3D-ArchGIS: Archiving Cultural Heritage in a 3D Multimedia Space

Nestor C. Tsirliganis,
Fotis Arnaoutoglou,
Anestis Koutsoudis,
George Pavlidis,
Christodoulos Chamzas
Cultural and Educational Technology Institute, Greece

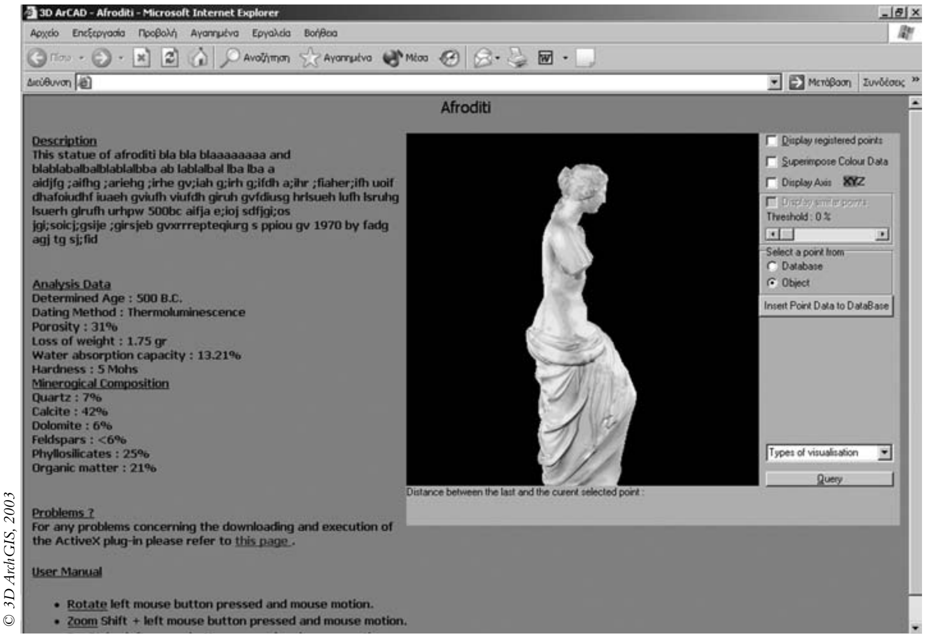

Figure 1. 3D ArchGIS plugin

3D ArchGIS is an experimental application that attempts to implement the capabilities and promises that new technologies bring to the field of documentation and preservation of cultural heritage. It enables scientists to map and browse physicochemical information on the surface of 3D scanned archaeological artefacts. In addition, it is a Web oriented application that provides functionality and features not commonly available from similar applications. The aim is to develop a flexible and user-friendly tool for combining and displaying various data types alongside 3D models – in some respects, an online GIS tool for objects of any size and shape, from a ceramic fragment to an archaeological site.

Preservation and dissemination of cultural heritage has always satisfied a multitude of psychological, aesthetic, social and political ambitions of humanity. The aspiration of the human race to dominate time was manifested early on with a genuine and ardent attempt to record, preserve and spread its present achievements and its cultural heritage. Vision, memory and narration were the original means used to serve this purpose, and remained basically unalterable until the revolution that accompanied the addition of writing to vision, stone and paper to memory, and reading to narration. The introduction of these 'supplements' made the communicated information more objective, enduring and precise. Further technological advances like typography and photography have since been used to expedite the process.

More recently, the advent of new technologies and their applications have radically altered the way information is stored, archived, retrieved and presented. The enormous impact this could have on the registration, documentation, presentation and, ultimately, preservation of cultural heritage was appreciated and explored early on. Systematic recording of the physical and chemical characteristics, typological description, and historical information of cultural objects led to the first databases, mainly for research purposes.

Digitisation of 2D images of the objects enriched the stored textual information and made it more appealing to the public. Physical and chemical characteristics were, however, still interesting only to a limited number of researchers. Images combined with historical excerpts in the form of digital catalogues became the standard in promoting private collections and museums. Catalogues with deeper descriptions and scientific facts were also used for educational purposes and typological research. Multimedia brought a new era with virtual worlds. Relatively simple catalogues, enriched with video and graphics, were transformed into virtual museums, while multimedia databases offer a multitude of information. Yet this wealth of information remains, to a great extent, bound to 2D media.

Great advances in 3D technologies offer new opportunities to record every detail of cultural heritage in high precision, and to present it in a more

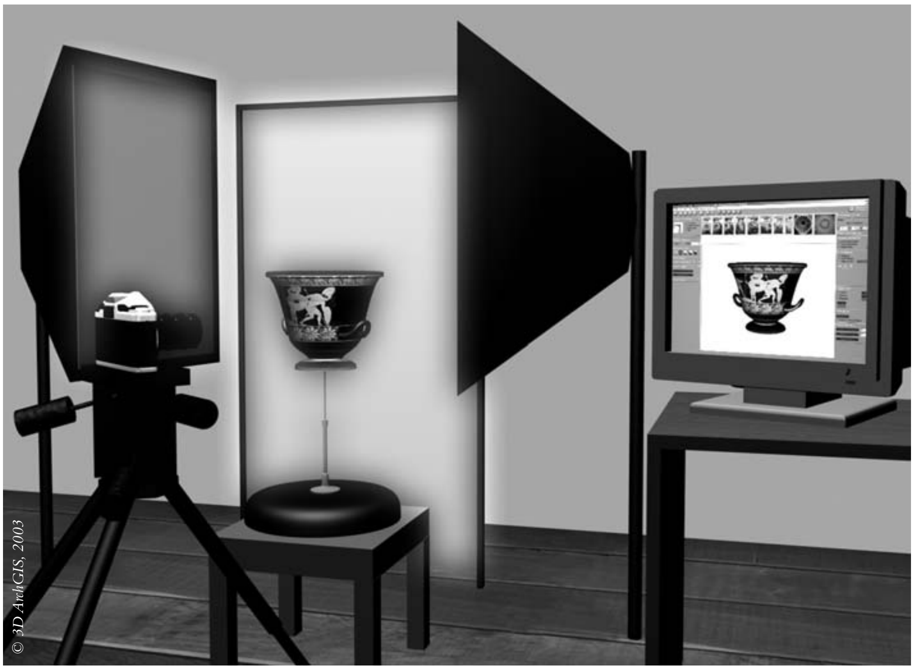

Figure 2. 3D Photographic scanner

attractive way. It is not only, however, the new imaging methods that help in the documentation and preservation of cultural heritage. In the early stages of archiving, information was derived mainly from the human senses, primarily vision and touch, since they described the perceived prominent and lasting characteristics of the articles. Advances in science and technology enriched this information and made it more complex, substantial, measurable, reliable and replicable. Today, innovations in instrumentation make possible the extraction of even more accurate, point-wise information of physicochemical characteristics and mechanical properties of objects.

The combination of modern measurements, 3D imaging, and mapping provides a field for the development of new ways to register and present information that can once again revolutionise the documentation of cultural heritage, leading to integrated and complete recording with the capability to visualise data not only macroscopically, but also in a point-size fashion, and enables the virtual reconstruction of an artefact in every conceivable detail. The effect that such a reconstruction will have upon scientific research, dissemination of knowledge and public interest is profound.

THE CONCEPT OF '3D-ARCHGIS'

The main requirements of a modern information retrieval system are: immediate access to distant stored data; an intelligent mechanism to turn raw data into useful information; flexibility to allow users to submit queries of varying complexity with a number of options; and finally a user-friendly environment. All these requirements point directly to Internet databases. There are many databases with specialised content providing services over the Internet. Specifically, a cultural database is a database that can provide information related to cultural objects, monuments, museums, heirlooms, and so on. At present, the majority of these databases' data are limited to 2D pictures and drawings, textual descriptions and tables of data, all used to describe the archived object.

The Cultural Technology Unit of the Cultural and Educational Technology Institute (http://www.ceti.gr), with the collaboration of the Institute's Multimedia Unit, initiated an attempt to incorporate the latest technologies and methodologies into an integrated documentation environment for cultural objects. This began with the development of a multimedia database initially focused on archaeological ceramic and glass artefacts. The database should include detailed 2D and 3D images of archaeological finds accompanied by morphological-typological descriptions, historical and scientific data such as dating measurements, mechanical properties and stoichiometric analysis that – where appropriate and possible – will be mapped on the 3D image.

A combination of different technologies were incorporated to implement this task: 3D geometry and texture acquisition technologies; 3D point-wise surface data acquisition technologies; relational database system technologies; Virtual Reality technologies (e.g. VRML); dynamic User Interface technologies realised through Java and PHP languages. Finally, borrowing ideas from GIS systems (where 3D information is structured in layers and the user can visualise any kind of information layered graphically over the base background layer), the effort was directed to the development of a system where a user can visu-

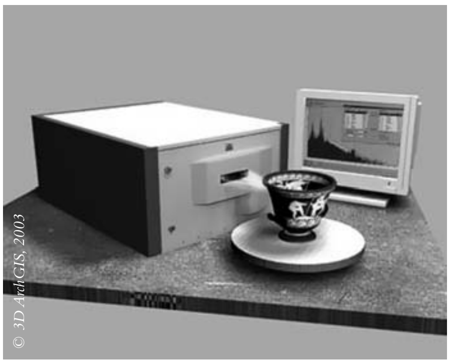

Figure 3. micro X-Ray Fluorescence (μ-XRF)

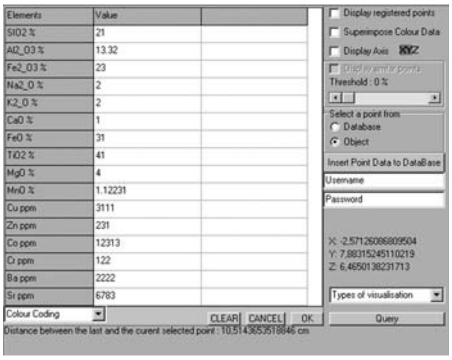

Figure 4. Entering data

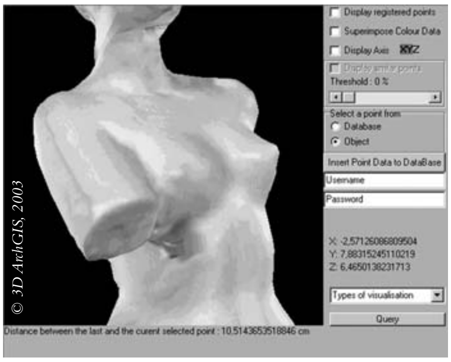

Figure 5. A new point selected

Figure 6. Registered points

alise not only the physicality of an object, but also how it is described in the physicochemical database (for example, the surface distribution of iron in the pigments of the decoration). This led to the name '3D ArchGIS' Cultural Database.

FEATURES OF 3D ARCHGIS

3D ArchGIS is an application based on the client-server architecture. The client component has been implemented as a plug-in for Microsoft Internet Explorer (see Figure 1). Web browsers are one of the most widely used and well-established platforms for presenting multimedia content while supporting numerous data formats, from simple text and images up to live streaming video and 3D graphics. Such a sophisticated client-side software component requires an equally powerful server that will be able to handle the complexity and size of the data. Modern multimedia databases can handle huge amounts of data in a very efficient manner. Thus, Web browsers are considered among the programming community as an ideal platform for the development of database oriented applications in situations where the main scope of the system is the global distribution of multimedia information. The current system of archaeological artefact archiving presents historical information in textual format accompanied by typological data alongside a realistic 3D representation of the artefact on the same Web page. A typical 3D scanning system (see Figure 2) is limited to export geometry and texture data (also known as 3 to 4 dimensions of data) in a Web compatible format like the Virtual Reality Modelling Language (VRML). However, the Institute's infrastructure makes possible the extraction of information from an artefact that goes beyond the typical 3 to 4 dimensions – 3D ArchGIS can be considered as an enhanced 3D model viewer with unique features. The system allows data mapping on the surface of the 3D model and at the same time composes a unique tool for browsing and retrieving these data. The information used for 3D mapping is grouped according to its physicochemical attributes, retrieved using the micro X-Ray Fluorescence (μ-XRF) technique against the object's surface to extract the chemical decomposition (see Figure 3).

The initial study involves the digital acquisition of geometry and texture from the actual artefact. Then it is parsed to the 3D ArchGIS to map the data retrieved from the μ-XRF system. The mapping of the data is performed manually at present (Figure 4). A region of interest is selected (Figure 5) on the surface of the 3D object that corresponds to the real object point where the measurements have been taken. The contribution of 3D ArchGIS to this task is that it enables study of the 3D model of the artefact and users can easily pick the 3D coordinates of the sampled point just by clicking on the surface of the 3D model (Figure 6).

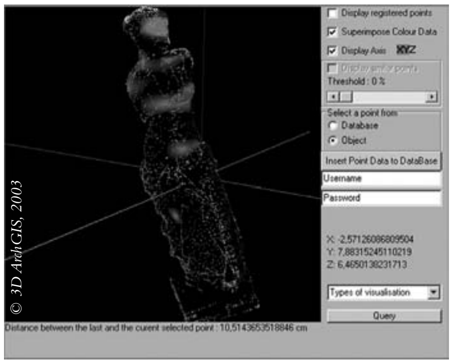

Figure 7. Colour mapping based on data

3D ArchGIS can be used for presenting all this mapped information or as a simple 3D viewer for displaying the 3D scanned artefacts on the Internet. The user can see the object from any angle, zoom in and out, and browse its surface for data. Furthermore, it is possible to visualise the object at spectrum bands invisible to the human eye, or even to observe the chemical elements distribution as mapped on the surface of the object (Figure 7). Furthermore, a point from a region of interest can be selected in order to grant access to the entire μ-XRF analysis for that point which includes chemical composition data followed by the respective spectrograms (Figure 8).

The system has the capability to block unauthorised users from inputting new data sets into the database; however, browsing and querying the database is a free access service with restrictions on the results. Querying is implemented through

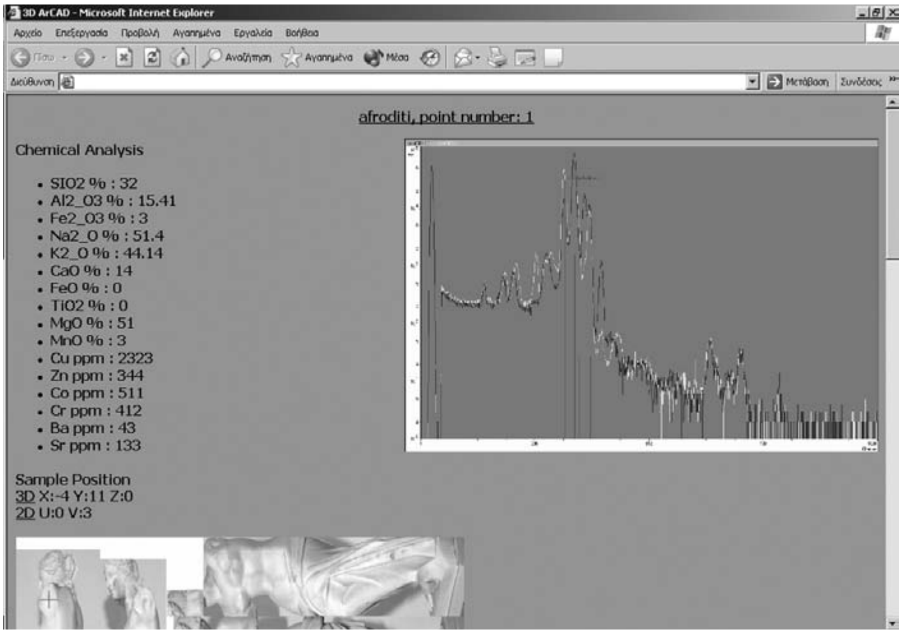

Figure 8. Data from a point

a friendly graphical user interface (see Figure 9). In this way, a laboratory which conducts an extensive study on an archaeological artefact can provide the entirety of the information regarding that artefact in a very valuable and efficient way to scientists all over the world.

TECHNOLOGY BEHIND 3D ARCHGIS

As mentioned earlier, the client component of 3D ArchGIS is implemented as a Web browser plug-in. The advantage of running the application as a plug-in within a single window is that it allows the user to work in a consistent and familiar environment without the need to switch between separate application windows. Furthermore, the versatile nature of a plug-in software component permits the application to be incorporated into bigger Web projects and allows real multimedia visualisation of the entire data set. This very useful feature is, however, also a restrictive factor that leads to some drawbacks. As a browser plug-in, 3D ArchGIS is restricted to Web oriented technology. The most widely used technologies for development in browser plug-ins are Java applets and ActiveX. Java applets are platform independent but the fact that accelerated OpenGL graphics are not supported by default raises the issue of the manual download and installation of large files (Java2 & Java 3D) by inexperienced users.

ActiveX plug-in is a well-established method for developing software components that can be executed within other applications (modularity). It is supported by a variety of software development platforms such as Microsoft Visual Basic, Microsoft Visual C++, and Delphi; however, the main disadvantage of this method is that it is operating system dependent (only available from Microsoft Windows version95 and later) and browser dependent (Internet Explorer and Netscape Navigator).

During the initial requirements analysis and specifications, the target group of the application was identified as a group of 'average, semi-experienced computer user[s]'. Therefore most of these users would have Microsoft Windows OS driven computer systems with Internet Explorer (installed as default during the OS installation) and the 'in window' accelerated OpenGL graphics support. The majority of Microsoft Windows operating system users steered the development process to the ActiveX plug-in solution.

For the real time rendering of 3D graphics Open-GL libraries are used. Open-GL (http://www.opengl.org/) is a well-established industry standard and is supported by most operating systems and graphics hardware developers. Thus, a large portion of the code is platform independent and the rendering of 3D graphics is hardware accelerated via the drivers of a standard graphics card.

3D ArchGIS retrieves the 3D object to be explored from a remote server, along with information from a database where the latest measurements and scientific data for each artefact are regularly updated. The communication between the server and the client is bi-directional (see

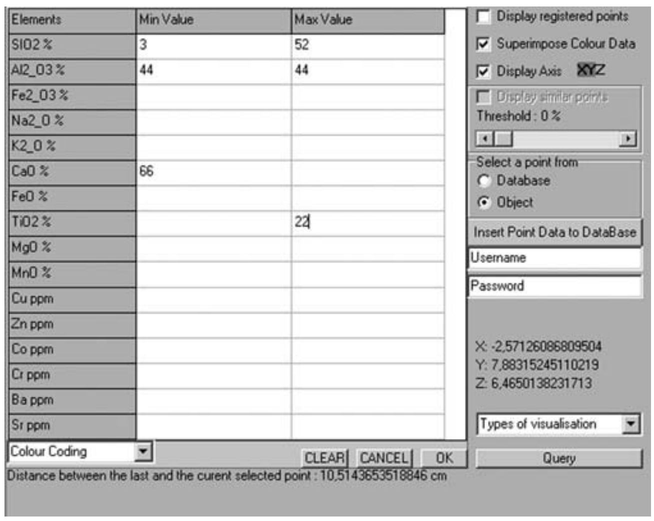

Figure 9. Easy querying GUI

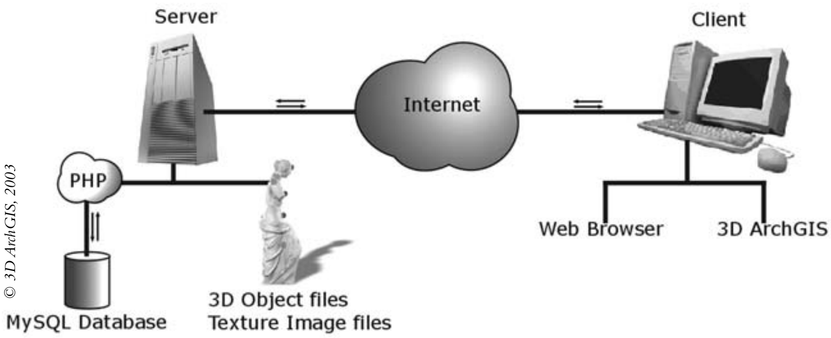

Figure 10. Communication Scheme

Figure 10). 3D ArchCAD communicates with the server by performing calls to PHP (a server based script language) pages and retrieving the output (simple text) from the server as a data set of input parameters. This technique is implemented by making use of operating system specific calls (which makes this part of the code platform dependent).

FUTURE DEVELOPMENT

3D ArchGIS is an experimental application and still under development. Currently, it is on the second *beta* implementation. Future implementations of 3D ArchGIS will address operating system dependency, which is one of the most serious limitations, and the needs of users with low bandwidth Internet connections.

Addressing bandwidth challenges will require innovative methods of data compression, including the 3D models, combined with progressive loading and display. At its current implementation the application is focused on mapping physicochemical data on the surface of the 3D models; future versions are designed to be more flexible on the type of mapped data and will allow mapping not only on the surface of the model but on its entire volume as well.

CONCLUSION

3D-digital archiving and presentation provides scientists and the general public with powerful means for the registration, documentation, preservation, display and dissemination of our cultural heritage. Modern measurement instrumentation combined with multimedia databases and the appropriate software tools can offer a very rich and coherent description of a cultural object – a description that meets not only the needs of a virtual museum, but also the very demanding and detailed requirements of an in-depth, precise and accurate scientific study, even from remote locations.

ACKNOWLEDGEMENTS

The 3D ArchGIS project at CETI is a collaborative effort of specialists in various fields of science and technology, as is clearly shown through the professional expertise of the members of the developing team: Dr C. Chamzas (Electrical and Mechanical Engineer), Dr N. Tsirliganis (Nuclear Physicist), Dr D. Tsiafakis (Archaeologist), Dr Z. Loukou (Chemist), G. Pavlidis (Electrical and Computer Engineer), A. Tsompanopoulos (Electrical and Computer Engineer), K. Stavroglou (Electrical and Computer Engineer), D. Papadopoulou (Chemist), V. Evagengelidis (Archaeologist), A. Koutsoudis (Multimedia Engineer), and F. Arnaoutoglou (Programmer). We believe this mixture of specialties reflects the demands of archiving of Cultural Objects in the twenty-first century.