Preserving Monuments' Astronomical Orientation by Using Different Databases

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Abstract. As many studies worldwide [25], [6], [9], [17] have proven, there is a significant reason on the study of a monument. This is the actual orientation that the founders gave to the monument during its foundation. The orientation of a monument, especially a religious one, follows some strict rules according to each religion, tradition and belief. Today, the orientation of a monument may be determined and registered accurately and easily thanks to advanced technology. Especially if astrogeodetic measurement methods are being used then the orientation may be detected with adequate accuracy. This gives future generation's reliable information which can facilitate for a better understanding on the purpose behind the erecting of each monument. This paper presents the results of two research programs, which focused on this subject. In order to disseminate the results of these two projects worldwide, the information, is organized in database. Two different software were used, Macromedia and ArcGIS. The ease of use and the various options of usage will be discussed as will the final results.

Keywords: astronomical monuments orientation, database, Macromedia, ArcGIS, Delos, Mystras.

1 Introduction

Monuments, present the history of a nation throughout the centuries, especially those of religious significance which play a major role in the progress of all nations. Every religion has developed specific regulations concerning the building of churches, temples, mosques, etc. All religions have strong beliefs and strong representations for each and every activity. This symbolism keeps religious beliefs warm and strong. Neolithic monuments such as the Stonehenge in Britain, taulos in Menorka [4], [5], the oche ″Dragon house″ in Euboea [32], [12], the late Minoan [24], the temples of the Maya, which were built according to their special calendar [35], the pyramids which represent the four directions of the horizon [30], the ancient Greek temples, which are directed towards specific stars on specific dates [26], [27], [10], [21], the early Christian Basilicas [8] and the Byzantine churches which were built in the direction of the sunrise and on a specific date, the celebration of the dedicated Saint [28], [19], [20], [11]. Moreover, the Muslim mosques had to be oriented towards the

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Kaabah of Mecca, so that all Muslims, worldwide could face Mecca when praying, regardless of their location on earth. [22], [1], [29].

Many studies were carried out in the late 19th and the early 20th century to reveal the actual orientation of several monuments and to interpret the schools of old thoughts [2], [3], [15], [16], [25], [13].

These studies constitute a significant heritage for our days. Although, one should bear in mind that these scientist used simple means of technologies pertinent to that epoch such as compasses and measuring tapes. Therefore, they were led to general conclusions with high uncertainties.

On the contrary, the evolution of technology and the computer give us today the possibility to achieve more accurate and reliable results. Thus, the astronomical orientation of a monument today can be calculated by an accuracy of some arc seconds as well as its plan can be drawn by an accuracy of some millimeters [17], [18].

Additionally, the calculations of the movements and the paths of a celestial body (Sun, Moon, Stars, Polaris, Canopus) can be achieved accurately by using advanced software [14].

Therefore, investigations have become more reliable and interesting as we realize that our ancestors were able to calculate accurately the above mentioned elements without the high tech instrumentation of our times.

The study of the orientation of a monument is a complex process. It includes several pieces of information such as the accurate survey of the monument, the position of the monument on the earth's surface, the plan of the perceptible horizon around the monument, the calculation of the main axis of the building or of any other characteristic line, the determination of the astronomical azimuth of the main axis, the calculation of the stars' or the sun's path and their position on specific dates and finally on the collection and the study of all the historical and religious data with reference to the monument and focused on the epoch of its foundation.

The combination of all the above data give scientists the opportunity to determine the actual orientation of a monument and furthermore, to conclude on the time of its foundation (dating).

The previous data and results consist of a large amount of information. The next step is to preserve all this information in order to bequeath it to the next generations. The best way to do so is to preserve all the data in a friendly to use, easy to access and legible data base.

Two research projects on the subject of the investigation of monument orientation were carried out at two very interesting archaeological sites in Greece. The first one concerns the ancient monuments on Delos island (Aegean Sea) where twelve temples were studied and the second one the Byzantine monuments of the Castle - town of Mystras in Peloponnesus, where twenty-four churches and chapels were studied.

This paper presents the creation of two data bases using the Macromedia and ArcGIS software in the frame of the above projects. The aim is to emerge the advantages and disadvantages of each one when information is being used for the presentation of the monument's orientation.

2 The Outline of the Data Base

The specific information and data that the study of a monument's orientation includes should be easily analyzed and presented in a way that can be followed by any one, even if he is not familiar with this subject.

The elements that a database should contain are the historical data which are gathered, the precise coordinates φ and λ of the monument, which are calculated by the use of geodetic GPS receivers, recent pictures of the monument that present its given state, diagrams such as the plan of the monument including its main axis and all other notable characteristic lines and finally, the facade of the perceptible horizon of the monument. In this diagram, the physical intangible line between the earth's surface and the sky is being presented, as one sees it from a specific point inside the monument. Furthermore, the astronomical azimuth of the monument's main axis and the path of the selected celestial body, on a specific date, are presented as lines.

Finally, the logical thoughts and the serial results, which lead to the interpretation of the orientation and the dating of the monument, must be included.

3 The Presentation of Delos Monuments' Orientation by Using Macromedia

Macromedia is user-friendly software. The end-user has the possibility to create independent menus and to write a text, but not insert a readymade one as .doc file. All the materials could be inserted in the software as pictures or videos namely .jpeg or .tiff files etc. No other types of files like .dwg, .xls, .doc can be inserted. Additionally, there isn't any printing possibility via this software [34]. The final constructed file is executable (.exe) so it can run on any pc. For this reason this file could be widely spread and used by anyone without additional cost. Moreover, the visitor to the database doesn't need to buy any software as the total size of the executable file is about a hundred Mbs, making it more flexible.

The usage of this software allowed for the presentation and registration of 12 temples of Delos Island. Specifically, the individual pages, which were created and the structure of the database, by using the Macromedia software, are as follows:

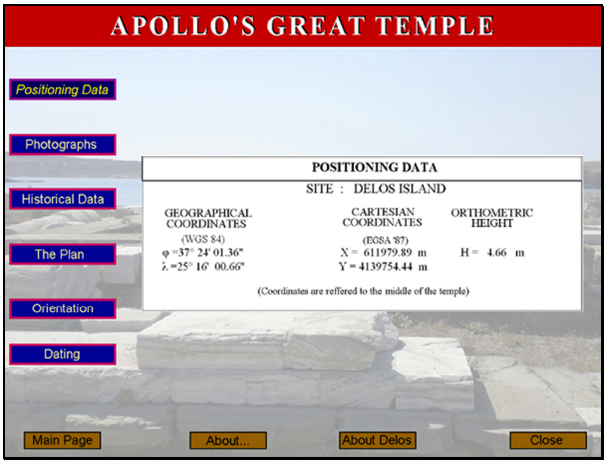
- *About Delos*. On this page geographic, mythological and historical information regarding the island, the archaeological site and the excavations, are given. This page also includes the final conclusions and the total results of the study with regards to all the investigated monuments (Picture 1).

  A series of pages follow, which are repeated for each monument:
- *Positioning*. Here, the coordinates of a selected point of the monument in the World geodetic reference system (WGS 84) and in the Hellenic geodetic reference system (GGRS 87) as well as its height above the mean sea level have been registered (Picture 2).
- *Photographs*. All pictures which were taken during the measurements "in situ" are displayed here for the documentation of the monument.

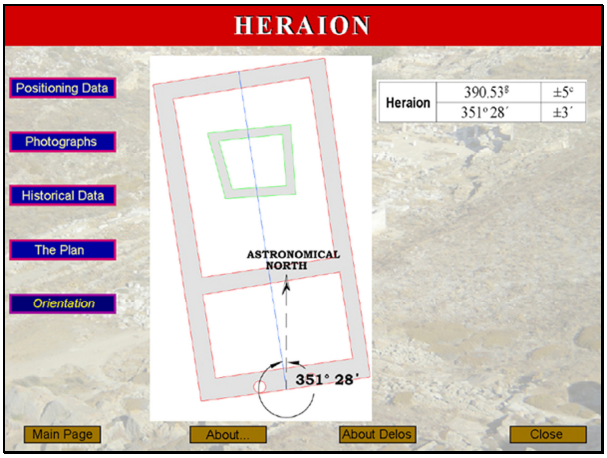
- *Historical data*. This page refers to the most significant historical data related to the monument. Emphasis is given to the foundation date of each monument, which is referred to by the sources.
- *The plan*. This page displays the accurate digital plan of the monument, measured by means of modern geodetic instruments (total station) and oriented in relation to the astronomical North.
- *Orientation*. This page presents the value of the astronomical azimuth of the main longitudinal axis of the monument and the uncertainty of its calculation (Picture 3).
- *Dating*. Here the following are given:

a) The diagram of the profile of the perceptible horizon in which the following lines are also observed:

Picture 1. The page ″About Delos″



Picture 2. The positioning page



Picture 3. The orientation page

- The main longitudinal axis of the monument with the corresponding line of its astronomical azimuth.
- The apparent path of the Sun at the specific date of its foundation.

So, the point of intersection of these three lines on the diagram, are clearly witnessed.

The calculated astronomical data incorporate the appropriate reductions at the time when the building was constructed.

b) The foundation date of the monument under the presupposition that it has been oriented according to the apparent path of the Sun, as it is seen from the monument. Also, the uncertainty of the calculation according to the applied methodology is presented.

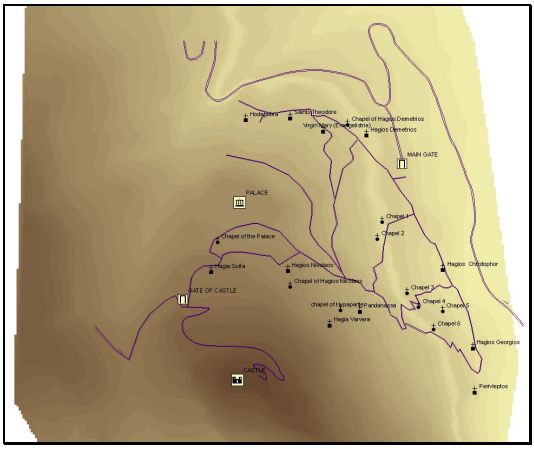
c) The results of the search for a possible relation between the orientation of the monument and the rising and setting of some prominent fixed stars. Also the relationship of the actual orientation of the monument with historical events (celebration) is referred.

4 The Presentation of Mystras Monuments' Orientation by Using ArcGIS

ArcGIS is a well known and a well disseminated worldwide software, which uses maps and permits the insertion of all file extensions (.dwg, .tiff, .doc, .pdf) so as to present geographic and other information. It is a complete system for designing and managing solutions through the application of geographic knowledge. The cost for the use of this software is its disadvantage.

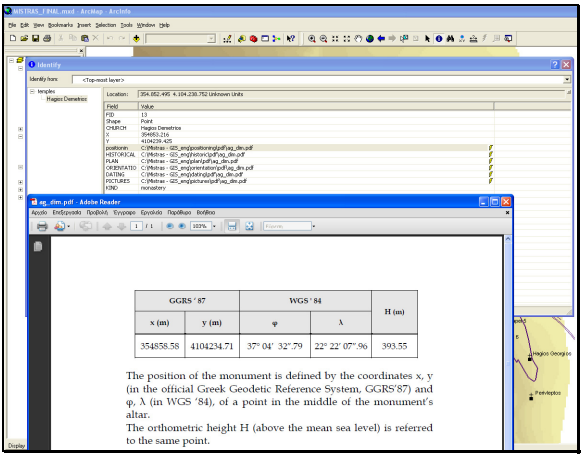
More specifically, this software permits its user to create and use maps, compile geographic data, analyze mapped information, share and discover geographic information, use maps and geographic information in a range of applications, manage geographic information in a database and print any file [33], [7], [31].

The information about the Byzantine monuments of the Castle town of Mystras [23] is presented using this software. Initially a digital terrain model of the site referred to as the Greek Geodetic Reference System ’87 is created and put on the first page. The 24 churches and chapels are placed on the model at their correct position (picture 4).

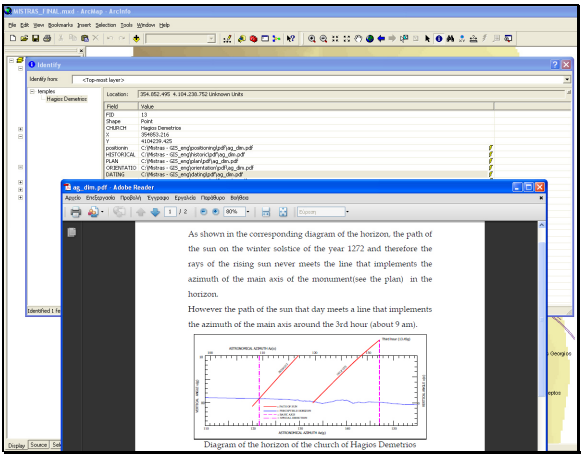


Picture 4. The digital terrain model of Mystras site

By selecting a monument’s plan a link-menu opens and the sub-menus are incorporated, corresponding to the previous application. These sub-menus include: historical data, positioning, pictures, plan, orientation and dating. Furthermore, they contain all the information in word or pdf format, for safety reasons. The user is navigated through these menus so as to access all the available information. Pictures 5 and 6 depict some pages of the sub-menus which have been created for each monument.



Picture 5. The page of the positioning information



Picture 6. The page of the dating

5 Discussion

This work focuses on the use of different software for the presentation and the preservation of the information about the investigation of a monument's orientation.

The orientation research is composed of multiple data. This fact makes the classification and the rational digital presentation of the outcomes, a pressing need.

Additionally, the investigation of a monument's orientation as is applied nowadays, by means of modern instrumentation and astrogeodetic methods, needs a multi-face and total presentation.

By gaining all this information firstly, the permanent record of all the data has been achieved successfully and secondly, the dissemination of all this information is assured worldwide to different scientific and non teams.

The use of two different kinds of software, for the support of the procedure, emerge advantages and disadvantages. It has been pointed out that Macromedia Software makes data insertion easier and makes the use of submenus much simpler. As the created file is in executable form, it runs on any pc without any additional cost. This fact plays significant role in the dissemination of the database. On the contrary, the uploading of .doc or .dwg files in not permitted. Initially this is viewed as a problem yet when in practice it ensures the safety of the documents However, the inability to print is a disadvantage.

On the other hand, the use of the ArcGIS software makes the uploading of all the data types (.doc, .dwg, .tiff) easier. However, the transformation of all these files to .pdf format was indispensable for safety reasons. Moreover, apart from quality information it also provides mapping and positioning information. The software's cost is a hindrance for the spreading of the information.

Finally, the presentation of the monuments by entirely using different software provides the possibilities of data diffusion worldwide and data registration.

Additionally, this fact elevates and consolidates the historical significance of Delos' and Mystras' Castle town monuments.

As both software proved to be appropriate for this presentation, the choice was left to the creator so as to make it easy and better accessible to any visitor.

By using such software creators are able to use geographic information in order to highlight the importance of a full investigation of the astronomical orientation of monuments.

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