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ABSTRACT

This paper results from a recently completed project that augmented an exhibition at the Powerhouse Museum, Sydney, entitled "1000 Years of the Olympic Games: Treasures of Ancient Greece" (July 18-November 18, 2000). This Exhibition offered an opportunity to supplement the traditional visitor experience with the introduction of "virtual reality" components. These include a 3D digital reconstruction of the archaeological site of Olympia in 200 BC; the laser scan of the famous statue of Zeus from the archaeological museum in Athens; and the construction of a large-scale Web (http://www.phm.gov.au/ancient_greek_olympics) that combines the Exhibition components with a host of other information sources.The paper reflects on the theoretical concerns companion to the processes of digital reconstructions using historical and archaeological data sets. From this position it is possible to examine the curatorial and technical decisions made in creating the works. An outline of the web architecture and design is presented. A statistical analysis of the web since its launch is also examined. (Contains 21 references and 11 figures.) (Author)

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1000 Years Of The Olympic Games: Treasures Of Ancient Greece: Digital Reconstruction At The Home Of The Gods.

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Abstract

This paper results from a recently completed project that augmented an exhibition at the Powerhouse Museum, Sydney, entitled *1000 Years of the Olympic Games: treasures of ancient Greece* (July 18 -- November 18, 2000). This Exhibition offered an opportunity to supplement the traditional visitor experience with the introduction of 'virtual reality' components. These include a 3D digital reconstruction of the archaeological site of Olympia in 200 BC; the laser scan of the famous statue of Zeus from the archaeological museum in Athens; and the construction of a large-scale Web (http://www.phm.gov.au/ancient_greek_olympics) that combines the Exhibition components with a host of other information sources.

The paper reflects on the theoretical concerns companion to the processes of digital reconstructions using historical and archaeological data sets. From this position it is possible to examine the curatorial and technical decisions made in creating the works. An outline of the web architecture and design is presented. A statistical analysis of the web since its launch is also examined.

as part of

AN EXHIBITION ORGANIZED AND LENT BY THE HELLENIC MINISTRY OF CULTURE, ATHENS

AS A CONTRIBUTION TO THE CELEBRATION OF THE SYDNEY 2000 OLYMPIC AND PARALYMPIC GAMES.
DEVELOPED BY THE POWERHOUSE MUSEUM

IN CONJUNCTION WITH THE UNIVERSITY OF MELBOURNE.

Keywords: Virtual reconstruction; ancient Olympia; Zeus; anaglyph; digital; three dimensions; 3D; Web; laser scan; polarised; heritage; zoomable; panoramic photography; digital cultural heritage.

Introduction

Here we enter the ancient sanctuary of the gods of Olympia, witness

Zeus the wielder of the thunderbolts, and walk the archaeological site of Olympia as it appears today. The works under discussion result from a recently completed project that augmented an exhibition at the Powerhouse Museum, Sydney, entitled *1000 Years of the Olympic Games: treasures of ancient Greece* (July 18 -- November 18, 2000). This Exhibition offered an opportunity to supplement the traditional visitor experience with the introduction of virtual reality components. These were a 3D digital reconstruction of the archaeological site of Olympia, in 200 BC, the laser scan of the famous statue of Zeus from the archaeological museum in Athens, and the construction of a large scale Web which delivered the Exhibition components together with a host of other information sources and interpretive information.

This paper begins by introducing some of the visions, opportunities and cautionary perspectives that are companion to the processes of archaeological reconstruction using digital tools. Observant to the potential and difficulties inherent in digital reconstruction, the paper will then discuss some the curatorial and technical aspects of creating the information complex: the reconstruction of Olympia; the laser scan of Zeus; and the presentation of materials on the Web.

The paper examines the data acquisition process at the site of Olympia, and the archaeological and historical data considerations that were the basis for creating the 3D visualisation of the site in 200 BC. The scan and display of the statue of Zeus is also outlined. A brief description of the web contents introduces the technical, architectural and curatorial decisions that were used to define the design. This section concludes with a statistical analysis of the Web usage since its launch. Reviews of the Web by industry, and education and research awards that the works have attracted to date, conclude the discussions.

Theory in Digital Archaeological Visualisations

Opportunities

In theory, digital reconstructions represent a paramount tool of enquiry for archaeologists. As Forte (2000) notes, this can occur when:

> ..."interactive-computational simulation" becomes the methodical ideal of the scientist: reason and observation permit the break down of an event into its primary elements and from these it is reconstructed. A tight link is established between computational information and the "architecture of thought", because both embody man's desire to be the "architect" of the "world". A portion of the real is no longer represented by a chain of ideas in which all pertinent information is housed; instead it is reconstructed in a way that the observer can immerse himself, react to it and be reacted to...
>
> ...Through the collection of multiple forms of data otherwise lost, that become homogeneous after calculation, a model of the event can be constructed. This allows for the step-by-step visualisation of all phases, providing humanity with extraordinary predictive power, since each level is the necessary condition for the next one.

The techniques of immersion, interaction, and sensorial interaction are all based on perceptive mechanisms (Gregory, 1998 in Forte, 2000). They represent instruments that permit the user to operate in synthetic space; that is, to be able to understand synthetic space in all of its richness through the shifting of points of view (Forte, 2000). In archaeological enquiries, the richness of the medium for teaching and theory testing in the form of alternate visualisations is potentially unlimited.

To situate digital visualisations of archaeological and historical sites into museums and to translate them for the Internet represents a powerful form of interpretation. It allows for complex datasets to be drawn together forming products that are multi-sensory and easily accessible.

Colonna (1994) presents his view of the flexible nature of digitally reconstructed environments (as discussed by Barceló).

> A virtual world should be, then a *model*, a set of concepts, laws, tested hypotheses and hypotheses waiting for testing. If in standard theories, concepts are expressed linguistically or mathematically, in virtual environments, theories are expressed computationally, by using images and rendering effects. Nothing should be wrong or "imaginary" in a virtual reconstruction, but should follow what we know, be dynamical, and be interactively modifiable. A virtual experience is then a way of studying a geometrical model--a scientific theory expressed with a geometric language--instead of studying empirical reality. As such it should be related with work on the empirical reality (excavation, laboratory analysis). As a result we can act virtually with inaccessible artefacts, buildings and landscapes through their models (Barceló, 2000).

For the Olympia project, the empirical reality was based on numerous excavation reports and historical and scholastic sources discussed below, and in aerial and geological ground survey data. A considerable component of the project was the acquisition and analysis of source information, especially as a high degree of veracity and verisimilitude was required. The digital reconstruction process attempted at all times to create an archaeologically correct interpretation of the research materials available.

Caution in reconstruction

Increasingly, archaeological reconstructions are used in cinemagraphic-digital formats or 3D interactive environments. These virtual models are criticized for their ability to portray scientific speculation as 'truth'. In general the more advanced the level of technology used in the reconstruction and display, the greater the belief in its authenticity (Emele, 2000). This mechanism is also reinforced when reconstructions are displayed in the context of museums with the inherent authority these institutions confer to the works.

Virtual archaeology has been accused of being more 'an artistic task than an inferential process' (Forte, 2000). Uncritical acceptance of the product has led to a point where 'fundamental questions relating to issues such as what we actually mean by virtual reality, and what our expensively assembled models truly represent have been left largely

unexplored' (Emele, 2000).

As Barceló (2000) notes:

> ...future advancement of virtual reality techniques in archaeology should not be restricted to "presentation" techniques, but to explanatory tools...
>
> ...VR techniques [are] not only for description, but for expressing all the explanatory process. An explanation can be presented as a visual model, which is as a virtual dynamic environment, where the user asks questions in the same way a scientist use a theory to understand the empirical world (Barceló, 2000).

The perspectives introduced above were to act as both visionary statements and cautionary notes to the visualisation project. Against the potential of a digitally reconstructed archaeological model, the project was constrained in a number of ways with regard to the final product. Resource restrictions (time and computing power) meant that it was necessary to fix an approximate date in the history of Olympia rather than use the model to examine the changes at Olympia over time. Interactivity was also restricted to force the users to complete a tour of the site (with choices along the way) in 20 minutes, rather than allowing free interaction. Juxtaposition of the reconstruction and the archaeological site was introduced by the use of panoramas from the Olympia site as it appeared in March 2000.

The paper will now introduce the Exhibition that gave the opportunity for the creation of the works and the impetus for the Web.

The Exhibition *1000 years...*

In 2000 Sydney hosted the 25th Olympiad and was also the recipient of the most significant selection of antiquities from ancient Greece ever seen in Australia. Sydney's Powerhouse Museum featured 54 ancient objects - most of them usually on permanent display in their museums of origin in Greece, and many being famous icons of Greek art. The exhibition, *1000 Years of the Olympic Games: treasures of ancient Greece* (July -- November 2000) captured some of the magic that constituted the essence of Olympia, and the vibrant ancient Greek society in which it thrived. The majority of objects coming from Greece to the Powerhouse Museum, including sculpture, grave markers, votive offerings, ceramic vessels and sporting equipment, date from around 700 to 200 BC. This slice of time is one of the most energetic periods of human endeavour ever recorded. Subdivided chronologically for our convenience into the Archaic (about 660-480 BC), Classical (480-323 BC) and Hellenistic (323-27 BC) Periods, it was during this time that the essentials of western life were defined - including philosophy, poetry, drama, architecture, art, and sport (Donnelley, 2000).

Due to a significant sponsorship offer by the Intel Corporation, the Exhibition had two interactive components - the digital reconstruction of Olympia and the 3D Zeus - incorporated into it. Most importantly (according to sponsors wishes), both of these works would be translated for the Internet in a state-of-the-art Web. Data acquisition was a major task in creating the initial exhibits.

The site of Olympia -- data acquisition

The site of Olympia is in fertile countryside squeezed by the steep and tree covered Mount Kronos into the elbow of two rivers - the Alpheios and Kladeos. Archaeology and historical records show that little has changed at this site over the past few millennia. In the prehistoric period, its verdant topography inspired the worship of nature gods and set it on a course for greatness as one of the glories of ancient Greece. This isolated glade was to spend 1000 years as one of the most important religious sanctuaries in Greece, with its Olympic Games a fundamental component of worship to the supreme deity in the ancient Greek pantheon: Zeus (Donnelley, 2000).

A team comprised of a curator, archaeologist, surveyors and photographers traveled from Australia to Greece early this year to capture the data sets in high resolution using laser scanning and digital photography. Most of the archaeological remains at Olympia are scattered across the site, the result of two earthquakes of the 6th Century AD and numerous floods. Those foundations that survive date to different periods, from the Archaic, Classical, Hellenistic and Roman times.

The excavations at Olympia were begun in May 1829, by French archaeologists. The initial finds (metopes from the opisthodomus and parts of the metopes from the pronaos of the Temple of Zeus) were transferred to the Louvre where they are still being exhibited. When the Greek government was informed of the looting of artefacts, the excavation was stopped.

Excavations were started again 45 years later by German archaeologists. Research continues today by the German Institute of Archaeology in Athens and the Ephorate of Antiquities in Olympia. The Museum of Olympia associated with the archaeological site houses many of the sculptural and object material that has been recovered from the site. Supplementary material on the archaeological site and its associated Museum can be found on the Hellenic Ministry of Culture's Web (http://www.culture.gr/).

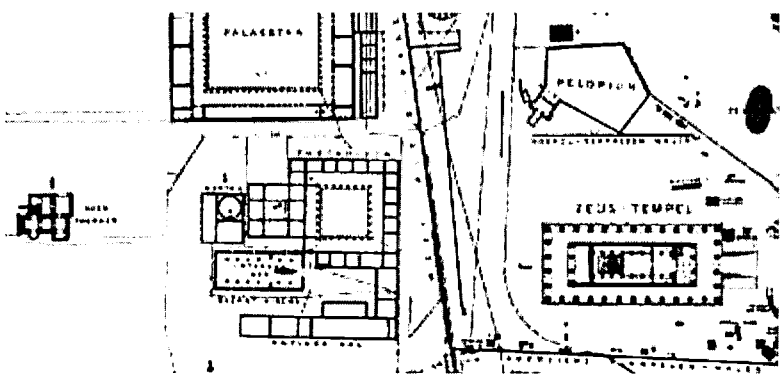

Fig 1: Detail from an excavation map of the site of Olympia, Adler & Curtius 1896.

The bibliography on Olympia runs to hundreds of items, although those dealing strictly with the archaeology of the site can be counted in the mere dozens. The most important sets of documents for the

reconstructions were some of the oldest. It almost goes without saying that any work on Olympia would be nearly impossible without Pausanias' *Guide to Greece* (2nd AD).

The five text volumes of the earliest German series, *Olympia. Die Ergebnisse der vom Deutschen Reich veranstalteten Ausgrabung* (Adler et. al. (1892-1897); referred to hence as the Adler and Curtius publications) contain incredibly detailed descriptions of buildings and objects, complemented by the hundreds of plans, sections, drawings and reconstructions in the accompanying folio volumes. Subsequent important updates have been published by Ashmole & Yalouris (1967); Grunauer (1971) and (1981); Miller (1971); Mallwitz (1972); Herrmann (1972); Koenigs (1984) (Da Costa et al, 2000).

Archaeological and historical considerations

The project team decided to attempt to reconstruct Olympia, as it had been around 200 BC. Of course, it is actually impossible to pick a single year to reconstruct an ancient site, given the relative coarseness of archaeological chronology. At a site like Olympia, used without interruption for over a thousand years, almost certainly with frequent refurbishment of quite old buildings, it is really only possible to establish the rough date a building was erected. Whether a building was undergoing renovation in a particular year cannot be stated. The length of time it took to complete buildings is also another issue.

The choice of 200 BC was therefore made for mainly practical reasons: the later the date in the site's history, the more buildings there would be, and the more interesting a virtual tour for modern visitors would be and would more closely correspond to the extant ruins; it was an Olympic year; it was just before the Roman annexation of Greece began. We acknowledge the date was stretched slightly in order to incorporate the entire gymnasium and the *krypte* entrance to the stadium.

Individual buildings

The Adler and Curtius publications provided detailed ground plans of most buildings. As well, the elevations were usually calculated, and the extant decorative elements, mainly terracotta *simae* and *akroteria*, were associated with each building. Major additions or changes to some buildings were taken from the later publications. The drawings were used directly by the modellers to recreate each building. An attempt was made to incorporate as much small detail as possible given the limits of time and computing power (both in rendering and delivering the animated tour). For example, the Adler and Curtius volumes contained the differing capitals and columns of the Heraion, and these were included in the model.

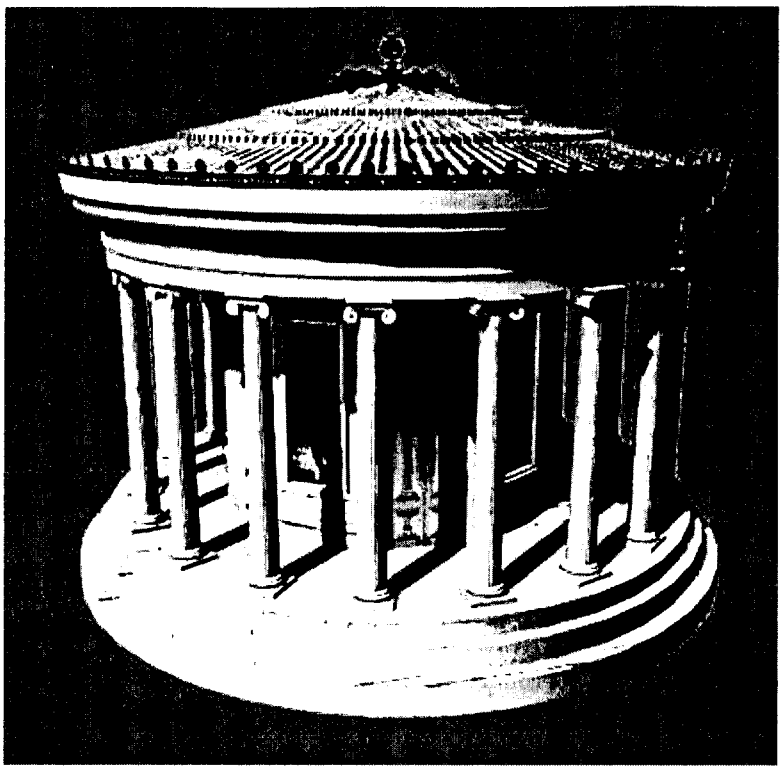

Fig 2. Work in progress, rendering the Pryaneion. © Powerhouse Museum.

Inevitably, there was missing information, and the limited timeframe meant that not every known detail could be incorporated. The application of colour, which is now standard in our concept of ancient Greek architecture and art, is still difficult because of the lack of evidence. One particular difficulty in using the early German work is that the colour plate published (Volume II, plate CXII) does not correspond with the text description of colours or placement, even though it is supposed to be the template for the painting of Doric buildings at Olympia. This is partly a factor of colour printing techniques in 1896 and the fact that we had the 1966 reprint, and also due to the difficulty of really knowing what colours such as "mild whitish cobalt blue" or "a strong but at the same time transparent blue" actually were. However, we followed the Adler and Curtius publications as closely as possible in terms of applying colour to the buildings, and the evidence of the terracotta roof decorations excavated at the site was particularly helpful in this regard.

Buildings which must have had pedimental sculpture or for which some fragments of sculpture remain, such as the Metroon, were given pale blue pediments, rather than attempting a poor reconstruction. Doors and lattice screens were based on those depicted on black and red figure vases.

Fig 3. Metope X from the Temple of Zeus. The Apples of the Hesperides. Archaeological Museum at Olympia. Photograph Powerhouse Museum. © Hellenic Ministry of Culture.

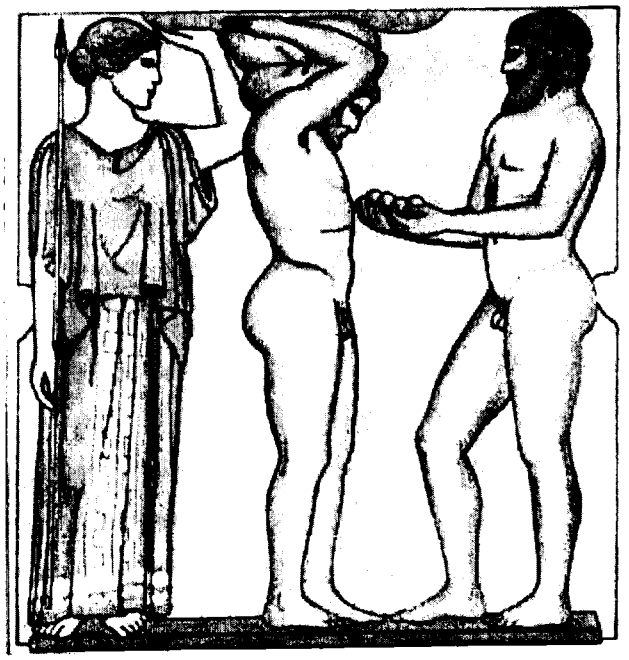

Fig 4. Colour interpretation Metope X from the Temple of Zeus, The Apples of the Hesperides. Drawing David Loong. © Powerhouse Museum.

Probably the least satisfactory outcome, given the time restrictions on the project, related to the addition of statuary to the Altis area of

Olympia. Literally hundreds of dedicatory statues and objects would have been placed into the sacred area, but we were able to reconstruct only a handful, modelled on excavated statue bases and the descriptions in Pausanias.

Our most ambitious reconstruction was the interior of the Temple of Zeus. This was based only on Pausanias' descriptions as no evidence remains. It is thought that some coins and Christian icons reflect the seated Zeus figure, once one of the wonders of the ancient world, but they have already past through the filter of later cultural biases.

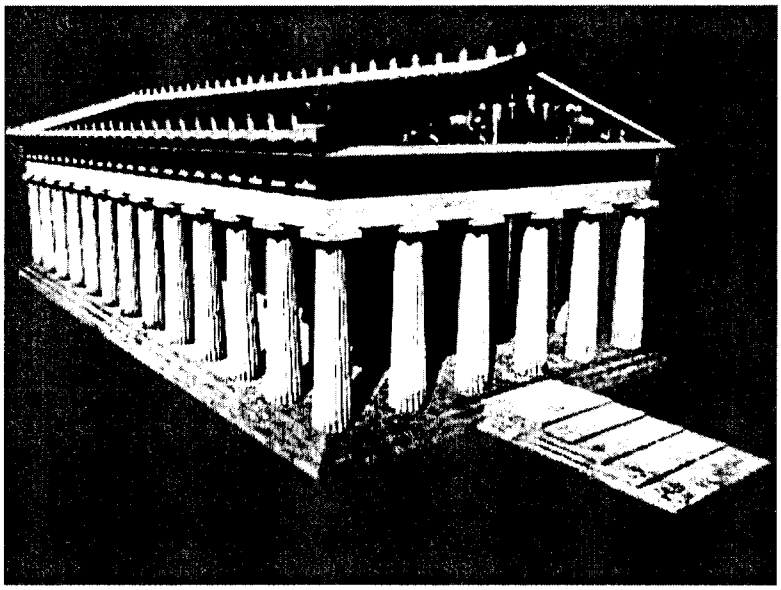

Fig 5. Reconstruction of the Temple of Zeus. © Powerhouse Museum.

A further discussion on the basis for reconstruction is available from the project web (http://www.phm.gov.au /greek/4/pdf/archaeological_basis.pdf).

The digital model

The topography of the site and the locations of key structures were surveyed by members of the team so that the present surface (which approximates the original ground level of the site) could be used in the visualisations. This was performed using surveying equipment loaned by the National Technical University in Athens. A digital elevation model was prepared from this data, and combined with a detailed terrain model of Kronos Hill obtained from large-scale topographic maps. In addition, the surrounding landscape was also modelled from smaller scale topographic series maps. As a result, the landscape of ancient Olympia used in the visualisations is a very close approximation to the terrain of the period.

Every graphic element was created for the project. Existing digital Greek architectural elements would not have allowed us to maintain a sufficiently high level of contextual accuracy. For example, the Temple of Hera (where the Olympic torch is ignited) has every column different as it was constructed and reconstructed over a long period of time.

Standard commercial digital library elements did not easily modify; in all cases it was easier to create new elements. The human figures and statues were modelled originally in Poser V4, and modified in 3D Max.

Display

The delivery of the VR reconstruction posed many challenges. The intention was to provide a 3D 'experience' of Olympia to an audience of up to 20 people at a time using affordable technology. A rear-projection polarised projection system with inexpensive plastic glasses was developed. Two JVC DLA-C15 rear projection capable projectors were used to overlap the left and right channel images onto a 3m wide screen in a 5m square room.

Fig. 6. South-south-east aerial view of the reconstruction. © Powerhouse Museum.

Future

The virtual reconstruction of Olympia was intended for the general public (with limited interactivity) rather than for use as a teaching tool. However, the underlying dataset of the model does allow for scientific use. Some areas for investigation include

- Modelling sun in relation to temples
- Modelling the earthquake effect on the Temple of Zeus
- Model allows for further research about the use of the sanctuary and liturgical practice
- Choices for colour applications invite responses from the academic community.

Statue of Zeus

One of the most significant sculptures in the National Archaeological Museum in Athens is the statue of Zeus from Artemision (Artemesium), also considered to be perhaps a statue of Poseidon. This bronze sculpture is slightly larger than life size, and was found in 1926 in the sea off Cape Artemision. It is one of the few surviving examples of Early Classical statuary. The laser scan of the Zeus allowed this object to travel, in a virtual sense, from Athens to Sydney.

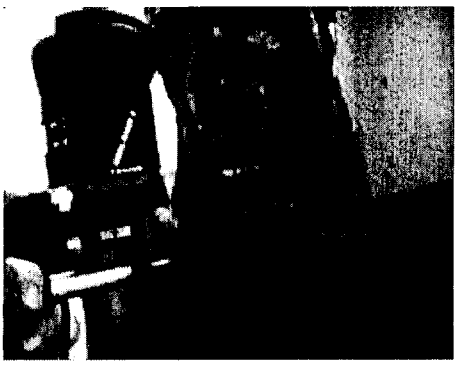

Fig 7. Laser scanning the statue of Zeus at the National Archaeological Museum in Athens, March 2000. Photo University of Melbourne. © Powerhouse Museum.

A laser scan

A Modelmaker Laser Scanner mounted on a Faro 3D Coordinate Measurement Arm was used to create high-resolution point clouds of the surface of the statue. A purpose-built scaffold was fabricated in Athens to enable elevation of the scanner to the top of the statue while ensuring a stable fixture. The entire sculpture was digitised over several daytime sessions in multiple parts. There were considerable restrictions on this part of the project, which included no method of re-orienting the scanning system datum and a very short working period in the Museum.

The data resulting from the laser scanning operation consisted of very dense clouds of points representing the surface of the statue with a coordinate accuracy of around 0.2mm. This presented many difficulties as the data sets were huge and needed substantial filtering before they were useful. The decimation process reduced the density of the data points without reducing the high level of detail in the model. The process used a variety of software packages, finally resulting in 3D Studio Max model of the statue. This contained over 2 million polygons.

Presentation

The Zeus model was presented in a separate virtual reality booth at the Exhibition. It was displayed using shuttered glasses technology driven by proprietary software running on Intergraph hardware.

A limited amount of interactivity was provided where users could rotate the model about its vertical axis, and zoom in and out. A higher degree of interactivity was not appropriate given the respect accorded the actual object itself, and therefore, its facsimile! (Da Costa et al, 2000).

The aforementioned works - Olympia and the Zeus - were both then translated into the products for a state-of-the-art Web.

Web site (http://www.phm.gov.au/ancient_greek_olympics)

Despite the great opportunity to produce these aforementioned interactive Exhibition materials, the sponsors of the project (Intel

Corporation) and the Museums' main interest involved the production of a state-of-the-art Web. This Web was intended to augment the Exhibition, and to demonstrate the viability of the Internet to supplement and extend materials offered locally in the Museum. The ability to give access to this material to wide audiences and the fact that it will eventually outlive the Exhibition by two years is also the advantage of this medium.

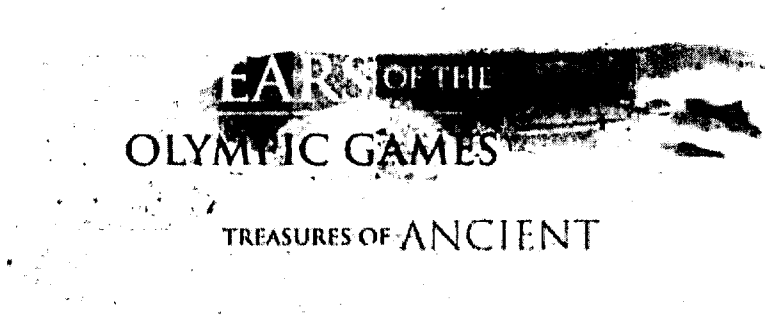

Fig 8. Screen grab from the homepage of the web, 1000 years of the Olympics Games: treasures of ancient Greece, 2000. (http://www.phm.gov.au/ancient_greek_olympics). © Powerhouse Museum.

To meet the sponsors' expectations, this Web was constructed to demonstrate the use of state-of-the-art technologies for the delivery of rich cultural content. The web was designed with a two-week exclusive period for the Intel Web Outfitter Service in the United States, where subscribers have a minimum of a PIII chip and are regularly updated with the latest plugins. From the Museum's perspective the opportunity to design a product with a high degree of sophistication outweighed the concerns over download times and minimum browser specifications. The Web was ultimately intended for academic, school and researcher markets.

Architecture, design and programming

The web was scripted as active server packages. A flash based navigation system was used. There was high use of 360° panoramas constructed with Live Picture from Reality Studio. Apart from the standard plugins such as Abode Acrobat Reader, the main plugin is the Zoom Viewer by MGISoft. The latter has two main utilities: it allows the high-resolution images to be stored on the server and streamed to the user on demand; and it prevents the users from saving the materials to their hard drives. This last feature is of extreme importance to the Greek Hellenic Ministry of Culture and the Museum who wish to protect copyright. As noted, none of the Exhibition artefacts (also on display on the Web) had travelled outside Greece before. With a history of contentious international relations over Greek antiquities, it was very important to all those involved that every measure be taken to prevent unwanted use of the digital materials. VRML was not considered to be a robust or user-friendly environment for translation of the Olympia reconstruction. However visualisation in 3D is certainly the way forward for the display of these materials in the future, and major developments continue in this field.

The web is constructed in six sections. These are:

1. The Exhibition: a series of zoomable panoramas of the Exhibition at the Powerhouse Museum augmented by 3D object movies and high-resolution zoomable images of objects, and supplemented with object information as text.

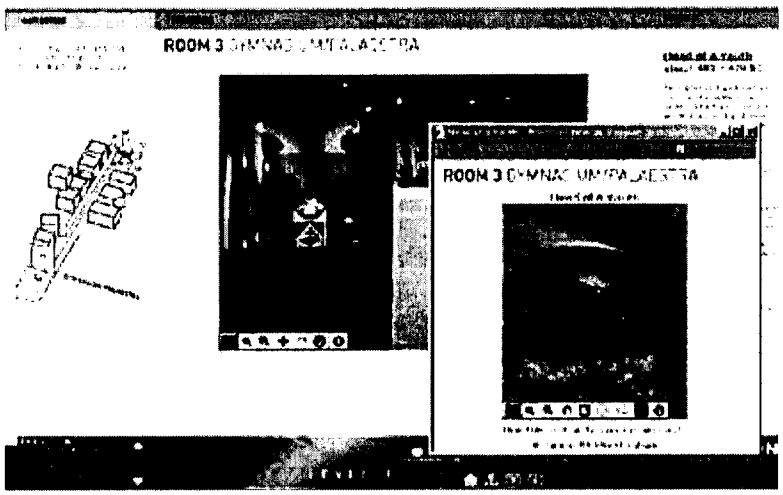

Fig 9. Screen grab from the virtual Exhibition of the web, 1000 years of the Olympics Games: treasures of ancient Greece, 2000. (http://www.phm.gov.au/ancient_greek_olympics). © Powerhouse Museum.

2. Virtual Olympia: this section contains a rich collection of materials separated into 4 sub-sections, including:

- Archaeological and geographic maps of Olympia
- A panoramic tour of the digital reconstruction of Olympia presented as 360° zoomable panoramas (viewable at full screen) with audio files. The option to download individual buildings to complement scholarly research is also available. Essays available as PDF files
- 29 zoomable 360° panoramas of the archaeological site at Olympia taken in March 2000 (viewable at full screen). Essays available as PDF files
- The statues from the Temple of Zeus shown as a 360° panorama of a room at the Museum of Olympia, and a series of zoomable object movies. The metopes are further supplemented by reconstructed line drawings and colour interpretations using archaeological and historical records as sources for reconstruction.

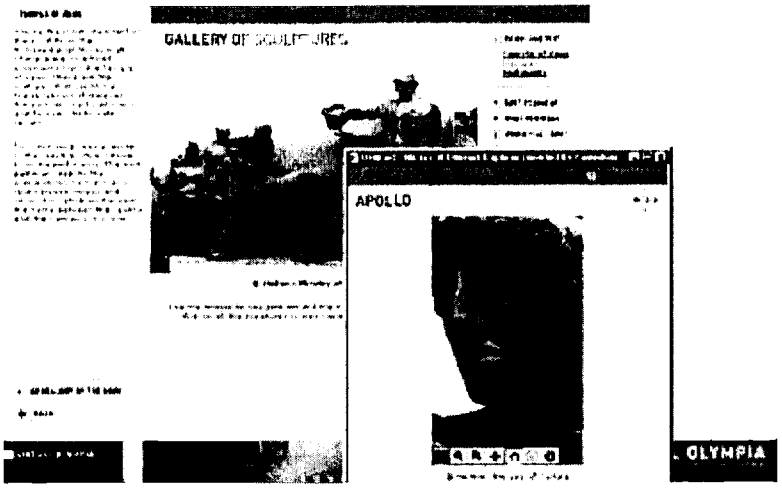

Fig 10. Screen gab from the Temple of Zeus statues as displayed in the Museum of Olympia, 1000 years of the Olympics Games: treasures of ancient Greece web, 2000. (http://www.phm.gov.au/ancient_greek_olympics). © Powerhouse Museum.

3. 3-D Zeus: a web version of the laser scan of the Zeus of Artemision, with the option to view as a 3D anaglyph through downloadable anaglyph glasses.

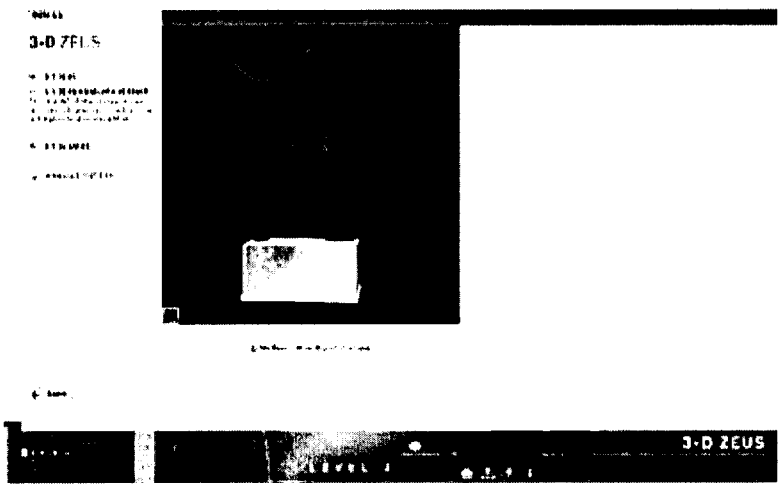

Fig 11. Screen grab from the 3D Zeus, 1000 years of the Olympics Games: treasures of ancient Greece web, 2000. (http://www.phm.gov.au/ancient_greek_olympics). © Powerhouse Museum.

Resources:

- 14 researched PDF articles
- Education programmes
- Glossary of terms linked to the PDF articles
- A nodal genealogy of the gods
- Supplementary programme of events to complement the Exhibition at the Powerhouse Museum

- All audio files are listed.

5. Image archive: because of the extensive visual components in the web, this section offers a quick entry to all the individual panoramas, zoomable images, object movies and jpegs. Selected buildings from the digital reconstruction of Olympia are available here, for research purposes, to download and print.

6. Timeline: a timeline of events at Olympia over a 1000-year-period is organised into three categories:

- Events specific to the Games at Olympia (events added after 200 bc not included)
- Events relevant to Olympia itself (building programme until end of Hellenistic period only)
- Events, political, around the Mediterranean world -- after 200 bc only events directly relevant to Greece or Olympia included: politics, arts & sciences.

The Web also contains extensive project information, help information, plugins and downloads pages.

Promotion and marketing

The Web was launched just prior to the Olympic Games. It benefited from a high degree of marketing through its association with the Intel Web Outfitter Services and was featured on the homepage for the Intel.com Web for a short time in the United States and Australia. The site was translated into three other languages: Korean, Chinese and Japanese. In conjunction with children, the Premier of the State for New South Wales launched it. There was a high degree of media coverage derived from the Web launch and also from the Exhibition itself.

Analysis

Statistical data has so far been analysed for the four-month period of the Exhibition -- from the beginning of August, 2000 until the end of November, 2000. The author acknowledges the restricted nature of basic statistics to determine true use of the Web. However, general statistics are presented here to demonstrate several observable trends.

The average number of hits per day over this period totalled 18,500. Other broad general-level statistics include these: the average number of visitor sessions of 52, 582, and the average visitor length of 12 minutes. The majority of visitors were from outside Australia (international at 55% and unknown at 29%).

A more thorough examination of the period shows a predictable variation in the data display. The most active day of use was during the Olympic period and on September 16, 2000 with 92,352 hits. Weekdays rather than weekends showed a larger number of hits although it was after-hours that numbers were marginally higher. This contradicts our initial expectations that the high bandwidth required to access the site would preclude extensive home use.

What is potentially of more interest is the length of stay by each visitor: 45% of visitors accessed just the first two pages of the Web. There was

a corresponding drop off as the number of pages increasesd. However, a relatively high proportion (8% of the visitors) was staying over 20 minutes to access 43% of the total page views. This last statistic would suggest that those visitors who were interested in the site found rich and rewarding content. At one point in the 4-month period over 18% of the visitors were staying more than 20 minutes. In Web lingo this has been referred to as Web "stick-ability" (and hopefully not a measure of slow content download!).

The Web will be hosted on the Museum server for two years. As is so often the case, the overall development time for the entire project was just 4 months -- including the Exhibition 3D materials. This prevented extensive usability testing before launch, and represents a classic scenario in museum projects. During the upcoming period it will be possible to further analyse the Web use in schools and tertiary institutions. There have been numerous complimentary emails from such organisations about the quality of the scholastic research, although there have also been requests for a CD ROM version to allay the heavy bandwidth requirements.

Awards

The overall project has won many awards in the short time since its launch. The most important of these include a Virtual System and Multimedia award for the Best Virtual World Heritage reconstruction; the Best of the Best web for the Australian Interactive Multimedia Industry Awards; the Best Interface Design at AIMIA; Hitwise Top 10 for Education and Research 2000; and the Web was a finalist in the British Association for Film and Television Interactive Entertainment Awards 2000 (short-listed to one of three along with the multi-million dollar 'Walking with Dinosaurs'). The judges described it:

> A fascinating and highly interactive site, this is elegantly designed and technically impressive and brings you closer to Olympian Greece with effortless navigation and appropriate use of all media, including superb panoramic photography and walk through 3D architecture. It is a state-of-the-art web with an excellent interface and very high-quality content. A technical tour de force deploying a broad range of impressive plig-ins to good effect (BAFTA awards catalog, 2000).

Conclusion

Any project of this nature is concerned with how to balance 'realism' with 'reality', and the decisions made in the creation of digital reconstruction were further constrained by the goals of the project, the intended audience, the desired product, the quality of archaeological information, and technological capabilities. In the construction of the Web, a further caveat on design decisions included the use of state-of-the-art technologies, which must demonstrate impressive content development and display for a sophisticated Web user demographic. This questioned the Museum's role as a provider of 'access for all', but at the same allowed for the Museum to push limits in Internet design and technology using rich cultural content.

The Web and its contents are being re-purposed for a DVD ROM which will be distributed free of charge to all schools in the State of New South

Wales, Australia, and in limited numbers for other markets. The 3D version of the digital reconstruction of Olympia has been sold to three international Olympic museums, and is to be used in university teaching in some form.

The project is an example of a digital reconstruction project that has been repurposed for a highly successful Web. It also demonstrates that rigorous scholarship is a worthwhile investment and can command a significant audience. The repurposing of the underlying content has enabled the works to be developed for different platforms and delivery mechanisms. The challenge lies in providing users with the ability to alter input data to test their own hypotheses. The development of VRML worlds on the Internet (ones that are robust in implementation) will hold much value for museum Web developments.

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[Sections of this paper have been included in the project information available on the web (http://www.phm.gov.au/greek/4/pdf/Grecian2000weba.pdf) and (http://www.phm.gov.au /greek/4/pdf/archaeological_basis.pdf)]. With regard to these documents the author would like to acknowledge co-authors 3/4 Kate Da Costa, Cliff Ogleby and John Ristevski].

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