DOCTORATE THESIS

PRACTICAL APPLICATIONS OF SPATIAL TECHNOLOGIES IN ARCHAEOLOGY. PREDICITIVE MODELS

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ABSTRACT

MOTTO: *„But besides these presumable treasures, there is another category, the possible ones,... (Glodariu Ioan, 1983, pg.110)*

Chapter 1 Introduction

The objectives of the research, necessities, opportunities.

When we refer to the integration of the sciences and fields that are part of our research, we can distinguish three types of integration:

1. Pluridisciplinarity when the sciences are associating in the research process
2. Interdisciplinarity when relevant changes of the basics lead to the implementation of a specific language and a common group of methods that are changing the basics of the competing subjects
3. Transdisciplinarity when integration is that strong that the results are outside the area of the classic subjects

The purpose of this study is not to do some historic interpretation. Without being a complete study, the main purpose of our thesis is to present modern working methods and interdisciplinary techniques, that can compliment or make the archaeologic and historic

research easier by using the archaeologic and historic topography, cartography, the computerized techniques and the geographic systems or the predictive methods.

Chapter 2 Definition of certain terms

2.1 Archaeology of the environment

Represents the study of the long time relationship between people and the environment and is one of the subjects that can emphasize the reaction of the humans to the environment. It has developed as a science of its own in the scientific studies in the last 30 years. When defining the environment today, the global characteristic of the relationship between the humans and nature is being emphasized in the systemic approach perspective. To begin the systemic study means defining the environment as a multitude of physical, chemical biological and social elements that create a space and influence the life of a human group while remaining a system open to the external factors of influence. (Voiculescu, 2002, 12)

2.2 Archaeology of the sightseeing

Represents a set of methods and techniques used to study the traces of the humans from the past while they interacted with the natural and social environment they use to live in. (Cambi&Terentano 2006, 122). By gathering and processing of these types of data, we can obtain information for the purpose of:

- Understanding the relationship between the humans, community and environment;
- Understanding the relationship between the archaeological site and the different shapes of the earth surface;
- Forming a general opinion about the human habitat along the years in a specific area;
- Identifying new archaeological sites;

2.3 Geoarcheology

Represents a subdivision of the archaeology that uses working methods from geology and other earth related sciences and studies the natural processes that affected the

archaeological sites and the human modifications that affected the shapes of a natural area. It includes other domains, some of them comprehensive, like

Geomorphology – science that studies the origin and shapes of the earth;

- Stratigraphy – science that studies the development and correlation of the sediments;
- Pedology– science that studies the soil, its origin and characteristics

Chapter 3

The Concept of maps. Basic terms. How are they being utilized in archaeological research

Definition, branches and relationship with other subjects. Where are maps being used

People started using the terrestrial measurements centuries ago when they needed to know the dimensions and the position of certain objects and surfaces with the purpose of creating construction, military, naval or agricultural projects.

Earth shape and surfaces reference

1. ***Topographic surface***
2. ***The surface of the geoids***
3. ***The surface of the ellipsoids***

Coordinates and reference systems

The position of a dot means, from the geometrical point of view, the determination of its place with an acceptable accuracy. This position is established through a set of coordinates connected by a protection system. In order to determine the position of certain dots from the field in order to create maps or topographic plans, so called coordination systems have been used.

This coordinates could be on paper or in space.

Chapter 4 Geo-Topographic instruments and systems. METHODS AND TECHNICQUES

Total stations.

The generic term for total or inteligent stations was used in the international publications by the papers done by the production companies. The total stations are a part of the new generation of the topographic instruments while based on the functionality of a clasic tachometer. Their origin, their continuous improvement, their almost exclusive usage as opposed to the teodolites, the big advantage as far as precision and comfort and the efficient productivity made the total station become the most used tool for the topographic and geodezic measurements.

Global positioning systems (GPS)

The positioning systems with satelites have been created in the 1970s in USA and prevoius USSR, after previous unsuccesfull atempts before that (Boş 2003, 35). The first successes were in the radio-navigation field (1920), coinciding with the creation of the LORAN system (Long Range Aid to Navigation), this being the first system that has used the diferrence of phase between two radio waves simoultaneously received in order to establish the positioning. In the 1960 the TRANSIT systems in USA and TSIKADA in USSR became operational, using 6 satelites with polar orbites of low altitude (11000 km) and receptors at the soil level that are capable to distinguish the change of the frequency transmited from the satelite in the proximity or at the distance. It became a necessity for the defense department of the USA after the WORLD War 2 to find a solution to the accuracy of the absolute positioning problem.

Applications in archaeology

Due to the systematic usage of the new topographic and geodezic measurement devices and the computerized techniques, the archaeologic technologies have developed very much in the last years.

The conservative trends in the traditional Romanian archaeology hardly give a chance to the new techniques in despite of their obvious advantages. Therefore, not using the modern techniques of archaeological digging not only will negatively impact the efficiency of the digging process but even more the scientific value in the future.

Chapter 5 Geographic Information Systems GIS

A GIS represents an informatic system that allows the reception, storage, integration, handling and analysis of the data that have spatial reference (Imbroane, More 1999, 17);
The Geographic Informatic System generally known as GIS, represents a complete set of programming and hardware methods that are being used for the handling and administration of the digital spacial data (and the relational attribute data) (www.geostrategies.ro, *http://www.usgs.gov/research/gis/title.html)*;
GIS stands for Geographic Information Systems (in SUA), Geographical Information Systems (Great Brittain, Australia, Canada), Geographical Information Science (academic). A specific type of information system is used for the geographical data. A complete set of equipments, programs and procedures are being utilized for the storage, administration, handling, analysis and modification of the spatial data and is also used to solve the problems regarding the complete planification and administartion. (Goodchild&Kamp 1990/după Iosub 2008).
A GIS contains four main functional sub-systems. Their functions are as follows:

- Introduce the data
- Store and correct the data
- Handle and analize the data
- Send out and display the data.

Models of spatial data. The main data reflect the traditional data generally found on a map. Therefore, the GIS technology uses two types of main data as follows:

- ***spatial data* – these describe the absolute and relative positioning of the geographic characteristics;**
- ***atribut data* – these describe the spatial characteristics as far as quantity and quality and are considered data found in spreadsheets.**

Applications in archaeology. Due to the fact that a large volume of data result from an archaeological research involving multiple subjects, to the destructive mode of an archaeological research and the actual opportunities of digital usage and modification of

the data, arrises the need to have these data used and processed in digital mode in order to be able to create data basis, maps, analysis and reports. The complex digital systems are the solution for all the above mentioned needs.

For archaeology, every GIS project represents a unique situation depending on the purpose of the research, the methods and techniques used, the characteristic and complexity of the site, the requests of the archaeologist.

As far as types of analysis that can be done during a GIS project, we can mention the following:

Making a decision regarding the preventive archaeology. If a request for a construction permit is made, it needs to be decided if the future construction is positioned inside of an archaeologic site and in what part of it and how difficult it will be to remove everything from the historical point of view.

Spatial placement of a specific object found and relationships between objects found on different step

Statistical analysis regarding an object or a specific category on layers or plain areas (at more than one archaeological sites during the same period of time);

Analysis in the proximity having as a result the area where the materials come from;

Besides the storage, management and information facilities, the GIS projects present more advantages as far as the presentation of data.

Chapter 6 Geo-referencing of the scanned images

The operator introduces in the geo-referencing program a number of dots from the image (a minimum of three) while the coordinates are being obtained from the following sources:

1. the intersection of the lines of squares in the image;
2. have been measured in the field with the GPS;
3. dots common with the dots from the geo-referencing maps are being used.

The image folder, after geo-referencing, will be saved in a folder with the same name but a different extension, for example jpw instead of the initial jpg. This allows obtaining the geographic coordinates of each pixel of the image, by simply positioning the mouse above it.

Chapter 7 Positioning of the fortresses. The visibility aspect

The positioning of the old fortress was taking into consideration also the characteristics of the Earth shapes as far as the level differences which made it possibile to calculate the visibility between two dots situated at a distance that the naked eye could not distinguish. The relation is reciprocal and represents the teritorry of a site as well as the area where it was situated.

Using the three-dimensional model of the Earth shapes and the virtual shades of the terrain, the areas with more or less tilting are being emphasized. This information along with the positioning of the sites could offer suggestions regarding the traces of the old strategic route that people were using.

Chapter 8 Statistic tests in archaeology

The comparison and association Test X^2.

This is one of the most utilized test in the social sciences, due to the simplicity of the calculations, the specific of the experimental data and the immediate possibilities of making decisions after the test. The test could be applied in various situations. In case two different types of populations are being used to compare the allotment of a variable to these two populations, this could be considered a comparison test.

In case more than two populations are being utilized diferentiated by the categories of a variable, for example the place of residence with the urban, sub-urban or rural value, the test could be considered an association test. We will be referring to this type of test next. We will present a few practical examples.

Chapter 9 Computerized Storage of Data Techniques

The information path from its origin to its possible usage in the decision making process, goes thorugh a lot of absolutely necessary stages, like gathering, organization and analysis of data. Presently, the only technologies that allow this type of data processing and make the usage of this huge number of data possible are the ones of the data basis.

The components of an Access data basis are also called objects and could be made out of spreadsheets, inquiries, layouts, reports, controls, macro-orders and modules.

An object could be processed and handled in a specific way. The objects created have properties that we can establish in order to model their image and the behaviour the way we like and methods that indicate what kind of operations can be done with that specific object. All the objects from the same category have the same properties and methods. They can be distinguished by the different values of these properties.

The SQL Language

The **SQL** term stands for este Structured Query Language – which represents a structured inquiry language. It is specifically created for the communication with the data basis and unlike Visual Basic or Java, it contains very few words, easy terms in English. Almost all SGBDs and important data basis accept SQL. Being a very strong language, it allows complex and sophisticated operations.

SQL Applications in MICROSOFT ACCESS.

Currently the Microsoft Access SGDB from Microsoft Office is interactively used for the creation and administartion of data basis. For data basis inquiries, Microsoft Access is using the Query Designer utility. A frequent characteristic of this utility that is usually not taken into consideration is the fact that it allows the writting of SQL instructions for their execution on an open data basis.

CAPITOLUL 10 Spatial Data Basis

The difference between the traditional data basis and the spatial data

Traditionally, the non-spatial data basis also known as attribute data basis are focusing only on the characteristics of the object or entity meaning that the difference between the object and its location is not precisely made, for example the location of an archaeological site and its characteristics, the classification data etc.

The rectification of this aspects led to the creation of some geographical data basis – true Geographic Information Systems that are contain an attribute data basis and a spatial data basis.

The organization of a spatial data basis. As we mentioned earlier, the digital maps involved in the data processing under GIS represents what is called BDS. A map can be decomposed in more layers of information and at the same time more layers form a map.

This idea constitutes the basis of the BDS organization. It is the most efficient way of maps storage. The layers could be combined in a way to generate maps that don't exist in the traditional way. When a layer is created, it is mandatory to know that it has to be used in its entirety, in other words the geographic entities can not be separated. In other words, if we have a layer that contains the rivers with the water catchment's area, we can not eliminate part of these areas from this layer.

Chapter 11 PREDICTIVE Models and Methods

A predictive model in archaeology represents an instrument that allows the determination with a certain degree of probability of the existence of an archaeological site in any landscape. Related to the map of the landscape, the predictive model also emphasizes the sensitivity of the archaeological map as that indicates the fact that some areas are better than others as far the existence of the archaeological sites is concerned. These prediction maps usually contain three areas: one of high sensitivity in which case in this area the existence of the archaeological sites has a large degree of probability, one of medium sensitivity in which case the existence of the archaeological sites is less likely and one of low sensitivity in which the sites are very unlikely. The usefulness of this type of maps, very important for the archaeologists, is also important in other domains like: remodeling of territory means of transportation (roads, railroads etc.) The prognosis of the existence of archaeological sites in various areas could influence and/or modify any kind of projects in order to avoid these types of areas. The economic and cultural advantages are obvious, these types of maps representing a planning instrument which could orient the construction projects – for housing, freeways or canals towards the regions with a low degree of sensitivity. Short term or long term, the waste of archaeological vestiges is being eliminated while the costs for archaeological projects are being reduced or eliminated.

Chapter 12 Predictive Modeling of the Archaeological Patrimony in the European Countries

The projects of predictive modeling from Europe, respectively of the authorities from Holland and Italy are being presented as well as the importance of these methods in the European countries

Between 2002 and 2006, a team of researchers from Holland performed a strategic research about the predictive modeling, on behalf of the Dutch government with the purpose of managing the cultural resources. One of the objectives of this project was to develop the best practices to design and implement these models. The purpose of this project was to perform a thorough analysis of the current models and methods to improve the situation and to come up with recommendations for the future research policy.

Chapter 13 Independent Castles and Fortresses in Dacia. Elements of system analysis

Areas and emplacements in Dacia. Their grouping was done by area and then alphabetical order. Due to the fact that the places and the emplacement could be different in some cases all of these, regardless of the emplacement areas, had to be introduced in a data basis:

The Eastern part of Dacia. Contains the territories from the East of the Oriental Carpati Mountains

The areas between the Carpati Mountains. Contains the territories between the two Somes rivers, the Oriental, Meridional and Occidental Carpati Mountains

The Southern part of Dacia Contains the territories between the Meridional Carpati Mountains, the Danube and the Buzau

The Western part of Dacia Contains all the territories situated West of the Occidental Carpati Mountains, in Banat, Crisana or even farther

The emplecement conditions are presented in detail, respectively the absolute and relative height of the castle, the slopes used for the fortress's protection, the distance to the water sources, the strategic placement at key-points as far as access to the castles or passing between different geographic areas, of interest in antiquity including the names used in antiquity, where known. A map containing the castles and fortresses discovered in Dacia

is also presented. The chapter is completed by the plans of some castles from Dacia, as much as we know about them.

Chapter 14 Case Study. Predictiv Models regarding the Area of the Dacic Castles from Southern Transylvania

Elements of system analysis. Gathering and organization of data. We are presenting the spreadsheets and the columns of each table “Area”, “Relief” and “Emplacement” from the data basis called “Predictive Methods and Models” Then we will be presenting the aspects regarding the used maps. The main source of the used maps was the MAPSTOR.COM site where a set of maps of Romania was ordered and purchased, that contains for the most part the map pages L-34 and L-35 and small parts of pages M-34, M-35, K-34 şi K-35. The file type was “gif”. For Sarmizegetusa Regia the file used was 100k - L34 – 095 – 2.gif , for which the analysis results have been presented. The file titled “SMZ Picture Google 1002 DIRECTIONS. bmp”contains the map of the capital Sarmizegetusa Regia, with the castle and the area of the sanctuaries of Gradiste in the middle. The analysis was performed in six directions, the azimuth of these being presented in the chapter. The features of the sites analyzed contain: the distance from the water source, the slope of the terrain, the exposure to the solar radiation, the placement in a strategic point and a conclusion.