consists of parts realized in Max (synthesis control, resource management system, message parsing) and FTS extensions written in C (efficient spatialisation modules, sound sample manager, custom synthesis algorithms, network communication).

The sound server an open toolkit adapted to a large class of applications. The application designer is free to choose from many templates, provided by the server, that solve standard problems. AVANGO provides a set of scene graph node classes, which define auditory scene elements. There are different nodes which describe the nature of the sound source (e.g. sample or sound model), the radiation pattern (e.g. directed or omni-directional), the mapping of event to synthesis parameters (e.g. intensity of impact to spectrum and amplitude), the rendering resolution (e.g. dynamic or static spatialisation), and the characteristics of the acoustic environment (e.g. reverberation time and frequency response). These nodes communicate with the sound server to invoke and control the corresponding sound synthesis and rendering processes. The application designers have the freedom to use the existing classes and their counterparts in the sound server, or develop new nodes along with new FTS synthesis and spatialisation modules.

3.3 Interaction And Navigation

AVANGO provides a variety of interaction and navigation techniques that support storytelling.

Interaction techniques such as point-and-click and drag-and-draw can easily be applied to select a scene from a list of scenes in the story. The user can also identify objects and invoke associated functions such as morphing. More recently, physical props have been tested for interaction in virtual environments. Devices such as the Cubic Mouse, or a toy submarine equipped with Polhemus sensors, can allow more intuitive interaction. Multiple lightspots on a screen can be tracked with vision-based methods, and speech and audio input can be used to trigger events too. Manual interaction has been extended to dual hand activities where one hand is used for navigation and the other hand is used for more detailed interaction.

Navigation techniques allow guided visitors to walk or fly though a scenario, freely moving from one location to another. Navigation modes in AVANGO include free flying, terrain following, flying within a corridor or flying according to animation paths etc. Transition areas that reduce the polygon load are sometimes used in these navigation tasks. In stories developed so far, animation paths are used to synchronize background music with the visuals. Free navigation is possible at any time with the caveat that the visitor might snap back to animated navigation in transition areas.

3.4 Storyboard Mechanisms

A set of classes was designed to allow easy implementation of large-scale narrative applications within AVANGO, based on the object oriented Oops package in the Scheme interpreter. The class design was influenced by traditional narrative disciplines from theatre or cinema, which include scenes, camera, plot, actors and effects.

The basic building blocks of our stories are scenes. To implement scenes we had to overcome the problem of reliable state handling of all active behaviors in the virtual world. This was achieved by hierarchical time management and encapsulation of branches of the scene graph in scheme classes. Scenes are derived from a base class which implements sound, light, geometry, time control and an enter, leave and reset mechanism. Special effects can be added as necessary and exported by separate methods as required. Spatial guarding of the virtual world described by a scene can be used to trigger events or active behaviors.

The basic special effects are implemented as C++ extensions to a scene-graph in the SGI-Performer API, and mainly address critical or geometry related computations (triangle mesh animation, changing material, lighting, etc.). We group smaller entities into semantically richer Scheme-objects (e.g. an animated door or water surface) as a higher level interface to the storyboard.

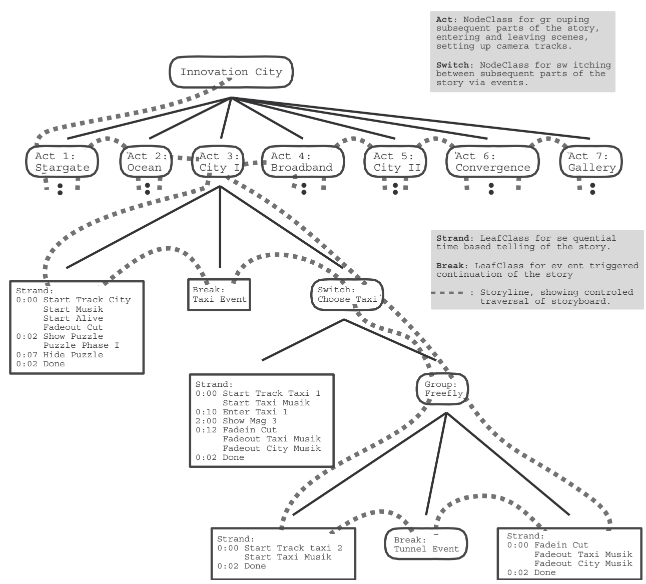

Figure 3: Object oriented storyboard for "Innovation City"

A camera abstraction combines the physical display and related constraints, like visual projections, sound output and various input devices, with automated or interactive navigation and selection tasks. We encapsulate this behavior in camera tracks triggered by the plot in order to prevent time or state related confusion in the environment of the active camera.

The sequential nature of the story is described in a tree-structured plot and processed by a non-continuous traversal. State changes of the active camera and scene related environment are triggered by entering or leaving nodes of the tree. Time-related behavior, event-related behavior and traversal continuation are implemented as leaf nodes in the tree. Direct method invocation and events do the communication between plot, scenes and camera.

Figure 3 shows an example of a plot of "Innovation City", which is one of our recent productions. Alternate sub-stories are triggered by user behaviors, which select switch nodes in the plot tree.

4. THE CYBERSTAGE

The CyberStage is a multi-person, room-sized, high-resolution, CAVE-like 3D graphics and sounds environment. The immersive features of the CyberStage are based on 4-side stereo image projection and 8-channel spatial sound projection controlled by the position of the user's head tracked by a position system. The sound projection is enhanced by vibration emitters under the floor which render low frequency signals that can be felt underfoot. The CyberStage system provides various interfaces and interaction metaphors that visually and acoustically respond to the users' actions to create the illusion of presence in virtual spaces. These interfaces allow navigation in virtual spaces, and manipulation of virtual objects. The CyberStage provides high degrees of immersion and presence for a wide spectrum of virtual environment applications in areas such as scientific visualization and sonification, product design, evaluation and marketing, architectural planning and walk-through, entertainment, infotainment, and media art installations.

4.1 Auditory Rendering On The CyberStage

Auditory rendering is a very important complement to visual rendering in virtual environments. The sound in virtual environments is at least as important as in cinema, where it subconsciously conditions the audience. Spatially rendered sounds are projected on auditory displays. The auditory display of the CyberStage produces a sound field illusion where localized sounds from any direction and distance seem to propagate through a reverberant acoustic environment. Localization is important for navigation and orientation and contributes mainly to the illusion of presence. Reverberation conveys important information about the environment shared by the sound source and the observer (e.g. inside or outside space, room size) and enhances the degree of immersion. In an application both localization and reverberation may vary dynamically as the observer and the sound sources move with respect to each other and the spaces in which they are located.

In contrast to visual scene simulation, auditory scene simulation is always event driven. Sound is always the consequence of some kind of event happening. If a sound has to be produced as a consequence of an event, then the characteristics of the sound have to follow those of the event. In the case of colliding objects, the material of both objects, the impact position, and the speed of the objects may determine how the collision sounds. Such flexibility is difficult to achieve with sampled sound material. Direct sound synthesis, as well as conventional sound sample playback, allows whole classes of sounds to be modeled in CyberStage applications. Instances are synthesized as required according to event-dependent parameters.

5. STORIES

5.1 CyberStage Productions

Immersive, interactive productions, rendered in real-time with spatial sound, are an unforgettable experience. The life and beauty of CyberStage productions comes from real time special effects such as artificial life such as butterflies or swarms of animals; virtual actors as animated guides; attribute animation to create water, explosions, deformations and morphing effects; intelligent objects; texture animation to create blazing flames and artistic effects, blending and cutting effects; live video input and QuickTime/mpeg support; animation import from modeling systems; reflection maps and reflective surfaces; 3D-textures for volume visualization; active and passive object and camera movement management; animated, interactive light and fog effects; rubber band effects for camera and objects, and underwater effects.

In the past we have developed virtual reality productions mainly for trade shows, museums and other kinds of public presentations. The portable CyberStage was installed and operated at each exhibition place. The stories were shown to as many as 3000 visitors over a time span of one or two weeks. The productions are about 10 minutes long and typically consist of several scenes with several different objects in them. Transition areas, such as tunnels, interconnect scenes to reduce the number of objects that must be rendered in real time. Transportation vehicles, like ski lifts, balloons or a flying taxi, are the navigation metaphors for animated camera paths.

5.1.1 CaveLand on CyberStage

"CaveLand" was the first CyberStage production [10] shown to the public in Europe. It was presented at the worlds largest computer fair, the CeBIT in Hanover, in spring 1997. The goal of the production was to show the capability of the high-end virtual reality display and to introduce the CyberStage to the public. CaveLand is a very complex and dynamic story. It starts with the visitors being welcomed by shoe-like virtual characters provided by the Academy of Media Arts, Cologne. These characters guide the visitors through the entire production.

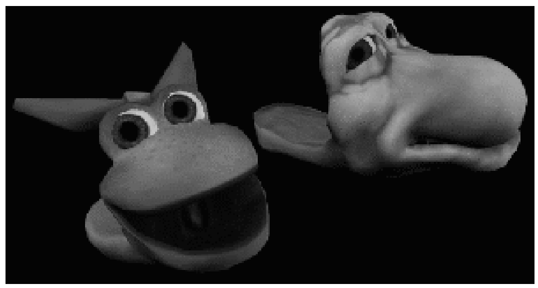

Figure 4: Shusi - an animated virtual character explaining CaveLand

The first scene the visitors pass through is a theme park, followed by an interactive sound installation. From there the trip continues through an ice tunnel to emerge into a breath-taking 270 degrees view of vast, open areas in an arctic landscape. The story continues in a system of fire caves (developed in cooperation with Iowa State University) that demonstrate the potential for photo-realistic visualization of a spacious geological structure within a virtual environment. The bubbling lava, swinging pendulum and burning torches in the fire cave demonstrate real-time effects such as animation, lighting models, and reflection that were commonly only found in frame-by-frame rendering.[10]

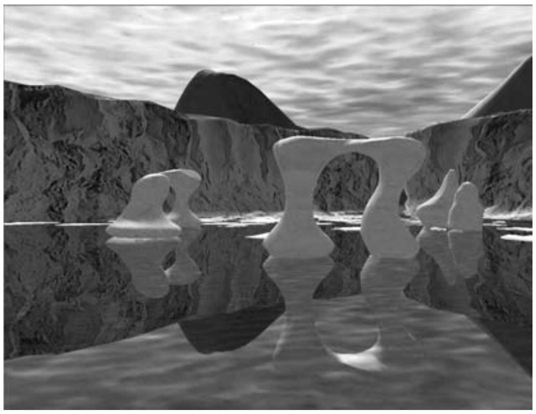

Figure 5: Iceland - an unique virtual boat trip into an Norwegian fjord

5.1.2 Theta Quadrant - Classified M

This production was designed for Silicon Graphics Inc. and presented a year later, in 1998, again at the CeBIT in Hanover. While CaveLand was designed to run on a 4-Processor, 2-Graphics-Pipe Onyx, this production required about 80% of the performance of a 12-Processor, 4-Graphics-Pipe Onyx2. The goal was to demonstrate the power of Silicon Graphics workstations (i.e. Onyx2) to the technical visitors. We wanted to impress to the max and also show the strength of AVANGO. To achieve these goals we developed a very complex and entertaining application [11] with a maximum number of special effects.

The story is about a weekend on Mars that begins at Cologne main-spacestation in the year 2020. The passengers board a spacecraft and wave good bye to those remaining in Cologne that weekend. The shuttle takes off and travels out into space past a space station, accelerating far beyond supersonic speed. The passengers unexpectedly get a warning about malfunctioning jet turbines, and moments later the spacecraft explodes into a million pieces. Instead of Mars the weekend travelers find themselves on an unknown planet where creatures, objects and plants are an order of magnitude larger than usual human experience.

The 3 scenes in the story needed far more than 1GB addressable space and challenged a 64-bit compilation of AVANGO and the underlying systems, especially the media libraries. We made use of the virtual studio facilities at GMD for the first time to record real actors in a blue room. These chroma-keyed sequences were imported as mpeg movies—each about 1-minute in length—into the virtual world. The movies are integrated into the virtual environment by system extensions that allow a movie to be downloaded from disk into the texture buffer of the Onyx. This extension also allows us to include preproduced dynamic video textures and even real time video into our stories. Video textures of a number of human actors recorded in the virtual studio can inhabit a scene, to provide guidance or other aspects of the story.

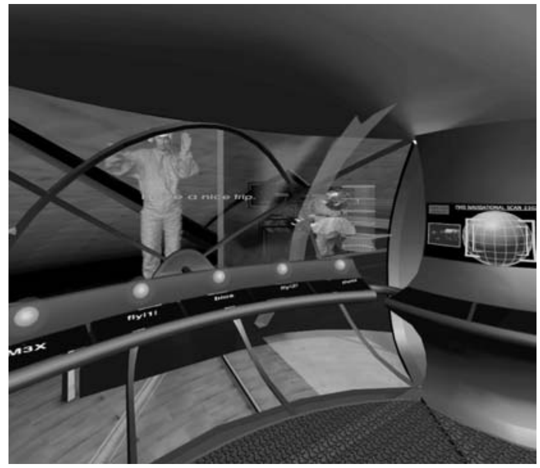

Figure 6: Video textures in Theta Quadrant - Classified M

5.1.3 Virtual Anima

André Heller, a famous Austrian artist, used the CyberStage for 14 days to present his new concept for an “experience park for the senses” which aimed to re-naturalize an outdated industrial zone within the center of the city of Bochum, Germany. The presentation was originally developed for prospective investors and later shown to the public in that region. In November 1998, the CyberStage was installed in a 100-year-old industrial hall called the Jahrhunderthalle—a large, empty, cold space 150m long and 80m wide. The sub-zero temperatures required us to heat the CyberStage, the SGI machine and the projection system to keep everything functioning.

The installation was controlled remotely from the GMD campus in Bonn, while in Bochum a trained guide hired by the artist led visitors through the park scenes.

Figure 7: The butterfly house from Virtual Anima

In order to develop the presentation André Heller asked us to express plans and ideas as a set of interactive virtual worlds. The story consisted of an individual fly-through and walk-through of the park. The visitors can see, hear and experience labyrinths, water fountains and lakes, light refracted by crystal glass, and a virtual meditation cave showing animated soft lighting effects to music composed by Brian Eno. Finally the visitor of the virtual park an walk around a butterfly house, listening to light café-house music and following swarms of butterflies within the exotic garden. It is even possible to feed the virtual butterflies by offering an open hand (registered by a Polhemus tracking system) upon which they will alight.

Technically this production required us to develop new real time features, such as a simulation of swarms (for the butterflies), animated water surfaces and the use of the texture buffer for transitions and blending in light effects (like projected slides in the Brian Eno cave).

5.1.4 Innovation City

"Innovation City" was developed for Siemens AG and presented at Telecom 99 in Geneva, Switzerland. Unlike any of our previous productions, "Innovation City" consists of two distinctly separate parts—a "pre-show" outside and an interactive experience inside the CyberStage.

The idea behind the production is to get 4-8 people to work together. In the pre-show the goal is for the group to paint a beautiful graffiti together by drawing with laser pointers onto a mono screen. The laser points are tracked by a video camera using highly sophisticated image recognition algorithms. At the end of the pre-show the graffiti painting explodes into (virtual) pieces.

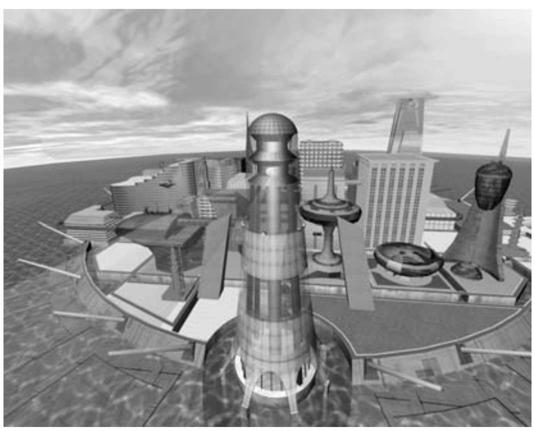

Figure 8: Innovation City

The goal of the second part of the production is to put the pieces together again so the painting can take its place in a graffiti exhibition gallery. The show begins with a scene in which the painting reappears as thousands of splinters that are absorbed by a huge stargate. From here a short adventure ride starts. The group must perform three collaborative tasks to win their painting back completely. The first task is to navigate a ship around a whirlpool in stormy weather at sea and locate a futuristic island city. The second task is to ride through the futuristic city to get to a broadband communication house where several doors must be identified and opened to initiate information flow at a very high bandwidth. The final task requires the group to reach “convergence” by singing or shouting together a specific “key” frequency. After accomplishing the tasks the visitors find themselves in the hall of fame where their original painting has attained its place among paintings from earlier teams. Each person could be given a print out of the painting as they leave.

From a technical viewpoint this production required an exchange of results between the two different installations to connect the interactive drawing of the pre-show with the collaborative experiences in the CyberStage. This exchange was implemented with a shared database, controlled by the distributed AVANGO framework. Various collaborative interaction techniques were developed to allow video-based position tracking of many laser pointers, and joint shouting for finding a `key' frequency.

5.2 Immersive Comics

5.2.1 Stell

"Stell" is an immersive interactive comic scene for the CyberStage following the outline of the science-fiction-comic "Starwatchers" by the French comic-book-artist Moebius. The scene is part of the project called "Aesthetics of Computer Games for Virtual Environments". One research aspect of it is to find out about the relationship of comic-like aesthetics and popularity of computer games.

In the scene the user meets life-size comic figures. With their words and gestures they try to get the user involved in their world. To increase the presence in the virtual scene a real object—a toy submarine designed in a very comic-like style—guides the user through the narrative action in the scene. Steve Stitt, a DJ from Frankfurt, composed a sound track for it, that uses computer game sounds, so that the viewer can have a combined experience of comic and computer game in an interactive immersive 3D environment.

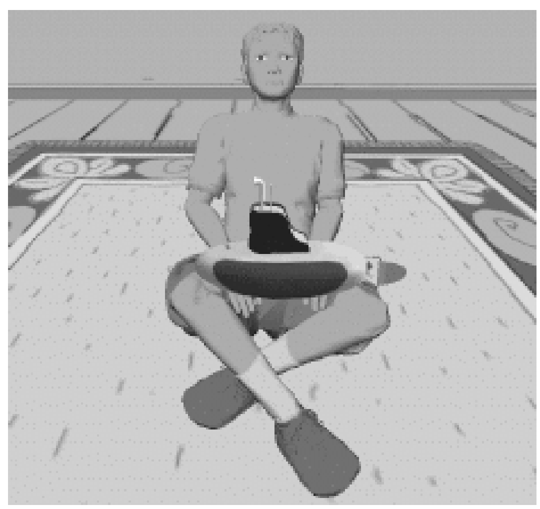

Figure 9: Stell as a child with the virtual version of the toy submarine

5.2.2 3D Manga

Among other phenomena, Japan’s Otaku culture seems to represent how video games spread the most powerful processors and the newest multimedia technologies. We plan to collaborate with the Japanese musician Mikiko Yui in this field.

A scene has already been initiated based on the famous Japanese animation manga film *Akira*. A sequence of the film is transferred to an interactive virtual installation, which shows—through an animation—how scientists try to find supernatural forces in children for further progress of technology. It regards how playful children step into the computer age especially inspired by computer games.

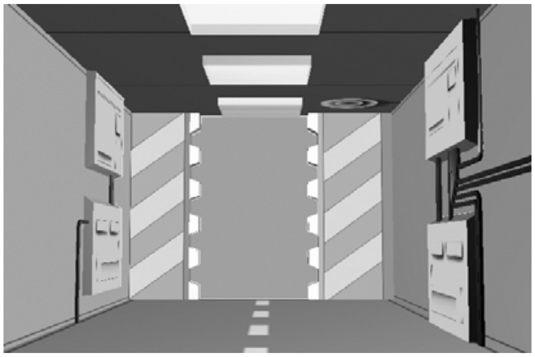

Figure 10: Part of the research laboratories

Completed immersive comic producions have been installed in the CyberStage for the opening of the multimedia theater “Animax” in Bonn-Bad Godesberg in July, 1999, and for or the opening of a 6-side CAVE in the Science Park NOVI at the University of Aalborg, Denmark, in August, 1999.

5.3 Exploring Audio-Visual Interaction Concepts On The CyberStage

5.3.1 Sound Spheres

"Sound Spheres" is a virtual sound installation conceived for and realized with the CyberStage system. The installation explores the basic features of the CyberStage audio-visual display with the aim of shaping some of the yet unstructured vocabulary of musical expression and auditory experience in virtual environments. The concentration on a few fundamental aspects of integrated audio-visual simulation was a conscious decision in the design process and led to the abstract and minimalist character of the installation. In essence, Sound Spheres is about localization of moving sound and light sources. The role of direct and reflected sound and light play in the perception of space is explored in an experimental context.

When entering the installation, we are left in complete darkness and silence. With a virtual flashlight we start to explore our obscure situation. While scanning the surroundings with the light beam, the scene slowly appears to our imagination. By pointing the flashlight in different directions we become aware of a big striped sphere enclosing us as well as several smaller rotating spheres slowly moving along circular paths. Then we discover how to activate these small spheres by inflating them with a virtual pump attached to the flashlight and operated by a button on the flashlight. The more we inflate a sphere, the longer it keeps on emitting percussive sounds and light flashes in periodic rhythmical patterns.

The omni-directional light flashes emitted by the spheres show the entire scene for brief instants and the reflections on the shiny spheres help to locate the light sources. The percussive sounds emitted synchronously with the light flashes excite the virtual room acoustics and provide us with a sense of distance and direction. The more spheres are active at a time, the denser the complex light and sound patterns will be. Pointing the virtual pump at a sphere for too long will lead to its explosion accompanied by a detonation flash and noise. While freely floating in the space of weightlessness between the flashing and sounding spheres, we experience an ever-changing rhythmical tissue of spatialized sound and light.

5.3.2 Bad Choir

"Bad Choir" is a demonstration of non-verbal sound gestures as a means to interact with inanimate objects in a virtual environment. It is a variation of the scene where a singer shatters a champagne glass by hitting a high note. The scene is remarkable because the connection between the singer and the glass is purely physical. Words are distinct categories and even wolf-whistles and sighs are discrete. Physical acoustics opens the possibility for continuous variations, which are not possible in speech recognition interfaces.

In "Bad Choir" the scene is expanded from a lone singer and glass to a group of people in a china-shop stocked floor to ceiling with vases, glasses, bottles, figurines and other fragile objects. You don't have to be an opera star to shatter this virtual glass by humming, whistling or singing with gusto. The size and shape of each object characterizes its resonance to acoustic energy. Larger objects resonate at lower frequencies, and more complicated objects respond more broadly. As an object accumulates energy it begins to vibrate and feedback a tone with increasing impetus until it shatters in an explosion of glass and sound shards. A large urn requires the concentrated attentions of several singers working together to finally rupture it. People can casually join in or leave the sing-along, because they do not have to wear special equipment to interact. Freedom from interaction devices allows everyone in the group to collaborate on equal footing.

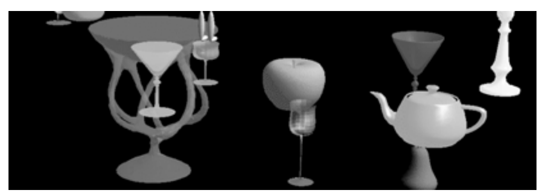

Figure 11: Bad Choir

Bad Choir is also a composition for a chorus gathered in an immersive virtual environment. The composition is structured by the resonant frequencies of the fragile objects. The traversal of the resonances is entirely open. The chorus typically begins with the chaotic exploration of unknown possibilities and thins through alternating passages of chaos and stability to the finale of a single note followed by a shattering silence. Choral movement is driven by the dwindling pool of resonance as fragile objects shatter. Feedback resonances from the objects merge with the vocal chorus, punctuated by percussive shattering, and usually some laughing.

5.4 Culture And Education

5.4.1 The Digital Beethoven Salon

"The Beethoven Salon" is a virtual environment experience of Beethoven's Pastoral Symphony designed for the Beethoven Haus Museum in Bonn [8]. The experience was designed to:

- Respect and honor the music.

- Complement and reinforce the expression in the music.
- Refer to nature but not in a literal way.
- Reflect that deafness is an integral part of Beethoven as a composer.
- Be fulfilling for young and old, casual tourists and analytical researchers alike.
- Ensure the virtual environment is an essential and meaningful medium for the experience.

The Beethoven Salon models a room where Beethoven composed his symphonies, and uses this room as a portal to an abstract world of expression generated by the music. The room contains authentic furnishings and artifacts seamlessly integrated with matching colors, lighting and materials in a virtual extension. Clearly visible on the virtual half of the piano is the manuscript of the symphony inscribed with the famous phrase "more a feeling than a painting." The piece begins when a breeze rustles the curtains and turns the pages of the manuscript to the 4th movement—the thunderstorm. The candles flicker and dim so that only the gold and silver notation on the manuscript is visible. The tranquil opening passages awaken the golden notes—which waft into the air trailing silver musical staves behind. The notes intertwine like fish schooling, leaving gentle symmetrical patterns in their wake. As the tension builds the notes become agitated, moving faster and more abruptly in a chaotic dance of twisting ribbons. In the climactic thunder the notes scatter to all corners of the room, diving back and forth in a frenzy, coming together in moments of calm only to be scattered again by the fury of the storm. In the quiescent closing moments the notes return to a placid schooling. At the end of the piece the stave trails have formed a 3d sculpture of the music which could be produced as souvenirs of the Beethoven Salon.

The notes are artificial-life algorithms that model the behavior of flocks, schools, and herds of animals. This musical artificial life is specially designed to react to Beethoven's music in an expressive way, and bring an abstract "nature" into the computer-generated environment. The notes respond not only to the music but to the other sounds in the room as well, so they seem to be alive and present, rather than projections from cyberspace. If someone laughs they will flitter, clapping hands will startle and scatter them. The image of the deaf Beethoven laying his head on the piano to feel his music is evoked through the acoustic floor of the CyberStage where the visitor can feel vibrations generated by the music underfoot. The possibility to engage with Beethoven's triumph over deafness may be a special attraction for people all over the world.

Figure 12: Beethoven's study

The Beethoven Salon is currently under construction. So far we have built a 3d virtual model of Beethoven's study which includes real-time candlelight effects. We have also built the musical artificial lifeforms, which respond individually to different parts of the sound spectrum and flock together in the CyberStage to create a 3d sculptural visualization of the music. These components will be integrated with other elements to build up the complete digital Beethoven Salon story.

6. INTERACTIVE GUIDANCE

The experience we gained in producing those early stories helped us understand some basic parameters for storytelling in virtual environments:

- Audible effects and background music are of high importance, because they provide a certain dramatic structure to predefined animations.
- Guidance is needed for visitors either by synthetic characters or by a human guide, to understand what is communicated.
- The duration of a story should be about 8-10 minutes.
- The amount of collaborative work to produce a 10-minute interactive story is still quite extraordinary.
- The logistics to set up an event and to run it reliably need to be arranged carefully.

Interactive stories, developed on high-end graphics machines, today have a duration of about 5-15 minutes. This is a very short experience compared to cinemas and IMAX productions and we recommend that a fair amount of guidance should be given to the visitors with the purpose of:

- Helping with the new technology.
- Introducing the background of the story.
- Explaining the interactive tasks to be performed.
- Motivating visitors to perform the tasks with best results.

Guidance might be provided by a story assistant. Either audible, virtual, remote or real, his task is to introduce to the content and help in (the many) cases of disorientation. One possibility is to provide a help-button for guidance-on-demand which may be pressed by the visitors but in most cases this is not really necessary due to the short duration of an interactive story.

One might distinguish between animated guidance and responsive guidance. Animated guidance is prefabricated, giving help after clicking a button, replaying predefined communication sequences, etc. Responsive guidance reacts to the situated problems of the visitors, by allowing a human to human dialogue between guide and visitor.

Different guidance representations can be identified by appearance:

- The audible guide: a non-personal voice from the speakers.
- The human guide: people helping with the technology and people telling the background.
- The virtual guide: a virtual characters with varying degree of interactivity, behavior and response.
- The remote guide: a human guide being keyed into the virtual scenario offering audio, video and gesture communication with the visitors.

We have used different types of guidance in our interactive stories:

- Human guides, such as people outside the CyberStage supporting in technical preparations and explanations and people inside the CyberStage, navigating through the story, telling the background of the story and motivating the tasks.
- Virtual guides: either animated or real time virtual characters;
- Remote guides, supporting eventually more than one story or acting from a geographically different location.

As an example we describe the use of remote guides in the CyberStage as we tested it for an educational scenario. One set of our AVANGO extensions aims at texture based effects that mainly deal with the dynamic exchange of the texture images and are capable of showing live video input, playing movie files from disk, or showing slices through a 3D image volume. For a trial in `97 we used these texture extensions to setup a stereo video telepresence scenario connecting the basic functionality of the virtual studio with one of our common demonstration applications in the CyberStage.

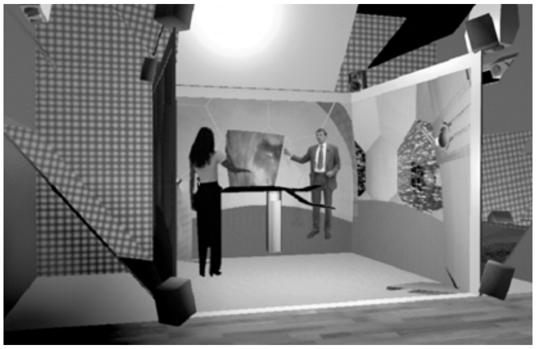

Figure 13: Reconstruction of the Schloßtag `97 event

A remote person captured with a stereo camera was keyed into a 3-dimensional scenario, being virtually present in a 3D virtual environment displayed in the CyberStage. For the first time ever, a fully immersed 3D virtual teleconference was demonstrated based on virtual studio techniques of keying video images into computer generated scenes [9]. The image quality of the imported image sequences was surprisingly good considering it had to pass through several SGI video options, delay units and chroma keyers before being taken as a dynamic texture into the AVANGO virtual environment framework. AVANGO handled the positioning and display of the remote person within the virtual world of an operation theatre. The remote person gave instructions to CyberStage visitors on how to operate various devices and instruments in this virtual operation theatre.

7. CONCLUSION

We have introduced our approaches in digital storytelling to different domains such as marketing, culture, arts and education. With the access to low cost graphics image generators, we hope that storytelling will be affordable by institutions like cinemas or theatres. There is of course an urgent need for authoring tools in this field. But we are confident that available tools can be extended according to the expected technical demand. Additionally, authoring runtime systems have to be prototyped, that make it possible i.e. to adapt a digital story to a specific performance environment such as a theatre and provide the experience to a bigger audience. Furthermore it is necessary to develop real time effects and real time simulations to a greater extent, if we want to extend the idea of digital storytelling to the traditional, popular venues for storytelling—theatres and cinemas. We take it as a sign, that stage and theme park designers don't hesitate to work with the technology, explore some of these novel concepts and show us their potential for the future.

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