Archiving Cultural Objects in the 21st Century

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Abstract

Recent developments in three-dimensional technologies and measurement instrumentation combined with multimedia databases offer today new possibilities for the integrated and complete description of Cultural Heritage Objects (CHO). In this work, we present an attempt to develop a database for archaeological ceramic and glass artifacts, where in addition to digitized two-dimensional images and three-dimensional reconstructions, description, typological characteristics and historical information for each artifact will also include point-wise surface data, forming a GIS-like[1] environment for CHO. This information will contribute significantly to the comparative study of artifacts, provenance studies, determination of weathering, authentication and detection of forgery, inspection of past restorations, and ultimately, their preservation.

Keywords: Cultural objects; Cultural heritage; Digitization; Archiving

1. Introduction

The advent of new technologies in digitization and digital reconstruction as well as their applications revolutionized the way information is stored, archived, retrieved and presented. Their impact on the registration, documentation, dissemination, presentation and ultimately, preservation of Cultural Heritage (CH) could be enormous. In addition to the visual recording (two-dimensional (2D) and three-dimensional (3D) imaging), systematic recording of the physical and chemical characteristics, typological description and historical information of CHO led to the first CH databases, mainly for research purposes.

The digitization of the CHO in two dimensions, using film or digital photography, and the storage of the 2D representation alongside the description of the CHO enriched the content and made it more appealing to the general public. A presentation in the form of a digital catalog, where images are combined with historical excerpts, has already become a standard in promoting private collections and museums. On the other hand, physical and chemical characteristics are interesting only to a limited number of researchers. When the digital catalogs describe CHO to a greater extend and go deeper into scientific facts, they can also be used for educational purposes and typological research [1,2].

Multimedia brought a new era with virtual worlds. The relatively simple catalogs, enriched with video and graphics, transformed the static presentations to virtual museums, while multimedia databases offer now a multitude of information formats. Still, even today, this wealth of information remains to a great extend bound to a 2D world. The latest great advances in 3D technologies offer today new opportunities to record the CH in high precision and detail, and to present it in an attractive way. The typical "do not touch" caution, becomes now a bold "please touch and examine".

It is not only the new imaging methods that help in the documentation and preservation of CH, but innovations in instrumentation provide with more accurate, point-wise measurements of physicochemical characteristics and mechanical properties of objects. Combination of such measurements with 3D imaging and mapping techniques give rise to novel ways to register and present information that can revolutionize once again the recording of CH: recording will be integrated and complete since we now have the ability to describe, digitally store, and retrieve CHOs not only macroscopically, but also in a point-size manner that enables the virtual reconstruction in every conceivable detail. The impact that such a reconstruction will have on the scientific research as well as the dissemination of knowledge and the attraction of public interest is profound.

An attempt, to this end, is made in the Cultural and Educational Technology Institute (CETI), with the collaboration of its Archaeometry and Multimedia Laboratories, aiming to the development of a multimedia database for archaeological ceramic and glass artifacts. The database includes detailed 2D images and 3D representations of archaeological ceramic findings accompanied with morphological descriptions and historical and scientific data such as dating, mechanical properties and stoichiometric analysis data. Where appropriate and possible these measurements are mapped on the 3D representation to form a GIS-like environment for each CHO. This way, the user-researcher will be able to examine CHOs from every aspect, avoiding at the same time to impose possible strain to the actual artifact. The main advantage of such integrated recording is that CHOs are stored and remain digitally available indefinitely in time and space.

The main contribution of our idea in the world of CH is the 3D recording and mapping of physicochemical properties in the form of a GIS-like system for every CHO, while the majority of existing databases are bound to a 2D world.

2. The database

The design of a cultural database requires the solution of several problems that can be divided into three main categories:

- *Precise definition* of the "problem" (theoretical concept), that is isolation of the various classes and objects into abstractions and definition of the connections or relationships between them. This is the least technical of the three categories but the most essential, since decisions made at this stage have to be followed to the end.
- Database *implementation*, using one or more available tools. A common solution to this issue is the use of a relational database model, which operates by defining the various classes into "table entities", which are linked to each other according to relationships guided by the classes.
- The *end-user aspect*: the target group must be defined in terms of demands and level of knowledge; the user interface must be friendly enough, while rich in terms of available options, so that the users can form various kinds of queries or combinations of queries to submit to the system. We have decided to develop two different interfaces, one for the ordinary users (general public) and another for the researchers.

The designer of a cultural database should also consider the possible limitations imposed either by the involved data or by the used database/archiving system. At present, our database supports multimedia content and multi-language-polytonic text for textual data. Specifically, for the multi-language-polytonic text requirements the chosen solution was the usage of Unicode fonts (although occasional problems are expected to occur, since Unicode [3] is not yet widely accepted). For enhanced flexibility in database management and data "warehousing" the adopted solution was to keep the multimedia content in separate external files, and include only file names in the database. We believe that this will be sufficient for the first stage of our implementation.

When dealing with archaeological objects there are two basic categories of data:

- *Cultural*: Comprises external characteristics of objects, such as the type of the object, its dimensions, etc., as well as historical and social information.
- *Technological*: Include information related to the chemical, mineralogical and physical properties of the material, archaeological dating information, etc.

A summary of the characteristics included in the database is given in Table 1. Each of the categories extends to an open list of sub-categories, with each sub-category being an open list of a variable length of elements (datasets).

3. Presentation of a 3D CH multimedia database

A combination of different technologies was recruited in order to achieve the best possible acquisition of detailed data and interaction level between the user and the database, within a 3D environment distributed over a network.

Internet has been acknowledged as one of the most challenging platforms for programming. The Java programming

Table 1
Data types in the database

Cultural data	Technological data
Object type (lycithos, pithos, etc)	Archaeological dating (measurement method, results)
Provenance (e.g., Corinthian)	Chemical content (elemental)
Historical era (e.g., Neolithic)	Mineralogical content (composition)
Morphological characteristics shape, size, color, decoration, etc.)	Physical properties (porosity, hardness, plasticity, strength, etc.)
Present condition (in fragments, a whole, etc.)	Surface traits (color, pigments, inks, texture, etc.)
Restoration and Conservation work	Structure–Microstructure
Excavation data	Other characteristics (e.g. firing temperature, vessel content, etc.)
Ownership museum, private collection, etc.)	Erosion and environmental effects (patina, cracks, etc.)

language is based on the power of global networks and the idea that the same software should run on different platforms and operating systems. A Java application can be easily delivered over the Internet or over any other network. Thus, it is considered as a powerful programming platform to evolve an application based on the "thin client–thick server" software engineering architecture.

In the late 1960s and 1970s, research on a number of fronts formed the basis of virtual reality as it appears today (e.g., projection-based VR [4,5], head-mounted displays [6,7]). In the mid-1980s, the different technologies that enabled the development of virtual reality converged to create the first true VR systems. The term "Virtual Reality" was originated at 1989 by Jaron Lanier, the founder of VPL Research, defining it as "a computer generated, interactive, 3D environment in which a person is immersed." Since then, virtual reality has captured the public imagination and lots of work has been done to explore the possibilities of virtual reality in new areas of application such as medicine, chemistry, scientific visualization.

Virtual reality is more than just interacting with 3D worlds. By offering presence simulation to users as an interface metaphor, it allows operators to perform tasks on remote real worlds, computer generated worlds or any combination of both. The simulated world does not necessarily have to obey to natural laws of behaviour. Such a statement makes nearly every area of human activity a candidate for a virtual reality application.

The Virtual Reality Modeling Language (VRML) and Java provide a standardized, portable and platform independent way to render dynamic, interactive 3D scenes across the Internet. Integrating two powerful and portable software languages provides interactive 3D graphics plus complete programming capabilities plus network access [8–11]. The Web is being extended to three spatial dimensions thanks to VRML, a dynamic 3D scene description language that can include embedded behaviors and camera animation. A rich set of graphics primitives provides with a file format, which can be used to describe a wide variety of 3D scenes and objects. The VRML specification is an International Standards Organization (ISO) specification [12].

Java adds complete programming capabilities and network access, making VRML fully functional and portable. This is a powerful new combination, especially as ongoing research shows that VRML combined with Java provide with extensive support for building large-scale virtual environments [13]. However, there were two major limitations in VRML 1.0:

- Lack of support for dynamic scene animation, and;
- No traditional programming language constructs.

Difficult issues regarding real-time animation in VRML 1.0 included entity behaviors, user–entity interaction and entity coordination. VRML 2.0 development tackled these issues directly, using event-driven ROUTEs to connect 3D nodes and fields to behavior-driven sensors and timing. If Java or JavaScript are to be supported in a VRML browser, they must conform to the formal interface specified in the specification [12] Annexes B and C, respectively. Major browsers now support both. Using Java is the most powerful way for 3D scene authors to explore the many possibilities provided by VRML [13].

4. VRML and Java interfacing

The VRML 97 standard does not support the development of shared multi-user worlds. Developers may implement the lacking multi-user and network support in the current standard by means of the Java interfaces without necessitating the definition of non-standard extensions to VRML. Although the current VRML standard does not provide explicit support for the development of multi-user worlds, it does, however, provide the developer with two Java programming interfaces which allow for the implementation of multi-user capabilities:

Java via VRML's Script node and External Authoring Interface [12–18]:

- *Java via VRML's Script node* is well specified and multiple compliant browsers exist. Sometimes is referred to as the JavaScript Authoring Interface (JSAI);
- *External Authoring Interface* (*EAI*). Rather than provide Java connectivity from "inside" the VRML scene via the Script node, the EAI defines a Java or JavaScript interface for external applets which communicate from an "external" HTML web browser [19]. EAI applets can pass messages to and receive from VRML scenes embedded in an HTML page. The primary benefit of the EAI is the ability for direct communications between the encapsulating HTML browser and the embedded VRML browser. The EAI provides an interface between the VRML world and a Java applet residing on the same page loaded in the Web browser. The EAI now allows for four types of access into the VRML scene:
  - access the functionality of the Browser Interface;
  - send events to eventIns of nodes in the scene;
  - read last value sent from eventOuts of nodes;
  - receive notification when events are sent from eventOuts in the scene.

The EAI thus provides all the functionality of the JSAI although being somewhat more difficult to program.

In the context of multi-user client/server VRML applications, we decided to adopt the EAI, since an applet, executing at the client, can provide with both the networking capabilities of Java and the access to the internal workings of the VRML world through the EAI [14].

A few years ago, Sun released the Java3D class library for 3D graphics programming [20]. Java3D is an API, providing a programming interface for 3D that is analogous to the Abstract Window Toolkit (AWT) for 2D graphics. Java3D programs are saved as Java byte codes, not as a modeling format.

All interfaces are well matched, well specified, openly available and portable to most platforms on the Internet.

Fig. 1. Representation, at work, of technologies that provide with surface and geometry data; (A) 3D laser scanner for surface geometry (0.1 mm resolution), (B) point chemical composition with a μ-XRF system (0.1 mm resolution).

VRML scenes in combination with Java can serve as the building blocks of cyberspace. Building large-scale internet-worked worlds now appears possible. Using VRML and Java, practical experience and continued success will move the field of virtual reality past speculative fiction and isolated islands of research onto desktops anywhere, creating the next-generation Web [13].

5. Presentation of a CH multimedia database using virtual reality (VR)

One of the most successful applications of VR is in the representation of historical and cultural heritage. The main reason for this success is that in many cases the represented data do no longer exist or are partially destroyed and cannot be viewed in any other way. In addition, the usual photographic (2D) representation often imposes the requirement to present many pictures of an object (taken from a number of different points of view) so as to be able to give viewers a complete description.

In order to implement a system that is able to deliver the virtual reality content of a multimedia database and to use a universal format compatible with most internet browsers, the obvious choice [21], today, is to adopt Virtual Reality Modeling Language (VRML) [22]. VRML is a well established solution, with ISO approval and the ability to run in many different Internet browsers. VRML appears to be even more applicable as its file format is supported by many state-of-the-art 3D applications in such a degree that importing and exporting from one application to the other is a process of a few mouse-clicks. This file format is fully compatible with the software and hardware CETI is using for the acquisition of 3D geometry and point-wise surface information from the artifacts. Fig. 1 shows the 3D scanning and data acquisition procedures.

The innovation of the proposed scheme is that there is no other multimedia database of cultural heritage with 3D data that can be accessed through the internet and also be able to provide with specific object data according to the viewer's point of view. A block diagram of the proposed system is depicted in Fig. 2. The block diagram of the work being carried out by the system is depicted in Fig. 3.

The usage of the system can be summarized within a three-stage interaction procedure:

- At the first stage, the user is prompted to access the database search engine in order to locate an object or a family of objects matching desired search criteria. The database generates a report of all matching records and prompts the user to select one from the list.

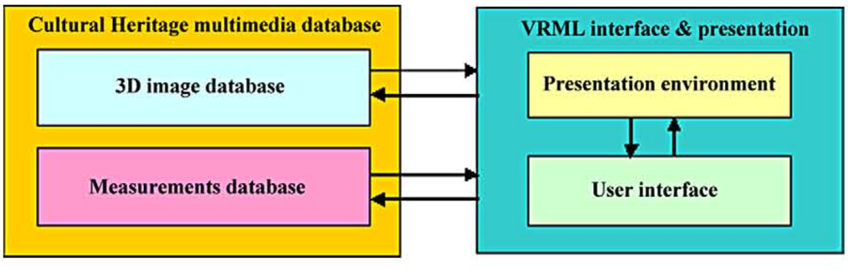

Fig. 2. The architecture of the VRML presentation system.

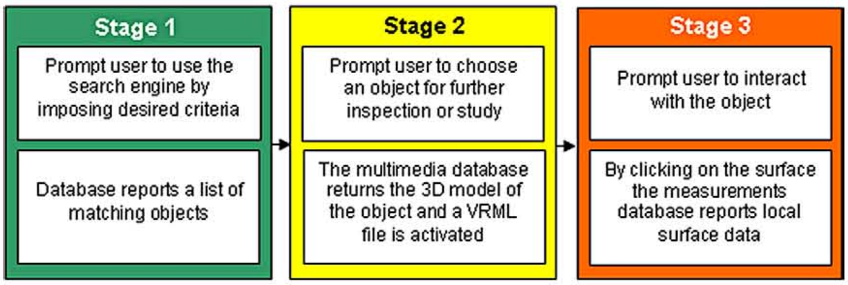

Fig. 3. The three-stages system interaction procedure.

- At the second stage, the user gets specific information concerning the selected object and a 3D representation through VRML language.
- At the third stage, the user interacts with the 3D representation of the object, by turning, zooming, and panning, and by clicking on the surface of the object the database reports specific surface information (such as erosion or specific element density and other measurements stored in the database).

More technically, a client implemented within a Java applet is used to forward user's requests (queries) to a server application via a TCP packet socket connection. The server application is responsible for constructing a SQL command, which will be forwarded to the multimedia database server. Once again, the server application will collect the data and forward them back to the applet where they will be presented to the user in a typical 2D environment of text fields.

The External Authoring Interface (EAI) is the core to the interactive communication between the VRML world and the Java applet. EAI allows a Java applet to control the contents of the VRML window. Of course, this requires that both VRML window and Java applet are embedded in the same HTML page. Having those two worlds merged, a powerful platform is delivered. A platform, where high complexity real time 3D graphics coexist with 2D user interface and parallel supported by database connectivity and distributed application issues.

Summarizing, the following technologies have been used in this implementation:

- a Java-enabled Web browser (standard, client-side);
- a VRML97 compliant browser plug-in;
- a Java applet running in the Web browser (downloaded from the Web server to the client);
- a Java server application (executing on the Web server).

Fig. 4 is an illustration of the technologies involved in the current development. The combination of these technologies gives the ability to the end user to run the client on any Operating System platform. Java is highly supported by Internet browsers and of course VRML plug-ins are freely available over the Internet [23].

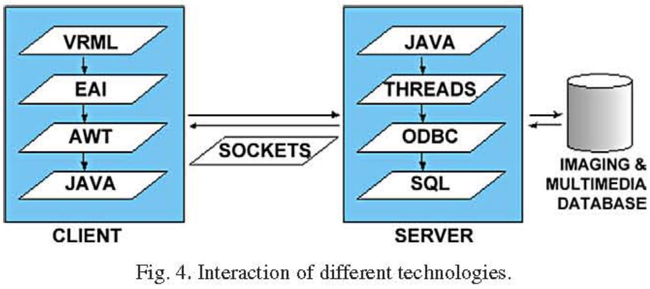

Fig. 4. Interaction of different technologies.

The user interacts with the object by a complete freedom of movements (rotation, zooming, panning, etc.). Selection of a specific area (region of interest) is done by selecting a rectangular region on the 3D object. With the EAI, the position of the region of interest is transferred to the client applet. The applet forwards the information in the format of a streamed string to the server. The server is now responsible for querying the database. Results are retrieved from the multimedia database, averaged over the selected region and sent back to the client. Apart from the technological data, the server supplies the client with a filename path, which the client uses to download a more detailed 2D image of the region of interest. This image is also presented to the user. Fig. 5 shows a screen-shot of the web application, which is under development [24].

In a second phase, the interface will be enhanced with 2D charts of technological data and its functionality will be improved with full control of the VRML world within the applet (preselected viewpoints, preselected-highlighted regions-of-interest, enhanced navigational interface, etc.). Furthermore, issues related with 3D data and image compression as well as network security issues currently under investigation will be embodied. Considered technologies include JPEG2000, MPEG4 3D, and future VRML revisions (2002). They are expected to lead in lower volumes of data transmission and higher speeds of interaction, which will address the most important network issues related with information retrieval in similar systems.

6. Conclusions

A multimedia database with real (digitized), realistic (reconstructions) and interactive 3D representations of objects was developed for archaeological ceramic and glass artifacts. The database contains historical, morphological and analytical data for the recorded artifacts alongside their 3D digital images and representations. The researcher/user has access to the entire information related to an artifact and can interact with its 3D representation by turning, zooming, and panning. In addition, the interested user can retrieve specific local surface data (elemental composition, pigment, etc.) by click-

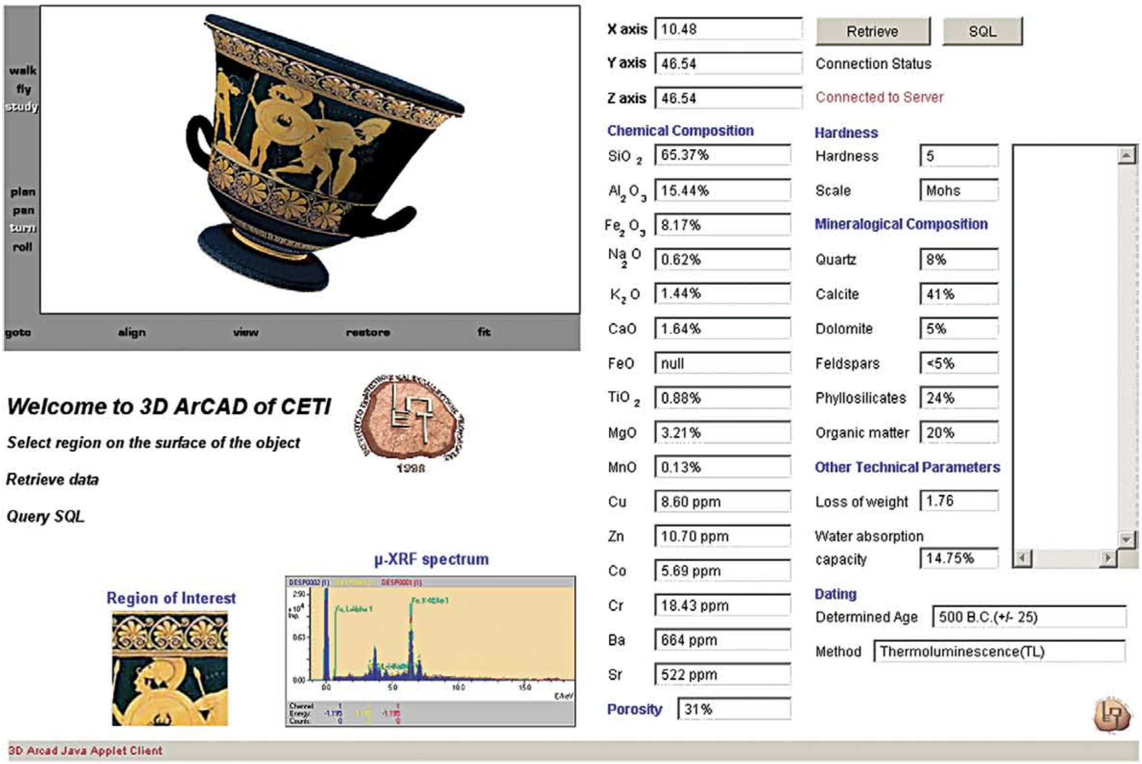

Fig. 5. Screenshot of the web application. The architecture of the VRML presentation system.

ing on the surface of the object, thus taking advantage of the recent developments in measurement instrumentation that contribute significantly to the integrated documentation of cultural objects. The database makes use of the "thin client–thick server" approach, implemented on a Java platform. External Authoring Interface enables communication with the VRML interface in the client side.

References

[1] Sample databases with typological and historical data. Available from http://www.beazley.ox.ac.uk/test/vases, available from http://www.perseus.tufts.edu/cgi-bin/, available from http://www.officenet.co.jp/~yoji/vase, available from http://www.art.uiuc.edu/oldkam/GreekKam, available from http://www.lists.bilkent.edu.tr/documentation/pottery/handbook/potteryform.html.

[2] Sample databases including chemical/geological data. Available from http://Srdweb2.dl.ac.uk:1080/FMRes, available from http://art.sdsu.edu:591/materialbasesearch.html.

[3] The Unicode Consortium, The Unicode Standard, Version 3.0, Addison Wesley, 2000. Available from http://www.unicode.org, available from http://www.web3D.org/WorkingGroups/vrtp/docs/vrmljava.pdf.

[4] M.W. Krueger, Responsive environments, in: NCC Proceedings, 1977, pp. 375–385.

[5] M.W. Krueger, Artificial Reality, Addison-Wesley, 1983.

[6] I.E. Sutherland, The ultimate display, in: Proceedings of IFIPS Congress vol. 2, New York City, May 1965, pp. 506–508.

[7] I.E. Sutherland, A head-mounted three-dimensional display, in: Proc. the Fall Joint Computer Conference, 1968, pp. 757–764.

[8] Elliotte Rusty Harold, Java Network Programming, O'Reilly and Associates, Sebastopol California, 1997. Available software at ftp://ftp.ora.com/published/oreilly/java/java.netprog.

[9] M. Hughes, S.M. Conrad, M. Winslow, Java Network Programming, Manning Publications, Greenwich, England, 1997.

[10] R. Lea, K. Matsuda, K. Miyashita, Java for 3D and VRML Worlds, New Riders Publishing, Indianapolis, IN, 1996.

[11] B. Roehl, J. Couch, C. Reed-Ballreich, T. Rohaly, G. Brown, Late Night VRML 2.0 with Java, Ziff-Davis Press, MacMillan Publishing, Emeryville, CA, 1997.

[12] VRML, 97, International Specification ISO/IEC IS 14772-1, December 1997, available via www.vrml.org.

[13] D. Brutzman, The Virtual Reality Modeling Language and Java, in: Communications of the ACM, vol. 41, no. 6, June, 1998, pp. 57–64.

[14] A. Ferscha, J. Johnson, Distributed Interaction in Virtual Spaces, Department of Applied Computer Science, University of Vienna, ferscha@ani.univie.ac.at.

[15] L. Andrea, D.R. Ames, J.L. Nadeau, Moreland, VRML 2.0 Sourcebook, second ed, John Wiley & Sons, New York, 1997.

[16] R. Carey, G. Bell, Annotated VRML 2.0 Reference Manual, Addison-Wesley, Reading, MA, 1997.

[17] J. Couch, VermelGen, Software Distribution, Virtual Light Company, December 1997.

[18] J. Hartman, J. Wernecke, VRML 2.0 Handbook, Addison-Wesley, Reading, MA, 1996.

[19] C. Marrin, External Authoring Interface (EAI, Proposal, Silicon Graphics Inc, Mountain View, CA, 1997.

[20] M. Deering, H. Sowizral, Java3D Specification, Version 1.0, Sun Microsystems Corporation, Palo Alto, CA, 1997 August 1.

[21] N. Leavitt, 3D Technology: Ready for the PC? Computer Magazine, November 2001.

[22] E. Gobbetti, R. Scateni, Virtual reality: Past, Present and Future.

[23] Available from http://www.cosmosoftware.com.

[24] Available from http://thermodosa.ceti.gr/~akoutsou.