The Sen-nedjem Project: Archaeology, Virtual Reality and Education.
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Introduction

Virtual reality, interactive computer generated sites and scenarios, theoretically creates great opportunities for archaeology, history, and education. Immersive computer driven environments impart information regarding space and human experience that would not be possible using traditional means of representation. Places and structures too remote, dangerous or deteriorated to visit can be experienced, and virtual models can provide the context in which to understand other complex issues surrounding an environment. In the past the technology required to produce such virtual 'worlds' has been expensive and complex, but Internet developments in the last few years have provided the means to generate three-dimensional interactive worlds cheaply and quickly. VRML, Virtual Reality Modelling Language, allows anyone to easily build 3D computer models of objects and places without specialised equipment, and more and more virtual archaeological models are becoming available on the Internet. However, few of these models have been evaluated to assess their educational or archaeological worth. The Sen-nedjem Project, undertaken at the Humanities Advanced Technology and Information Institute, University of Glasgow, Scotland, between May and October 1998, investigated the success of an archaeological virtual reality model for use in a museum context by building an interactive computer model of an Egyptian tomb based on pre-published archaeological evidence and testing this model with a view to installing it in the Kelvingrove Museum, Glasgow. The project illustrates that although it is technically possible to create an archaeologically sound virtual reality display there is a lack of meaning and purpose intrinsic to virtual models which complicate their educational value, an issue that needs to be resolved before virtual archaeological reconstructions become commonly used for pedagogical purposes.

Background

Although three dimensional representation has been used in archaeology for many years and multimedia is becoming increasingly used in museums, the costs involved in producing a three dimensional model for public use have proven prohibitive until recently (Economou 1997). The swift growth of the Internet and the development of associated software, hardware and protocols has provided a solution (Mitchell 1997; Sanders 1998). A three dimensional sister to HTML, VRML describes a space textually in terms of primitive objects, co-ordinates and behaviours. A relevant browser parses this ASCII text file, recognisable from the suffix ".wrl", and the resulting representation can be viewed and interacted with on the majority of systems available today simply using the mouse and screen. World files can either be scripted by hand, exported from various CAD programs, or written with the help of a World-builder, an application that facilitates the creation, placement and sizing of objects within the scene. As the software is readily available and VRML is platform independent, these virtual worlds can be produced relatively cheaply and easily using data from archaeological reports (Gillings and Goodrick 1996).

Choosing the Site

The tomb of Sen-nedjem (a pyramid worker from the 19th Dynasty) at Deir El Medina was selected to be reconstructed for various reasons. A model of this tomb would reflect the Egyptian collection of the Kelvingrove Art Gallery and Museum, most of which comes from such individual tombs. Also, as Egyptian tombs go, it was thought to have fairly detailed archaeological reports which would hold the information required to reconstruct the site (Bruyere 1959; Toda 1920). A recent publication contained comprehensive full colour images of the tomb (Shedid 1994), and it would be possible to use these to produce a photo-realistic reconstruction of the inner chamber of the tomb (copyright permitting). The tomb was also a suitable size for reconstruction, not too complex, and contained unique, detailed and well preserved frescoes.

Constructing the Model

After becoming familiar with the technology involved, there were certain defined phases in constructing the model, each bringing with them their own problems. First, the archaeological evidence was collated and assimilated into a series of detailed drawings. The basic model of the tomb structure was constructed using VRML 2.0, taking its dimensions from the plans. Images and textures were then digitised and prepared for integration with the basic model, and these images were mapped onto relevant surfaces of the tomb. The model was refined to aid rendering speed, and lighting and animated elements were added. The user interface was then designed, and the model was fully tested and evaluated, highlighting areas for development and cause for concern.

Collation and Problems with Archaeological Evidence

The first major obstacle encountered was the archaeological evidence. As this was to be an educational reconstruction it was imperative that the model was as archaeologically sound as possible, but it soon became apparent that the tomb was not as well documented as first thought. The reports failed to supply comprehensive measurements of major surfaces, there was little documentation regarding the courtyard and the main entrance of the tomb complex, and the plans of the tomb supplied in the reports were very basic. Data obtained from the reports and plans was used to construct a basic model in VRML but any missing areas and details had to be based on the hypothetical archaeological drawings and other information regarding similar tombs (for example, it was presumed that the floor of the tomb was of packed earth.) Also, due to the fact that the majority of artifacts listed in the archaeological reports are now lost, it was decided that the tomb would have to be presented without any contents. It is acknowledged that the model is flawed due to the quality of data available; a problem which will face others should they try to construct models from older archaeological reports.

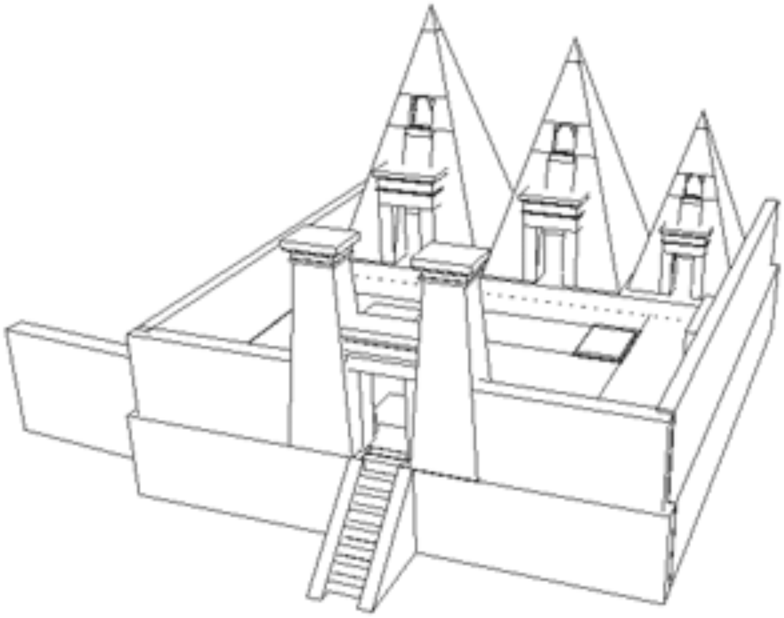

Figure 1: The basic model viewed from above before texture mapping.

Image development and texture mapping

One of the features of VRML is that images can be `texture mapped' onto surfaces, allowing photo-realistic models to be created. Small images are tiled over a larger area to give a repetitive surface, reducing file size and rendering time. Making the model photorealistic involved two procedures; producing small images for the application of textures such as stone, sand, and grit, and constructing larger images to make the individual faces of the painted barrel vaulted chamber. Smaller texture images were created by scanning pictures of the site as it is today, and taking samples of the dirt, sand and stone found there.

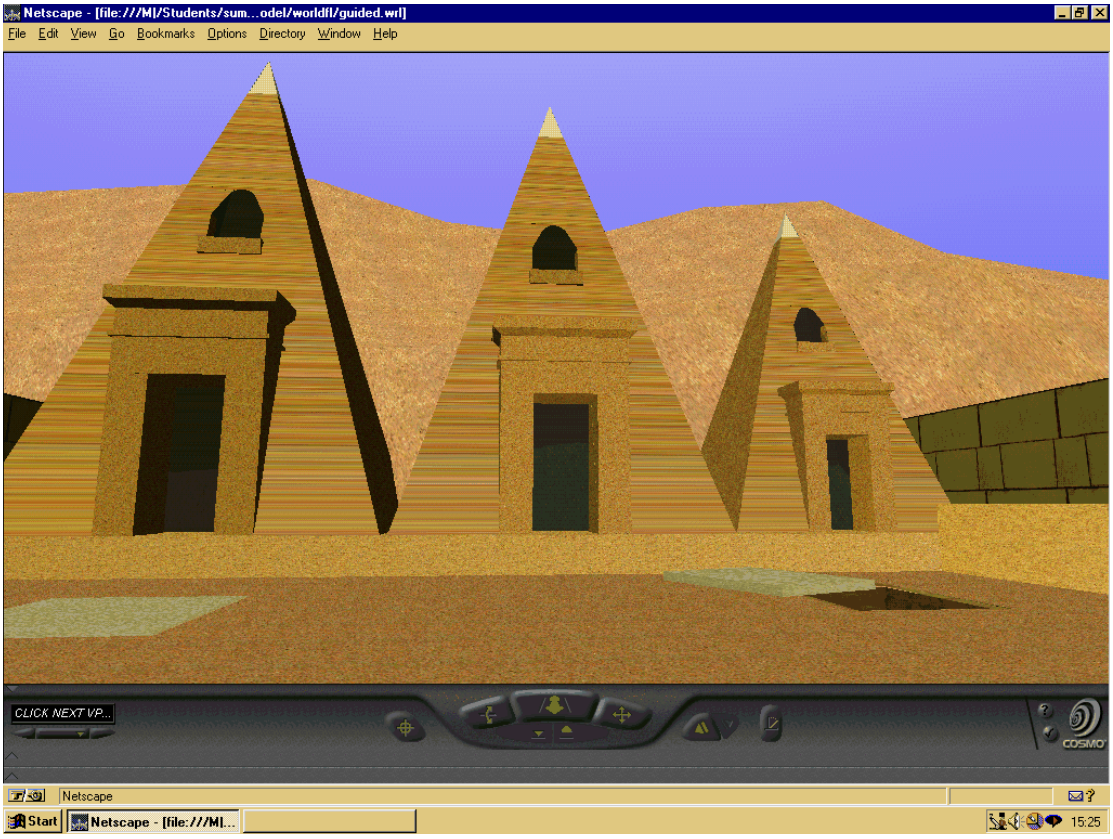

Figure 2: A view of the tomb complex from inside the courtyard. This shows the use of the image textures to give the background and courtyard ground their texture.

Preparation of the larger images was more complex. As each wall surface in the inner tomb was covered with individual frescoes the tiling mechanism was not applicable and images had to be prepared which would cover each wall surface fully. The first issue confronted was the resolution and size of the images needed to cover such a large virtual area. VRML browsers allow the user to ëzoom in' to surfaces and, because each wall painting contained so much detail, it was important that this manoeuvre did not produce a pixelated unintelligible mass of colour when the surfaces were viewed at close range. It was discovered that the minimum resolution needed for the wall surfaces was 150 points per inch, resulting in a file size of over 2 MB for each wall surface, and although various attempts were made to decrease the file size these large files were required to ensure the visibility of the tomb paintings in the computer model. The mapping of the images onto the virtual tomb surface was not a straightforward process. Many of the walls were photographed in two or more segments, and the roof was recorded by a series of ten images, meaning a composite image for each surface had to be constructed. Once again, it was also discovered that many surfaces on the tomb had not been properly documented. Panels and inscriptions were missing from the `comprehensive' photographs. It was decided to try and recreate such areas to give the overall feeling of the painted vaulted chamber, but it was noted that the authenticity of the model was fast decreasing.

Refining the model

These images were mapped onto the surfaces of the tomb. The final result was a realistic model of the tomb, but the major drawback with using such large images was the time taken to render the model; five minutes on an average system (Pentium 2, 64 MB RAM, 350mhz, 9GB HD).

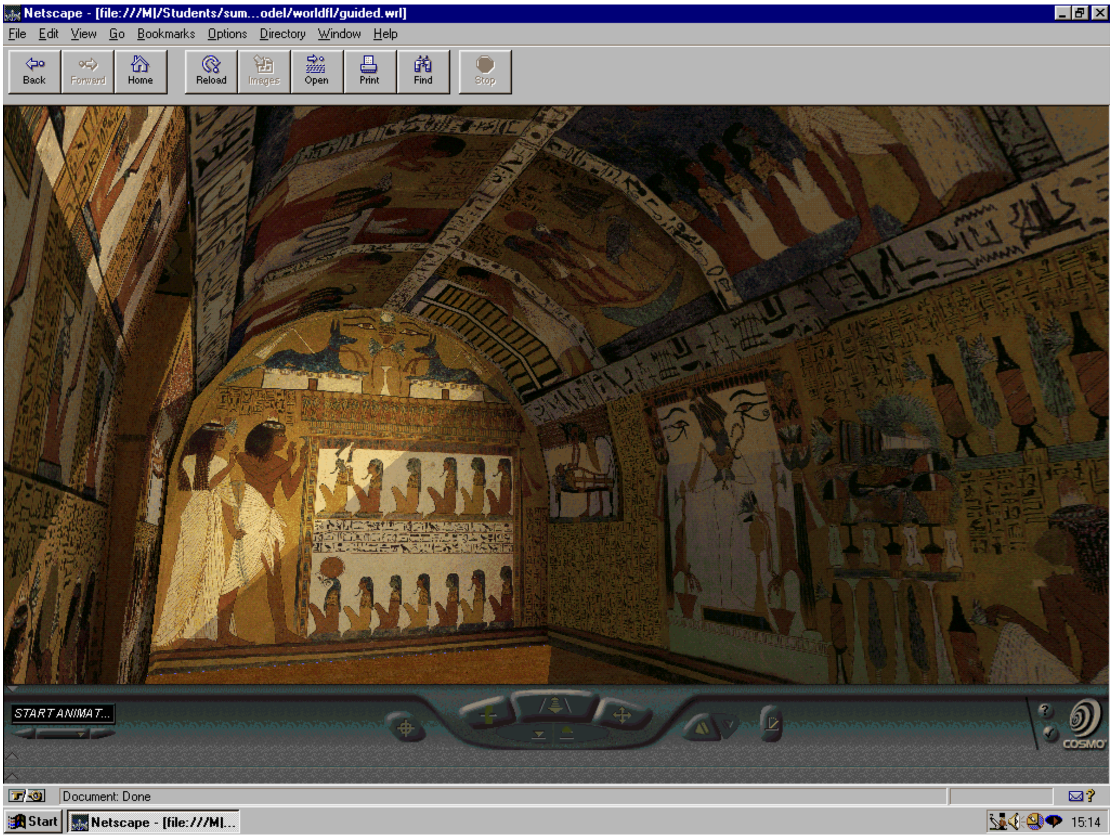

Figure 3: A view of the completed inner chamber of the tomb model. This illustrates the left wall, the barrel vaulted ceiling and the lower long wall. The viewer is standing just in front of the entrance to the chamber. The two large figures illustrated on the large left wall are that of Sen-nedjem and his wife Eineferti.

After the basic construction of the model, it was then decided to add other features that would improve the presentation and user experience. Interactivity was added with a moving door and sliding tomb covers. Lighting was experimented with. A landscape was created to place the model in some context. A series of viewpoints were defined, and a seventy second animation of the model was constructed.

Testing

The model was evaluated to see if it succeeded technically, archaeologically, and educationally. There are many problems in testing such a display, mostly due to the fact that very little research into the evaluation of such systems has been carried out, affording little framework to base a comprehensive testing strategy upon. However, a program of formative evaluation was adopted to systematically observe a series of potential museum visitors (Economou 1997;

Terras 1998). Data was collated and any issues raised were clarified, bringing some empirical evidence to the testing process.

Evaluation

Technically, the model was shown to have succeeded. Although there are a few small areas that could be adjusted within the model it is fully functioning and is in a finished state. However, there were many problems presented by the means which the user could explore the structure. Although an elementary user interface had been designed, the model was tied to using CosmoPlayer 2.1 (the Netscape VRML 2.0 plugin) as its browser. The toolbar provided by CosmoPlayer was found to be wholly unsatisfactory for users both familiar and unfamiliar with virtual reality, and it was noted in all cases that the experience of the model was greatly effected by the poor tools provided. It is very doubtful that a non-computer literate user would have the required skills to explore and view the model, posing a problem for the display of such a model in a museum. Although a successful, working computer model, it was obvious (in this case) that the archaeological evidence did not provide all the information necessary to create an authentic model. Throughout the construction of the model care was taken to document any questionable areas but the relationship between the recorded data and the interpretations made around it is not clear within the final model. It is accepted that such reconstructions remain only one permutation of the possible evidence, but unlike illustrations the photo-realistic qualities of virtual reality add some faux authenticity to flawed representation. An uncritical viewer may be convinced that that was how the structure was, not how it could have been; the model may look in places realistic, but it does not express the theoretical nature of its interpreted form. This problem is coupled with the fact that although the model may look good, it provides no knowledge as to what it is, what the user has to discover, and what is the point of trying to navigate around the virtual space; a common problem with VRML models. Some kind of feedback system needs to be incorporated into the model to tell the viewer what they are looking at, what period of history it belongs to, and how the structure relates to the archaeological site as it can be found in the present. Many users approaching the model asked `is that it?' `have I completed the task?' and `what is it I'm looking for?' stressing the fact that virtual reality by itself is not the best means of imparting knowledge regarding a structure. Undoubtedly, virtual reality provides an alternative means for viewers to gain spacial awareness of a site (in the case of Sen-nedjem's tomb it showed the complex relationship of one wall painting to another which was not apparent by looking at two dimensional prints in the publications) but without any ancillary documentation the meaning of certain elements will always be beyond the educational limit of a virtual model. It was very interesting to see the wall paintings *in situ*, but there was no way to explain their content and how this related to the other paintings surrounding them.

Conclusion

There is no doubt that virtual reality does provide an alternative way to view complex three dimensional data, providing an alternative medium for educational and archaeological reconstructions. However, it remains only one means of presenting information and should be used in conjunction with others to ensure the user understands the context and meaning of the computer model presented. A great deal of thought must be put into the design of the user interface to allow non computer literate users to access the model, and it doubtful whether the tools provided at present are adequate for uninitiated users to view a VRML model. The Sen-nedjem Project has shown that it is possible to create a virtual display from pre-published archaeological evidence (although older archaeological reports rarely contain the level of detail required to build such a model.) However, these models carry with them theoretical problems regarding authenticity, and the user must be made aware that any computer model is merely one possible illustration of the past (this may be understood by archaeologists but it is not obvious to a member of the public.) There are also logistical problems involved in the creation of such a virtual display which may still prove prohibitive for an institution. Even with the new technology available it is still a time and labour consuming process, and it remains technically intensive. Costs of software, hardware and staffing remain to be met, and as there are no methodologies in place for the evaluation and testing of such a model, the educational success of virtual reality remains uncertain. VRML does provide the means to create an archaeologically sound virtual reality display, but at present there are not the user tools available nor the understanding of how it relates to other resources to make it a viable educational tool. Only after further research, experimentation and testing should archaeological virtual models become a common fixture in public institutions.

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