A DIGITIZED INFORMATION SYSTEM FOR THE DOCUMENTATION OF MONUMENTS

by

A.G. Badellas, J.D. Doukas, P.D. Savvaidis

Section of Geodesy, Department of Civil Engineering

University of Thessaloniki, Greece

Abstract

In this paper an extended description of a digitized information system's philosophy for the documentation of monuments is made. This system is capable of handling all kinds of graphical and non-graphical information for a specific monument. The structure of the system is described in detail and various methods of data input are discussed. Lastly, reference is made to an attempt of using this system for a monument in Thessaloniki in order to gain experience for the generalization of the use at town or country level.

KEY WORDS: Monuments, documentation, GIS

1. INTRODUCTION

The task of creating an archive to record all-available information is a major factor that helps the documentation and the future restoration of a monument. Under the term "documentation", we mean the recording, supplementing and filing of the existing material about the architecture, geometry, history, age, changes and use of a monument and its surrounding environment. This material may come from different sources, may be gathered in different ways and it is of great importance for many scientists. Under the term "monument", we mean any structure with prominent archaeological, architectural, historical or cultural interest. According to this definition there can be many monuments in countries with a rich historical and cultural background, as Greece.

Frequently this large number of monuments and the variety of shapes as well, are a significant problem for the preservation of the historical and architectural heritage (Zahopoulou et al., 1986). Many agencies and individual experts provide support in monument documentation and maintenance and have established a considerable volume of material. On the other hand, this material is usually scattered among various branches of the civil service and personal libraries, and it is not always kept in the most suitable conditions. Consequently, the main problem lies in the inability to study the existing material and, by extension, in the neglect which is the fate of work and research carried out laboriously and with intellectual effort.

In this spirit, the best solution may be a Geographical Information System (GIS) (Onsrud and Dansby, 1989); a system of computer aided tools for the digital collection, storage, research, analysis, transformation and production of spatial data about the real world, in which representations of measurements and non-graphical data are combined for a series of specific aims and goals. This may be achieved by the use and collaboration of the proper software and hardware (Doukas and Savvaidis, 1990).

Such a digitized information system can very well be used for monument documentation given that it is adapted to the specific needs of the problem's frame. The structure of this system will be discussed in the next paragraphs.

2. STRUCTURE OF A DIGITIZED INFORMATION SYSTEM FOR THE DOCUMENTATION OF MONUMENTS

The ultimate aim is to design, feed and supplement a relational database which will form the nucleus of the corresponding GIS containing all the information, in whatever form, that is connected to a specific monument. The structure of this system depends on the different categories of information that have to be entered into and the aims put by the end-users. GIS systems work in a dynamic way. Software (S/W) consists of different programs and utilities performing different tasks (modular programming and structure). All subprograms can work independently. There is much freedom for GIS improvements and modifications (in S/W and hardware-H/W). Theoretically the only limit in this procedure is the capability of H/W-S/W itself.

A GIS application for the documentation of monuments may contain the following basic categories of information (fig. 1):

1. General information about the monument.

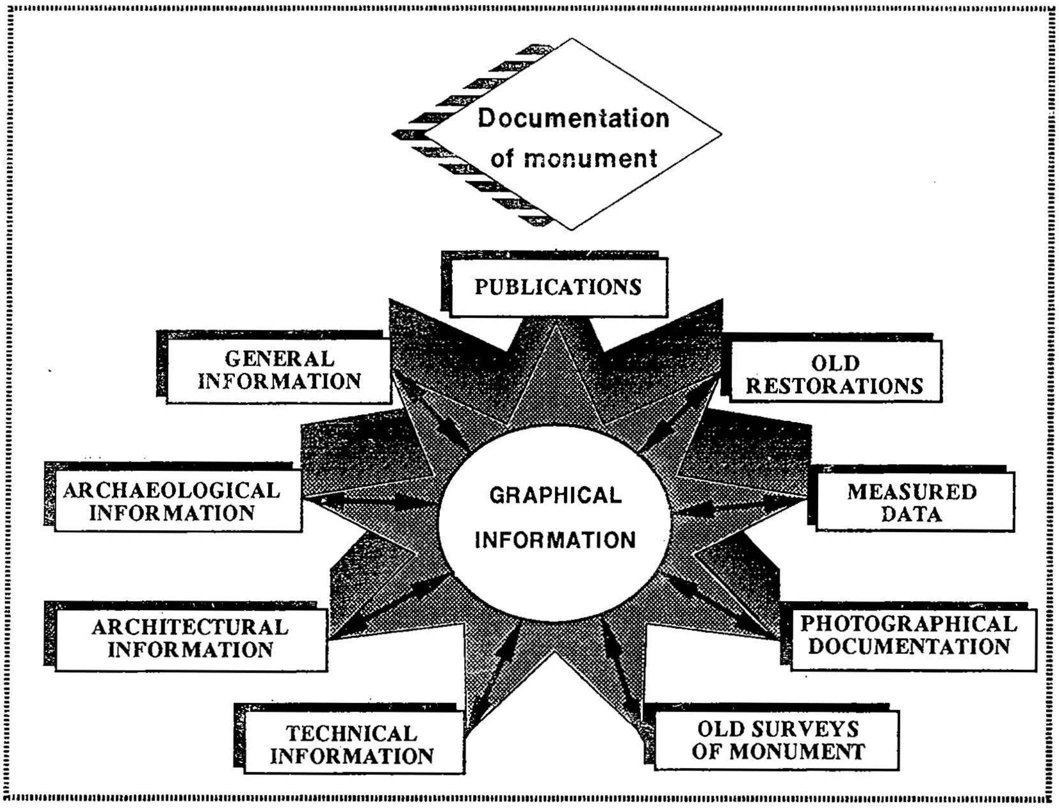


Figure 1. Basic structure of a digitized information system for the documentation of monuments

In Table 1 the procedures leading to the development of a GIS are shown (Harrison and Dangermond, 1989).

2. Archaeological information.

TABLE 1. GIS LIFE CYCLE

LIFE CYCLE	Tracks and Activities: DESIGN	ACQUISITION INSTALLATION	DATA BASE	APPLICATIONS	TRAINING SUPPORT
❶ Feasibility Assessment	•Orientation •Needs •Requirements •Cost and Benefit •Perspective				
❷	•D.B.* design	•HW/SW** Specif/tions			
Design	•Application definition	•Tender documents	•Physical D.B. design	•Specifications	
and	•HW/SW Concept	•HW Vendor Contracting	•Pilot study	•Prototype creation	
Procurement	•Organization	•HW/SW Acquisition			
❸			•Data standardization		•User training
	•Impl.ementation strategy	•HW/SW Installation	•Data conversion	•Application creation	•Administrator training
Implementation		•System integration	•DB/Library creation	•Documentation	•Programmer training
	Funding and Financing strategy	•System programming	•Product creation		•Application training
❹					•Ongoing education
Operations		•System upgrade	•Update procedure definition		•Contracted support
and			•Service bureau to users	•Application enhancement	•Onsite support
Maintenance					•Funding program

Note: * HW/SW = Hardware/Software ** D.B. = Data Base

3. Architectural information.

4. Technical information.

5. Information about old and planned restoration campaigns.

6. Measurement data.

7. Photographical documentation.

8. Information about old monument surveys.

9. Publications about the monument.

10. Graphical information of different types.

From the above stated categories of information, (1) to (9) are non-graphical or descriptive information while reference to maps, diagrams, sketches, digitized photographs, slides and videos involve graphical information (category (10)).

The database fitted to the specific GIS should combine the capacity to handle graphical information with the capacity to handle descriptive information and with the capacity to structure topology and models for the correlation of data from one category to another.

This requirement presupposes the presence of powerful graphical operations (input-handling-creation-production), a suitably-structured database of descriptive information (storage-retrieval algorithms-response time) and a powerful S/W package adjusted and adapted to the specific requirements and needs. Usually, the S/W has a graphical editor with full 2D- and 3D-drawing capabilities, raster graphics handling routines etc.

Output units other than conventional (printers, plotters etc.) can be used. Results can be obtained on slides, audio-visual devices, video tapes etc.

Animation techniques for the representation or the simulation of events could enhance dramatically the system's potential resulting benefits like:

- Representation of events with time at different speeds.

- Representation of events that never occured, or occured at an earlier epoch, or it seems impossible to occur.

- Detection and preservation of events for further study.

- Study of picture frames or elements for maintenance purposes.

- Comparison of events that occured at different epoches (or even different places).

The philosophy of the structure of the GIS in combination with its S/W-H/W capabilities has to be ready to implement (now or in the near future) multimedia techniques and applications (i.e. interactive information manipulation based on computers and audio-visual means).

The multimedia era is already present in many fields with extraordinary results opening new horizons for research and education (Bellas, 1989).

A brief description of the earlier mentioned GIS categories of information for the documentation of monuments is to follow.

2.1. General information about the monument

In this category basic data about the monument are included (fig. 2). Such data are the location of the monument, the estimated (or known) time of construction, ownership records, the state agency responsible etc.

These descriptive data are correlated to different maps of the area, a general surveying drawing and the corresponding terrain model. General photos, slides and videos can also be used here.

2.2. Archaeological information

This category of information contains brief but complete data about the history of the monument, the archaeological excavations carried out at the spot (Zahopoulou et al., 1986, Savvaidis et al., 1988) with details about the chief archaeologist, year of excavations, important findings and other similar and worth-mentioning information (fig. 3).

Graphical information correlated to the above stated descriptive information includes general and detailed excavation plans and sketches.

A lot of valuable information can be produced by using the GIS tools (multi-layered drawing, colors, libraries of symbols etc.). Photographs or slides of excavation phases and findings can be digitized and entered into the system. Such data can be processed and printed/plotted in conventional ways or can feed dedicated multimedia applications (representations, simulations, tour of procedures, educational scenarios).

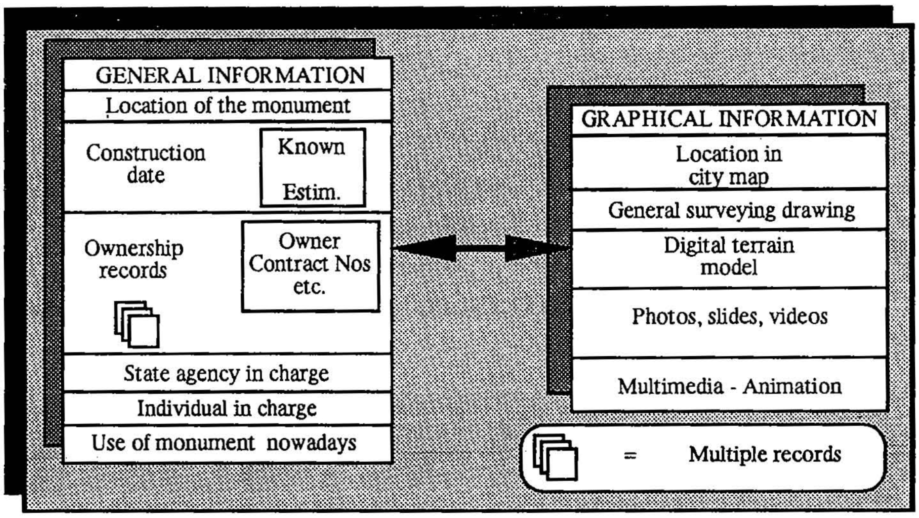


Figure 2. Correlation of general information to graphical information

2.3. Architectural information

Architectural information (combined with archaeological data) is probably one of the largest categories of information in the GIS under consideration.

Descriptive data in this category include information about the building materials and techniques, foundation, masonry, wooden-stone-marble structures etc.

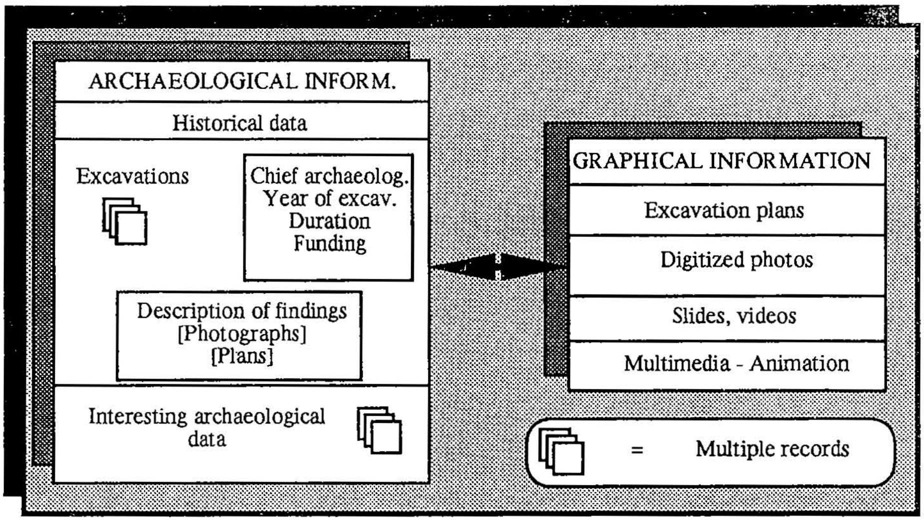


Figure 3. Correlation of archaeological data to graphical information

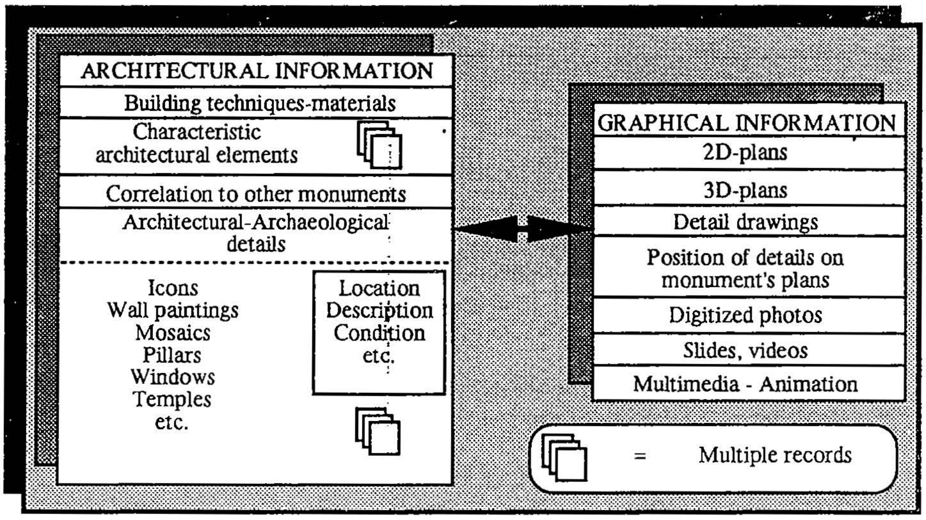


Figure 4. Correlation of architectural information to graphical information

Brief description of other architectural elements of interest are also entered into this category (fig. 4).

The corresponding graphical information contains digitized 2D- and 3D-plans of the monument, computer generated shadow and/or color models, drawings of interesting and characteristic details, digitized photographs etc.

2.4. Technical information

This category of data is supplemented with particulars from studies of the static and dynamic condition of the monument. The information can contain the type of foundation, existing damage and cracks, deformations, settlements etc. Furthermore, information about all-existing utility networks, fire-protection, heat-sound insulation is given here (fig. 5).

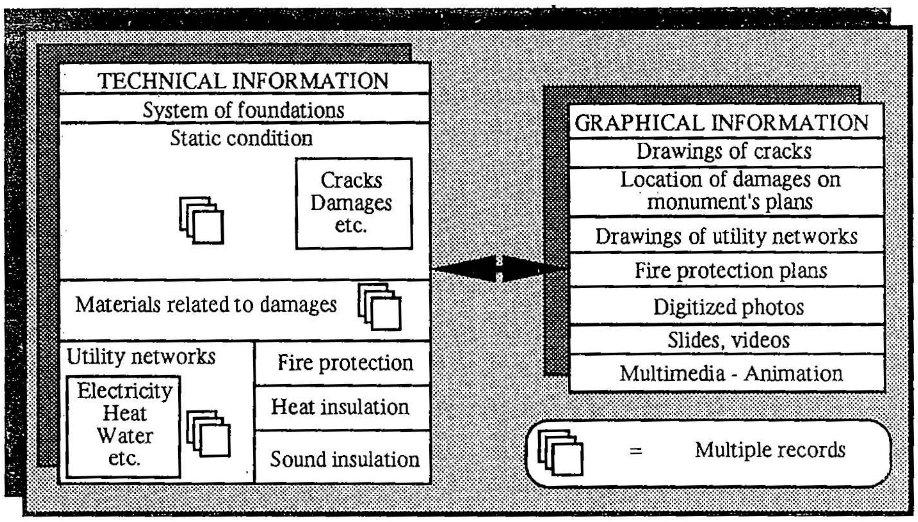


Figure 5. Correlation of technical information to graphical information

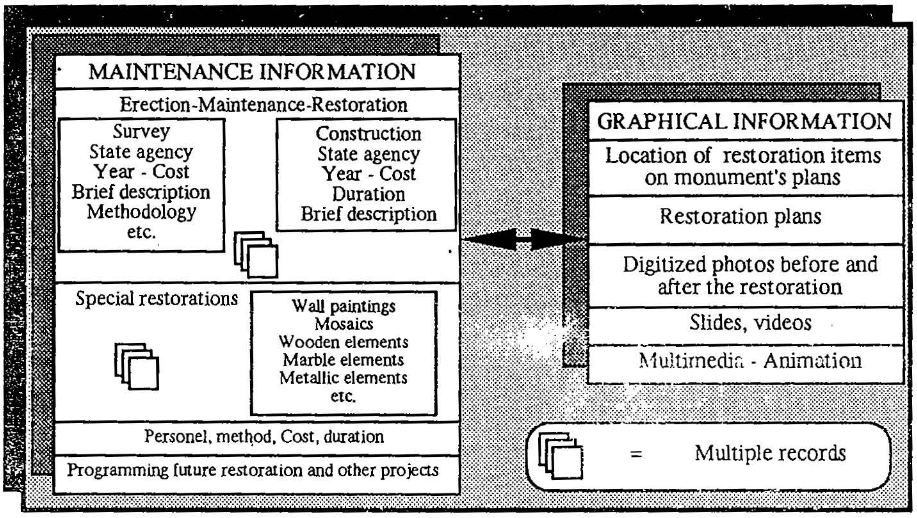


Figure 6. Correlation of information about past restoration campaigns to the graphical information

A lot of graphical information can be entered into this category containing detailed drawings of cracks, the position of damages on the monument plans, drawings of the utility networks, digitized photographs of places with damage etc.

The combination of descriptive and graphical information can result into valuable conclusions about the static and/or dynamic condition and behavior of the monument. Restoration studies will then become easier and more efficient.

2.5. Information about old and planned restoration campaigns

This category of information contains the available data about maintenance and restoration works carried out in the monument in the past. Input data include both elements of the

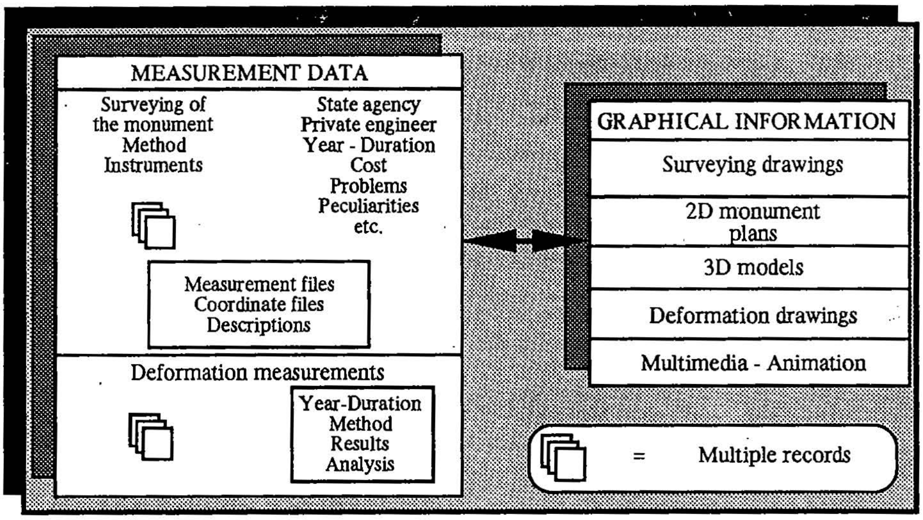


Figure 7. Correlation of measurement data to graphical information

studies and the works done. Special attention is paid to restoration and maintenance of mosaics, wall paintings, portable icons and other elements with archaeological, religious or architectural importance. Organization schedules of future works may be entered into this category as well (fig.6).

The corresponding graphical information contains restoration plans, position of restorated items on monument plans etc.

2.6. Measurement data

This category of information includes all geometry data that are the base of the development of graphics. These data are coordinates of points (measured or digitized). All files of measurements and point coordinates are included here (Badellas and Savvaidis, 1981, Zahopoulou et al., 1986, Savvaidis et al., 1988). Part of the measurement files may include deformation data of the monument and the surrounding area measured at different epoches (Doukas, 1988, Doukas et al., 1990, Badellas and Savvaidis, 1990) (fig. 7).

The descriptive information is related to virtually all digitized drawings of the monument. Animation techniques can play an important role in the study of the monument's deformations.

2.7. Information about past surveying campaigns

In this category, information about measurements of the monument carried out in the past is included. Digitized old maps and diagrams contribute to the study of the monument's shape (fig. 8).

2.8. Photographical documentation

This category of information includes digitized photos, slides or special video films of aspects of the monument, of exterior-interior details and of the general environment in which it is located.

With suitable equipment and commercially available S/W, it is possible to compile selected digitized photographs with digitized plans of the monument resulting into the reproduction of plans with photographical detail on ar-

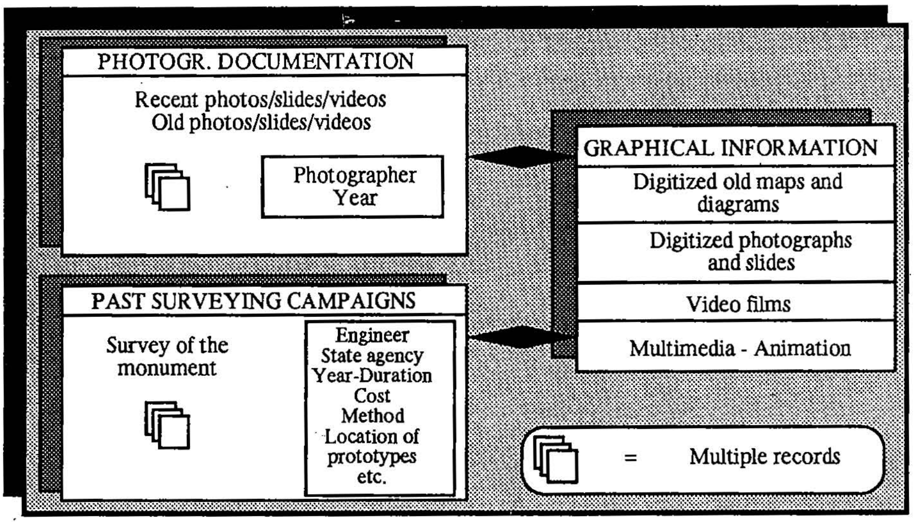


Figure 8. Correlation of photographical documentation and data of past surveying campaigns to graphical information

chitectural scales (fig. 8).

An important and very promising dimension of this category is that it is possible to draw attention to and show specific parts of the monument as a whole, by using special data processing to produce integrated audio-visual shows (multimedia applications) for education or even tourism. Being in this revolutionary dimension, the creation and publication or books, calendars etc. is easy feasible if we recall the desktop publishing potential.

3. DATA INPUT - OUTPUT

Given that the digitized information system will be fed with a multiplicity of data of various categories, it has to be able to accept data by a variety of methods and means.

Descriptive information is entered into the database by using S/W based procedures (keyboard input, read-in ASCII files etc.) (Doukas and Savvaidis, 1990).

Old maps, maps and all drawings not based on measurements, can be entered into the GIS through digitizers or CCD optical scanners. When using optical scanning methods, the resulting digitized images are in raster format. Special S/W is needed to transform them into vector format in order to correlate them to other digitized vector plans. Optical scanning can be also used for the digitizing of photographs and slides while the use of video-films calls for special S/W-H/W (interfaces, frame grabbers etc.).

The creation of the graphical database containing the 2D- and 3D-plans of the monument is performed with the use of special dedicated graphics S/W (CAD) based on measured data. Measurement of the monument results into coordinates of discrete points used for drawing of plans, faces, sections, 3D models etc.

Surveying a monument can be made in different ways:

A. The classical geodetic method with measurement of triangulations, traverses and polar coordinates of detail points (Zahopoulou et al., 1986, Savvaidis et al., 1988).

B. The combination of classical geodetic method with 3D-measurement systems incorporating electronic theodolites, servotheodolites, laser units and CCD cameras.

C. The classical photogrammetric method.

D. The simpler photographical-photogrammetric method incorporating an almost ordinary 35mm camera with grid and the special S/W.

The few last years new experimental methods for the measurements of buildings (and monuments) have been introduced, such as:

• optical scanners of large objects with the use of a laser beam (Wehr, 1989).

• 3D-systems using two or more specially designed CCD cameras (Riechmann, 1989).

In order to achieve maximum benefit, the GIS must have the capability of using different interfaces to accept data from new sources or new instruments and methods.

The system must provide output to various units for different scopes. Indicatively, it can make possible:

º The production of plans (or maps) of various types, on transparent or other kinds of paper.

º The production of reports on screen or on paper.

º The production of slides.

º The production of video films (at an advanced stage of the system's operation).

4. PRINCIPLES AND DESIRABLE FEATURES OF THE GIS

The accomplishment of the above mentioned requirements presupposes the presence of powerful graphical features (input-handling-production) and a suitable structured database for non-graphical data (storage-retrieval algorithms-response time). Furthermore, the digitized information system for monuments must also meet the characteristics of the generalized GISs, such as data compression solutions, supporting of many users and tasks, levels of user access, back-up etc. (Doukas and Savvaidis, 1990).

The philosophy of what are called open-ended systems should be applied to the database, governed by the following principles:

① The principle of uniformity and correlation: Under this principle, the various data are arranged in uniform groups with the common characteristic always being sought in its simplest form. Subsequently, the various correlation models can be developed separately as they emerge from the needs of the users whenever.

② The principle of data format knowledge: Under this principle, it becomes feasible to use (to incorporate into the database) all the most recent technological achievements in data processing and storage mechanisms. In this way it is possible to make full use of recent developments without being forced to discard any of the work done in the past.

By seeking to use the principle of uniformity and correlation referred to above, the GIS will be able to respond very rapidly to questions seeking information or to decision-planning questions (data queries). In this way the GIS becomes a powerful tool, not only for the documentation of the monument but also for the complete study of all-available data and for the programming of future restoration projects.

5. APPLICATION OF THE DIGITAL INFORMATION SYSTEM FOR A SPECIFIC MONUMENT

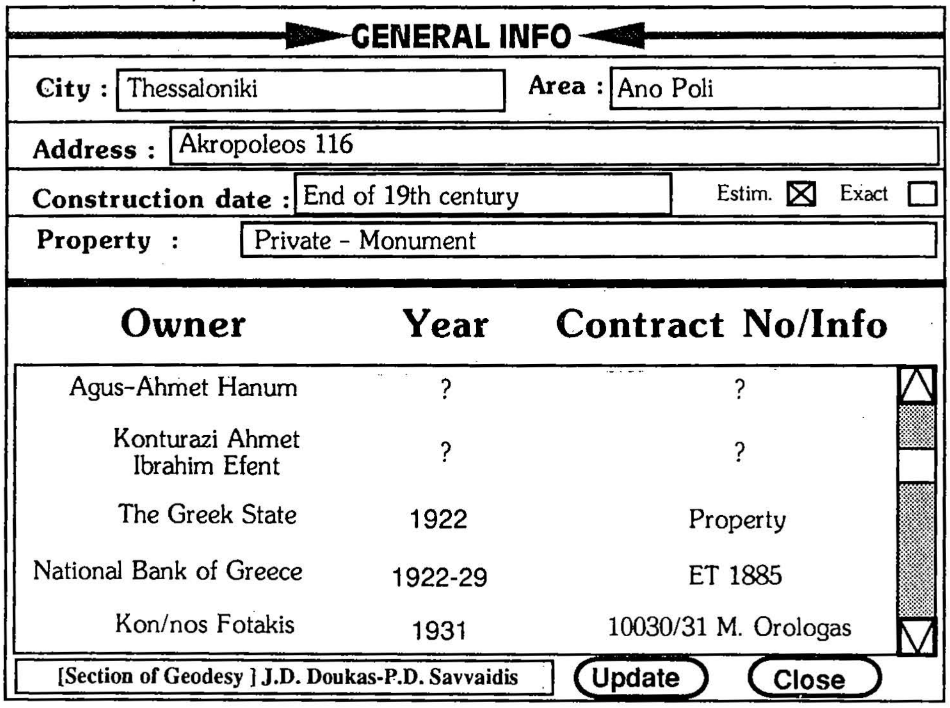
The Section of Geodesy (Department of Civil Engineering, Aristotle University of Thessaloniki) has started the development of a digitized information system for the documentation of monuments based on the principles and the philosophy described above. The system is planned to work under the two most widely used operating systems for personal computers (MS-DOS® and Apple Macintosh®).

An example of the performance of this GIS, concerning the manipulation of both graphical and descriptive information, is described in this paragraph. The example deals with an old building located at the upper town of Thessaloniki (Ano Poli), 116 Acropoleos Str. The building was constructed during the end of the 19th century, a period when the place was occupied by Turkish invaders.

All information about the monument's history was found in the archives of Vlatades Monastery and in the old Turkish cadastral books dated from 1906. It is maybe worth mentioning that in these books (ESAS and HULASA) the Turkish authorities recorded a lot of data about the properties of Thessaloniki. Other information regarding the different owners of the building were found in Greek state agencies.

Descriptive information about the building includes historical background, building techniques, building morphology, damages and planned restoration campaigns.

The building was measured in detail by using geodetical methods. A photographical survey was carried out as well (Kyriazopoulos and


GENERAL INFO

City : Thessaloniki — Area : Ano Poli

Address : Akropoleos 116

Construction date : End of 19th century — Estim. ☒ Exact ☐

Property : Private - Monument

Owner	Year	Contract No/Info
Agus-Ahmet Hanum	?	?
Konturazi Ahmet Ibrahim Efent	?	?
The Greek State	1922	Property
National Bank of Greece	1922-29	ET 1885
Kon/nos Fotakis	1931	10030/31 M. Orologas

[Section of Geodesy] J.D. Doukas-P.D. Savvaidis — Update — Close

Figure 9. General information about building's location, owners etc.

Safaridou, 1990). Files containing the coordinates (x, y, z) of all detail points and files containing scanned photographs were also created from the above data.

The H/W requirements are met by an IBM® AT compatible PC (1Mb RAM, 40 Mb hard disk, co-processor) or an Apple Macintosh® (2Mb RAM, 40 Mb hard disk, co-processor).

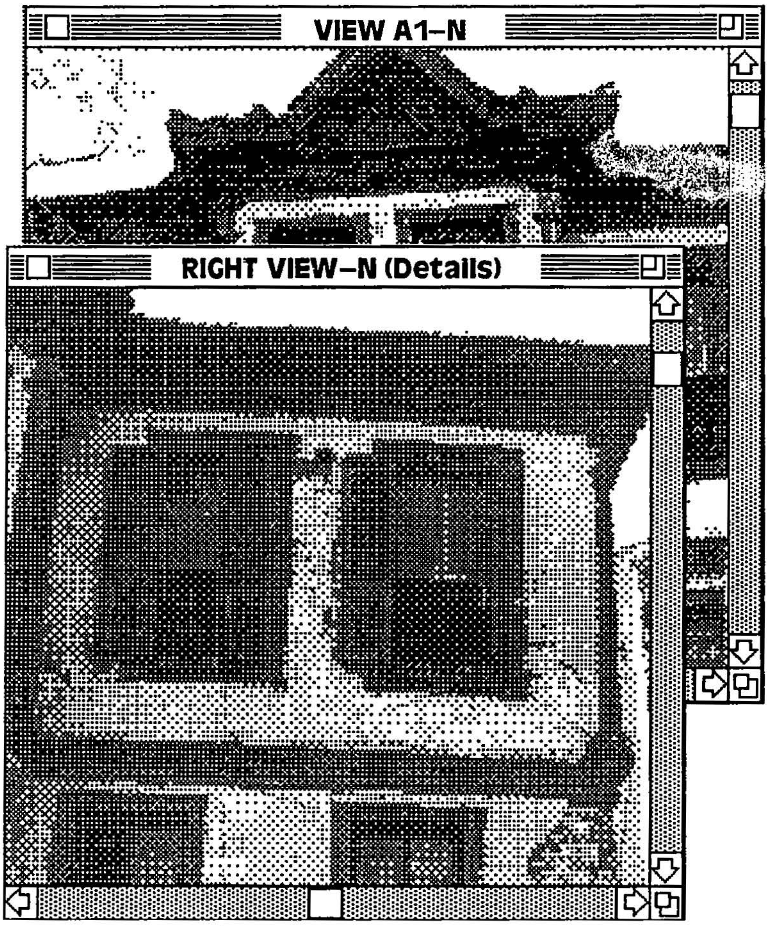


Figure 10. Multiple windows with digitized photographs of building's views

Figures 9 and 10 contain sampled screen dumps which show the way the available information is displayed. Multiple windows are available on the computer's monitor for the presentation of both graphical and descriptive information. An example of this system's capability is shown in fig. 11 were multiple windows illustrate the phases from a digitized photograph and building's drawing after its geodetic measurements to the final output of the retouched view.

An optical scanner with 300 dpi resolution was also used.

The S/W requirements are met for the present by commercially available packages (databases, CAD, image processing etc.) which are under tests in order to obtain the best combination for each computer platform. On the other hand, several utility programs are under development in order to complete a user friendly working environment.

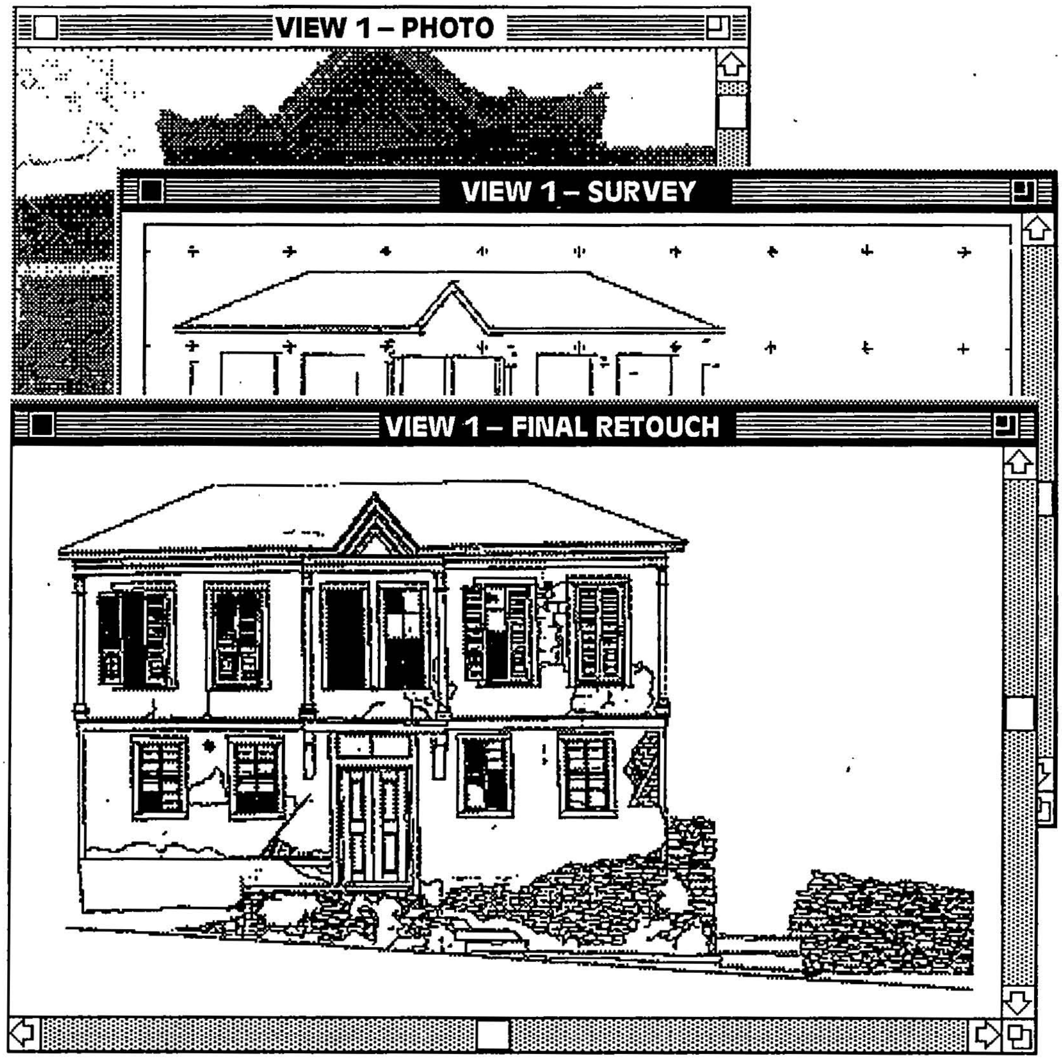


Figure 11. Multiple windows showing phases, from digitized photographs and drawing based on geodetic measurements, to the final building's retouched view

6. CONCLUSIONS

The use of a properly adapted GIS for the documentation of monuments can be of great assistance to the study and processing of all-available data. The GIS is a dynamic system and therefore, it can also be used for the continuous monitoring of all the changes on a monument.

The cost of H/W may be kept as low as the specific demands of the end-user permit. The cost of S/W is not high, compared to the benefits.

The cost effective procedure may indeed help the systematic research and the (re) organizing of restorations, a task which is impossible to be performed with conventional techniques.

GIS and multimedia-can also open new horizons for the documentation, education, research and the presentation of the cultural, architectural, historical and religious heritage.

The development of a low cost GIS described in the previous paragraphs seems to give very promising results. The integration of the system by entering into all-available categories of information is to be done. Such a system can be established for a single monument or a group of monuments with extraordinary importance. Experience derived from the extensive use of the system, after its completion, will lead to the organization of a larger GIS at city level.

REFERENCES

Bellas, T. 1989. Information metrics. Magazine: To Milo, Vol. 7-10 (in Greek).

Badellas, A.G., Savvaidis, P.D. 1981. The measurement of monuments with geodetic methods (Application on two old churches of Thessaloniki). Conference: Contribution of Geodesy and Photogrammetry to the Documentation and Measurement of Monuments and Historical Sites, Athens (in Greek).

Badellas, A.G., Savvaidis, P.D. 1990. Deformation measurements of technical works and landslides with geodetic methods. Papageorgiou Publ. Co., Thessaloniki (in Greek).

Doukas, J.D., 1988. The contribution of geodesy to the problem of deformations. Publication of the Section of Geodesy, N° 12, Department of Civil Engineering, University of Thessaloniki, (in Greek).

Doukas, J.D., Savvaidis, P.D. 1990. Cadaster of public utilities in the city of Thessaloniki-Problems and future development. Conference: The Surveyor Engineer towards 2000. Evolution - Perspective - Possibilities., Thessaloniki (in Greek, in publ.).

Doukas, J.D., Badellas, A.G., Savvaidis, P.D., Ifantis, I. 1990. Engineering surveying: The need of precise observations on physical and artificial constructions. Conference: The Surveyor Engineer towards 2000. Evolution - Perspective - Possibilities., Thessaloniki (in Greek, in publ.).

Harrison, J., Dangermond, J. 1989. ARC/INFO - Five tracks to GIS development and implementation. ESRI, USA.

Kyriazopoulos, A., Safaridou, M. 1990. Surveying an old building at the Ano Poli of Thessaloniki. Diploma Dissertation N° 141, Section of Geodesy, Department of Civil Engineering, University of Thessaloniki, Thessaloniki.

Onsrud, H.J., Dansby, B. 1989. Geographic information systems and the legal community. American Congress of Surveying and Mapping Bulletin, N° 118, pp. 30-36.

Riechmann, W. 1989. Hochauflösende digitale Objekterfassung mit Hilfe einer Resean - Scanning Camera. Symposium Optical 3D Measurement Techniques, Vienna, pp. 67-74.

Savvaidis, P.D., Doukas, J.D., Badellas, A.G. 1988. The measurement of excavations with geodetic methods (Application on an excavation at Mandalos of Giannitsa county). Archaeologia, N° 28, p.p. 55-56 (in Greek).

Wehr, A. 1989. 3D - Mapping by a semiconductor laser scanner - Description of an experimental. High Precision Navigation, Springer, p.p. 469-489.

Zahopoulou, P.S., Doukas, J.D., Savvaidis, P.D., 1986. Survey of the Acropolis of the prehistorical site at Sesklo of Magnesia county. Symposium: Modern methods of surveying and documentation of monuments and archaeological sites, Thessaloniki-Mount Athos, pp. 297-308 (in Greek).