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Virtual Stonehenge: a Fall from Disgrace?

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Abstract

In October 1995 English Heritage, with sponsorship from Intel (UK), began a project to use Virtual Reality to create a model of Stonehenge and the surrounding landscape. Two products were created and premiered on the eve of the 1996 summer solstice: one designed for the internet where browsers can download, explore and interact with the 3D world in a variety of time periods; and another which contains much more detail, utilising three dimensional data produced from a recently completed comprehensive photogrammetric survey of the monument. The following text discusses the construction and specific features of these two developments which include the accurate positioning of stars in the night sky, the use of draping photographs in an attempt at photorealism, as well as the first 'virtual sunrise'.

1 Introduction

Interest in Stonehenge has been as abundant as ever over the past few years. Visitor numbers are on the increase (up 5% to 753,000 in 1996/7 financial year) and academic curiosity still persists (Cleal *et al* 1995; Cunliffe and Renfrew 1997). Meanwhile the presentation of the site is constantly described, using the well-flogged comment from the Public Accounts Committee of the House of Commons, as a 'national disgrace'.

The highly publicised attempts to alter the situation have led to numerous proposals for road alterations and the relocation of visitor facilities (Darvill 1997), the establishment of partnerships for development, and various applications for funding (see CBA website for a concise commentary, Heyworth 1997). Accompanying these changing proposals has been a constant hunger for information, and just as importantly, a need to present this in an accessible manner in order to express a point of view, better visualise a proposal, and aid the planning process. This has lead to an increasing use of, and profitable return from, the involvement of computing and computer techniques in many areas of work within English Heritage.

As well as the need for data to support the planning process, there also exists the responsibility to seek effective methods of presenting sites and monuments to increase awareness, understanding, and access to information. Virtual reality (VR) along with the use of the internet was considered to be a way forward in a number of the issues surrounding the monument. A VR model of the stones and surrounding landscape could be used both to help improve presentation and interpretation, raise the profile of the monument and the planning issues surrounding it, as well as helping to communicate and demonstrate a long-term vision for the area.

This technology also clearly offers opportunities for two other important areas, archaeological research, and surveying methodology. It is not difficult to see the advantages of improving the manipulation and visualisation of survey data and then moving around the landscape checking various vistas, examining the stones in detail or analysing astrological alignments.

A model which could be accessed through the internet would also allow many more people to access this information. Therefore two distinct developments were established, a VR development containing as much detail as possible, and another, less detailed model, to sit on the internet.

2 Background

At the same time as project initiation, October 1995, Intel Corporation (UK) were looking to promote their latest line in chip technology, the Pentium Pro. They viewed the Virtual Stonehenge project as a good opportunity to demonstrate the capabilities of the new processor and offered to provide sponsorship as part of their Community Liaison Programme. Support arrived in the form of an Intergraph TDZ-300 Workstation upon which to develop and run a 'photorealistic' model. As well as this hardware, funds were also provided to enable specific expertise to be hired. Two companies were used, VR Solutions under the directorship of Professor Robert Stone for 'photorealistic' model development, and Superscape for construction of a VR website.

This enabled the two different developments to be carried out concurrently, and completed in time for the release deadline of the 1996 summer solstice.

3 The Website development

Although much of this paper discusses the creation of the 'photorealistic' model of the monument, it is important to at least describe the website and more importantly, highlight the differences between the two. Indeed, there has been confusion over these two distinct developments, both often being mistaken for a single end product.

The Internet site is a VR world that users can download from a website[1], and then navigate around the landscape using Superscape's Viscape, a free piece of Netscape plug-in software.

Figure 1. Virtual Stonehenge on the Internet.

Upon entering the model the screen splits into two (see Fig. 1), text on the left and the 3D world on the right. Here there is a two-way link in operation so that highlighting given words or phases reveals the related object, and highlighting an object invokes a text description. As well as this textual-graphical interaction, and the ability to manoeuvre freely about the landscape, there are other options. For example, a visitor can take a guided tour or stand within the stones and watch the sun rise along the Avenue. But perhaps the most exciting feature is the ability to explore the landscape within a series of time slices spanning 10500 years. The inclusion of this further dimension creates an even more dynamic model, allowing any user the ability to quickly build up a picture of the current opinions on the evolution of the Stonehenge landscape.

This development has a clear function in communicating and allowing access to this information in a new and effective way, and it does it well (Armbrust 1996), but it also has limitations. The internet obviously puts a large constraint upon the amount of data, and therefore detail, which can be included. This model compresses down to 388 Kilobytes for downloading. All the major monuments and their components are present and include some detail, but most, the stones for example, are kept quite geometric, and texturing is simple.

4 The 'Photorealistic' model

To achieve a VR model with more graphical detail meant turning to a separate development, not dependent upon the limitations of the internet, but both constructed, stored, and demonstrated upon a machine based upon the Pentium Pro. For this part of the project, we wished to achieve much higher topographic detail, as well as the inclusion of photorealism, that is, realism derived through the use of photographs rather than generalised textures.

Figure 2 gives an example of the results which show the variation in both shape and colour of the stones.

Figure 2. Photorealistic Virtual Stonehenge.

The differences between the two developments are now hopefully much clearer, one internet based with less graphical but much more textual information, and the other, a more topographically correct, partially 'photorealistic' model. The rest of this paper is principally concerned with the latter.

4.1 The data

One of the great advantages of working with Stonehenge is the wealth of data which now exists.

Although the intention to create a morphologically and topographically correct model for a major monument would, in most cases, mean the initialisation of a huge data collection programme, almost all of the data required was already available due to previous projects. Indeed, it is fair to say that the project would not have been considered a possibility had not much of the raw data already existed.

Three major data sets were required to construct this model; colour photographs of each face of each stone of the henge, three dimensional survey data of each of these stone faces and three dimensional survey data of the surrounding landscape.

The first two data sets were provided by the same initiative, under the guidance of the regional inspectorate for the HPSW (Historic Properties South West) team of English Heritage. The project, 'Mapping the Stones', began in 1993 with the principal aim of providing a photogrammetric survey of the stones in order to use the data for future conservation, monitoring work and as a basis for further interpretation of the site.

Under the guidance of English Heritage's Photogrammetric Unit (part of the Survey Team currently within the Professional Services Division), a complete stereophotographic survey was carried out from which 3D data has been derived (see Bryan and Clowes 1997 for a detailed account of this process). This was achieved using the LEICA DSW100 high resolution scanner and DPW750 digital photogrammetric workstation capable of automatically generating x, y, and z values across a selectable grid spacing for each face of each stone. A value of 20 mm was chosen for the grid spacing after first calculating the amount of data which would be generated, a major stone typically producing 60,000 points in this instance. After re-surveying some of the more irregular shaped stones and editing around 10 per cent of the points, the resulting models were tied into the existing site co-ordinate system allowing each face to be viewed in its correct location.

Photogrammetric data for the surrounding terrain was also produced using the same team and equipment, this time using 1:10,000 scale colour aerial photographs, previously flown by Cambridge University. Again the time and costs involved in processing this photography into usable survey data were reduced as the photographs had already been flown for use within a GIS for the Stonehenge Conservation and Management Project.

4.2 Model construction

This was carried out using Sense8's WorldToolKit software on the Intergraph TDZ-300. Firstly, the survey data for each face was used to create wireframe models for each of the 75 or so stones. The major problem facing VR Solutions was the amount of detail provided by the photogrammetric survey. A judgement had to be made on the amount of data that could be used for each face of the stone which would still allow real-time rendering to take place on the Pentium Pro-based machine (Stone 1996a). This manual optimisation led to the final model containing 40,000 polygons to represent the stones and immediate topography, and another 10,000 for the surrounding 6 Km^2.

Figure 3. Problems of texture mapping onto irregular shapes.

To give each stone a realistic texture, one of the pair of stereophotographs for each face was scanned onto KODAK’s Pro Photo-CD format and then mapped into its correct position. This works well upon the major faces but again, irregular shapes cause problems, as is shown in Figure 3. An additional problem was also caused by changing lighting conditions throughout the photographic survey, some images were taken in bright sunlight while others were taken in low light conditions. However, it is still possible to identify subtle features upon the stones such as erosion, hollows, and lichens.

The constant balancing act of trading off visual quality against rendering speed is not only left to the developers, the software also plays its part. 'Object culling' is a technique which judges the distance between the viewer and the object and then renders those objects using imagery displayed at different pre-defined resolutions. Figure 4 shows different coloured stones indicating those which are nearest and therefore rendered using a higher resolution.

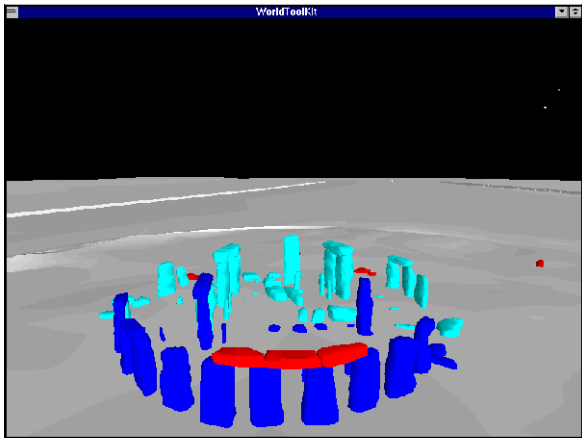

Figure 4. Object Culling. Changes in colour indicate the different rendering resolutions.

So, unlike most VR models which deal with regular geometric shapes, the rather softer lines of Stonehenge have meant that there are more problems when looking at, what may be considered to be, other standard VR features. For example, 'collision detection', a function which prevents the user from travelling through solid objects, is more difficult to achieve and has not been included. This does mean, however, that some weird and wonderful views are now possible (see Fig. 5)!

Figure 5. No collision detection permits some unconventional views.

The rest of the landscape has been formed using much less detail than the stones while using much the same construction technique. Again, the data were optimised and a wireframe model built. However, rather than aim for photorealism, simple textures were used to drape over the terrain. The final model therefore not only contains the stones but also the visitor centre, existing roads and fences, as well as two other monument groups, King Barrow Ridge and the Cursus Barrows.

4.3 Further features

During the project design there were specific features which were requested for inclusion during development. The first of these is an accurate representation of the stars. The correct positions for the summer solstice (right ascension and declination) for each star with an Apparent Visual Magnitude greater than 3.55 was obtained from the internet and then projected onto a hemisphere within which sits the landscape. The Apparent Visual Magnitude was also used to determine the size of the cube used to represent each star, giving the impression of relative brightness (see Fig. 6) (R. Stone pers. comm.).

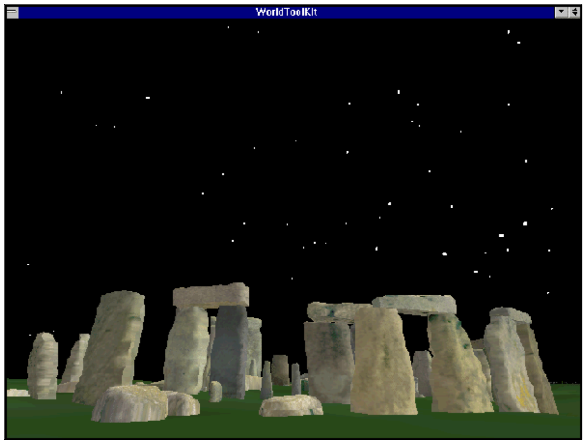

Figure 6. Astronomical mapping.

The second major feature is the creation of a summer solstice sunrise (Fig. 7) (Stone 1996b). This complicated effect uses a 'virtual' sun and a hemisphere to represent the sky, whose pixel colours are calculated according to the distance from the sun. The developers created the sun from a number of ellipsoidal bands, each representing a fixed colour, which were then used for interpolation, giving the effect of smooth, gradual change from night to day as the sun travels from its furthest band distance from the dome, inwards. When completed in June 1996, the virtual sunrise was a world-first (English Heritage Press Office 1996).

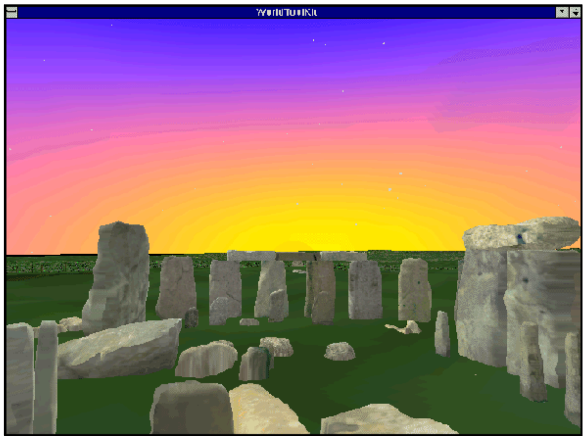

Figure 7. The virtual sunrise over Stonehenge.

The intention to use a VR development to help in the many discussions on the plans for the area meant that the landscape had to include the major features which presently exist. Therefore, it is possible to 'walk' through the turnstiles past the visitor centre and into the tunnel underneath the A303. However, an obvious step to take is to use the same tools to present what the area may have looked like, or what it could look like in the future. This is indeed what has been done. Using a toggle switch, all the twentieth century constructions are removed, giving an impression of what the landscape would look like were the A303 diverted or buried, the A344 grassed over, and the visitor facilities re-located beyond the extent of the model.

5 Discussion and Conclusions

Although obviously not a replacement for visiting the area, many people who get the chance to view Virtual Stonehenge could now see much more, and gain a greater understanding of the surrounding landscape, and the context of the monument than they otherwise would. 'Real' visitors are currently guided along a pre-determined route and view the monument very much in isolation, marooned on its small triangular island between the two busy roads. The internet version, although less well graphically defined, is also valuable in achieving this greater understanding and dissemination while also allowing 'virtual visits' at leisure. At present the average visitor stays on site for 40 minutes, either an indication of its current facilities and setting within the landscape, or of the heavy itinerary of summer tourists, in a rush to also 'do' Bath and Stratford the same day!

This last comment could imply what is next for the model, that is, installation at the visitor centre. This however, is not the case, it is arguable whether it is necessary at all. More value should come from CD-ROM publication enabling copies to be held at local museums, other historic properties and schools and universities. In fact the future for the project is uncertain. One option is to stop now as the 'photorealistic' model is at a stage where it could be published while the internet version is already well established and widely used. Brian Bath (1996, 16), former Head of Design and Interpretation at English Heritage, has expressed some of his views on the matter, suggesting that

‘...it [the model] will later include reconstructions of earlier periods and a Geographic Information System for the entire World Heritage Site, giving access to powerful analytical tools, and an up-to-date archaeological database. This will be relatable to a full moving model of the night sky. The relation of these two elements will allow one of the more important functions of the model to take place, that is a research tool in its own right.’

However over-ambitious or technically difficult the inclusion of this functionality may be, it is true that much of the initial potential for the VR world as a research tool has not yet been realised. This is, in the main part, simply due to a previous concentration upon issues of presentation. Were English Heritage to resume work, advantages would not only be gained from adding more features, but technology would allow developers to work with much more of the raw survey data. For example, an increase from 32 MB to 256 MB of real-time texture memory could now be employed, allowing even better definition of the stones, higher resolution imagery for draping, and a much improved Digital Terrain Model.

The Virtual Stonehenge project and the two developments which it produced have been, and continue to be, an exciting use of new technology for helping with some old problems, and at the time of production was one of the biggest and best PC-based heritage reconstructions to date. Much more work must be done if it is to become established as a serious tool for analysis.

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Notes

1 The internet model of virtual Stonehenge is available at the following addresses:

http://www.superscape.com/intel/shenge.htm

http://connectedpc.com/cpc/ecs/stonehenge/

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