Hierarchical multi-view representation of spatial data; application to the analysis of Corsican Neolithic tombs

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ABSTRACT

Starting from a joint project undertaken at the University of Corsica between computer sciences researchers, anthropologists and astronomers we deal in this article with the problem of the definition of the concepts of abstraction levels and views of spatial data for analyzing archeological data. This interdisciplinary project begins with a first research work concerning in particular:

- *The GPS localization of Neolithic sites and toponyms in the Corsica Island.*
- *GIS representation of the previous data through spatial entities*
- *Analysis of the previous spatial entities described at various abstraction levels.*

This first work enabled us to highlight a set of problems when dealing with data coming from the following domains: archaeology, anthropology and astronomy. The solution that we propose for solving the previous problems rests on a definition of abstraction levels for spatial data, as well as the definition of automatic transfer functions between abstraction levels. The implementation of the solution has been carried out using an oriented object design.
We present in detail in this article how the definition of the concepts of levels of abstraction and of transfer functions allows the resolution of problems previously highlighted.
Moreover we point out how starting from these concepts we can offer a generic software infrastructure allowing in particular:

- *To manage several levels of abstraction,*
- *To define or use transfer functions between levels,*
- *To carry out geometrical or astronomical analysis between various spatial archaeological data.*

The generic software infrastructure is developed in Visual BASIC because this language facilitates on the one hand the implementation of the various concepts and on the other hand the integration of these concepts in a GIS.

1. PROBLEMS

1.1. CONTEXT OF THE STUDY

The study presented in this article belongs to a set of work concerning the use of the GIS in archaeology. In our case the context of the study [KHO 04] is the following: by taking a mix of data from natural and cultural inheritance, the general objective is to offer a powerful software tool for archeologists or anthropologists. This tool should be "open" in the way that it has to offer possibilities, which can comply with complex requests. This gives the researcher all freedom to correlate information. As we will see it below the archeoastronomy rests on studies coming from three distinct fields: archaeology, anthropology and astronomy.
The goal is to work at the interface between the preceding fields in order to try out the capacities of the GIS to being used in the context of a research in archeoastronomy. Archeoastronomy [HOS 01] is the science which relates to the discovery and the study of beliefs and the astronomical practices of the ancient societies; it is initially a tool to include/understand the intellectual achievements of the primitive cultures, such as for example, the builders of megalithic alignments. In order to help archeoastronomers from a point of view of software tools, we have to facilitate the following analysis using GIS: (i) simulate the sky of the ancient people and to calculate the suitable ephemeredes, to then be confronted with oral saves (reconstitution sources of celestial phenomena by the simulation of the aspect of the sky at one time and with a given place); (ii) to establish geometrical links between the different sites, (iii) to study the bonds between toponym and interesting sites from a point of view of archeoastronomy.
The goal is to be able to help the archeoastronomers to define following information in a GIS:

- GPS localizations of menhirs and dolmens
- Abstractions of this information (for example a point represents an alignment of menhirs)
- It must possible to carry out geometrical and astronomical analysis.

2. BASIC CONCEPTS: CONCEPTS OF DOMAINS AND LEVELS OF ABSTRACTION

After an analysis of the capacities of the GIS for researches undertaken in archaeology we identified the following problems to be solved from a computer science point of view:

- Difficulty of representing information about space at various levels of abstraction
- Difficulty of representing information about space, corresponding to various points of view of localization

- Difficulty of connecting information about space in a geometrical way
- Difficulty to deduce and of represent data resulting from an astronomy point of view on a GIS.

In order to propose a solution for solving the four previous highlighted problems we developed the concept of levels of abstraction and the concept of domain of spatial data.
A spatial zone will therefore have to be able to be visualized according to various points of view (domains) and at different levels of abstraction: several spatial representations could be associated at a spatial zone. In our study we represent a spatial object as being an elementary spatial pertaining to a representation of a given domain and to a given level of abstraction.
The translation of a representation towards representations more (less) detailed requires the definition of transfer functions of information making possible the automatic generation of a new representation more (less) detailed.

3. IMPLEMENTATION OF THE CONCEPTS IN VISUAL BASIC

The concepts presented in part 3 are validating by the realization of a prototype of software called Gis-Archeo-Astro developed in Visual BASIC. We chose to validate the previous concepts using the language Visual BASIC (VB) for two main reasons: (i) the integration of the concepts in the GIS Arcview is facilitated by the use of VB since the personalization of Arcview rests on the use of VBA (Visual BASIC Application); (ii) the use of VB completely meets the requirement in terms of the ergonomic features associated with the development for interfaces dedicated to not-data processing specialists such as archaeologists or anthropologists.
We highlight in this part how a user interested by the three fields (archaeology, astronomy, anthropology) will be able to define without problem the representations of the same spatial zone according to 3 different fields at different levels of abstraction. Moreover it will be able to visualize and of course to generate a representation from another for a given field.
The validation was carried out starting from a concrete example concerning the archaeological sites of Monte Revincu.
We have to point out that the megalithic Corsican civilization flourished in the first half of the fourth millennium B.C. This early phase has left numerous traces in Corsica that are to be found everywhere in the southern half of the island and in some very few parts in the northern part (Nebbiu region). As regards burials, there seems in megalithic times to have been the same orientation custom all over the island. The site of Monte Revincu is located in the area of Agriate at the North of Corsica.
Figure 2 illustrates the different buttons of the user interface corresponding to the concepts presented in section 3. This figure also highlights a representation of the localization of the site Monte Revincu at the highest level of abstraction; we will call thereafter this first representation R1 (level 1, Domain archaeology). Figures 3 and 4 highlight the transition between levels of abstraction. We see on figure 2 that the first representation R1 is made up of a space entity of type node (coordinated X and y) and models an archaeological complex. However in order to be able to study this archeological complex we need a more detailed view of the complex (level 2). For that, the user will be able by using the decomposition to generate the representation R2 given of figure 3 (level 2, archaeology field) made up of three space entities of type node. These three points can be broken up on a lower level (level 3) in order to study the types of structures composing each one of these sites (dolmens or non-dolmenic tombs). Of course the user can if it wishes it to refine the level of detail by generating the representation R3 (level 3, archaeology field) starting from the representation R2 by clicking on the button "Down". Figure 4 illustrates this decomposition. The user can also carry out an automatic passage of the representation R2 towards the representation R1 by using aggregation (button "Up").
We must moreover note that the sites at the highest level are indicated by a red point, on level 2 by squares red (see figure 3). Finally on the level 3 several types of points are available corresponding to dolmens or non-dolmenic tombs. The dolmens are located by a red symbol pointing out the shape of a dolmen while the non-dolmenic tombs are represented by a blue symbol having the shape of such a tomb.
On level 3, by changing the field (transition from the field "Archaeology" to the field "Astronomy", the user can have access to the functions of tracings and calculation of astronomical values related to the entities of levels 3. In section 5 we give the methodology for computation of these astronomical values.

4. ORIENTATIONS OF THE MEGALITHS

4.1. SOME ASPECTS OF METHODOLOGY

Our task in this section is to report the orientations that the builders selected for the megaliths of Monte Revincu. We define these orientations to be the azimuths of the principal axis of the rectangular chamber of the measured tombs, in the direction from the closed end to the entrance.
These directions (azimuths) were measured in June 2004 with compasses whose errors had already been established. In the case of dolmens there are no doubt that the relevant direction is from the interior towards the entrance. However we have to precise our choice about the cists because the decision about which of the two directions of the principal axis of

the cist becomes important. In the course of our fieldwork we also measured a number of additional non-dolmenic early tombs and the relevant data are also listed in sub-section 4.2. In this case we choose the direction which seems to be the most obvious for us.
If and this is no more than a possibility the intention of the builders was astronomical and the megalithic sepulchers were constructed to face the setting or rising points of celestial objects, then angular altitude of the skyline must of course be taken into account when we calculate the declinations corresponding to these azimuths. The angular altitude has been measured with hand-held clinometers.
A third datum is needed for an astronomical interpretation: the latitude of the studied site. The use of a GPS is very useful for obtaining this last datum.
Given azimuth, angular altitude of the skyline, and latitude, the corresponding astronomical declination is easily found from a simple trigonometrically formula. In our case we used a computer program developed by C. Ruggles at the University of Leicester, England and which can be obtained using the web [RUG 99].
Our measurements of the dolmens and early non-dolmenic tombs (azimuth, angular altitude, latitude and corresponding declination) are set out in the next sub-section.

4.2. ORIENTATIONS OF THE DOLMENS INVOLVED IN MONTE REVINCU

In our fieldwork we came across the measurements of the three dolmens and four early no-dolmenic tombs (cists) listed in section 4. Their orientations are listed in Table 1 and Table 2. We have to point out that the dolmens "Casa di u Lurcu" (Lurcu dolmen) "Casa di l'Orca" (Orca dolmen) and involved two orientations because it has a clear defined entrance but also a clear defined passage with a different orientation.

Table 1 – Orientations of dolmens in Nebbiu zone.

Az. °	Alt. °	Lat. °	Dec. °	Tomb
128	2	42.6	-25 1/2	Dolmen Monte Revincu
110	4	42.6	-12	Casa di u Lurcu – entrance (Lurcu dolmen)
130	4	42.6	-25 1/2	Casa di u Lurcu – passage
75	21/2	42.6	12 1/2	Casa di l'Orca entrance (Orca dolmen)
60	6°	42.6	25 ½	Casa di L'Orca – Passage

Table 2 – Orientation of early non-dolmenic tombs.

Az. °	Alt. °	Lat. °	Dec. °	Tomb
87	3	42.6	5	Cist near u Lurcu
95	4	42.6	-1	Cist near l'Orca – Tozzola 1
108	4	42.6	-10 1/2	Cist near l'Orca – Tozzola 2
68	2	42.6	17	Tomba di u Lurcu – Pivanosa

Once the data have been collected, the first question we have to answer is whether the previous collected orientations fall within a range. After this first analysis we have consider whether or not the motivation originated in the sky or whether it was terrestrial or even meteorological.

4.3. ORIENTATIONS ANALYSIS

In this sub-section we detail that although we are dealing only with 7 monuments and nine orientations, it is most unlikely that their orientations would be so similar purely by chance, and the GIS nature in azimuth must result from some astronomical intention on the part of the builders.
From the two tables we can see that the azimuths are highly non random (from 60° to 130°) measures about 1/6th of a circle. Such a concentration of axes cannot have come about by chance.
Furthermore the declination of the tables 1 and 2 show that all the nine orientations are in the correct range to face the rising sun or moon. The declinations that all the declinations correspond to the rising of the sun or the moon.
We point out in this article that the orientations of the great majority of these dolmens confirm the conclusions already

described by Michael Hoskin and concerning the south Corsican dolmens. The orientation customs observed by builders of communal tombs in Corsica have been presented in detail in [HOS 01].
The seven megalithic sepulchers of the Nebbiu region we investigated face roughly between north east and south east; more exactly between azimuth 60° and 130°.
We already point out that the builders seem to orient these monuments for reasons of astronomy.
Furthermore we can deduce that all the tombs are SR according to Michael Hoskin classification.
We can also point out that the Lurcu dolmen is faced the rising sun around midwinter sunrise while the orca dolmen is facing the rising of the sun around the midsummer sunrise.

5. CONCLUSION

We presented how the introduction of concepts of fields and levels of abstraction allowed the resolution of problems highlighted within the framework of an interdisciplinary research project led to the University of Corsica between anthropologists, archaeologists and data processing specialists. The definition of the concepts of levels of abstraction of space data as well as the concepts of fields allowed an original structuring of space data. Moreover we showed how starting from these concepts we can offer a generic software infrastructure allowing:

- To manage several fields and levels of abstraction of space data,
- To define or use transfer functions between levels,
- To carry out astronomical analyses between various space data.

The goal of the project is thus to offer a convivial software environment allowing the development and the use of a GIS integrating the anthropological, archaeological and astronomical data.

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FIGURES

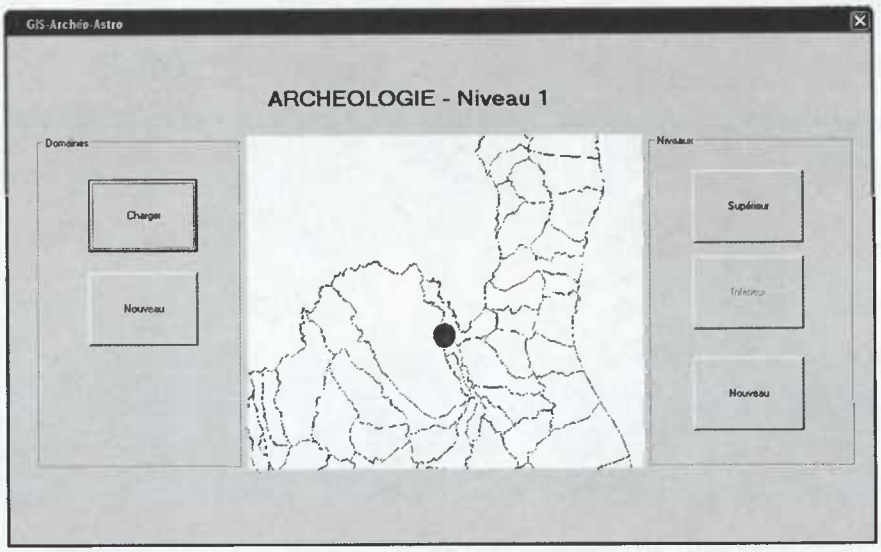

Fig. 1 – Localisation of Monte Revincu (Représentation R1).

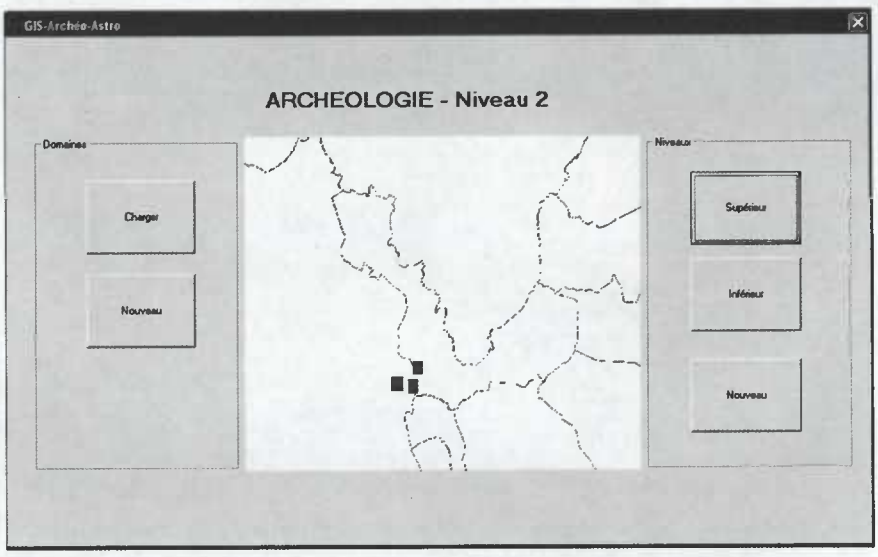

Fig. 2 – Decomposition site on 3 sub-sites (Representation R2).

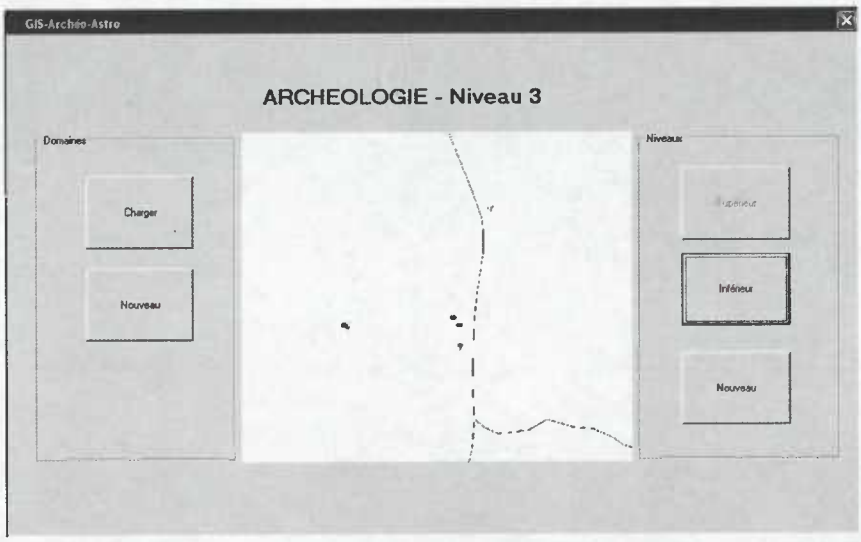

Fig. 3 – Detailed description of the 3 sites (Representation R3).