A GIS and Hypertext-based System for Excavation Documentation

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0.   Introduction

Published papers that simply describe a computer-based system rarely justify their place: too boring, too narrow or too soon outdated, they are seldom read. A good system will be used: a short introduction and hands-on by far outweighs a detailed description. Thus an explanation is needed for the present publication which appears to be describing the functionality of a System for Excavation Documentation based on specific technologies, namely GIS and hypertext.

Time-honoured "technologies", such as the hammer or the bound-notebook-and-a-pencil, are extremely reliable and general-purpose. Portable, robust, inexpensive, energy source independent, very easy to start using and providing the expert user with unlimited capabilities, are not readily replaceable by those "highly efficient" tools, such as the computer or the electric-drill-with-modular-accessories, except when the latter reach a high maturity level.

So this paper is about the maturity of certain enabling computer technologies for the substitution of the classic excavation documentation tool, namely the Archaeological Archive recorded with pen on paper. A "proof of concept" system was designed and implemented with the average archaeologist and a middle-of-the-road excavation in mind, i.e. a system requiring reasonable computer and human resources. The Excavation Documentation System (EDS) consists of a Database, of the Excavation Archive and a module to handle spatial information.

The contribution of this work is in the user needs analysis, the system architecture and the design choices of the system implementation. The user needs analysis, presented in Sections 2.1 and 2.2, although originating from specific needs (of a prehistoric excavation in Toumba, Thessaloniki [4], [5]), are put in a suitably general framework. The main requirement of the system is the ability to store all types of information, multiple representations for the process -and not just a state- of an excavation and a set of simple but complete data querying and manipulation tools. This allows for the design of software adaptable to user preferences and technological evaluation. The basic technological choice is inexpensive, light, off-the-shelf software packages, like Arc/View, Access, Front Page, Netscape browser and a web server.

Section 3, is a description of the functionality of the system. Finally, in Section 4 an assessment of the system and a discussion on further issues are presented.

1.   Overview of the problem

Computer technology has a special role in the development of systems for excavation documentation because of the destructive nature of the process of the excavation. The science of archaeology is based on the efficient manipulation of the data collected during an excavation. Archaeologists are faced with the difficult task of organising large quantities of interrelated data in order to produce valid conclusions and publish their results. It is difficult to handle both the volume and the format of the data. That is where computer technology contributes significantly to archaeology.

1.1.   Description of the situation

[1]The present methodology in documenting an excavation is paper-based. All information gathered during the excavation is recorded in a book and afterwards the information is processed in order for the archaeologist to present his work and arrive at conclusions about the findings. The artefacts found after being recorded are removed from the site and stored so that later they can be examined in a laboratory.

- [1] Brief description of the process of the excavation and in what way the information technology will help and even promote the work of archaeologists.

1.2. Description of the needs that led to the system

As mentioned earlier, the process of an excavation is a destructive one which alters the morphology of the scenery, the ground and the appearance of the site and the settlement. Also a common situation during an excavation is the existence of successive settlements built one on top of the other in different time periods and the way to access is by removing the subsequent settlements in order to reach the prior ones. Concerning the data collected, the archaeological information is characterised by three dimensions:

- spatial

- descriptive

- chronological

The effective manipulation of all three dimensions specify the framework for the organisation of archaeological information and thus specify the technical problems as well. GIS is used to handle spatial information without distorting its 3-dimentional aspect. Hypertext technique is used to handle all of the information in the excavation archive.

Based on the grouping made above along with the information about the process of the excavation and records from the excavation archive, the types of information collected, apart from spatial information are:

- Text from the excavation archive.

- Pictures, drawings, even video if suitable.

- Information regarding all the elements of the excavation, such as decoration of pots, composition and texture of the ground in every stratum, material and possible use of small artefacts, and also overlay of strata and the use of hearths.

- Information regarding the chronology and the construction phases of the settlement.

2. System analysis

2.1. Original prototype

The Excavation Documentation System(EDS) is based on a previous prototype for excavation documentation [1],[2],[3]. The tools used to develop that first prototype are ArcInfo and Oracle. The platform used is the UNIX operating system on a Sparc workstation. Some of the operations implemented are:

- *Draw:* With the menu *Draw* the map that are to be drawn are selected. There are 5 available thematic maps: Squares, hearths, pots, walls and small artefacts.

- *Zoom:* The menu *Zoom* presents different areas of the maps in greater or less detail. There is the capability of zooming in and out.

- *3D viewing:* This menu displays 3-dimentional aspects of the excavation site in different stages of the excavation and different construction phases of the settlement, and also of the morphology of the ground in two levels of strata. On the same screen with the 3-D aspects, appears a photorealistic aspect of the same view of the site with the advantage of showing the volume of the ground.

- *Queries:* Adding to the previous operations there can some queries made on the data stroed in the database like: *Find the pots that date a specific time period, Find the small artefacts that are near a specific hearth, Find the pots that a specific decoration motif, or In which stratum was a specific small artefact found?*

2.2. Specifications

The general system specifications are the storage and manipulation of all information that arises from the excavation. The system should store all types of data collected during an excavation, such as pictures and maps with the spatial information, tables with their descriptive information, information concerning the height of the site and all the findings in it, and text describing the findings and the process of the excavation.

As well as storing information, the system should relate its parts according to objective criterions, like common attributes or other subjective ones, like the opinion of the archaeologist. The aim of the system is to reproduce the excavation site during all the phases of the excavation and eventually reproduce the archaeological scene.

The primary intention of the system is to reverse the destructive results of the excavation, by placing "imaginary" items in place of the ones excavated or removed from the site. That gives the archaeologist an overall view of the original settlement, and reveals the successive stages of its construction.

2.3. Functional architecture

The main part of the system is a database that stores the spatial and descriptive information of the site and the findings from it. The database is connected to a number of tools for the data input, representation and processing. The system presents the data in the form of maps and layouts. It queries them according to spatial or other attributes.
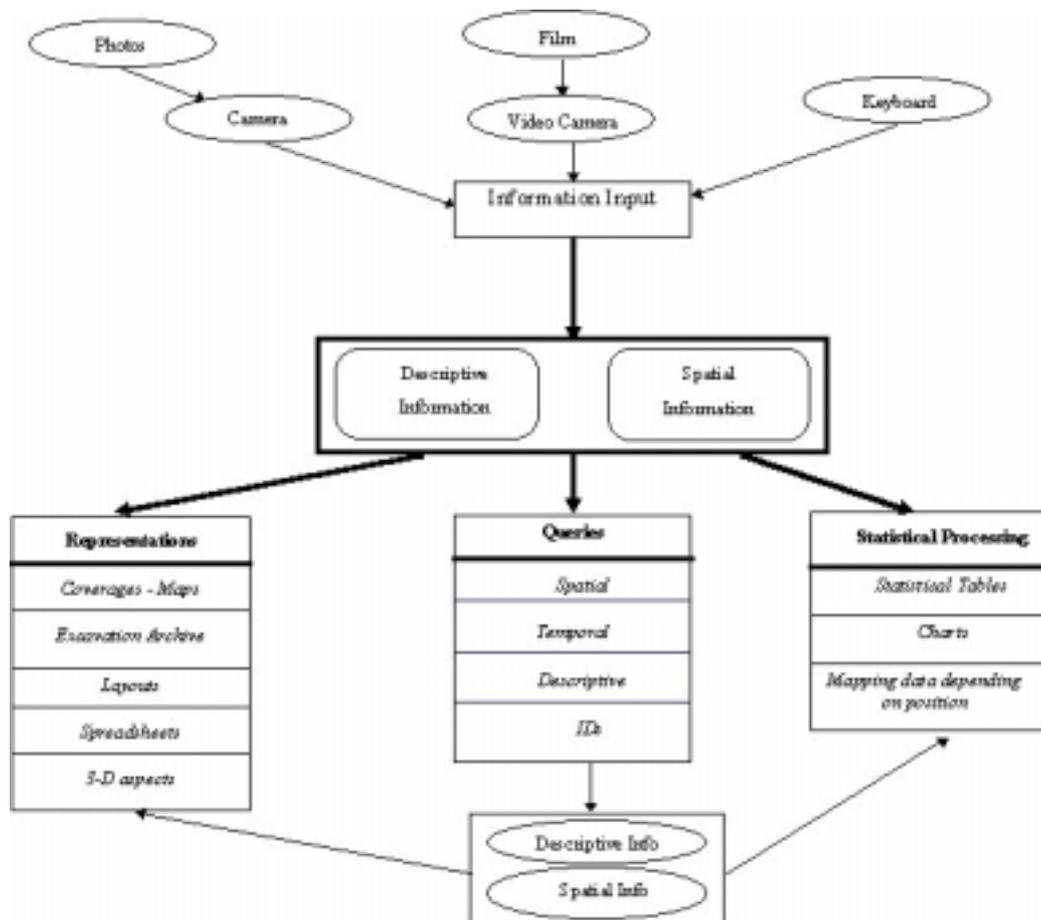

Figure 1: Functional architecture of the system

2.4. Physical architecture

The system for excavation documentation consists of a database which exchanges information with a GIS system and an application developed on a web browser which is the excavation archive. It outputs the information in electronic form, or in paper and can publish it in the World Wide Web.
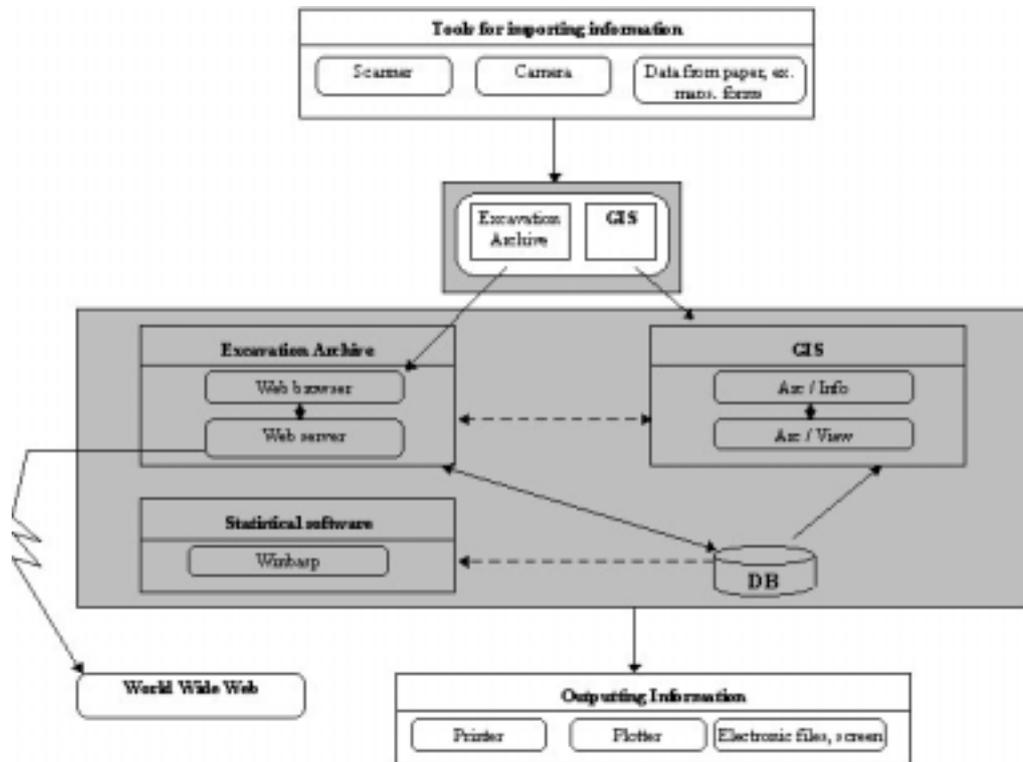

Figure 2: Physical architecture of the system

3. System Description

The Excavation Documentation System (EDS) is a system for the archaeologist in the field. It is developed on a PC platform under Windows95. The tools used are ArcView and Access.

The operations developed in the EDS are for the presentation and the querying of spatial and descriptive data. A way of supporting the capabilities of GIS in the science of archaeology, is the transfer of part of the excavation archive into hypertext format. Advantages that derive from the certain way of implementing the excavation archive is, apart from the navigation through hyperlinks, the queries posted to the database through it and the viewing of the results.

3.1. ArcView and implemented functions

The functions implemented based on the spatial attributes of the objects are based on:

- the relative distance of some of the findings

- the place or time that they were found or constructed

- the height inside a stratum or in relation to other strata.

The system can perform querying of every category of items, depending on the user's wish, around certain items and according to the radius in which they were found. The user can decide on the original set of findings around which the selection will be made, on the distance that will be searched, and also on the outcome of the query. For example, *Find the pots and small artefacts that can be found around*

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the selected set of hearths in distance of 4m. The outcome of such a query can be a new set, or can be added to the previous one, or even substracted from it. *(See figures 3,4)*

Determining the height of every point of the excavation site and the height in relation to two different levels of the excavation is also possible. These operations return the height as well the depth and level of the excavation in which they were found.

There are also operations based on the descriptive attributes of the archaeological data, such as the ID, description, or pictures. For example, *Draw images and descriptions of all the selected features,* or *Show the labels(ids) of all the selected features,* or *Print a report on all selected features using some of their attributes,*ie. ID, Description, Chronology, Category, Use, Material.

Time related operations have been implemented in which the chronological dimention of archaeological data is examined. For example: *Find all the pots that date a specific time period.*

On presenting features, and creating different representations of data *(See figure 5)*:

- Show the 3-D views of the different levels of the excavation site, or show maps of the categories of objects found,

- Construct layouts with the map of the site and the pictures of the selected features, or show an overall aspect of the map of the site, focusing on the zoomed in area of the map. Create a layout using the different 3-dimentional representations of the levels of the excavation.

3.2.   *ArcInfo and stratigraphy/ 3D selection*

The operations developed can be expanded to meet requirements in 3-D space. The stratigraphy of the ground can be outputted from the spatial information about the configuration of the different levels of the ground of the excavation. The stratigraphy is determined by the depth information of the ground and can be calculated along every line on the excavation site according to the archaeologist's needs, by cutting vertical sections on the desired levels of the excavation *(See figure 6)*.

Another operation in 3-D space is the querying of data, based not only on the horizontal distance from findings, but also the vertical distance. So, the search could be done inside a sphere or a cylinder, and all the dimensions can be provided by the archaeologist.

3.3.   *The excavation archive as hypertext*

The way in which the archaeologist searches his/her data to arrive at conclusions is by associating parts of the information found on different days, or on different levels of the excavation. Findings can be associated with others of the same type or can be grouped according to their use, shape, decoration, color, depth or square in which it was found. The information collected during an excavation is recorded in a book. This sequential process, makes it difficult and at often unfeasible for the archaeologist to interrelate the records of the excavation archive in all the possible ways that could lead to conclusions essential for the outcome of the excavation's documentation.

The hypertext technique is a way of associating all the different types of archaeological information in a non serial way. The data can be linked in many ways depending not only on the day that they were found, but also depending on the attributes of the findings stored in the database, closeness in space, or even according to the archaeologist's judgement *(See figure 7)*.

This particular way of organising the information has many advantages when applied to the excavation archive. The hypertext can connect parts of the archaeological information through hyperlinks for better navigation and management of the information. Dynamic organisation of data, i.e. during its collection, is also an appealing feature of hypertext. According to the new findings, new categories can be added. The findings can also be grouped into more than one way. Finally, the excavation archive in the form of hypertext has the ability to combine all the different representations of the data. For example, text describing the findings can point to their pictures or text describing the work done in one day. Or the configuration of the ground can point to a sketch or other text describing similar processes. Also, by using the map, the archaeologist can view findings based on their position.

3.4. Querying mechanism and the database

With the help of a web browser, the user can access the records of the excavation archive in the way explained above. On top of that, records in the database can be accessed through the web browser. In that way, the user can pose questions about the data and view the results as a web page containing links to the actual information. The questions can be in relation to all the attributes of the objects stored in the database. Examples of such queries are:

- Which small artefacts were used as tools?

- Which pots have a decoration of ex. birds?

- Show all information associated with the finding with ID number ex. 3405.
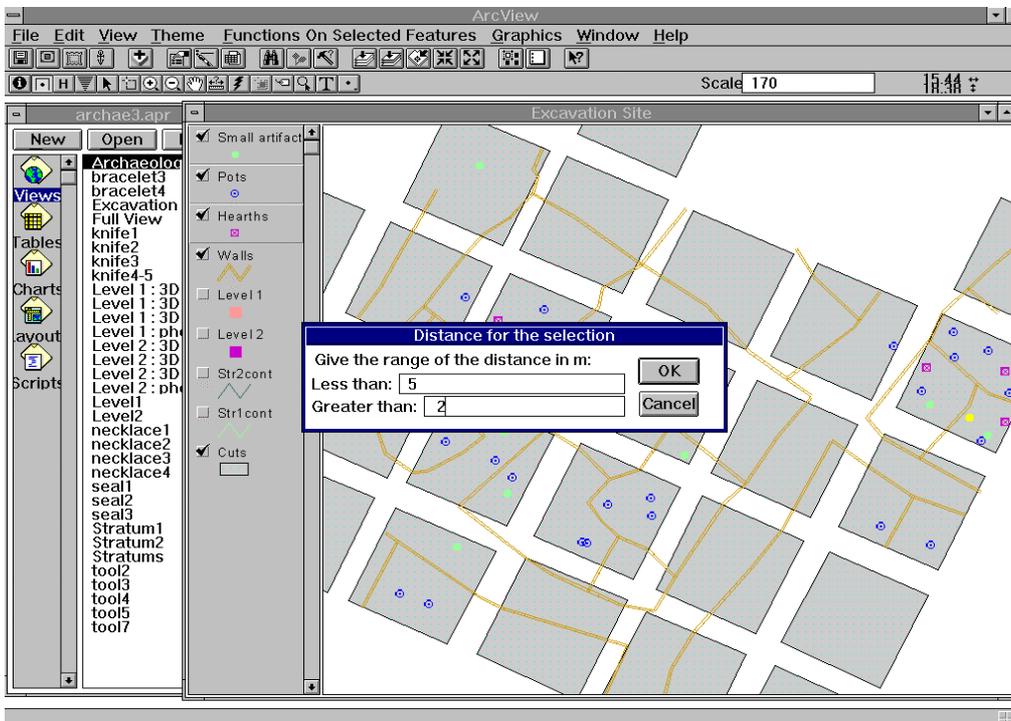
3.5. Pictures of the system

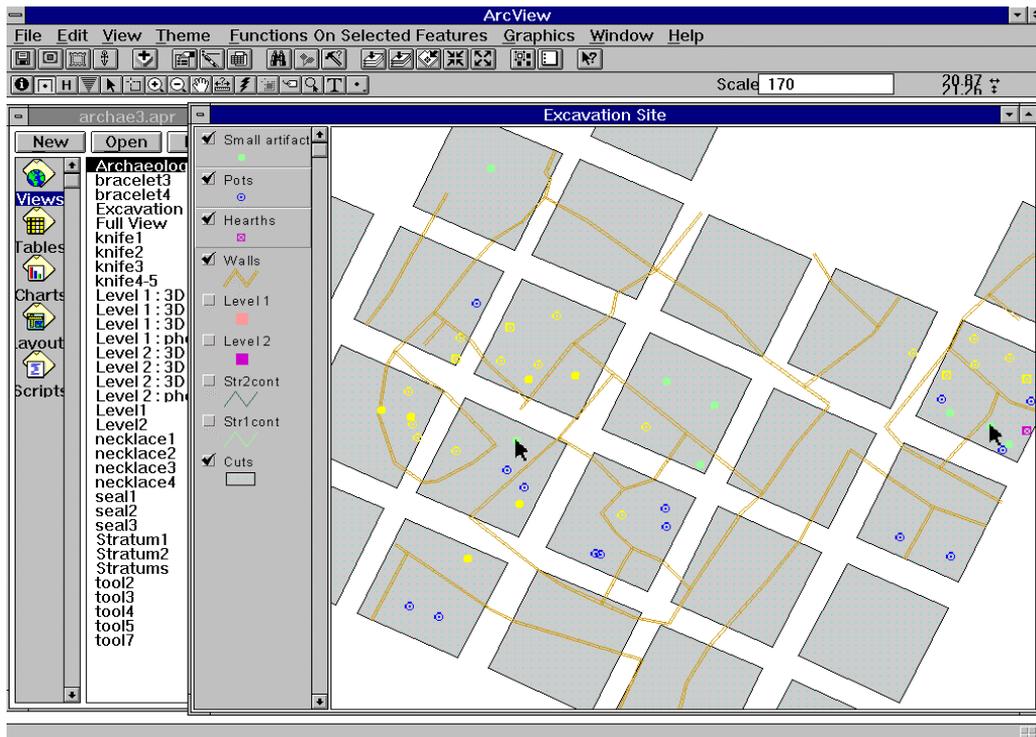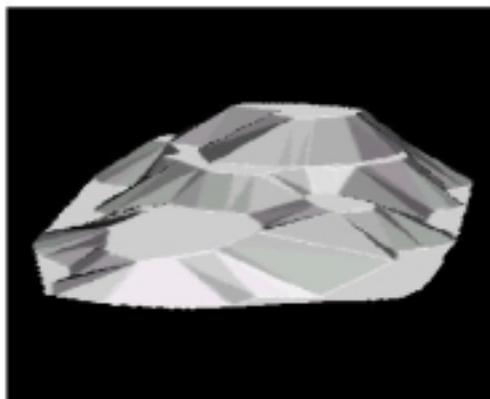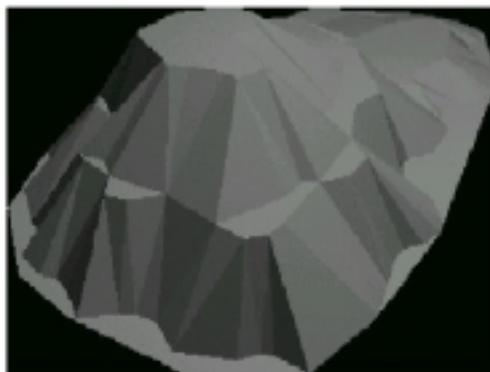**Figure 3: Feature selection based on the distance inside a ring**

Figure 4: Result of the previous selection

Different views of the first level of the excavation site. These are:

Photorealistic view
Shaded relief view and
the contours of level 1.

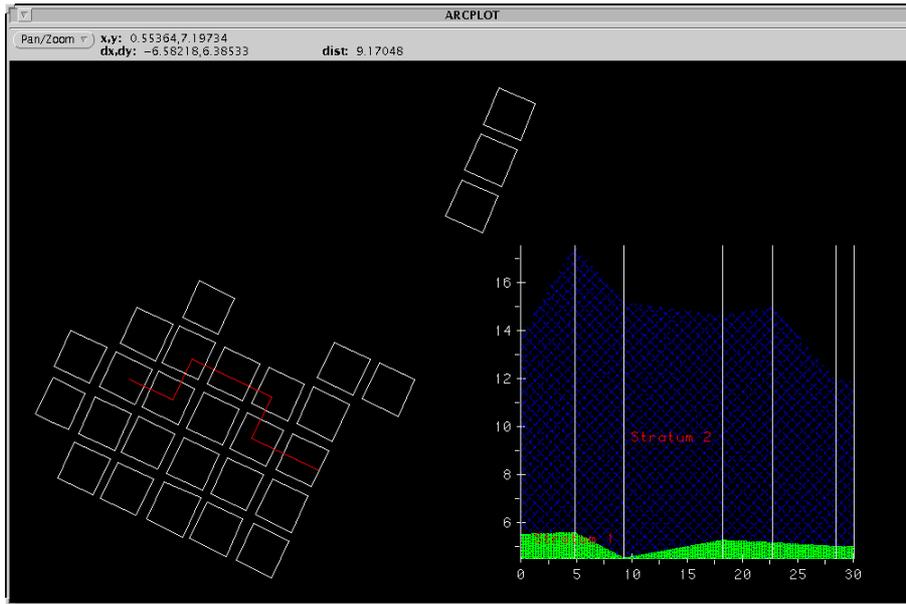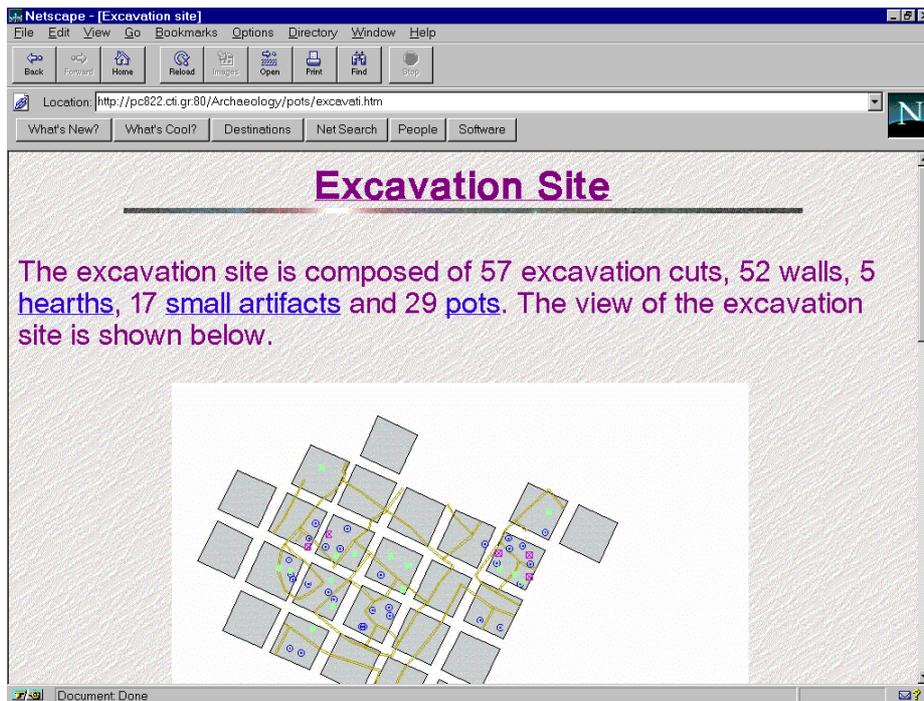**Figure 5: 3-D aspects of the first level of the excavation**

Figure 6: Stratigraphy

Figure 7: The excavation archive in hypertext

4.   Discussion

4.1.   Future Developments

There are many interesting directions for future developments, some of which are described below.

- Connect the database with a thesaurus for a more accurate search in case of:
  - synonym words

–   abstract/generalised concepts

●   Connecting the system with tools for simulation and movement through the archaeological site

●   Enhancing the system for a better representation of the evolution of the archaeological site through time

4.2.   Problems/New issues arisen

New issues that arose from the present phase of the system are:

●   The need for a new database schema in order to meet the requirements for a better representation and management of the temporal nature of archaeological data.

●   A more vivid representation of the site, based on the information available from the excavation, with the application of virtual reality techniques.

4.3.   Conclusions and system evaluation

This work is part of developing an integrated system for excavation documentation. Such a system involves the collection of data during the excavation and the processing of that information during and after the excavation is completed. The basic idea is a system that will enable a tour through the excavation as well as the archaeological site, in space and in time. A system that provides the user with the ability to place himself inside an archaeological site and "see" what was found there, what interpretations have been attributed to it, and the images that have been generated based on that information.

The system developed, so far, is meant for the archaeologist in the field. It is a system for the recording all the information gathered during the excavation and performing some operations on the data. The data is stored in a database and the excavation archive is recorded as a hypertext document. These are two of the modules that constitute the system, used to record and manipulate the various types of information collected. A GIS package is used for manipulating the spatial data and queries, a database for storing information, a web browser to view the excavation archive and a web server to connect the database with the web browser for performing queries on the data. The system can be configured by the user to meet her needs.

The work presented here has resulted in an evolving tool for excavation documentation that an archaeologist can use in the field, since it can reside on a laptop and needs little programming effort to make adjustments to already existing tools or add new ones. It also has low technological complexity regarding both software and hardware.

5.   References

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