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Hybrid 3D Visualisations of Archaeological Sites: Dynamic 3D Visualisations of Harris Matrix Data for Rescue Town Excavations, Gdańsk / Szafarnia Site, Poland

Abstract: In our solution a rich database model is used to represent stratigraphic data. This allows for the easy selection of ranges and types of data for visualisation. Using a simple data management application, several archaeologists can easily share the same dataset, enabling group work. Using a database management system for data storage instantly gives numerous benefits, which, among others, include efficient data representation, robust data access, transactional processing and data integrity constraints (verification of possible values, their constraints, their relationships, etc.). A prototype of an X-VR based Harris Matrix visualisation system has been developed. 3D diagrams can be displayed using standard VRML plug-ins to internet browsers without installing any specific software. The system has been tested on data from Gdańsk town excavations – Szafarnia (Schaferei) site.

Background

In 1973 Sir Edward C. Harris developed a model for the graphic presentation of relationships between cultural strata on the archaeological position called, in honour of the author, a Harris Matrix. Stratigraphy asserts that if one can prove an upper layer lies on a second one, the lower one had to be deposited before the upper one's rise (Harris 1989). This is a fundamental principle of archaeology. Stratigraphic diagrams can be manually realized, but the simplest method is the use of an appropriate computer program, which would automatically correct errors and make the addition of corrections or removal of data possible.

Significant progress has been made in the 30-plus years of computer applications used in the archaeologist's work. Let us consider only the aspect of programs used for stratigraphic analysis from archaeological positions. First, the best known application for studying stratigraphic sequences was the STRATA program, created by Wilcock in 1975. The operator of the program gained the complete stratigraphic sequence for an archaeological position after entering data concerning all stratigraphic relations. In practice, program-equipment restrictions heavily limited the program's possibilities and lengthened the analytical-visualisational process to many hours. Many other high-tech solutions came into being after significant hardware and software development in the 1980s. Articles presented during the CAA conference in 1985 deserve attention, including the mathematical point of an archaeological sequence view (Haigh 1985), and informatics algorithms helpful for data graphical presentation (Ryan 1985). Programmers in cooperation with archaeologists began to concentrate on the problems of stratigraphic analysis itself, and there appeared more universal applications joining stratigraphy with a comprehensive system of data recording from archaeological stands. Rains presented the idea of integrated database building for the needs of archaeology in 1985 (Rains 1985). In the following years many different applications for stratigraphic data presentation were presented: the *Hindsite* (Alvey 1989) application came into being in 1989; using AutoCAD plans, a solution using SQL for charts creation was presented in 1991 (Boast / Chapman 1991); and in the same year Herzog and Scollar presented the first, fully automatic application building Harris Matrix (Herzog / Scollar 1991). Every year, new databases for archaeology and solutions for the graphical representation of archaeological stratigraphy, together with equipment and program platform development, emerge. In most cases, authors of the programs aim at the production of solutions that build charts in flat forms, not providing for the space. A basic visualisation includes data concerning a chronology relative to a given individual, whereas spatial data, which locates an individual within the area, are omitted in connection with the restriction of the chart's 2D possibilities. A possibility of working on many stands during country research is also significant, and an application based on net access (eg. through wireless LAN on the research area) is an ideal solution. We can regard N. Ryan and his project *jnet* (Ryan 2001) as a pioneer of net solutions and the introduction of a 3rd dimension to charts. STRAT tool provides a 3D visualisation of archaeological sites[1]. A combination of *jnet* and STRAT tools enables archaeologists to visualise archaeological stratigraphy data and all information from an excavation. As compared to STRAT, our tool is simple, designed for producing 3D Harris Matrix charts (optionally with hyperlinks to graphic files). X-VR technology enables us to create a virtual reality with the help of X-VRML language. The main aim in choosing the software is to render possible a presentation of user results (archaeological stratigraphy data) within a standard VRML browser plug-in to a web browser.

The Project

Polish research on the project of X-VR type computer application in modelling and visualisation of archaeological data in the spatial form of Harris Matrix was started in 2005 as a result of a cooperative agreement between the Institution of Archaeology, Ancient and Medieval History at the History Institute of the University of Zielona Góra and the Faculty of Information Techniques of The Economic Academy in Poznań.

A spatial presentation of Harris Matrix has been executed on the basis of data descended from the municipal position in Gdańsk-Szafarnia str., headed by Bogdan Bobowski. It concentrated, for visualisation needs, on data descended from one object dated from the period of the Napoleonic wars, including an interesting secondary deposit in the form of an ancient gem hidden by a French soldier during struggles for Gdańsk.

The X-VR Approach

X-VR technology enables the creation of virtual reality active applications based on databases. It allows for the building of precisely defined models of virtual scenes forming the application, a dynamic generation of exemplary virtual scenes based on the model and its parameters, the introduction of questions defined by the user, a determination of user preferences and privileges, and the determination of the current system state. The model of a virtual world, being on high level, can be written in the database's memory for convenient information management, highly efficient retrieval, safety improvement, as well as access insertion for many users. Dynamic modelling of the virtual reality is realized with the help of the X-VRML[2] language being projected in this order. The solution can be used for building virtual reality active applications; that is, applications which require user interaction with the server, dynamic composing of virtual scenes, current access to databases, continuous visualisation, assurance of data constancy, etc. The proposed solution of an archaeological visualisation of the Harris Matrix would certainly widen the functionality of the X-VR technique to the ground of country archaeology, and the system seems to be quite similar to applications known from GIS technology.

3D Visualisation of Archaeological Site

Archaeologists collect data in the form of horizontal and vertical plans, drawings of artifacts, descriptions of stratigraphic units alongside their mutual relations, and they photographically document all revealed units during country research. An important factor of an archaeological stand's correct record is an establishment of the primary location of historic substance in the field. We make use of different methods, from the establishment of units' coordinators with the help of simple geodesic equipment, to the preparation of precise digital maps of the stand with the help of specialized geodesic equipment. When preparing flat plans of successive settling levels analyzed with the stratigraphic method, we, in fact, create a 3-dimensional map of the stand, the basic element of which would be a single visible stratigraphic unit. The best solution for creating 3-dimensional models of the stand would bring

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1 http://dea.brunel.ac.uk/project/murale/strat.htm
2 http://xvrml.kti.ae.poznan.pl/, http://xvrml.net

GIS technology adaptation. Modern GIS applications, e.g. ArcGlobe[3], allow for visualisation built on multilevel data from the local or global perspective. Our project is based on the introduction of elementary coordinates determining the stratigraphic unit's range in the country (E, W, S, N coordinates as well as top and base levels) in X-VR technology adopted by us. Such a solution presents units in a very simplified way (regular geometric figures), but it allows significant reduction of data number constituting small visualisational files in VRML form, ready for online presentation through the Internet. The smallest visible stratigraphic unit's view (filled place, structure) can be additionally bridged by descriptive data, figures, even photos, through hypertext links. The 3-dimensional stand's chart, based on the smallest elements as stratigraphic units, enables us to look at the stand from different perspectives and to notice relations invisible on flat plans, thanks to the virtual wandering within units.

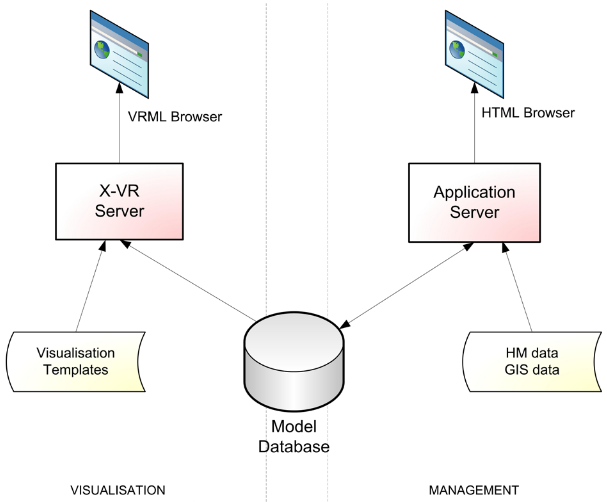

Fig. 1. System architecture.

Dynamic 3D Visualisations of Harris Matrix Data

The purpose of most applications for Harris Matrix creation is a presentation of a standard (easy to publish) 2-dimensional image. Of course, the chart does not present the units' real topographical location. Archaeologists read the information (and all descriptive, drawing and photographic information) looking through scattered documents enclosed in databases, digital maps and archives of photographical documentation. In principle, we have not found a commendable (simple and cheap) digital solution for archaeological documentation based on Harris Matrix, as an elementary screen of archaeological information with a simple system of references to detailed information. The use of an elastic X-VR technology enables building a 3D Harris Matrix, integrating vertical stratigraphy with horizontal topographical presentation. Visualisation is created by data stored on the databases' server. These data can be loaded indirectly (e.g. on the basis of information recorded in the country by archaeologists) on context recording sheets or directly through web forms available on the equipment used in the country (e.g. with the help of PDA and wireless LAN). The application enables looking through the unit in the view of topographical location and in the view presenting stratigraphic relation and position. The parameters of presented data also can be changed with the help of web formats. Each stratigraphic unit is conventionally presented as a cylinder placed topographically in the discovery place. The cylinder's pressing (a symbol of the stratigraphic unit) enables one to look at the real size of a given unit. Such a solution makes the presentation more readable, where we can look at real 3-dimensional units' models sometimes found within the same locations. The units' colours relate to the types of objects they represent. It is possible for the user to define groups of colours for individual objects or settling levels.

System Architecture

The system consists of two components: a *data management subsystem* and a *data visualisation subsystem*. Databases used by subsystems contain all information loaded during excavations. The data management subsystem is responsible for controlling data from excavations in the database, and it enables inspection and editing of database content, as well as data loading manually and from external sources. The subsystem is available from the standard internet browser's window. The data visualisation subsystem constitutes spatial visualisation with installed Cortona Virtual Player plugin (due to the

[3] ArcGIS 3D analyst, product website: www.esri.com/software/arcgis/extensions/3danalyst

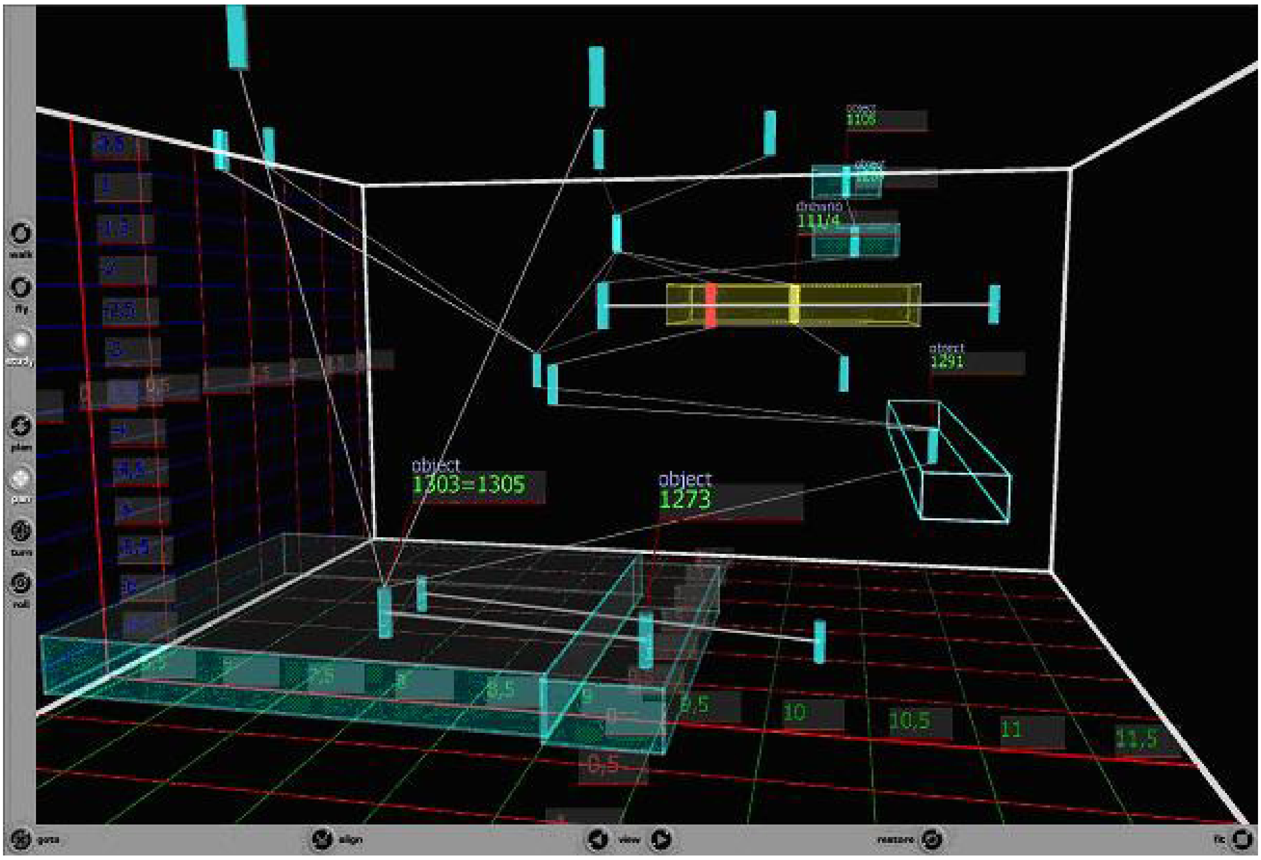

Fig. 2. Harris Matrix visualisation.

shortage of plugins, visualisation is presently possible only in the Internet Explorer browser).

Visualisation Tour

With our solution, the user has access to all functions of a Web 3D Browser[4] type application. Free navigation within 3-dimensional space, change of point of view, image rotation, and zoom in and out functions are all possible. The ability to change the point of view is especially useful for researchers. One can easily access additional descriptive information, as well as files corresponding to a given unit (by clicking on the unit). Visible figures in the forms of symbolic cylinders are found in the central place of spatial location of a given stratigraphic unit. Descriptive information (name) is presented in a separate window and contours are revealed by running the cursor over the unit. When one clicks on the unit, he or she obtains the view of the unit's real size in the space (contours' filling). In the case of spatial visualisation, one can obtain an image of units placed in real locations with X, Y, Z coordinates. However, when choosing Harris Matrix visualisation, X and Y coordinates relate to the real location of the 2D unit, and the Z coordinate is dependent on real stratigraphic position in regard to remaining units. In this case, the relationships between particular units (cylinders' figures joined by lines) are marked. Also, the heights of particular figures representing the units are unified and do not relate to their real thicknesses.

Conclusions

Irretrievably devastated historic substance can be presented in multiple configurations enabling the testing of complicated features thanks to the application of a modern visualisation tool. The tool for data collection should be available for many users.

[4] Browser product website: www.parallelgraphics.com/products/browsers/

This is important especially in the case of working on large stands, where data are collected by many persons at the same time. Base net management would significantly speed up data access, solve the problem of their transmission at a distance, and standardize data values. Those changes would be visible by all system users instantly after loading by one of its users. Spatial visualisation of an archaeological stratigraphy, near the elementary information concerning relations between particular units, contains data concerning the real location of the object in the stand space. Any descriptive data concerning the unit, loaded from context recording sheets having a certain standard, can be additional information. Dynamic 3-dimensional data visualisation can widen current methods of stratigraphy graphic presentation and combine elements of higher capacity information. When adding a third dimension to the Harris Matrix, we enable the visualisation of additional data, concerning the object location in a 3-dimensional stand's net, often not visible in the form of a flat chart. From the user's point of view, the application does not cause installation problems with different equipment platforms and it assures high security of collected data.

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