Web-based, Three Dimensional, Virtual Learning Environments: Featuring Navigable Spaces Defined by Complex Curved Surfaces

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Abstract

This paper reports on a pragmatic, project-based exploration of the challenge of delivering web-based, navigable, 3D learning environments, which are constrained by demands for accurate detail and complex geometry. Specifically the project required the creation of a digital model of a 16th century ship. The project grew out of a collaboration started in 1998 between the Portsmouth School of Architecture, nine local junior schools, an educational authority and an archaeological trust. The project provided lessons in the creation of web-efficient models, techniques for combining familiar multimedia and 3-D modelling, with desktop virtual reality. It demonstrates the technical potential for sharing geometrically complex environments over the web.
Keywords: 3-D web model, model creation, vitrtual reality, learning environment.

Inception

During 1998, The University of Portsmouth School of Architecture began working with the Mary Rose Trust, nine local junior schools, and the Portsmouth education authority, in a 'Learning Cities' project. The objective was to create a unique web-based, history resource based on the Mary Rose, an English navy ship that sank close to Portsmouth in 1545. The School of Architecture became involved because of previous experience in creating web-based interactive 3-D worlds. The new project was planned to present not only a large archive of photographed objects, text and drawings, but also a three dimensional, digital model of the ship, which children would be able to explore whilst seated at a computer in their classroom.

This new form of model was of particular interest to the Mary Rose Trust, which is responsible for a museum displaying not only the artefacts recovered from the sunken ship, but also the remains of the ship itself. These remains were recovered from the sea in 1982, after 437 years submerged. However, less than half of the timbers had survived. Because the ship had come to rest at the sea bottom on its starboard side, the port side had gradually disintegrated. Hard grey clay was deposited on the starboard side of the ship, and this preserved the timbers, and many of the ships contents and the sailors' personal possessions. This was a remarkable find, but it must often challenge young visitors to recognise the surviving half hull as a ship that had once formed a living space and a work place for around 700 people.

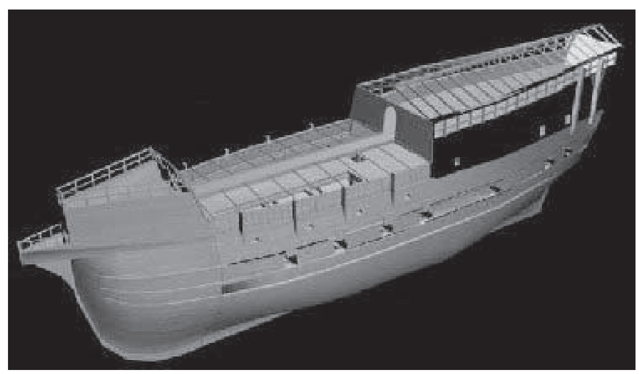

Figure 1 A digital model of the Mary Rose - a 16th century warship. A geometrically complex hull defines the working environment. The challenge in creating the digital model was maintaining dimensional accuracy, whilst keeping file size small enough for efficient Web delivery.

Background

The School of Architecture had previously created models of building environments using Superscape VRT virtual reality software package [1]. Improvements in user comprehension when using such animated presentations, in comparison with still graphics had also been measured [2]. The group also demonstrated that these virtual worlds could be delivered over the World Wide Web, providing user controlled navigation through three-dimensional models [3].
The modelling of a 16th century ship, however, presented

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new challenges. Firstly, in a project designed to contribute to the National Curriculum in History (Key Stage 2) it was important to maintain accuracy in the proportions and form of the environment. Secondly, there is the significant technical problem of operational adequacy in delivering the model over the Web and providing real time navigation through the geometric complexity of an model featuring three-dimensional curvature of the walls and structural elements.

In its completed form (May 2002), the model will be integrated with the multimedia site created by Stuart Vine of the Mary Rose Trust. Children will be able to examine the role of one of a selection of characters, based on members of the ship's crew (pilot, barber-surgeon, cook, carpenter etc.), and discover information, tools and possessions which belong to the character, using actual locations on the ship where artefacts were discovered, and where the character would once have worked. The locations on the digital ship model will be linked to a multimedia presentation of historical details and photographs of recovered objects.

Model Creation Methods

The software used to develop the Mary Rose digital model was Discrete 3D Studio, chosen for its modelling capabilities, and Superscape VRT, for its ability to allow web browsers to view and interact with 3-D virtual worlds in real time, using a free-to-download plug-in called Superscape Viscape.

The shape of the original ship was determined by the shape of the ribs, or frames, and the shipwright almost certainly used moulds, thin strips of wood cut to a pattern from a full scale plan chalked out on the mould loft floor, or laid off on a scrive board.

In constructing the digital model, the first reference documentation that was obtained was a series of eleven elevation drawings made by archaeologists of the surviving parts of the ribs on the starboard side - approximately two thirds of each rib that had lain under the silt. After re-copying and re-scaling to a uniform standard they were scanned in to a drawing package as TIFF files, then into a line tracing package. Each line-traced rib section was then taken into the shaper in 3D Studio and when all eleven ribs had been imported, work began to clean up the images and to introduce some form of uniformity. Because the surviving ribs had lain submerged and been subjected to tides and pressure from silt, many had lost their original shape. By over laying the images, the distortions could be clearly seen.

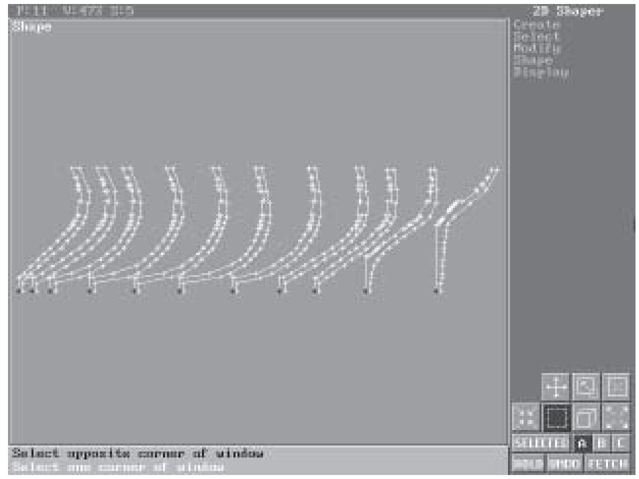

Figure 2. Scanned drawings made by marine archaeologists were used to create vector images, which were corrected to allow for warping of the original form.

The digital description of the rib geometry had to be edited to ensure that each rib section had the same amount of vertices. This is a requirement for linking the ribs in the lofter module, which is used to create a three-dimensional shell between the ribs. These shells become components of the ship's hull.

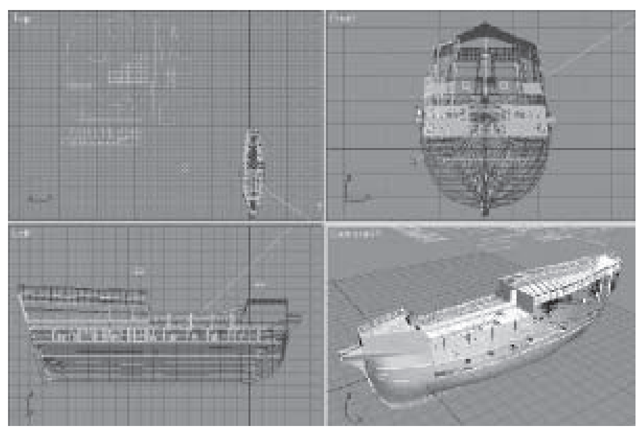

Figure 3: Screen grab from 3D Studio showing plan, section and perspective views of the model.

The components of the digital model had to be transferred into Superscape VRT - a virtual reality modelling tool. Superscape VRT places certain constraints on the data imported. The data conversion process is not guaranteed to give perfect results every time. The Superscape manual notes that the chance of getting a perfect VRT file from a DXF file reduces in inverse proportion to the complexity of the drawing, and recommends that the DXF to VRT converter is used on single objects which can then be assembled using the VRT editor. After much experimentation it was concluded that VRT would not accept geometry with more than 2,000 facets.

In later stages of the project the data conversion problem was eased, although still not entirely solved, by the use of Polytrans software from Okino Computer Graphics of Toronto, Canada. It provides a comprehensive set of precise import/export converters for most popular, industry standard, 3D model formats.

Once imported into the virtual reality software, the components were assembled to create a starboard half of the hull, and that geometry was later mirrored in the 3D editor. After the bow, stern and decks had been added, the gunports were cut out using the Boolean operation.

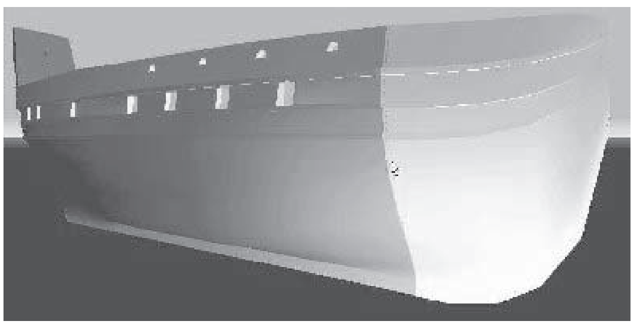

Figure 4: Starboard view of the hull, stern and bow, which were assembled in Superscape VRT after creation of the components in 3D Studio.

The geometry of early versions of the model was so complex that any additional imported elaboration would noticeably slow animation of the model. This limited the scope for introducing artefacts and textures.

To tackle the problem of growing file size, it was planned to create separate worlds for the exterior, and then one for each deck of the ship. These would be loaded as the viewer navigated through the hatches connecting the decks. Due to improvements in the VRT software, and in the efficiency of the model, the currently published model does in fact contain the exterior of the ship, and three decks in a single model.

Results

An early version of the model has been in use in Portsmouth schools for two years, and can be viewed as part of the Mary Rose web site at www.maryrose.org. This will be updated with a more complex version before the end of May 2002.

It demonstrates the level of geometric complexity that has been achieved, without making navigation too slow. The file size for the current 3-D world is small enough to fit on a floppy disk.

Some users have experienced difficulties in downloading the 3-D model, and have complained about the need to first download the Viscape plug-in to their web browser. The use of the VRML standard might have avoided some of these problems, but at the outset of the project it was felt that the standard had not been sufficiently established, and that Viscape offered a higher level of functionality than VRML. Tests have demonstrated that it is possible to link sound effects to the model, allowing users to ring the ship's bell, and fire a cannon. The updated public site will feature voice recordings of simple messages from the principal characters on the boat.

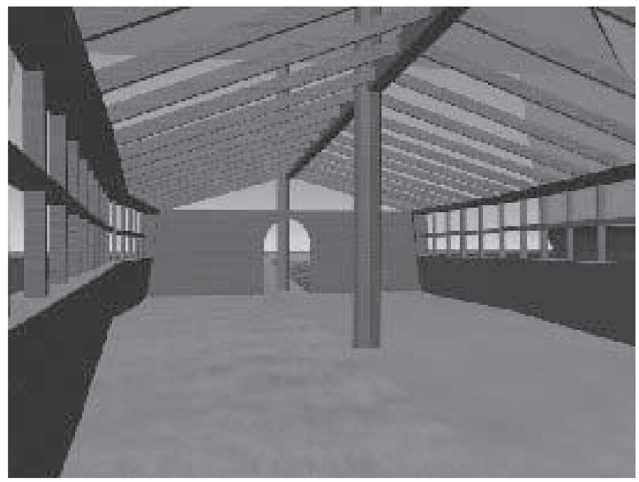

Figure 5: View of the stern castle, shows the flat shading used in the virtual reality rendering.

Figure 6: Interior view from the ship's holds. The galley and the brick ovens are three-dimensional models, populated by two-dimensional bitmap images of crewmembers.

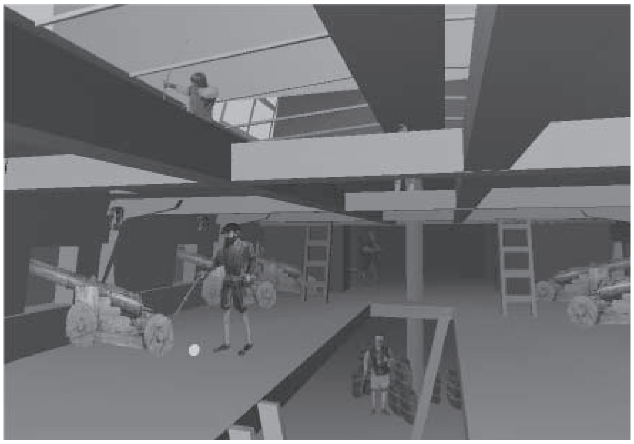

Figure 7: View of the main gun deck from the bow, illustrating the nature of the space through which users can navigate. Within the three-dimensional model, guns and crew characters are two-dimensional bitmap images to facilitate real time navigation.

Conclusions

Given the growing interest in combining geometrically complex representations of data, and communicating such information rapidly and economically, it is of interest to establish that graphically rich, three dimensional, non-orthogonal, geometrically defined environments can be shared across the World Wide Web, with links to multi-media data bases. It has furthermore been demonstrated that virtual reality software can be combined with more familiar multimedia techniques to enhance the level of user interest in educational material, and allow communicators to adopt 3-D models to demonstrate spatial relationships between objects, and photographic representations, to convey accuracy and authenticity.

Within the built environment professions, there is likely to be growing interest the ability to share geometrically complex 3-D models across the Web. This is particularly true in the context of the growing exploitation of digital modeling in the design process, which has coincided with a revival of interest and ambition in creating geometrically complex buildings, using irregular, multi-curved components. The most public expressions of this development are probably the Guggenheim Museum in Bilbao by architect Frank Gehry, and in the new roof of the Great Court of the British Museum, by Norman Foster Architects. Controversy over the visual impact of the British Museum roof, due to its height relative to surrounding buildings, broke out soon after completion of the construction. This could have been overcome before construction started, if a proportionally accurate visualization of the new construction, in the context of the neighboring properties, had been made freely available on the Web.

References

[1] McCartney, K. Rhodes, P. & Ismail, A. (1993), A Multimedia City Model, in Proc. of ECAADE-93, Conference of European Computer Aided Architectural Design Education, Technical University of Eindhoven, Netherlands.

[2] McCartney, K. & Jacobs, A. (1997), Educational Benefits of Animation, Proceedings of AVOCAAD-97, Conference on Added Value in Computer Aided Architectural Design, Brussels.

[3] Field, J. (1997), VR to the Rescue; Building Analysis: Portland Building, in Building Services Journal, July, 1997, p19.