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QTVR and the Preservation of Pompeii Regio VI: Using Digital Technologies to Document and Preserve Archaeological Sites

Michael Andrew Anderson

Department of Archaeology, University of Cambridge
Corpus Christi College
Cambridge, CB2 1RH
maa35@cam.ac.uk or inpw@hotmail.com

Abstract. QuickTime Virtual Reality panoramas present unique opportunities for the digital preservation and presentation of archaeological sites. This article presents the results and methodology of a pilot project that used QTVR panoramas to produce a comprehensive digital record of Pompeii, Regio VI. It assesses the advantages and potential problems of QTVR technology and examines post-fieldwork processing difficulties in light of the experiences of the project and with an eye towards future directions. Issues of design, usability and interface construction are discussed with particular reference to education, public awareness and academic research.

Keywords. Panoramas, Pompeii, QuickTime Virtual Reality, QTVR.

1 Introduction

QuickTime Virtual Reality (QTVR) panoramas require no introduction. Their popularity on the Internet is attested by such prominent web sites as that of the recent Winter Olympics in Salt Lake City, which featured a QTVR interactive panoramic view from the top of the Olympic alpine ski runs. Their potential has been recognized by web rings such as Metis and World Wide Panoramas,[1] collections of links to a number of panoramic movies of locations all over the world. The ubiquity of this protocol in the Internet, the availability of plug-ins for the major HTML browsers, and the possibility for the creation of databases linked through panoramic movies make this an excellent platform for the presentation of spatio-visual information.

Four years ago at the CAA, it was suggested that QTVR technology could and should be used for archaeological presentation. (Krazniewicz, 2000) This article presents the actual results a project undertaken in Pompeii during the summer of 2000, aimed at the digital preservation, documentation, and presentation of the quickly degrading Regio VI using QTVR technology.[2] After a brief examination of Regio VI's history and its need for preservation, each phase of the project will be evaluated with an aim to increasing reproducibility and consistency of future projects. The advantages and potential problems of QTVR will be assessed in light of recent field experiences and solutions will be presented for processing difficulties encountered. Finally the usability, design, and organisation of the final HTML interface will be examined for opportunities for education, public awareness and academic research.

2 Pompeii Regio VI –A History

The motivations for a project of digital recording at Pompeii perhaps seem readily apparent. Its status as one of the most famous archaeological sites in the world, the degree of public interest in its dramatic destruction and remarkable preservation and scholarly interest in what it can tell us about Roman daily life mark it as a prime target for digital preservation. It was none of these reasons, however, that ultimately motivated this project, but rather the special nature of Regio VI: its unique history, destruction, subsequent excavation and especially its current state of abandonment and peril.

Regio VI had rather humble beginnings, but would come to play a role in almost every historical event documented at Pompeii. When the city was founded the area later known as Regio VI was a field. Local Italic peoples, the Oscans, likely first settled an area known as the 'altstadt,' the central core of the city observable in a deformation of the otherwise regularly planned city grid which was possibly a fortified acropolis. (von Gerkan, 1940) Traces of this early period are found in the Temple of Hercules in the Triangular Forum, and the Temple of Apollo, both founded in the 6th c. BC, evidence of the great influence that the Greeks from Neapolis (Naples) had over the town.

Regio VI therefore represents one of the first areas of urban expansion, consisting of sixteen more or less parallel blocks that appear to have been planned at the same time that the Via Mercurio was extended north from what is now the forum area. Famous 'Italic' houses such as the Casa del Chirurgo and the Casa di Sallusto, which in theory preserve the earliest form of atrium houses at Pompeii, indicate that this expansion occurred near the beginning of the 3rd century BC if not before. (De Albentiis, 1990:81)

Later, in the Social War of 91-87 BC, the Pompeians were amongst the last to remain in rebellion against Rome and as a result the city was besieged by the general *Lucius Cornelius Sulla Felix*.[3] Finds of the Anglo American Project in Pompeii in Regio VI and damage on the Herculaneum gate give further evidence that the city was likely taken by storm. About three years later, perhaps as a punitive action, the then dictator Sulla settled his war veterans at Pompeii, making the city into a Roman colony – the *Colonia Cornelia Veneria Pompeianorum*. Regio VI's Casa del Fauno, notable for its Alexander Mosaic and fine first-style decoration, probably belonged to Sulla's nephew. In the Augustan period, the town received its first aqueduct, and made great use of this piped water for fountains

[1] Metis – http://www.stoa.org/metis/index.html and World Wide Panoramas – http://www.panoramas.dk/.

[2] Made possible by Louise Krazniewicz, the UCLA Digital Archaeology Lab, the Anglo-American Project in Pompeii and the UCLA Friends of Archaeology.

[3] Livy, *per*. 75; Valerius Maximus 9.8.3; Orosius 5.18.22-23.

as a display of wealth. Regio VI was also at the forefront of this trend as is documented by the fountains of the Casa della Fontana Grande and the Casa della Fontana Picula.

Despite a riot in the amphitheatre in AD 59, the period of the Roman colony was largely one of peace and prosperity. Such tranquillity was to end in AD 62, however, when Pompeii was hit with a pre-volcanic earthquake that destroyed much of the city. Its effects were particularly dramatic in Regio VI, which contains some of the best post-earthquake fourth style painting preserved in Pompeii. The famous Casa dei Vettii, the Casa degli Amorini Dorati, and the Casa del Labirinto all present excellent examples of re-building activity. At the same time some houses in Regio VI, such as the Casa di Pansa were converted to more utilitarian functions as inns, bakeries or centres of 'industrial' activities. The realisation that a considerable portion of the damage from this disaster had not yet been repaired when the eruption occurred has had major repercussions on the study of Pompeii but let it suffice to say here that the 'Pompeii Premise' does not exist even at Pompeii itself. (Schiffer, 1985).

2.1 The Modern Period

Regio VI presents an area of Pompeii that is of great scholarly interest and value. In spatial terms, it presents the largest contiguous sample of the city that is not either hopelessly overgrown or heavily reconstructed – as is the case in Maiuri's later excavations in Regions I and II. Unfortunately, it is also in the greatest peril. It was one of the first areas to be excavated and extensively plundered by the Bourbons in the 18th century, and has lain exposed to the elements ever since. It was also subject to accidental Allied bombing in World War II, and suffered greatly under the more recent earthquakes of the 1980s.

Most of Regio VI is cordoned off by wooden barriers, but no real system of security is in place. Gates lie in disrepair; debris from collapsed walls is strewn about and the area remains prey to dogs, the weather, and gate-hopping tourists. Due to its loss of wall decoration, and because of its dilapidated state, neglect has condemned it to further degradation and exposure. Nevertheless, archaeologically there is great opportunity in these walls. Attempts at area-wide survey, however, instantly reveal that the information contained in published plans is insufficient for most studies of architectural morphology. The need for a comprehensive resource – a collection of visual material documenting Pompeian buildings – is particularly great in the isolated, unprotected areas of Regio VI, where publications do exist for many of the finely decorated houses, but not for the more humble or poorly preserved houses that surround them. Truly comprehensive study of entire Regions has not been possible because of this lack of documentation, but is necessary before any citywide analysis can take place.

3 QTVR—The Advantages

The project's primary goal was to produce a database that could start to fill this gap and be used as a tool by scholars to further Pompeian studies. The aim was to provide complete coverage of every room of every house in Regio VI and to make the resource widely accessible by placing it on the Internet. Because of the specific demands of the project, the decision was made to use QTVR in the creation of a database of linked panoramas. The advantages that this technology grants for the recording of archaeological information are unique and numerous.

Perhaps the greatest advantages of QTVR production are its economy, speed of production and simplicity. The process followed by the project was very straightforward and the amount of necessary equipment was minimal and relatively inexpensive. A digital camera, the Olympus D-600L, was used to take the pictures and a field laptop for basic image storage and organisation. Other equipment involved two sets of rechargeable Nickel-metal hydride (Ni-MH) batteries, a battery charger, memory-cards for the camera, and a tripod with an L-bracket camera mount to ensure that the images were taken at regularly overlapping intervals and that the camera rotated on the centre of its lens in a level plane. The L-bracket helps to prevent parallax (an optical illusion in which foreground objects appear to move relative to background ones as the movie view rotates) a problem that can ruin the immersive effect of panoramas.

It was found that student volunteers could be easily trained to set up the tripod, record node information and take the actual pictures, and that after just a few sessions they began to produce high-quality results. Working in a team of two to three people the better part of two average sized houses could be documented in one hour. One person working alone performed similar quality output, but at a rate which was somewhat slower (a little more than one house per hour). The survey was carried out over the period of five weeks, working only after the field school's normal excavation had been completed on five days of the week, afternoons on Wednesdays and a full day on Saturdays. The total number of hours devoted to the project did not exceed sixty, but the data produced – over seven thousand digital images of Pompeii, comprehensively covering Insulae 1, 2, 5, 7, and 9 of Regio VI – is considerable. It should also be noted that student assistance aside, the majority of this work was performed by one person working alone. Based on this pilot programme, I estimate that two teams of two or three people each equipped appropriately could document all of excavated Pompeii within a 5-week field season.

3.1 Cross Platform Processing

As is always the case, the truly time consuming work in the project has been the post-fieldwork processing. While the field season amounted to sixty hours, after two years of mainly peripheral work (fitted into free moments during master's degree research), one insula and street have been completed, and another stands near to completion. An estimate of the time investment at this phase would be approximately one hundred hours. Dedicated work, rather than occasional forays would have reduced the overall investment of time. The development of procedure, and the learning of new techniques meant that the initial investment of time was considerable, while current work goes much more smoothly. Authoring was performed on a variety of systems, platforms and programs, demonstrating the flexibility of QTVR in the academic computing environment.

Ideally, the processing of images should be relatively straightforward. A stitching program is used both to stitch the images together and then to warp them so that the resulting panorama appears to be seen from the correct perspective at all times. This stage is important, as it is what distinguishes the immersive effect of the panorama from a standard panoramic

photograph. Images are adjusted for varying exposure, inconsistencies in the level of the tripod, and the like. The resulting 360-degree image is then compressed and saved as a QTVR movie or 'node.' Interactivity is added to the panorama by means of 'hotspots' that can be linked to other panoramas, still images or any other media that can be coordinated through HTML. These links are the way that the user navigates the house.

3.2 Processing difficulties

Partly because of errors made during fieldwork and limitations on equipment, the conditions for post fieldwork processing have been less than ideal. Most of these problems could have been avoided in the field with proper planning and experience. It may therefore be useful to examine these obstacles and their post-season solutions so as to help others avoid such mistakes in future projects. One factor hampering the processing of images has been that of exposure. Because previous QTVR preservation projects have been entirely outdoors, such as the UCLA projects in Belize and on Easter Island, the difficulties that resulted from dealing with an architecturally rich, and therefore high contrast, environment such as is found in the ruins of Pompeii were unexpected. Once a node has been established and a sequence of photos begun, it is not possible to alter the course of rotation in any way, lest it become impossible to stitch the images together into a panorama. This means that very careful planning is necessary to avoid pointing the camera into areas where high contrasts will make the exposures vary considerably. The camera will always attempt to take a 'good' photo, resulting in very different exposures depending on the percentage of light and dark in each shot. Because the camera is taking a sequence of images the juxtaposition of highly contrasting images is quite common. While extensive experimentation with exposures, resolutions, and resulting images both prior to departure for Italy in Southern California, and also upon arrival at Pompeii gave some indication of the possible difficulties, they did not anticipate the vast number of problems that arose in the field. To a certain extent, there are no solutions for the problem of exposure – a window inside a dark room will always appear to be washed out, and mild variations in exposure for images are inevitable. Panorama stitching software will not always be able to correct such problems. The best field procedure is to set an exposure manually and retain it, bracket shots frequently, and plan the locations of nodes carefully.

Though it makes sense that QTVR images might be best taken within an hour or two of noon, when shadows are at a minimum and the sun will not create lens flares;[4] the nature of this project meant that images had to be taken at about six o'clock in the evening on most days and all day long on others. This was not as significant a problem as was at first feared, and in fact, the images taken at noon were normally more washed out and of poorer diagnostic quality. Lens flares seem to enhance the immersive effect rather than harm it, as the viewer expects to be blinded by the sun in that location.

The project's most difficult problem was caused by the tripod itself, which had a faulty bubble level. Results have emphasized the importance of ensuring that the camera rotates in a level plane. Some variation can be corrected with stitching software, but extreme flux can often result in disaster. Even if the images can be made to line up properly QTVR software will crop a straight image from the slanted result, discarding material as necessary. This means that information that exists in the images themselves is lost in the processing. Functional equipment would have prevented most of this.

As a result of these problems the challenge of stitching and blending many of the projects' panoramas proved to be too great for software to handle. Processing has therefore involved using the software to stitch together the images, and then manually adjusting the exposure in Photoshop with liberal use of the burn, dodge, and clone tools. Use of the clone tool was carefully considered prior to use, as it essentially modifies the pictures. The increased quality of immersion created by smooth transitions between photos was deemed to be worth the cost especially since the actual images remain accessible in a database and can be checked for absolute accuracy. The clone tool was used cautiously, so that as little information was obscured as possible. For example, modern gravel on the ground and the sky were considered to be irrelevant, while structures, paintings and wall fabrics were given priority in the blending process. Hand-working the images is considerably more labour intensive, but produces a better and more thoughtful result than does computerised blending.

3.3 Experimentation

Since the L-bracket conveniently aligned the camera on its side, a certain degree of vertical information could be recorded. A circular area on the ground around the tripod will inevitably be lost, however, as will any details that are taller than the camera's field of vision. It was found that important archaeological details were frequently on the ground or otherwise out of the camera's sight, particularly in confined spaces. Experiments with adjusting the camera to face slightly downward have been successful, but result in mildly warped panoramas and an increased degree of complexity in their stitching. Such limitation has been overcome by 'cubic-panoramas' that are possible with QuickTime 5. Though requiring even more pictures to be taken for each node, the resulting immersion is greatly enhanced by being able to direct the view in three complete planes of motion.

4 The Interface

The format chosen for presentation of the project was HTML, which because of the Internet destination of the project was the only logical choice. This would probably also have been true even if a CD-ROM had been chosen as the method of presentation. HTML browsers such as Netscape and Internet Explorer are (largely) cross-platform and freely available, can be distributed with the database, and allow for complete customisation of the viewing interface, design, and experience.

4.1 Testing the Interface

Considerable testing was performed on the Interface design during the creation of the HTML template files for the presentation and linking of the QuickTime panoramas. This involved receiving feedback from actual users on what aspects of the design enhanced their experience and what more they required for immersion to be more effective.

Frames were chosen as the method of co-ordination as this means that the page does not need to refresh completely after every click. Frames allow the greatest degree of control over content and its adaptability to various monitor resolutions and

[4] Due to Kitchens, 1998.

system capabilities, but also restrict backward-compatibility for browsers that do not support frames. Opting for frames was the first of several difficult decisions that revolved around the choice between compatibility and functionality.

Initial testing indicated that a floor plan was necessary, as users could easily become disoriented by the amount of information presented by a panorama. Working closely with a set of houses means that one becomes familiar with them, and no longer requires a map for guidance or direction. It is easy to forget that those who are less familiar with the site may need additional help in order to navigate effectively. To ease navigation further, a red dot was added to the map that dynamically indicates the location of the user at each stage of movement.

Particularly interesting were the difficulties of integrating still images with panoramic content. While panoramas can record general conditions, environment and spatiality much better than still images, details of objects on the ground, of specific features, or wall paintings are often better presented by still images. Initially, it seemed desirable to include these images in an interactive way, linking the still images through the panoramas and then making the images themselves click-able with image maps. This was particularly true when still images were necessary links in house navigation. In practice, however, users had a great deal of trouble in adapting to the changing interactivity between still images and panoramas, despite many efforts to make the interaction system both intuitive and consistent. The primary problem seemed to be that the panoramas overpowered the still images, making the user expect similar interactivity from every image. This realisation has had major impact on both current design and future plans. An effective temporary solution has been the addition of buttons to aid in navigation, but the best answer would be to coordinate all motion through nodes and to link still images to nodes only as close-ups. Such lessons are important for all future goals of QTVR projects.

4.2 File Structure and Nomenclature

As of the time of writing, the current version of the interface consists of a frame that coordinates three HTML content files into separate windows. The frame can dynamically adjust to browser window size and display resolution without increasing load times. The three content files are coordinated to each other through nomenclature (cf. Fig. 2). For instance files `n01.htm`, `n01p.htm`, and `n01t.htm` are the page for QTVR node-01, its corresponding map page and accompanying text page, respectively. This naming protocol was established once it became clear that the number of HTML files for an individual house could easily number well over a hundred, and that giving distinctive names to each of the locations was pointless. Images, movies, and other media that are to be loaded into each page are also keyed to the same naming system, so that `n01.jpg`, `n01.gif`, and `n01.mov` also relate to node-01. All nodes, still images, and other details such as links are recorded on a plan of the house itself, which aids in construction and link debugging. Text and image files for a given house are located in the same folder, but because of the consistent naming system, they can easily be identified without confusion. The resulting modular file structure allows the linking of many houses created at different stages of the project without undue difficulty.

4.3 Making the Work Easier – JavaScript.

After careful consideration the decision was made to use JavaScript in the HTML in order to adjust dynamically for different display resolutions, and to take some of the burden of the creation of the interface. Taking advantage of the nomenclature system detailed above, prototype files were created which would load images that matched their own name. For example the file `n01a.htm` will load images `n01.jpg` and `n01.gif` without changes to its internal code. This allows the mass production of many identical files, which when renamed will automatically find their associated images, movies, and other material. Unfortunately, this means that browsers that balk at dynamically generated content will not be able to view the site. However, as JavaScript was incorporated by the last several versions of most major browsers, this was deemed to be an acceptable cost. The appendix includes the relevant code for one such file.

5 Management of the Digital Heritage

One of the topics of this year's CAA meeting has been the management of the digital archaeological heritage. I propose that QTVR is the perfect tool for this task. As the results of this pilot project prove, the visual database created for Regio VI does an excellent job of preserving the site. It does this better than a simple collection of still images for the following reasons:

5.1 Multiple-Levels of Information

QTVR provides access to place, location, space and dynamic better than two-dimensional plans by providing the experience of movement within the house. Visibility, space and morphology in each house can be examined by 'walking' through the database. More importantly, details of construction, building materials, methods and indications of upper stories can be examined, without the confusion caused by ambiguous signs on a plan as is frequently the case with the Eschebach and Ricca maps of Pompeii.

Panoramas provide multiple types of sensory information at once such as spatial relationships, movement possibilities and scale. Organisation of information in this manner presents images in relation to each other, making use of our ability to perceive patterns in our experience of the world, something impossible with still photographs. I recently received verification of the effectiveness of the QTVR experience when I visited Pompeii with one of the people upon whom I tested the interface. Her reaction upon entering a house that she had hitherto only experienced via the computer was 'I've been here before!' This has convinced me of the power of the QTVR experience.

5.2 Presentation Advantages

QTVR panoramas are particularly useful in the academic world because they are designed for use on the Internet. The problem with most virtual reality work is that it requires extremely expensive and powerful machines in order to run. QTVR panoramas however, can be run on low-end computers, are cross-platform compatible, and require software that is freely available, if not already loaded on most systems. QTVR is virtual reality with photographic images, not photo-realistic rendering. As such it does not add extraneous information to the material it documents. It is dispassionate in its recording,

and does not make assumptions necessary for CAD renderings or other virtual reconstructions.

5.3 Education

The uses of such a resource for educational and public purposes are considerable. A virtual Regio VI would allow public access to areas that are officially off-limits, while at the same time presenting an excellent opportunity to educate both students and the public at large. The project's presentation format gives an educator the ability to insert commentary at each stage in the navigation of the panoramas. This means that narrated tours could be integrated with the QTVR database. These might not only explain how to use the interface, but also give non-specialists information on the historical or archaeological significance of what is being viewed. 'Hotspots' within the movies could be links to detailed enlargements of features, other educational sites, or detailed discussions of particular topics. Learning through exploration, users would determine their own course through each house, exploring those things of personal interest, while experiencing some of the wonder of actually visiting Pompeii.

Such a tool could never replace the experience of visiting Pompeii itself, and we would not want it to do so. Its capacities for generating public interest, boosting tourism and increasing general awareness of the precarious state of preservation of the ancient city should also not be underestimated. Most tourists who visit Pompeii see only the famous, well-preserved houses and the forum. Few are forced to come to terms with the areas of Regio VI that have been left to decay. Public knowledge of the condition of much of Pompeii could be a significant factor in campaigns for the generation of funds dedicated to the preservation of Regio VI, the providing of roofing, weeding and adequate protection for this delicate archaeological resource.

5.4 Archival Images

Source images for the panoramas were taken at 640x480 resolution, as this was the most efficient rating for over seven thousand photos. This resolution is more than accurate enough to record all extant archaeological details of the standing remains of Regio VI including construction material, methods, current condition and repair work. Wall paintings were preserved in close up still images, accessible through the QuickTime interface. Although the production of material for the Internet reduces quality for the sake of transmission speed, the original images remain individually archived and accessible, preserving the current state of the site for scholarly and scientific research into details lost in the production of panoramas.

6 Conclusions

If action is not taken soon, large segments of Regio VI will be lost forever. Even the processes of conservation and consolidation that will be necessary to maintain Regio VI will themselves irrevocably change and obscure details that are currently visible as nowhere else in Pompeii. A digital record can preserve what is there now, quickly and cheaply, and produce a result that is cross-platform, accessible, and easily manageable. Pythagoras philosophical statement, 'All is Number,' was never more applicable than today. The digital preservation of archaeological sites such as a virtual Regio VI opens up new doors in terms of digital resources, documentation, and final publication. QTVR is an excellent way of managing, presenting, and preserving that digital heritage.

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Appendix: Prototype Node File

```
<HTML>
<HEAD>
<TITLE>VIRTUAL POMPEII PROJECT</TITLE>

<SCRIPT LANGUAGE="JAVASCRIPT">
<!--
function loadurl() {
var pathname = document.location.pathname;
var end = pathname.length+1;
        if (pathname.lastindexof("/"))
                {var div = "/";}
                else{var div="\\";}
var beginning = pathname.lastindexof(div)+1;
var file = pathname.substring(beginning, end);
var dot = file.lastindexof(".")-1;
var pre = file.substring(0, dot);

parent.plan.location = pre + 'p.htm';
parent.text.location = pre + 't.htm';
}
//-->
</SCRIPT>
</HEAD>

<BODY BGCOLOR="#660000" TEXT="#FFCCCC"
ONLOAD="LOADURL()">
<SCRIPT LANGUAGE="JAVASCRIPT">
<!--
if (navigator.appname == "netscape") {
var imagewidth = window.innerwidth*(.8);
var imageheight = window.innerheight*(.8);
} else {
var imagewidth = 400;
var imageheight = 265;
}
var pathname = document.location.pathname;
var end = pathname.length+1;
if (pathname.lastindexof("/"))
        {var div = "/";}
        else{var div="\\";}
        var beginning = pathname.lastindexof(div)+1;
        var file = pathname.substring(beginning,
end);
var movie = file.substring(0, 3) + ".mov";

document.writeln
('<TABLE WIDTH="406" BORDER="0" ALIGN="CENTER"
HEIGHT="300" VSPACE="2"\N ' +
'SPACE="1"CELLPADDING="" CELLSPACING="0"> ' +
' <TR> ' +
'  <TD HEIGHT="197"> ' +
'<DIV ALIGN="CENTER"><EMBED SRC= ' + MOVIE + '
ENABLEJAVASCRIPT="TRUE" CACHE="TRUE"\N' +
'CONTROLLER="TRUE" PAN="350" ' +
'               HOTSPOT1="../../START.HTM" ' +
'               TARGET1="" ' +
'               SCALE="TOFIT" WIDTH= ' + IMAGEWIDTH +
' HEIGHT=' + IMAGEHEIGHT + '> ' +
'    </EMBED></DIV> ' +
'<TR> ' +
'  <TD> ' +
'  <DIV ALIGN="CENTER"><IMG SRC="MOVBUT.JPG" HEIGHT =
"' + IMAGEHEIGHT/6 + '" WIDTH="' + IMAGEWIDTH +
'"></DIV>' +'  </TD> ' +
' </TR> ' +
'</TABLE>');
// -->
</SCRIPT>
</BODY>
</HTML>
```

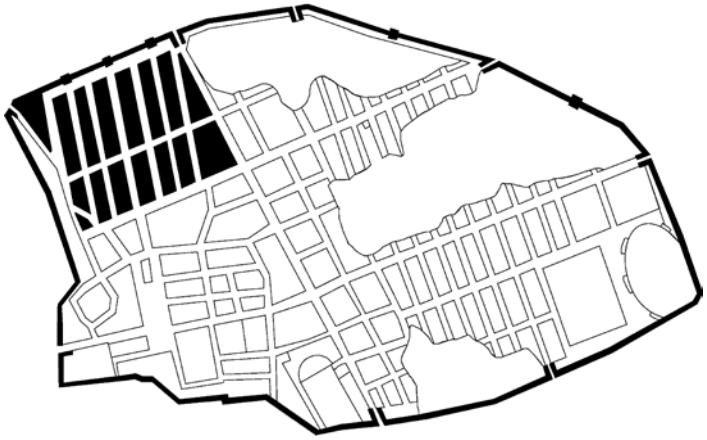

Fig. 1. *Pompeii Regio VI. (Plan after Etienne).*

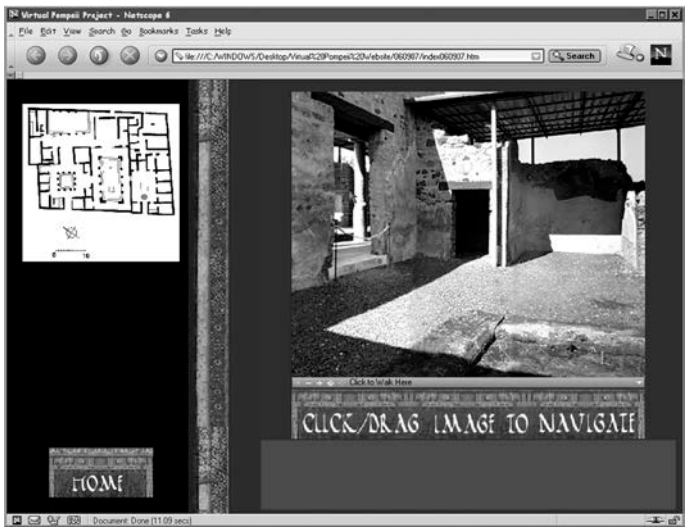

Fig. 2. *The QTVR presentation interface.*

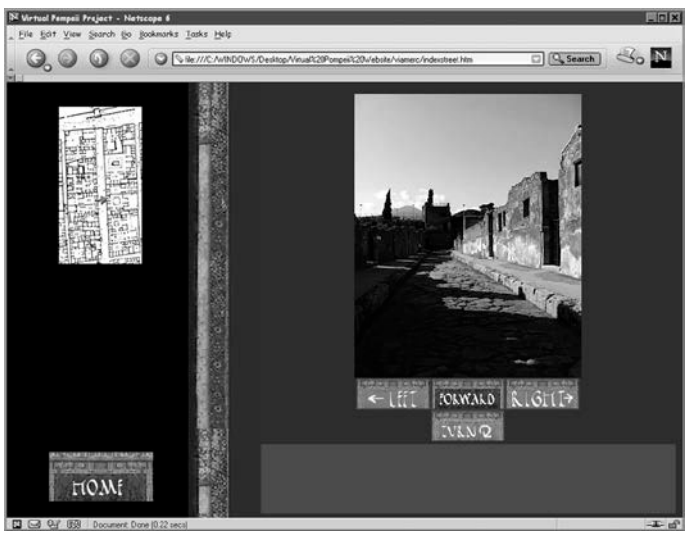

Fig. 3. *The still image presentation interface.*