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Modes of Virtual Environments Integrated within Collaborative Environments

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Abstract

This paper describes the timeline of large display virtual environments used by Manchester Visualization Centre and a few of the main applications of such systems. Moreover, it describes a few simple common modes of use as well as stages of development, categorising and explaining how best practice may be achieved. In addition this paper considers the development and use in the last few years of multi-functioning spaces that combine both a large scale VE with the next generation of video conferencing system. These have been used to create new modes of interaction and collaboration.

Categories and Subject Descriptors (according to ACM CCS): I.3.1 [Computer Graphics]: Hardware Architecture I.3.3 [Computer Graphics]: Picture/Image Generation I.3.4 [Computer Graphics]: Graphics Utilities I.3.6 [Computer Graphics]: Methodology & Techniques

1. Introduction

Up until recently it has been very expensive to build large display virtual environments (VEs), for instance in 2000 it would have easily cost £1.5 million for a Silicon Graphics Reality Centre installation. This paper describes a timeline of VE facilities used at the University of Manchester in the Visualization Centre and a select few of the main applications of such systems. Moreover, it describes a few simple modes of use, categorising and explaining how best practice may be achieved. These systems are now being integrated within the Access Grid (AG) – the next generation of video conferencing system, creating a richer interactive and presentation environment.

The following section describes the main common modes of use within a standard VE as well as comparing them to stages of development. Section 3 integrates the VE philosophy with the AG video conferencing system, and section 4 describes some future work using combined portable stereoscopic and AG units.

2. Virtual Environments Deployment: Three Common Modes of Use

In 1999 Manchester Visualization Centre constructed one of the first large-scale scientific visualization spaces in the United Kingdom; consisting of three overlapping active stereoscopic images projected onto a seven metre curved wall similar to a flight simulator (figure 1). The aim of projecting data onto a large wrap-around display was to allow scientific users to achieve a higher understanding of their data, and increasing the level of presence but its cost, including building work, was over one million pounds which meant only a few institutions could afford to build such a centre for their researchers [SSC02]. It should be noted that the University of Manchester already had an SGI Onyx 300 6xIR3, to drive the system which is not included in this cost.

The original pioneer users consisted of four scientific based groups consisting of the following fields; surgery, engineering, polymer sciences and fluid mechanics. Although they were active, one of the new user groups to take advantage of the facility were the earth scientists which we will focus on in more detail throughout this paper. Much of their software benefited from large displays and could transfer to VEs quickly. In figure 1 a user is shown exploring a three dimensional geological data field consisting of underground surface levels of rock, as well as a volume of ultra sound readings. The user operates on his own, viewing the data through active stereoscopic glasses providing near perfect three-dimensional vision. The system tracks both his head and the interactive wand in his right hand thus enabling in-

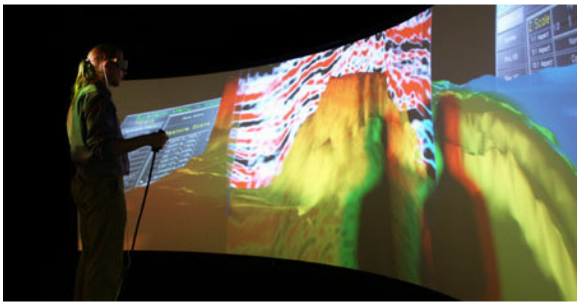

Figure 1: *Earth scientist using Schlumberger's Inside Reality; Virtual Geological Exploration software. The data shown is the geological subsurface areas found in a region of the North Sea (Software from Schlumberger 2007).*

tuitive exploration in three dimensions of large data sets as well as adding the ability to interactively cut away layers of ultra-sound data or reveal different intensity levels of the rock. This is an important mode of interactive visualization, involving often only a single individual exploring their own data sets in order to discover for themselves new insights. It is postulated, although far from proved, that filling the user's visual senses with data, both the focus and periphery creating a so-called semi-immersive experience, aids this process of discovery and insight [SSC02].

In a recent report [LLG*07] while developing and studying the HydroVR software Lidel *et al.* described three stages of development in using intensive interactive analysis within VEs. The first stage is to create and use a single data set with real-time interaction throughout the large display. Then the second stage is adding collaborative modes where users within multiple VEs can interact and view the same data set simultaneously. The final and third stage is the incorporation of multiple remote data sets that can be added as required by the user. This report tracked their development of using CAVE systems over a decade from 1997 to 2007 and covered mostly our first mode of operation with often just a single dedicated operator.

Later in 2003, one of the authors, while working at De Montfort University, Leicester UK, specified and built a similar visualization centre. More modern components were used which decreased the cost and a generally more frugal reconstruction brought the overall price to just under £250,000. Reducing the cost had the effect of extending the user base to include for example architects and product designers. As Wright et al. [WBD00] stated:

> Throughout the design cycle, visualization, whether a sketch scribbled on the back of a spare piece of paper or a fully detailed drawing, has been the mainstay of design: we need to see the product.

The same levels of development stages occurred but we also can now define different modes from the individual dedicated researcher. One obvious mode of operation that is now common is of enabling elaborate group presentations. Figure 2 shows a complex example of this where Drs I. Burness and J. Leng are running a computationally steered program (using the RealityGrid Steering library http://www.realitygrid.org). This is calculating a faster than real-time epidemic prediction algorithm, on a remote HPC, which is being viewed via web services SOAP data snapshots. Graph visualizations are created using AVS/Express and the presenter was able to modify both simulation parameters and visualization parameters on the fly. Feedback can be given from the audience but the key part is a one-way presentation and demonstration. The important mode here is that the presenter(s) can "tell a story" to the audience.

Figure 2: *Remote HPC Computationally Steered Program connecting a parallelised epidemic prediction algorithm with the AVS/Express visualization system, as well as allowing the steering of the parameters through the RealityGrid API.*

The final common mode of operation, which we have experience of, involves small team interaction exploiting all parts of the VE space. Figure 3 shows evolution simulation scientists, with a palaeontologist intently discussing the structure and speed of computer generated creatures. The large screen allowed the simulated creatures to be raced against each other, in an endless loop of varying parameters. The creatures represent dinosaurs and birds that can be shown at approximately life-size. The VE allowed for the space to hold a specialist group together creating vigorous academic debate over the visualizations.

This third mode also illustrated a use of a VE in the way of a visualization "what if" analysis. This can be considered in the same way as a spreadsheet allows users to experiment with financial "what if" questions, but by dynamically changing parameters a VE can be used to visually verify simulations. The group interaction allows consensus, or otherwise, between different specialist to occur in an efficient manner.

We have shown briefly with examples, three common

Figure 3: *Palaeontologists - Evolution simulation showing structure and speed of computer generated creatures.*

modes of interaction; individual exploration, group team work and audience presentation occurring within VEs as well as combining them with the three development stages; using single data sets, collaboration cross-VE integration and links to multiple data sets.

When setting up a VE for use by a specialist group it is worth focussing on which mode of use is going to be required and then creating a space and environment to best benefit from this. This may appear fairly obvious but it is extremely common to have requests for all modes of use at once often resulting in that no constructive research objectives are completed. Every session should have defined objectives that can be quantified in some way, and this is even in the case with simple presentations of previous research that would then have learning objectives for the audience.

It was proposed that a wider use could be achieved by combining the principles of a VE with those of a high end video conferencing system. The next section considers the results of integrating the philosophy of VEs with the Access Grid environment [CDO*00].

2.1. Adding Video Conferencing: and the Three Modes Repeated

After the successful utilisation of a standard VE centre there was user demand and need for new resources to be constructed. In 2004 the authors oversaw the construction of an AG node, promoted as the next generation of video conferencing system [AGD08]. This was fully equipped with a three projector passive stereoscopic visualization facility, and cost only £80,000, which enabled stereoscopic visualization to augment, or take over from, a normal remote video conferencing meeting. It should be noted that the original principles of the AG system also embraces the idea of using large screens offering high resolution; creating again semi-immersive presentations. Figures 4-6 show visualizations presented to a research audience within this node. The first, figure 4, shows a representation of geological borehole samples, positioned in their correct three-dimensional geographic location, but abstracted with a pseudo-colour histogram of the elements superimposed along the borehole length. The researcher can interactively explore the three dimensional space and understand spatial geolocations; for example detecting areas where specific heavy metals exist (using the GeoExpress software product range from Oxford Visual Geosciences Ltd.). Figure 5 presents Google Earth stereoscopically projected onto part of the screen describing a virtual mapping tour through a three dimensional University of Manchester (Google Earth software version 4.0). This has been presented to groups of geography students and it is proposed that using stereoscopic presentations with a large screen creates an environment where understanding geographic space becomes intuitive.

These two examples show the same individual and audience presentation modes as previously used in a standard VE. The third mode of visualization that is presentation for team interrogation, where a small group of experts interact collaboratively with data sets to discover new patterns and understandings can also occur. Figure 6 shows LiDAR (Light Detecting and Ranging) data of a detailed scan from the 'badlands' of South Dakota, captured during a recent field trip (VR Geosciences software). This was presented by palaeontologists for open discussion to a group including geologists and seismologists. They were encouraged, and able, to discuss openly contentious issues regarding the spatial layout. In this case understanding why certain fossil finds should occur at specific locations and where to explore in subsequent field trips. To enable this visually the fossil find locations are superimposed as sets of markers positioned on top of the three dimensional geological features of the surrounding terrain. This mode of interactive visualization enabled a virtual field trip to occur that could never happen, or be very expensive; and to be repeated again and again.

The video conferencing facility automatically allows remote collaboration but also has extra features. The AG system links multiple sites together allowing for remote comments and interaction. Endurance tests on the AG (based at SC Global conferences) have demonstrated across the world-wide academic network up to 56 simultaneous video links with only a 10% packet loss. As stated previously the AG is more than a video conferencing system allowing shared applications and data sets to be included as well as open access to the video and audio encoded streams. Collaborative and shared systems include;

- Integration of text chat in the form of a Jabber client allowing all sites to communicate parameters and instructions separately from the main presentation. This also allows a form of asynchronous questioning to occur.
- Remote recording and playback – the JISC funded VRE Arena recording system is shown in figure 12. This is a screenshot of almost a full replay from a performing arts recording with choreographers adding annotation.
- Remote timestamped non-linear annotation –

Open University Compendium software system (http://compendium.open.ac.uk/). This is shown in the right hand side of figure 12 where each of the annotations are time stamped with the video timeline.

- Desktop and video-feed capture streaming – the JISC funded ScreenStreamer system is used to transmit synchronised desktop streams at full-resolution when required. This can allow single or stereoscopic video streams to be transmitted at full-resolution. Although it should be noted that this can be bandwidth hungry and there are other methods for encoding and synching video streams directly.

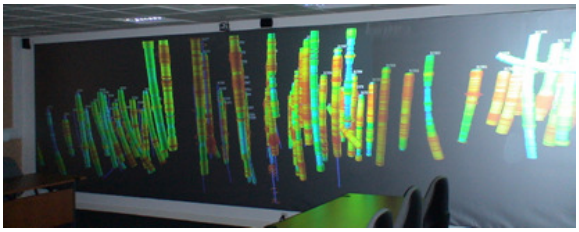

Figure 4: *Geographical visualizations in the combined Access Grid conference node using a stereoscopic three dimensional display. This shows the GeoExpress visualization software, projecting boreholes presented as a histogram displayed along their length and placed in their correct spatial drill position.*

Figure 5: *Google Earth projected stereoscopically within the conference node with added layers of three dimensional objects superimposed at the correct position.*

Two examples of complex interactions are shown in figures 7 and 8. The first, figure 7, shows video streams being rendered stereoscopically from a remote HPC, that were transmitted to multiple stereoscopically enabled sites on both sides of the Atlantic during the SC Global 2005 conference. The presenter was also transmitted stereoscopically to all sites who was both able to describe the 3D computer generated model as well as hold and present in 3D the original archaeological finds. With the use of the video conferencing modes the computer operator and the presenter could be controlled by verbal commands from the remote audience. This was termed "computational steering by shouting" and in a well controlled video conferencing environment worked fairly efficiently.

Figure 6: *Illustrates a joint research group discussion where palaeontologists interacted with geologists and seismologists. (Public engagement event for a National Geographic Channel science documentary).*

Figure 8 shows two photos of the first of a series of experimental workshops being carried out by an e-Dance research consortium [BTB07]. This project brings together choreographers from remote sites using both the AG and VEs to create new performance compositions. The modes of operation analyse team interaction over multiple rehearsals, but also addresses important research issues of liveness, and space.

3. Affordability

Unfortunately, all these systems suffer from being relatively expensive, in both resources and management time and are not portable. In recent years it is now possible to build cheaply, small transportable versions, based upon a design concept product termed a GeoWall [TL06], using commercially available components for a few thousand pounds sterling. Quality has been sacrificed, but these systems are now affordable across disciplines for a variety of purposes. In fact the original GeoWall concept was proposed as an augmented part of the AG termed a AGAVE [LDT*01]. A basic polarisation passive stereoscopic projection and recording system is shown in figures 9 and 10 that can be easily taken to meetings, lecture rooms and conferences with minimal complexity and still produce high-quality, semi-immersive presentations.

The whole unit including computer, projectors and screen

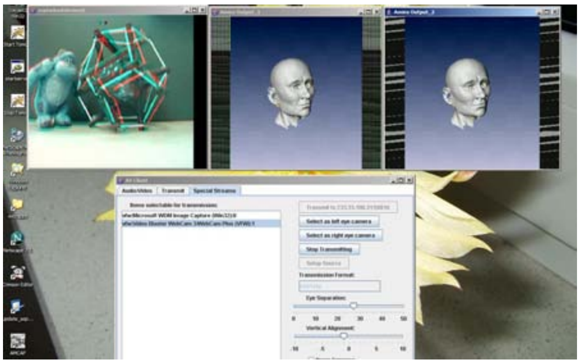

Figure 7: *A screenshot showing the control window as used during SC Global 2005. This shows the calibrated pair of stereoscopic images and the control window built within the remote visualization for Amira VR that directly links to the AG video stream standard. Also shown on the left is an anaglyph mode (red-cyan) video stream that allows stereoscopic camera feeds to be transmitted as a single 2D video stream.*

Figure 8: *Two photographs of experiments within a workshop event for the e-Dance project. These show experimental placement of data and video feeds within two VEs, one stereoscopically equipped.*

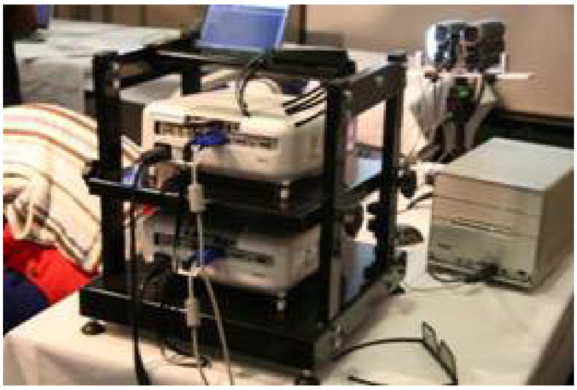

Figure 9: *Portable system being exhibited, consisting of two projectors powered by a compact PC shuttle system creating a combined two- and three-dimensional presentation facility.*

Figure 10: *Presentation using the portable system at the GSA Penrose conference. (Source: N. Holliman and J. Imber for the image). This illustrates a combined 2D presentation, on the right, with a rear projected 3D presentation, on the left, which allowed users to quickly switch between the two modes.*

fits comfortably within the back of a car and it is possible for a single user to carry all the components at once. This system has, over the last eighteen months, been to over forty locations and presented to thousands of users; and versions of the system are now available at various universities across the United Kingdom. Set-up time by non-expert operators can be under half an hour and a minimal amount of training is required.

From this knowledge the JISC funded Collaborative Stereoscopic Access Grid Environment [TL06] project, of which the portable system was a deliverable, encompassed a new range of users from humanities to physical scientists and social sciences to the arts. One example that used all the components described was the StereoBodies project [BT06] (Figures 11 and 12) that consisted of a series of test performance pieces with the Ersatz Dance Company. This resulted in the understanding of the five key modes of stereoscopically based choreography that can exist when projected from multiple VEs through the use of the AG. The portable units were both key to aid training and experience at remote sites, as well as increasing the range of users.

4. Conclusions

An overview has been given of the types of VE facilities that have been used at The University of Manchester since 2000 and their users. The common modes of use for such environments have been categorised as:

- Individual exploration/interactive visualization
- One way presentation and demonstration ("telling a story")
- Team interaction ("what if" scenario)

Figure 11: *The StereoBodies project using the Portable system for a test piece and a permanent curved passive projection system for inter-visualization centre choreography improvisation.*

Figure 12: *Screenshot from the StereoBodies Access Grid recording being replayed on the passive stereoscopic node to aid the process of research annotation.*

After integrating VEs with the Access Grid technology the modes were reviewed. The modes were still the same but more advanced. The size of the screen in an AG environment is hugely attractive, with the area that the scientists can work in extremely useful in tackling [LLG*07]'s third mode of incorporating multiple remote datasets. The AG allows us to go even further than their need to display multiple remote datasets and allows that team interaction need not only be restricted to the room where the VE resides. Other groups can come in across the AG and share their datasets, as well as make face-to-face decision making.

Secondly, new functionalities within Access Grid allow the remote recording of such events with timestamped annotation, and the ability to capture desktop and video-feed streams (screen streamer). This means that such investigations are available after the event for researchers who may not have had the time to make the meeting or want to learn from the experience.

Currently, such recordings and annotations of visualization demonstrations/virtual field trips are only available as prototypes. Future work will see repositories of the user experience become available externally, with the added ability for the user viewing the materials to annotate areas of interest.

We have shown how visualization is not just about the equipment and presentation devices but importantly about the use of the system and furthering the functionalities for the user.

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