The 5th International Symposium on Virtual Reality, Archaeology and Cultural Heritage VAST (2004) *Short Presentations*
K. Cain,Y. Chrysanthou, F. Niccolucci, N. Silberman (Editors)

Breaking Through Rock Art Recording: Three-Dimensional Laser Scanning of Prehistoric Rock Art

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Abstract

This paper will explain work-in-progress of two projects to test 3D laser scanning for the recording of prehistoric rock carvings in Britain. The main objectives of the projects are to assess the reliability, accuracy and precision of this technique for recording purposes and to assess the potential of the technology for monitoring rock surface decay. The paper will focus on a discussion on data capture and processing, data management as well as digital reconstructions and visualization of prehistoric rock art.

Categories and Subject Descriptors (according to ACM CCS): I.3.3 [Computer Graphics]: 3D Reconstruction, Laser scanning, British rock art

1. Introduction

Two projects are currently underway in the United Kingdom to record, in detail, prehistoric rock carvings using laser scanning techniques. The first project, „Fading rock art landscapes" project, has been funded by the British Academy and aims to assess the rate and nature of degradation of prehistoric rock-art through comparison of recordings made with the technique of laser scanning. The second project, „Breaking through rock art recording: three dimensional laser scanning of megalithic rock art" has been funded by the AHRB (innovation award schemes). The project aims to assess the reliability, accuracy and precision of the laser scanning technique for the recording of prehistoric rock carvings. Both projects are led by Dr Margarita Díaz-Andreu (Department of Archaeology, University of Durham) and are in collaboration with the Computer Graphics Group of the University of Bristol).

2. The Scanning Process

Laser scanning is the process of recording three dimensional data Figure 1, in the form of a dense grid of distance sample points. For these projects the 3D data was the surface of the stones. Due to the size, shape and accessibility of the stones many scans were required to be joined for each artefact. The recording process can therefore be split into two separate phases.

2.1. On-site Data Capture

There are several issues regarding the capture of laser data from outdoor archaeological sites. A major issue is the availability of power to run the equipment. We initially used a generator as a power source, but this proved inconvenient to move and required constant supervision due to the risk of igniting dry moorland. The alternative means of power which we now use exclusively is a high capacity rechargeable lead-acid battery. On one battery we are able to run the scanner and a pair of florescent lights for up to 6 hours.

The sensitivity of the equipment to the ambient light at the scanning site initially caused a few problems with poor results in the recording of the point data, simply put the light was masking the laser and the scanner was unable to retrieve the reflected beam. This was overcome in two ways, the use of a „forensic" style tent which is a self supporting light proof structure that can be placed over the site enabling scanning to be performed using electric light sources inside. Such light sources have an advantage when the data is examined because they provide a uniform lighting of the subject. This has the further advantage of allowing scanning to be undertaken in the sometimes less than clement Lake District weather conditions. However, the sites involved had the restriction that the tent could not be anchored to the ground with tent pegs as this might cause damage to the site. Consequently the tent could not be used when there were high winds as it became difficult to scan whilst holding down the tent. This led to the second solution of performing the scanning at night. Clearly this could only be undertaken on nights when there was no rain, but it meant that there was no longer the restriction of the tent on the location of the scanner and consequently the scanning process was much quicker as only the tripod and scanner needed to be moved. During the capture process careful recording of the scans taken and their position relative to each other and in absolute terms on each stone was critical to ensure both that the stones were fully covered and to make the stitching process possible.

Figure 1: Capturing data on site.

2.2. Post-Processing

Once the data had been captured the second stage was the compilation of the individual scans for each stone Figure 3. This was done with GSI Studio. Figure 2 illustrates the number of scans that are needed to comprise one complete model. This example is of Long Meg, a 4 meter tall, red sand-stone Sarcen stone in Penrith, England. It is made from 102 scans and the raw data takes up about 700Mb on-disk. In most of the subjects that we have captured, the sheer physical size of the model -and therefore the file size of the models -has meant that we must work on the data as point clouds. Point-cloud representation reduces the amount of memory required to manipulate the model. One cost of this is that the surface of the model does not appear as a continuous surface on screen, but this is less of a problem because the massive quantity of points make the model appear believably solid.

In addition, we have combined long-range laser scanning which has low resolution (of about a centimeter) with high-resolution (under a milimeter) to produce a model of about 40Gb. The low-resolution, long range scanner undertaken by Nick Rosser of the Department of Geography, University of Durham, provides a macro-scopic perspective of the site (Figure 4, Castlerigg Stone Circle, near Keswick) gives a basis upon which to align the high resolution scans of the 49 stones. The long range scan is combined with GPS data to give accurate positions of each stone in the circle.

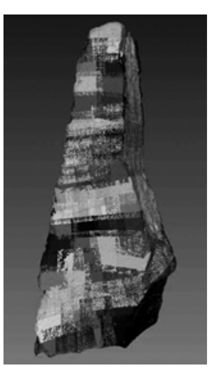

Figure 2: Patchwork of scans being aligned to form a composite whole.

2.3. Conclusions

The technique of three dimensional laser scanning has the potential to greatly enhance recording, analysis, presentation and management of British rock art. It is a non-contact technique, and is entirely objective, in contrast to the hugely subjective and potentially damaging traditional recording technique of wax „rubbing". The resulting three dimensional models capture both natural and carved features on the surface as well as the curvature of the rock which is often integral to the design and difficult to depict in a two dimensional representation.

The fieldwork undertaken during this project has demonstrated the viability of scanning in situ at several very different rock art sites. A number of practical considerations, particularly relating to recording conditions have been highlighted, and solutions explored to address these in the field. Work is currently being undertaken to fully exploit the resulting three-dimensional models in order to analyze the carvings and to present the recordings using a variety of treatments to manipulate the models and maximize features in a virtual environment.

Although currently a specialized and expensive process, three dimensional laser scanning has the potential to revolutionize the recording of rock art in Britain. With many carvings threatened by both natural erosion and human activity, recordings such as those undertaken within this project will ensure that this prehistoric heritage is preserved as a virtual model for posterity.

Figure 3: A final, textured model (Long Meg Sarcen Stone).

Figure 4: Long Range, Low Resolution Scan of Castlerigg Stone Circle. By Nick Rosser.

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Criticism Begins at Home: Developing a Methodology for Critically Reading 3D/VR Reconstructions

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Abstract

Just within the past twenty years, three dimensional (3D) and virtual reality (VR) visualizations have become an acceptable part of historical and archaeological dissemination. By their very nature, images are more powerful than words in terms of conveying a message to a user. 3D/VR images are also subject to more editorial decisions than a text is, as text is linear and images are not. Authors of these visualizations should be aware of the decisions they are making, as the users should be aware of the decision that the author made. The user of a visualization should be able to distinguish between a meaningful manipulation and a deliberate distortion. As a part of the Netherlands Organization for Scientific Research (NWO) project 'Paper and Virtual Cities: New Methodologies for the use of Historical Sources in Virtual Cartography', I will be addressing issues related to visualizing historical and archaeological data in 3D/VR. The more 'real'-looking visualizations become, the less people seem to question their authority. But much like maps, these visualizations can never fully represent the 'truth' about a landscape. Under the specific sub-project, entitled 'Visualizing the Historical City', I will approach the increasing need for a methodology for critically reading 3D/VR visualizations. This paper discusses this need and cites examples of both current visualizations and potential future examples which would benefit from such a methodology.

Categories and Subject Descriptions (according to ACM CCS): I.3.7 [Computer Graphics]: Virtual Rea

1. The problems

There are numerous problems surrounding the issue of visualizing archaeological and historical evidence in 3D/VR format. When viewing a visualization of this type it is easy to be swept away by its realism whilst it is difficult to determine what types of editorial decisions were made during its creation. If the entire visualization is based purely on evidence, this is less of a problem than those which visualize interpolated data. The following are only some of the larger problems surrounding this type of dissemination of data.

People enjoy pictures. They are what people look forward to when reading a long text. It has been put forth by Martin Jay that, 'beginning with the Renaissance and the scientific revolution, modernity has been normally considered resolutely ocularcentric' [Jay88]. High-tech visualizations therefore, quite literally, become eye candy for the user. Unfortunately, many of the users may not think to question what they are being presented with.

It is the job of the practitioners of the visualizations, then, tonot just keep up with the technology, but also the mostinformative and honest way to disseminate it in 3D/VR.

Archaeological reconstructions have had a long-standing tradition in reality prior to the introduction of digital means. Traditionally, truthful reconstructions not just in archaeology, but also in history and art history, differentiate clearly between that which is reconstructed based on evidence and that which is interpolated, guessed or fabricated. Examples of this practice are prevalent in most areas of archaeology, from the 17th century Swedish warship, the Vasa, to the 1st century BC Roman settlement of Bet Shean in Northern Israel. This is a method of accountability that has not fully caught on yet in digital visualizations. Erik Champion, a scholar of Game Studies and Cultural Heritage, believes that this issue is quite challenging because 'a computer model almost invariably implies certitude, and archaeologists are still not sure how to convey the murky battle of historical interpretation [Cha04]. It is important to a viewer, who is looking to learn from it, to know what different types of evidence and interpolation were used during a visualization's creation. But first the author needs to decide how to represent and account for uncertainty.

Beyond the tendency for 3D/VR visualizations to unintentionally claim authority where there is no evidence, they can also be quite dramatic. The so-called 'Hollywood effect' on visualization makes it possible for a skilled CAD technician to take virtually no evidence for what he or she is representing, put in a few high-contrast clouds, a setting sun and . . . voilà, the lost city of Atlantis as it looked to the Atlantians! When the author of a visualization does not differentiate between or account for the varying sources (and validity thereof) for what they have created and instead polish over the differences with glitz and glam, they are, in effect, lying about the past. There is nothing wrong with an impressive and dramatic visualization that is based on fact. But those which pretend to represent the past by concentrating on the drama rather than the factual evidence fall short and, quite literally (and dramatically), betray their entire purpose.

David J. Staley discusses several issues surrounding historical visualizations in his 2002 book entitled Computers, Visualization & History: How new Technology will Transform our Understanding of the Past [Sta02]. One such issue is the fact that traditional history books use mainly text to convey their evidence. Text is a linear form of dissemination; it can only go in one way, from the beginning of the sentence to the end, from the beginning of the book to the end. The advantage that comes with being linear is that not everything needs to be discussed in a scene. This is not true of visualizations. 3D/VR visualizations are not at all linear. They cannot simply ignore something which is, could be or is not in a scene.

2. Virtual historical cities

A good example of a virtual historical city is the NUME project, fully named Nuovo Museo Electronico: La città in 4 dimensioni: Bologna virtuale. It was masterminded by a team of historians in collaboration with a supercomputing think-tank called CINECA. NUME wanted to base all of their visualization on solid evidence, which led them to a problem which has been discussed already in this paper: how do we represent uncertainty? The NUME team decided to use flat brown surfaces where there was not enough data. Was this a wise decision? It adds to the historical correctness of the visualization because the user will easily be able to distinguish between a façade with detail and a massive brown wall, but does the choice say something else to the user? Is the color choice more important than one might think? Does the color brown have any historical connotations in Bologna? Does admitting that they do not have reliable evidence for a certain façade somehow detract from the reliability of the other façades in the eyes of the users? These are only some of the questions that the designers may have been forced to confront.

3. Digital archaeological reconstructions

For as long as realistic visualizations have been a possibility in archaeology, there have been practitioners who are wary of their impact on the viewer and the trickiness of representing uncertainty. In a 1998 article, Eiteljorg confronted the issue of photorealistic visualization being ‘too good’. ‘As the quality matches photorealism, visualizations will become harder and harder to treat as an artist’s view of a particular time and place in the past. They will simply appear to be real photographs’ [Eit98]. He then gives an example of a good visualization (for the time) which distinguishes between uncertain data and real data. This form of admitting when information is missing (hard borderlines and distinguishable colors) could be a viable option for those who need it. However, a reconstruction of a more or less uniform surface is an entirely different interpolation from that of a complicated building façade.

4. Working toward a methodology

The project Paper and Virtual Cities has only just begun, so a solid methodology for critically reading visualization of historical and archaeological data in 3D/VR is far from complete. In the project, I will be approaching the creation of a methodology from a few different perspectives. Much like experimental archaeologists learn about past cultures by recreating artifacts which they have excavated, someone interested in the editorial decisions of those who make 3D/VR visualizations of our cultural history can benefit greatly from personally learning these techniques. It is my intention in the project Visualizing the Historical City to learn the most up-to-date techniques in creating 3D/VR visualizations of historical and archaeological sites and landscapes. In doing, I will be able to be able to make more purposeful, sensible and most of all educated criticisms of editorial decisions or indecisions in 3D/VR visualizations of historical and archaeological sites.

5. Conclusion

If criticism of historical and archaeological data in 3D/VR can begin with those who are well-trained in the practice of creating them, the standard for conveying information about past people and cultures through them will be raised significantly. Furthermore, people will be invited to view visualizations as temporary and use a critical eye, constantly questioning what is based on fact, what is based on conjecture and what is made up.

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