Computer Games and Archaeological Reconstruction: The Low Cost VR

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Abstract

As computer game designers struggle to reproduce reality ever more faithfully for game players, they simultaneously provide archaeologists and researchers with an inexpensive and effective tool for real-time three-dimensional reconstructions of ancient sites. This paper presents the results of recent work examining the potentials of 3D game rendering engines for the production of educational and scientific visualisations of ancient sites. Since games are designed to run on personal computers with minimal system requirements often far below those required for many immersive real-time virtual reality environments they present a resource that can be accessed by many different users without great expense. In addition, most recent game engines come packaged with software designed for the creation of new 'levels' and features. With careful planning, these tools can be used to create non-game environments that allow users to experience an archaeological reconstruction by personally navigating it at their own pace. Following in the footsteps of recent work at the Martin Centre for Architecture, Cambridge, which used the QuakeTM engine to produce new architectural designs, the present work critically appraises the advantages, disadvantages and utility of this resource for the archaeological reconstruction of ancient Roman domestic environments.

VR and Computer Games

The value of virtual reality and computer visualisation in archaeology for scientific research, archaeological preservation, public access, documentation and publication has been the subject of considerable interest in recent years. Projects like the UCLA Cultural VR lab's Roman Forum project, the Troia VR project, and the CNR ITABC[1] have set the standards for realism, scientific examination, archaeological accuracy and transparent documentation in computer reconstruction and emersive virtual reality. However, while much effort has centred on improving the quality and scientific validity of computer-aided visualisation, their actual production has only been possible for large-budget projects with access to powerful computers and specialised interface equipment. While most projects do not have the funds necessary to work at this scale, they would nevertheless benefit from computer visualisation and reconstruction.

I suggest that the computer game industry has already provided archaeologists with tools that can be used to produce virtual reconstructions at a fraction of the cost of more 'academically recognised' software with only marginal losses in quality with minimal investment of time on low-end systems. Furthermore, the growth of the computer game industry will continue to provide ever more useful and realistic visualisation tools. Computer game platforms also have unique abilities that their more official cousins do not, such as inherent Internet functionality and multi-user access. While game engines cannot and should not replace high-end reconstruction, they do offer a greater spectrum of choice for individual projects and the opportunity to use the appropriate tool for the job.

The Project

As a component of my PhD research, I began a project in order to examine whether computer game engines could provide the tools necessary for archaeologists to create scientifically acceptable emersive 3D environments that would ultimately be useful for academic purposes as well as for public presentation. Since my research centres upon the use of Roman domestic space and on Pompeii in particular, I decided to reconstruct a single Pompeian house: that of P. Paquius Proculus (or C. Cuspius Pansa - Regio I, 7, 1), restoring it to its appearance just before the AD 79 eruption of Vesuvius. I already had a large database of digital photographs of this house including images of each side of every wall.[2] In many cases floors were also photographed, but the archive had not been taken with this project in mind. This meant that many of the photographs had to be rectified before they could be used as flat textures in the virtual environment. Nevertheless, I felt that this resource, in combination with accurate floor plans[3] would allow for a reasonably accurate reconstruction of the house. The project used a Compaq Presario 1700 Laptop, Pentium III 800MHz with 512MB RAM and an 8 MB graphics card for authoring and presentation.

Many different game engines were considered for the project. Because of similar work previously carried out by the Martin Centre for Architecture at the University of Cambridge, and also because of an amateur production of an accurate model of the Titanic with this engine, Quake 2 seemed at first to be a strong candidate.[4] However, from a cursory examination, both the interface and the graphics quality seemed to be inferior to other engines. Ultimately, I decided upon the Quake 3 engine because it offered a greater degree of control over lighting and 'radiosity' reflection properties as well as true

curved objects. While it lacked the ability to create 'story line' scenes that might have been ultimately useful for presentation or teaching, I felt that greater accuracy of the model itself was more important.
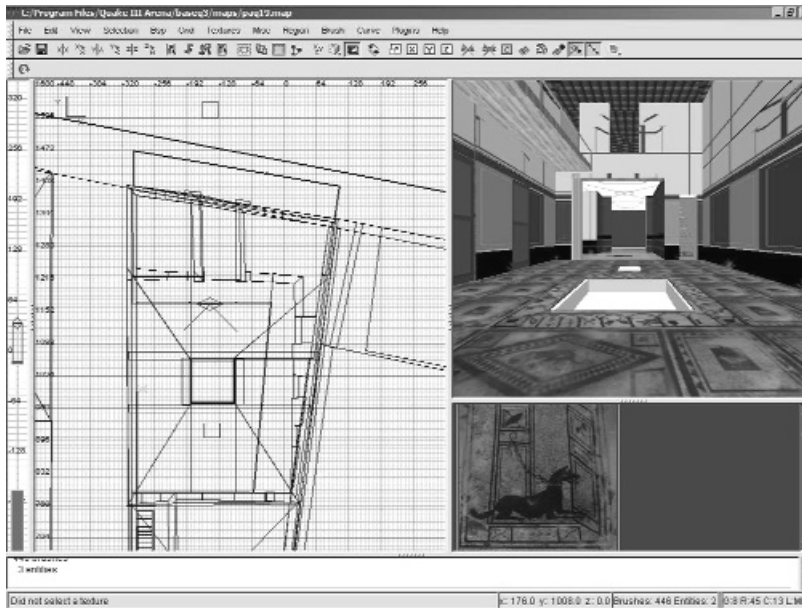

Figure 1

The project used a variety of software packages to achieve the greatest possible degree of processing convenience and accuracy. The primary editor used was Gtk-Radiant 1.2.11, which was freely available on the web.[5] The interface consists of three windows that present the map overview, an elevation window, and a low-resolution 3D view (Fig.1). However, while this editing package does place objects on grid of coordinates, there is no direct command line for accurate point entry such as is found in many CAD packages, and archaeologically accurate placement would have required a painstakingly slow approach of carefully placing each vertex by hand using the x, y and z coordinates displayed in the corner of the screen. To make matters worse, Gtk-Radiant does not support the DXF format either for import or export.

I found that a freeware beta version of Discreet's 3DStudio Max called Gmax: Tempest could import DXF files.[6] It provides a similar interface to that provided by Gtk-Radiant but I found that exporting maps for the Quake engine was not as straightforward. The beta status of Gmax:Tempest also meant that complete documentation was lacking and this hampered its use. The decision was therefore made to use Gmax:Tempest to produce a map containing the basic structure from DXF files, but to detail and finalise it in Gtk-Radiant.

Accordingly the floor plan of the house was digitised in Adobe Illustrator and saved as a two-dimensional DXF file, which was then scaled appropriately in AutoCAD. Afterward, the two dimensional DXF file was imported into Gmax:Tempest and the polygons were extruded to a standard height. This resulted in a set of 3D Studio Max polygons that were then capped and turned into Quake polygons. The result was saved as a map file in such a format that Gtk-Radiant would understand. After loading the new map file into Gtk-Radiant, it became apparent that the polygons would have to be replaced by hand, as miscommunication between the two programs meant that when maps were compiled rather serious errors occurred.

Finally, with an extruded floor plan consisting entirely of stable polygons, the true work of reconstruction and detailing could begin. Upper roofing configurations and wall heights had to be largely hypothetical, but this is not unusual in virtual reconstruction. Once the polygonal structure of the building was complete, textures had to be created in order to recreate their AD 79 appearance. Wherever possible, the actual preserved walls were used as templates for the textures. In cases where no information was known about the wall decoration, they were either left as plain white or decorated with a standard wall texture that could be easily identified as merely representative.

The most challenging stage of the production was the final rendering, which required setting light values for the sky and sun and working with the radiosity settings. Surprisingly, these did not function as would have seemed logical, and it was often necessary to use ridiculously high values in order to generate 'realistic' results.

RESULTS

The final result of the project was the successful reconstruction of the house of P. Paquius Proculus as it may have appeared just before the AD 79 eruption of Vesuvius. The model compared favourably to photos taken within the currently preserved ruins, and the interface through the game engine provided a realistic experience of the house structure, size
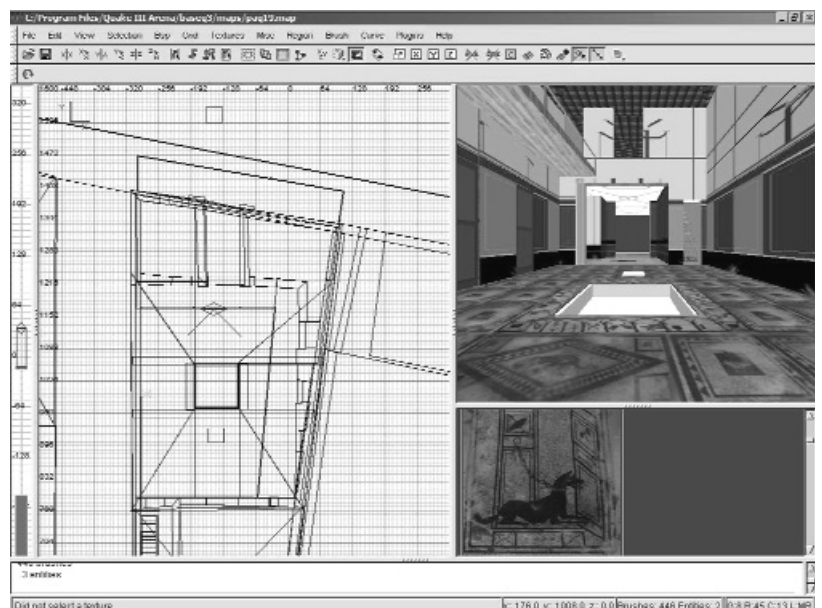

Figure 2

Figure 3

and phenomenology (Figs.2 and 3). The surrounding city environment was created in 'movie set' fashion so that the vistas from upper stories would be more accurate and the visualisation more complete. Surrounding landscapes were also supplied so that standing on the balcony of the house the Sorrentine peninsula is visible. All lighting in the model comes from the sky and reflectance within the house, and highlights the fact that some rooms were evidently quite dark even at noon.

LIMITATIONS

This project set out to assess whether computer game engines could be used for scientific archaeological VR and visualisations. While the final results certainly justify the use of computer game engines for archaeological reconstructions, it is apparent that they do suffer from significant limitations that will need to be overcome before the use of such engines can become widespread.

The most pressing issue for the use of computer game engines is access to the source code. Even in cases where the source code is 'open' and can be modified into completely different games certain aspects of the code remain occluded either because of 'black boxes' or more frequently because the information is not clearly documented but must be gleaned from endless online forums filled with extraneous material.[7] For instance, while it is possible to change almost all aspects of the Quake 3 engine mechanics the exact functioning of the radiosity calculation used for rendering Quake maps is not immediately transparent. This means that evaluating the accuracy of results is difficult, especially since the immediate effect of changes made during compilation is not always clear. This is made all the more frustrating by the fact that problems do exist with the compilation process that are infuriatingly hard to solve.

Most notable of these is the 'light leak' problem that exists at the edges of polygons. When the polygons are too thin (i.e. less than 16 units) light will leak between the join, no matter

how the polygons are arranged. Indeed, this will occur even if they are not touching at all, and the problem is even worse if the polygons are not aligned with the main grid axes. This light does affect the overall radiosity calculations and can lead to some very inaccurate results. Clearly when the game was written, it was felt that thick, heavy constructions were the type of architecture likely to be built by game players. Unfortunately, since scientific visualisation aims at accuracy, one cannot simply thicken the walls to solve the problem. In fact, the only reliable way to solve this problem is to scale up the entire structure so that all polygons are more than 16 units thick. In turn the height of the player's viewpoint is too low to approximate reality.

Another major problem is that of the polygon dynamics themselves. The game engine has difficulties when polygons overlap in any way, and generally expects all joins to occur perfectly on the imposed grid system. Of course, when designing a game level of an imaginary place, then this is a simple matter of keeping the polygons relatively simple and angles sharp. However, it is much more complicated when using real archaeological data which does not always line up perfectly. This can lead to walls that suddenly disappear during the rendering process, or are visible from some locations within the model and not others. Such infuriating problems consumed many hours of the time and solutions to such problems were not immediately apparent or available on the Internet.

Finally, there is the problem of the scientific nature of the reconstruction. I have already suggested that lighting values are somewhat arbitrary. In fact, not a single measurement in the system corresponds to a real-world measure. Units on the grid are 'units' and although on-line there is a general belief that eight units equal one foot, in my experience this measure does not seem to be accurate. One can only be certain that objects in the current model are accurate with respect to each other since the floor plan was scaled correctly to begin with and all vertical projections were carefully performed.

Finally, there are certain limitations that are not related to the actual functioning of the software, but rather rest on the idea of using game engines at all. To begin with, there is the problem of using proprietary software for academic work. Distribution of the end product relies upon the end-user having access to specific software and licenses. Since the production of low-end virtual realities, particularly ones to be experienced over the Internet is one of the major goals of this project, it must also be considered whether requiring users to purchase proprietary software in order gain access to information is really in line with the goals of academia and democratisation of information.

Persistence and longevity of the data are also a problem because the vagaries of the market may suddenly cause a game to be no longer supported, or future operating systems may no longer enable it to run properly. Of course, this pro-

blem exists for using any proprietary software, and to a certain extent is a problem with digital data as a whole, but the situation is more acute with computer games due to the velocity of development. Certainly this will continue to be a problem for any digital reconstruction using a game engine.

With these limitations noted however, it should be pointed out that not a single one of them is insurmountable. The creation of an online academic community dedicated to the production of scientific VR and visualisations with game engines would soon lead to workable solutions. Such a consortium could produce its own compilers, or at least properly document those currently available. At the same time, additional features could be added such as a standard scale for light and size. New features such as ODBC compliant database interaction allowing documentation and transparency of reconstruction decisions are also a possibility.Such modified versions might present a more serious user interface specifically designed for the archaeological audience.

While the fast paced development of new game engines and computer abilities means that current work will need to be constantly migrated to newer and better systems, the result is that continually greater degrees of realism and emersion will be possible. So long as archaeology constantly remains just behind the crest of the wave of development, then the money spent on the computer gaming industry can be made to work for archaeology at the same time. The Quake 3 engine cost the current project about ten pounds sterling, and the original Quake has already been made freeware. As engines become outdated, they will become increasingly accessible to all. There could be no greater force for the democratisation of information.

ADDITIONAL ABILITIES

It should also be pointed out that the use of computer game engines provides a host of advantages not provided by any other system. Most notable is the ease with which such material can be presented over the Internet. While the map files could be downloadable via the Internet for personal use, they could just as easily be hosted either on a LAN or the Internet. Because they are designed with a multi-user environment in mind, the games contain systems for communication between participants. I can envision such a reconstruction being visited by a set of experts from around the world, who could discuss in real time and give immediate feedback on the

reconstruction they were experiencing. Additionally, experts could give guided tours for students or the interested public regardless of their physical location. Since certain game engines were also designed to present non-adversarial entities for interaction, this presents the possibility to 'repopulate' these ancient spaces with computer-controlled agents performing their daily tasks, or an expert 'tour guide' with audio explanations of various aspects of the reconstruction.

FUTURE DIRECTIONS

This project has critically assessed the use of computer game engines for the construction of scientific visualisation and virtual realities, and has found that while significant limitations do exist, that this avenue of work should provide useful and worthwhile results. It is particularly important with the rapidly shrinking budgets of academic projects that money be spent wisely. The computer gaming industry has funds and expertise with which archaeologists can never hope to compete, and we should not attempt to do so. Extending or adapting existing technology to our purposes is an excellent way to avoid reinventing the wheel. I have suggested ways in which future development should iron out problems that exist in the current games engine software. Since the gaming industry will continue to advance technology, future projects will be able to produce even more impressive results. We must continue to bridge the gap between tools and products designed for games and those that produce results acceptable to academia. As the gap between the highest quality academic VR projects and computer games closes, it will become even more important that standards, methods, tools and community be created to make these programs more accessible and acceptable to the archaeological community. It is the further goal of this project to begin work on these tasks.

[1] cf. Forte, M., this volume.
[2] By the kind permission of the Soprintendenza archeologica di Pompei, and with help from the Anglo-American Project in Pompeii.
[3] Plan taken from Corpus Topographicum Pompeianum, 1986.
[4] http://www.arct.cam.ac.uk/research/pubs/pdfs/rich00a.pdf, http://www.planetquake.com/titanic/, cf. also Meister, M., Boss, M., this volume.
[5] GtkRadiant is available from: http://qeradiant.com/.
[6] Gmax and Tempest are available from: http://www.discreet.com/products/gmax/.
[7] Such as those found at: http://planetquake.com and http://www.quake3world.com.

REFERENCES

VAN DER POEL, H., 1986. Corpus Topographicum Pompeianum. Rome.