Archeologia e Calcolatori
15, 2004, 449-464

DIGITAL SPACES: POMPEII, THE INTERNET, AND BEYOND

1. Introduction

Archaeologists of the future will perhaps look back at our era and call it the Early Digital Age. Not since the development of the printing press has our ability to exchange information with others been so greatly augmented. Simultaneously, digital recording and storage have expanded the possibilities for recording and preserving information on a scale that must be compared with the invention of writing itself. While it is easy to get wrapped up in the new opportunities presented by the Internet, global communication digital recording, processing and preservation, we must not forget that new abilities also bring new responsibilities. Writing itself could not have functioned without the development of relatively consistent symbols, and printing also brought about standardised spellings, calligraphic simplifications and the development of a ready-made book trade and supply market.

While advent of the "digital age" and the growth of the Internet have revolutionised the world in less than ten years, we have not yet witnessed the growth of the requisite standards and regulations that must attend these changes. This is not the end, but rather the beginning, when much work remains to be done, both in making new technology useful to archaeology, and understanding the changes that have been brought about.

Perhaps the first step towards coming to terms with the changes wrought in archaeology by advances in digital and Internet technology for communication is to realise that for the most part these changes are at once spatial and visual in focus; a quality I call *spatio-visual*. One example of this is Internet publication. Traditional archaeological publication has been in the form of books and journals. Whilst computers and the web *can* be used to communicate in the manner of a book (the first intention of HTML was, in fact, to coordinate and format text in this way), this is not the form that has flourished. JavaScript, Flash and other web enhancements quickly developed in order to enable the computing world to create a more exciting virtual "space" inside the computer. Today, hyperlinks often illuminate as the cursor is placed over them, and frequently one is meant to interact with imitations of real, physical objects that cast shadows and depress when clicked.

This is particularly common in the commercially-driven segment of the Internet, but is true in all aspects of communication represented by the World Wide Web and computer technologies. Almost unconsciously, academic communication has also shifted significantly towards spatial and visual cues in the communication, analysis and presentation of research.

Even the terminology we use reveals a mental overlay of space and visibility. We speak of website *addresses*, email *inboxes* and spending time in *chat rooms*. We organise our computer files in *folders* placed on a *desktop* in an analogy that bears no relation to the actual way in which the computer stores our information. These attempts to anchor the intangible world of computers to a more concrete and physical world are a form of mental map; a crutch created by computer users to help navigate a confusing new medium. As the acquisition, processing and storage of information become increasingly abstract (after all, what is a digital photograph but a unique sequence of zeros and ones?), it is only natural that an artificial spatiality patterned after our own physical experiences in a spatio-visual world should be applied in order to make it acceptable to human users.

While on the one hand spatial and visual cues have begun to dominate the way in which academia interfaces with computers, spatio-visual information itself has increasingly become a focus of academic research and has also begun to drive the questions we ask. This is particularly true in the field of archaeology, which has always had a geographical and spatial bent of mind. Dramatic expansion in the number of projects using Geographical Information Systems (GIS), three-dimensional reconstruction or other means of visualisation in their research is indicative of this change. Motivation for these projects is not limited to landscape analysis or the examination of site resources, but has also begun to include ideological and phenomenological interpretations of spatio-visual information[1]. It has been observed that current two-dimensional archaeological recording techniques such as drawing plans and sections are inadequate given our ability to digitally record in three dimensions (Avern 2004; Barceló, Vicente 2004; Merlo 2004). Increasingly, the questions we ask require detailed spatial or visual knowledge in order to find answers, and the production of such resources will be the work of many future years.

It is clear then, that space and visibility are the new currency of communication in computing and academia, presenting at once a new source of research and also a means of presentation, preservation and documentation. This paper will examine both sides of this aspect of the digital revolution from the perspective of two projects that deliberately set out to preserve and present spatio-visual information in archaeology through digital means[2]. The first was dedicated to preserving an endangered area of Pompeii (Anderson

[1] T.G. Whitley's work on the ideologically patterned landscape of colonial slave plantations is particularly effective in this regard (Whitley 2003).

[2] There are other similar projects in Pompeii as well (Dobbins 1997; Tronchin, Bonilla 2002; Scagliarini Corlàita *et al.* 2003; Scagliarini Corlàita, Corallini, Vecchietti forthcoming.).

2003), and the second used the Quake III computer game engine to create an immersive virtual reality reconstruction of a Pompeian house: that of P. Paquius Proculus (Regio I, vii, 1: ANDERSON 2004). The aims, process, and results of each project will be presented as well as potential benefits and challenges encountered during the course of research.

While neither project was envisioned as an experiment testing the depth and meaning of the digital age, they do provide actual examples of attempts to apply the advantages of computers, the Internet and the digital revolution to academic research. Problems encountered and realised during the course of these projects have significant and far-reaching implications for the standards and conventions that, like those that surrounded the development of writing or printing, must be established for the digital age to reach its true potential.

2. QUICKTIME VIRTUAL POMPEII

QuickTime Virtual Reality (QTVR) presents unique possibilities for the preservation and presentation of archaeological sites. It can recreate the physical experience of spatial relationships by presenting interactive 360-degree views that immerse the user in the surrounding environment as though actually at the site. Using a mouse, the user manipulates the view as though turning within the site itself. Because a complete panorama is recorded, the process preserves aspects of ancient monuments that are lost by recording with plans and still photographs alone, and is particularly good at documenting spatial relationships. Due to its computer medium, QTVR also has certain advantages over standard text and photographs (KITCHENS 1998; KRAZNIEWICZ 2000). QTVR can be coordinated though HTML in order to link with databases, other types of interactive content, records and documentation. In this way, it can provide three-dimensional spatial information to tie together disparate archaeological information into a cohesive whole.

In the summer of 2000 I began a project to use QTVR to document a rapidly disintegrating area of Pompeii: the northern parts of Regio VI. This was one of the first areas of Pompeii to have been excavated and was uncovered as the early excavations of Bourbon treasure hunters moved from the Herculaneum gate towards the forum during the eighteenth century. After excavation, it remained exposed to the elements so that for many houses, only a few panels preserved in the Museo Archeologico Nazionale in Naples remain of the once fine wall paintings. This is in addition to the loss of the small finds that were long ago whisked away to private collections. The area also suffered from Allied bombing during World War II and, with the exception of a few lucky houses, stands largely abandoned due to chronic lack of funding for its care. For Pompeianists, Regio VI presents one of the largest contiguous areas of the city available for regional study and also contains many of the largest and grandest houses in the city. Because the wall structures have not been reconsolidated, as is the case on the eastern side of the city, the area also presents the opportunity to trace building history through wall construction events. For this reason, it is very important that the area should be available for study.

My project created a multi-purpose resource of linked QTVR panoramic views, coordinated through HTML and prepared for presentation and publication over the Internet (Figs. 1, 2). The finished product provides a resource for future study of the region, and if placed on the World Wide Web could allow this important area of the city to be studied by scholars or "virtually" visited by tourists from around the world without further damage to the actual remains. This archive could also be coordinated through PHP and Perl to a database of additional resources for each house, including detail photographs of salient features, further scholarly research and bibliography, observations and excavation reports[3]. The QTVR data clarifies currently available documentation such as citywide house plans, which are often quite ambiguous in terms of conventions for windows, built platforms and thresholds[4]. It also supplements higher-quality publications, which because of the expense of publication, must often be selective in their photographic coverage[5]. QTVR captures and coordinates such information in an interactive, dynamic and inherently spatial manner.

2.1 *Digital advantages*

The process of data collection and coordination was a clear demonstration of the power of digital recording. The Olympus D-600L digital camera was used to capture the images at a resolution of 640×480 pixels. This is not a very high resolution but it is certainly adequate for QTVR and for Internet presentation. Since an average of about eight hundred photos were taken each day, it was vital that a digital camera be used. The most important additional piece of equipment was a tripod and mount designed for rotating on the centre of the lens with stops at 20 different intervals on the rotation. With these tools taking the photographs necessary for a QTVR 360-degree image was simply a matter of levelling the tripod and then quickly rotating the camera through each stop and depressing the shutter release. The project acquired over seven thou-

[3] PHP, MySQL and Perl present viable methods for connecting and coordinating data, and have already been used to great effect in this regard. Cfr. http://www.oxarchdigital.com/.

[4] The plans of Pompeii such as the *Corpus Topographicum Pompeianum* and that produced by H. Eschebach (1970) can be quite unclear at times owing to their two dimensional nature.

[5] Even excellent publications like the *Häuser in Pompeji* series or *The insula of the Menander at Pompeii* by Ling (1997) are limited to a certain number of photographs.

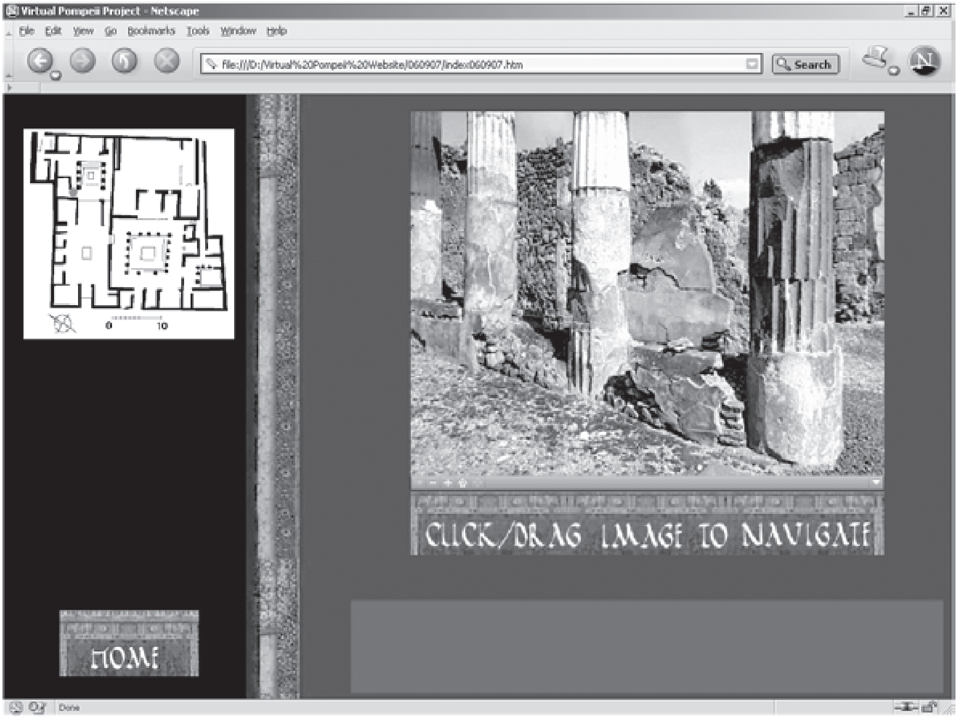

Fig. 1 – QTRV Panorama embedded into the HTML interface (Casa del Centauro, VI, ix, 03).

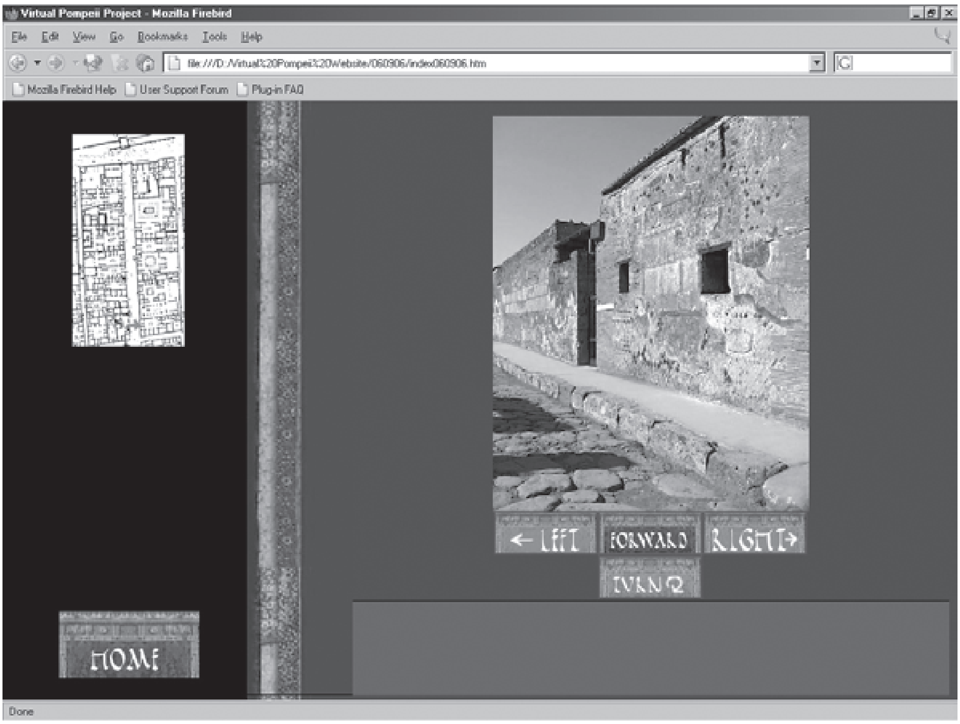

Fig. 2 – Still image to assist in navigation of the HTML interface (Vico di Mercurio).

sand digital images of the northern part of Regio VI during 65 hours of fieldwork at very little expense[6]. This would never have been possible with conventional film nor would it have facilitated the production of QTVR movies.

The interface for the presentation and use of the QTVR resource also demonstrates the strengths of digital media for data presentation. It was carefully designed to enable the user to gain as much information as possible through interactive exploration encouraging users to "navigate" the houses and streets of Regio VI by clicking on links embedded into the 360-degree images themselves, simulating the experience of walking through the ruins. At each step, a plan reveals the user's location and each link that the user follows loads HTML web pages that are designed to contain supplemental information or links to database material. These could consist of descriptions, publications, or a visitor's tour.

2.2 *Digital disadvantages. Longevity of image quality*

That the project successfully produced a useful, Internet-ready resource for the spatial and architectural study of Regio VI demonstrates the power of digital technologies for archaeology. However, it has also brought to light a number of problems that need to be addressed. Perhaps the most immediate problem is the archival quality of the images and the longevity of the digital resource. The resolution of the QTVR panoramas is sufficient to convey the spatial organisation and much of the archaeological detail of the houses preserved, but because the resource was designed for the Internet, compromises had to be made between image quality and download speed. Future researchers running more powerful computers may find the images to be small and of low quality by current standards. In fact, in the three years since the completion of photography, digital technology has far outpaced the resolutions of the images taken for this project.

However, no academically-accepted standard exists to indicate whether a given resolution is sufficient for archival documentation. At the moment, higher resolutions would simply hinder the use of this archive but future users will almost certainly not experience the same technological restrictions that we currently do. It is very difficult to solve this problem because we do not know to what extent future technologies will expand our capabilities, making current image qualities seem insufficient.

Resolution will always be a weakness of digital images that can only truly be solved by supplementing a digital record with traditional film recording as well. For a database of seven thousand images it is neither feasible nor cost-effective to duplicate every image on film raising questions regarding how useful any digital resource is likely to be in the future. Decisions will

[6] All relevant equipment was provided by the UCLA Digital Archaeology Lab.

need to be made about archival resolution standards, especially as archaeological projects increasingly incorporate digital imaging into their work.

2.3 *Instability of digital data*

To make matters worse, digital data is inherently unstable. It may feel reassuring to see one's data recorded securely on a CD-ROM. However when we remember that these may begin to degrade after 50 years, and even more quickly if frequently used, print suddenly seems a more durable option[7]. The journals of well over a hundred years ago can still be found in university libraries everywhere, but finding a CD-ROM written today that still functions a hundred years from now might be more difficult.

This problem may be solved through the migration of data into more modern formats. However, it is a simple matter to estimate when the effort spent in transferring old information will take up so much time as to render it impossible to collect new data (Zemanek 2004). The computing and digital revolution has made it possible for us to collect astronomic amounts of information and spatial and visual data tends to take up a lot of space. We can now record more on one CD-ROM than could be stored on forty computers like the one I had twelve years ago, and yet it took five CDs to store the images used for my QTVR project alone. It must be assumed that this sort of exponential growth will continue in the foreseeable future.

Is there a point when we will know that we have collected enough information, or will new abilities continue to expand the expectations of archaeological recording indefinitely? Even more importantly, how will this information migrate, where will it be preserved, and who will take care of it and who will pay for it? The choices we make now will have a definite impact on the future, particularly in the creation of databases and archives.

2.4 *Internet destination problems*

Worries over permanency are not limited to the images themselves, and the Internet as a proposed destination for my QTVR resource raised a completely different set of concerns. Website publications do not have the same feeling of authority as do the print versions of the same material and this is with good reason. Information found on the Internet varies considerably in quality, and rarely are there easy ways of evaluating its reliability.

[7] Considerable debate exists over longevity of optical storage media such as CD-ROMs. Manufacturers quote tests that simulate the effects of age through intense heat and light, indicating life spans of over two hundred years, but others, including myself, are more sceptical, especially if a given CD-ROM will be in active use and subject to scratches. Cfr. http://www.cd-info.com/CDIC/Technology/CD-R/Media/Longevity.html or the website of the Optical Storage Technology Association http://www.osta.org/technology/pdf/mo_disk_life.pdf.

The number of broken or dead-end links encountered on even the simplest web search hints at the underlying problem. There is no permanency on the web. Once a paper publication has been printed, no matter how limited the distribution or how poor the publication, the information contained within it is relatively permanent and will remain stored in a library somewhere for future use. However, it is impossible to publish certain types of spatio-visual data (like QTVR panoramas) through traditional methods. Although web journals such as Internet Archaeology (http://intarch.ac.uk/) work hard to present the same degree of permanency to the academic world, and have achieved some success, they cannot alter the inherently temporary nature of the Internet. A compromise will have to be reached that solves this dichotomy.

2.5 *Copyright concerns*

A second problem with the use of the Internet for academic publication is that of copyright. What meaning can the concept of copyright have in the digital age, when information is exchanged at lightning speeds across the globe? The original and naive goal of my QTVR project was to place image databases, QuickTime files, and copyrighted text on the net for use by anyone. However, it should be noted that to date the resource has never reached that destination. The Soprintendenza di Pompei is quite rightly very concerned about releasing such a resource over the Internet and is mindful of its potential for abuse. Since QuickTime loads its files into a computer's memory, there is no way to ensure that it is not being captured by the computer savvy and put to other uses.

In my project the image quality was not high enough for any practical use other than Internet transmission, but nevertheless copyright is not easy to maintain, and other images attached via future databases might be of much higher quality. It would be undesirable for these images to be unlawfully copied. An easy answer would be to strictly control access to copyrighted material, but this is harder than it sounds, and undermines the democratic goal of the project. One possible solution would be to distribute the database via CD-ROMs on sale on the site, which would license the images for personal use. This has already been done for rock art sites in South Africa[8]. However, this would severely limit access and would fail to take advantage of the positive aspects of having such a resource available on the web.

Multi-million dollar lawsuits currently revolve around the issue of intellectual property and are currently driven by the music industry. The dream of

[8] The "Cederberg Rock Art Survey Project" of C. Meister and B. Asmus (2004) produced a linked QTVR database of rock art sites that has been produced for sale at the monument site.

complete access to information, the democracy of education and knowledge cannot be fully realised without abandoning or altering current views towards intellectual property. Ultimately it will not be for archaeologists to decide, but rather to be prepared to make the best use of the new shape of the Internet that results from these actions.

3. Quake III

In 2003 I began a second project as a component of my PhD research that aimed at fully engaging with the spatial potentials of the digital age[9]. This project used tools designed for the computer game Quake III to create a real-time, three-dimensional reconstruction of the house of P. Paquius Proculus, a relatively high-status house in Pompeii (Regio I, vii, 1; Tav. XII, a-b; Figs. 3-5). The purpose of this project was to access the use of computer game rendering engines for scientific visualisation and reconstruction, and to consider whether they could provide a low-end option for projects that wished to benefit from virtual reconstruction without paying the often-prohibitive costs incurred by cutting-edge technology. I felt that since computer games, and in particular what is called in the industry the "first-person shooter" aim to create dynamic, real-time three-dimensional immersive environments that transport the viewer to another place or time, they might indeed possess many of the required aspects but at a fraction of the cost.

Furthermore, these games almost universally provide editing software so that their users can create additional "levels" or even complete modifications of the games' source code. This means that the tools already exist for archaeologists to begin to create complicated three-dimensional reconstructions of archaeological and architectural environments at very low cost. Since these games are designed to run on personal computers, the hardware required by any project wishing to begin such work is rather minimal. Finally, game engines are often designed to run over Internet connections. This provides a set of abilities not found in any other three-dimensional rendering software, including the ability for multiple users to interact with each other whilst simultaneously experiencing the same virtual space. They offer a high degree of immersion in the virtual environment: sound, animations, and realistic movement restrictions (e.g. gravity) that mimic the real world. Many high-end virtual reality projects result in "fly-throughs", and rarely consider the movement capabilities of real human beings. Game engines, however, are designed to reproduce reality as closely as possible, so as to immerse the user in the world of the game.

[9] Inspiration for this project is owed to the Martin Centre for Architecture at the University of Cambridge (http://www.arct.cam.ac.uk/research/pubs/pdfs/rich00a.pdf).

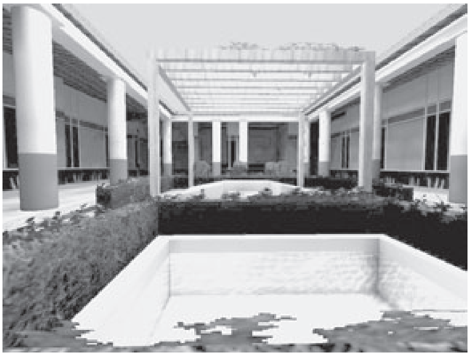

Fig. 3 – Peristyle of the virtual Casa di P. Paquius Proculus (I, vii, 1) showing fountain and outdoor *triclinium*.

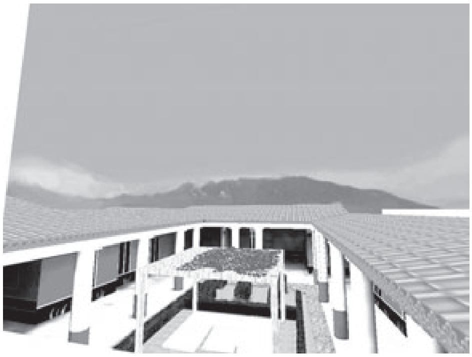

Fig. 4 – View from the upper storey of the virtual Casa di P. Paquius Proculus (I, vii, 1) over peristyle towards southern mountains.

In the use of visualisation and three-dimensional reconstruction, archaeology begins to incorporate the nature of communication in the digital age. Shape, volume, visibility and area are all expressed within a computer model. Their very creation tests hypotheses by forcing the modeller to consider every angle and each join between objects. When simply imagining past architecture from excavated remains and plans it is a simple matter to overlook such details in favour of the bigger picture. This is also true of artistic reconstructions that are not actively forced to come to terms with measurements or scale. A computer model itself therefore provides a degree of error checking. Additionally, just like QTVR, the use of spatial presentation software enables users to interact with the data on a spatial level, without the abstraction of plans or sections, so that the archaeological remains can be considered in their true contexts. Linked databases would therefore mean that the data could be analysed in a dynamic and holistic manner not previously possible.

3.1 *Disadvantages*

Of course, there are drawbacks. Virtual reconstructions suffer from all of the same concerns as QTVR projects and generate a host of new problems as well. In order for the digital age of computer and Internet presentation and publication to reach its potential, it is necessary to develop the tools and standards that will overcome and manage these challenges. Perhaps the most worrying aspect of the use of computer game engines as low-cost and low-end three-dimensional rendering engines is that they were not specifically designed for use as scientific tools. The code for much of this software has been released so that we can actually see how it works, but in some cases, notably, the light rendering and ray-tracing and radiosity methods, it is not so

Fig. 5 – The atrium of the virtual Casa di P. Paquius Proculus (I, vii, 1).

straightforward. Additionally, the tools provided by the software manufacturers do not include accurate scales or means of measuring in real-world units. This means that for reconstructions to be scientifically credible, it will be necessary either to produce complementary software components or to document the existing software more carefully.

This lack of adequate documentation is another major concern, as academic use will require expert and knowledgeable application of software to gain credibility. Unfortunately, such documentation that is available is often deeply buried in discussion boards and on-line forums filled with largely irrelevant material. This makes the search for useful information or assistance a time-consuming and frustrating process and aptly displays the double-edged nature of the Internet. While on the one hand, free high-quality editing software and compilers are available because the Internet gaming community exists and experienced and expert programmers are willing to donate their time for these projects, this also means that there is often little time for complete or coherent documentation. The notable lack of references on this topic in the current paper is symptomatic of the situation.

3.2 *The power of images*

On a more general level, computer reconstruction, three-dimensional immersive environments and ray-traced images have opened exciting new avenues of research allowing one to "see" into the past and to draw conclusions about how the environment (either natural or man-made) patterned life and cultural development. Visualisation can be a great tool of research and is of at least equal use for the presentation of theories, both to other archaeologists and the public.

However, it also presents a superficially complete and convincing picture of the past that may not represent true facts. The power of an image is very great. If a picture is worth a thousand words, then how many is a three-dimensional visualisation or QTVR movie worth? We must be careful lest the visual impact of our visualisations create a more powerful impression than the words that accompany it. This is especially true when the assumptions and theories that are encapsulated in the reconstruction are not clearly cited or detailed. Complete transparency in documentation of reconstruction has long been the goal of certain projects, such as UCLA's Cultural Virtual Reality Lab (http://www.cvrlab.org/) and the Cultural Virtual Reality Organization (http://www.cs.kent.ac.uk/people/staff/nsr/cvro/workshop.html). It is much more difficult to give the wrong impression in print than it is using computer generated virtual reality and images. Since it is the goal of VR research to achieve photo-realism in images and to recreate ancient environments accurately, we should realise that it will always generate images that are far more convincing than our words could ever be, and which may imply conclusions we did not intend or knowledge we do not have. My three-dimensional reconstruction of the house of P. Paquius Proculus presents a particular view of the ancient environment, and is not without flaws. We must be cautious that we do not convey more than we intend with our spatio-visual communication.

3.3 *The role of business*

The software used in digital projects itself raises questions regarding the role of businesses in the academic world. It is ironic that academia initially designed and developed the Internet, when today the majority of academic work present on the Internet depends heavily upon commercial software. Although in most cases, academia can opt for open-source or academically developed software, such as that based in Linux, most decide not to do so. Academic projects frequently purchase licensed software in order to complete, present, or publish their results, or even to gather the data in the first place. The implications surrounding the dependence of academia on commercial products are severe and my projects are not free from this concern. My QTVR project depends upon proprietary software designed by Apple and stitching software designed by VRWorx, while the Quake III project requires the purchase of the computer game in order to run.

What set the Quake III project apart is its reliance on low-cost and freely available software that was in a sense subsidised by the computer games industry. In this case, I decided to embrace the relationship between business and academia by exploiting the growth and development of computer gaming technology. The results of the project indicate that the relationship between proprietary software developers and academia can be a fruitful one (Tav. XII, a-b). This is certainly the case for computer game engines, since the amount of funding and expertise directed at the production of realistic three-dimensional games could never be matched by academic pursuits. In this time of rapidly shrinking research budgets, academics should not consider themselves to be above collaboration with business and the use of "less serious" types of software.

However, since the goals of business and academia are often considerably different, the reliance on "proprietary" software generates difficulties that must be considered. Perhaps most important is the issue of hidden or unpublished aspects of the functioning of certain programs. Because proprietary software is created for profit, its rights are carefully protected. The software use agreement for almost every major piece of software makes it illegal to reverse-engineer and release its code, even as an attempt to understand and evaluate the processes at work in it. While from a legal standpoint this is completely understandable, it does mean that the manner in which code functions can be completely occluded.

Consider the number of archaeological projects in the world that maintain Excel-calculated spreadsheets when it is a fact that the actual functioning of these calculations has been called into serious scientific doubt (McCullough, Wilson 1998; this work has also been confirmed and further detailed by other sources). The problem becomes even more acute when one is performing a least-cost path analysis on a terrain map with GIS software. How many of us stop to consider whether or even how the software is making the correct calculations? This "black box" situation is unlikely to be resolved any time soon, but archaeologists need to be aware of what black boxes they are dealing with in their work, and attempt to explain them, or at least test them for reliability.

Secondly, reliance on proprietary software presents its own set of issues related to the preservation and longevity of data. As industry standards change, and certain companies succeed whilst others fail, data preserved using less popular standards will face serious longevity problems in a relatively short period of time. For a telling analogy, simply consider the Laser disk: how could anyone have known during the height of its success that the DVD would quickly render it obsolete? (Newman 2003)

This problem is even more acute in the case of software. While in theory, once a given piece of software is installed, it can continue to read its own files indefinitely. But this assumes that it can be installed and made to function properly. Many programs written for DOS fail entirely under Windows platforms. The problem is less acute for Apple – or Linux – based systems, but the development of Mac OS X means that earlier software may soon become obsolete. Similarly, Microsoft has recently phased out the MS-DOS mode and the MS-DOS based native operation from all future versions of Windows. Progress determines that changes such as this will and must continue, but ensuring that data is still accessible in the future often means that it must be constantly migrated. Such has been much of the work of the ADS (Archaeological Data Service) which runs out of the University of York with the express goal of maintaining resources and addressing the problems of digital heritage (http://ads.ahds.ac.uk/); but the future of digital data must be considered by all projects that create it.

4. Conclusions

I have argued that the interactive, multi-user nature of the Internet and computer publication means that spatio-visual information can be presented in a way unlike ever before. This does not simply present us with unique possibilities. Rather, it presents new standards, new directives and new obligations. It is no longer sufficient to publish two-dimensional plans or sections, databases of descriptive terms or site reports that give only the general details and no photographs. Instead, we must begin to examine new ways for the presentation of spatial information. Much more than impressive pictures, flashy interactivity or crowd-pleasing visualisation, the coordination of information through means of visual and spatial tools means that an extra dimension of information is recorded, considered and conveyed. Spatio-visual information not only opens a new dialogue with the non-archaeologist, but is increasingly a tool allowing archaeologists to communicate with each other, to record and preserve data, and to coordinate, analyse and understand the diverse material culture which we as archaeologists use to understand the ancient cultures we study.

However, these new directions do not come without new challenges, and the relative youth of this medium means that many problems are yet to be overcome. The results and self-critical analysis of two of my own projects have pointed out some far-reaching theoretical obstacles, which I believe can be summarized as a general lack of paradigms. Academia must outline acceptable publication standards and regulations for digital media. These must provide guidelines for issues of archival resolution quality and longevity, migration and data preservation, publication and intellectual property rights, acceptable documentation and citation and the role of non-scientific, commercial and proprietary software. The advantages and opportunities presented by the digital revolution and the growth of the Internet are considerable, and they will only increase in the future. Spatio-visual information is the currency of modern communication. The academic and archaeological sphere must now consider exactly how to take advantage of it.

Michael Andrew Anderson
Department of Archaeology
University of Cambridge

REFERENCES

Anderson M.A. 2003, *QTVR and the preservation of Pompeii Regio VI: Using digital technologies to document and preserve archaeological sites*, in Doerr, Sarris 2003, 21-28.

Anderson M.A. 2004, *Computer games and archaeological reconstruction: the low cost VR*, in Fischer Ausserer *et al.* 2004, 521-524.

Avern G. 2003, *Small- and medium- scale 3D modelling in archaeology*, Workshop held at Vienna, CAA 2003 (unpublished).

Avern G. 2004, *The orthographic approximation – A simple geometrical model for avoiding perspective error in construction photomosaics*, in Fischer Ausserer *et al.* 2004, 405-408.

Barceló J.A., Vicente O. 2004, *Some problems in archaeological excavation 3D modelling*, in Fischer Ausserer *et al.* 2004, 400-404.

Cantone F. 2002, *3D standards for scientific communication,* in G. Burenhult, J. Arvidsson, *Archaeological Informatics: Pushing the Envelope. Computer Applications and Quantitative Methods in Archaeology. Proceedings of the 29th Conference (Gotland 2001),* Oxford, Archaeopress.

Corpus Topographicum Pompeianum 1986, *Ricca Maps,* Roma, H. Van der Poel.

Cox N. 2000, *Use of Excel for Statistical Analysis* (http://www.agresearch.cri.nz/Science/Statistics/exceluse1.htm, retrieved on 2nd June 2004).

Dobbins J. 1997, *Pompeii Forum Project Website* (http://pompeii.virginia.edu/pompeii/, retrieved on 2nd June, 2004).

Doerr M., Sarris A. (eds.) 2003, *The Digital Heritage of Archaeology. Computer Applications and Quantitative Methods in Archaeology. Proceedings of the 30th Conference* (*Heraklion 2002*), Archive of Monuments and Publications, Hellenic Ministry of Culture.

Eschebach H. 1970, *Stadtplan von Pompeji im Maßstab 1:1000*, Mainz, P. von Zabern.

Fischer Ausserer K., Börner W., Goriany M., Karlhuber-Vöckl L. (eds.) 2004, *Enter the Past. The E-way into the Four Dimensions of Cultural Heritage. Proceedings of the 31st CAA Conference (Vienna 2003)*, BAR International Series 1227, Oxford, Archaeopress.

Forte M., Pescarin S., Pietroni E., Rufa C., Bacilieri D., Borra D. 2004, *The multimedia room of the Scrovegni Chapel: a virtual heritage project*, in Fischer Ausserer *et al.* 2004, 529-532.

Game Studies = The international journal of computer game research (http://gamestudies.org/).

Kitchens S.A. 1998, *The QuickTime VR Book: Creating Immersive Imaging on your Desktop*, Berkeley, Peachpit.

Knusel L. 1998, *On the accuracy of statistical distributions in Microsoft Excel 97*, «Computational Statistics & Data Analysis», 26, 375-377.

Krazniewicz L. 2000, *Immersive imaging technologies for archaeological research*, in J.A. Barceló, M. Forte, D.H. Sanders (eds.), *Virtual Reality in Archaeology*, BAR International Series 843, Oxford, Archaeopress.

LING R. 1997, *The Insula of the Menander at Pompeii*, Oxford, Clarendon Press.

MCCULLOUGH B.D., WILSON B. 1998, *On the accuracy of statistical distributions in Microsoft Excel 97*, «Computational Statistics & Data Analysis», 26, 375-377.

MEISTER C., ASMUS B. 2004, *QuickTime Virtual Reality (QTVR) and the documentation of rock art localities*, in FISCHER AUSSERER *et al.* 2004, 548-551.

MEISTER M., BOSS M. 2004, *On using state of the art computer game engines to visualize archaeological structures in interactive teaching and research*, in FISCHER AUSSERER *et al.* 2004, 505-509.

MERLO S. 2004, *The "Contemporary Mind" 3D GIS as a challenge in excavation practice*, in FISCHER AUSSERER *et al.* 2004, 276-280.

MURRY W.P., MAEKAWA K. 1996, *Reliability evaluation of 3M magneto-optic media* (http://www.osta.org/technology/pdf/mo_disk_life.pdf, retrieved on 10th September 2003).

NEWMAN M. 2003, *Auditing Heritage Data – Ensuring Quality,* in DOERR, SARRIS 2003, 385-390.

Oxford ArchDigital Ltd. 2002, *OAD projects online* (http://www.oxarchdigital.com/, retrieved on 30th September 2003).

RICHENS P. (no date), *Playing Games* (http://www.arct.cam.ac.uk/research/pubs/pdfs/rich00a.pdf), retrieved on 22nd December 2002.

SCAGLIARINI CORLÀITA D., GUIDAZZOLI A., SALMON CINOTTI T. *et al.* 2003, *Archeologia virtuale e supporti informatici nella ricostruzione di una* domus *di Pompei*, «Archeologia e Calcolatori», 14, 237-274.

SCAGLIARINI CORLÀITA D., CORALLINI A., VECCHIETTI E. (forthcoming), *The role of scientific reconstruction in Virtual Archaeology: education, communication and valorization. The "Pompei – Insula del Centenario (IX 8) Project"*, in *Proceedings of the 32nd CAA Conference (Prato 2004)*.

The CD-Info Company Website 1998, *CD-R Media Longevity* (http://www.cd-info.com/CDIC/Technology/CD-R/Media/Longevity.html), retrieved on 10th September 2003.

TRONCHIN F., BONILLA D. 2002, *Quick Time VR tour of Pompeii Website* (http://hypergraphia.com/francesca/QTVR.htm), retrieved on 2nd June 2004.

WINTERS J.C. 2003, *Towards Sustainable Electronic Publishing for Archaeology,* in DOERR, SARRIS 2003, 415-420.

The CD-Info Company Website 1998, *CD-R Media Longevity*, http://www.cd-info.com/CDIC/Technology/CD-R/Media/Longevity.html, retrieved on 10th September 2003.

WHITLEY T.G. 2003, *GIS as an Interpretive Tool for Addressing Risk Management and Cognitive Spatial Dynamics in a Slave Society*, in DOERR, SARRIS 2003, 209-218.

ZEMANEK H. 2004, *Archaeological Information – An Information Scientist Looks on Archaeology*, in FISCHER AUSSERER *et al.* 2004, 16-29.

ABSTRACT

The emphasis of archaeological communication is no longer simply text on paper, but has moved on to encompass the expression of space and visibility. This paper discusses these new phenomena from the perspective of two recent projects, both of which presented spatial research material for dissemination on the World Wide Web. The first created a QuickTime virtual reality of Pompeii, Regio VI, and the second used an Internet based game engine to create a real-time virtual reconstruction a Pompeian house. The paper also examines issues central to the integration of academia with the Internet and computing technology such as the advantages and disadvantages of using proprietary software and the opportunities and responsibilities presented by communication in the global community.