GIS for archaeoastronomy studies

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***Abstract* – We present an original approach for performing the study of astronomical events around Neolithic tombs. This approach involves three main steps : (i) the definition of a methodology for generating a 360° view of an horizon using a GIS ; (ii) the integration of the previous view into a commercial software dedicated to astronomy ; (iii) the study of astronomical events linked to the view. We give in this paper a detailed description of software implementation. We point out how the proposed approach has been defined for obtaining an evolutive and efficient tool.**
Finally, this paper deals with experiments conducted on megaliths belonging to the Monte Revincu zone situated in northern Corsica in order to validate the proposed approach. The effectiveness of the software approach is clearly demonstrated through the obtained results.

I. INTRODUCTION

The field of archaeoastronomy studies the astronomical understanding of ancient cultures and how this understanding influenced their lives. It incorporates the fields of astronomy, archaeology, engineering (for surveying), and anthropology. It focuses on the role that astronomical phenomena have played in human societies, ranging from the applied (such as the basis for calendrics and orientations) to the ceremonial (the significance given the "ritual landscape" of the sky). Archeoastronomy is thus trying to answer the following questions :

- when our earliest ancestors looked up at the sky, what did they see?
- how did they interpret what they saw?
- Which astronomical events were most significant and why?
- Did astronomical principles govern the construction of their cities, buildings, and temples?

The goal of the paper is to propose a software approach which will help any researcher in the field of archaeoastronomy to analyse the links between landscape and celestial events. This approach leans on three main steps :

the definition of a methodology for generating a 360° view of an horizon using a GIS ;

the integration of the previous view into a commercial software dedicated to astronomy ;

the study of astronomical events linked to the view. We give in this paper a detailed description of software implementation.

We will point out how the proposed approach has been defined for obtaining an evolutive and efficient tool.

Furthermore we will also detail how this approach has been used successfully in the framework of excavation conducted by the DRAC in the area of Monte Revincu in northern Corsica. In this paper we are interested in the megaliths of the Nebbiu Region [12,13,9] and specially those situated around the Monte Revincu. One of our task here is to analyse according to astronomical considerations the orientations that the builders selected for the megaliths which can be found near the Monte Revincu.

The rest of the paper is organised as follows : (i) the field of archaeoastronomy, which is the study of the role of astronomy in early human cultures, will be then presented in detail before a brief overview of our software approach; (ii) the third part will deal with the generation of a 360° view using a GIS ; (iv) in the fourth part we will present how to integrate the previous view into a commercial software dedicated to astronomy ; (v) the last part will describe the results obtained when analysing the astronomical orientations of the megaliths of Monte Revincu.

Finally the conclusions and perspectives will be briefly evocated.

II. ARCHAEOASTRONOMY SOFTWARE APPROACH

A. Why a software approach for archaeoastronomy studies

One of the most famous monuments involved in archeaostronomy studies is Stonehenge, England, used between 3000-1800BC. It is a set of huge stones. Figure 1 gives in (a) a view of the site while figure 1 (b) shows us a reconstruction of the monument The main axis of the monument is aligned so that when the sun rises on the summer solstice, it can be seen rising over the distant "heel stone". Other stones are aligned to mark the risings and settings of the sun and moon on other key days. Of course megaliths erected all over Europe are being studied by European archaeoastronomers since the beginning of the seventies. We present in Figure 2 a famous site of Brittany : la Table des Marchands. Figure 2 (a) shows the tumulus with his entrance while figure 2 (b) presents a view of the entrance from the backstone pointed out in figure 2 (c). Two kinds of important sites are the Navetas an dthe Taulas from Menorca presented in Figure 3. Figure 3a gives a nice illustration of a naveta from Menorca within an example from the west part : the Naveta called Es Tudon, while figure 3 (b) and (c) presents two examples of Taulas : Figure 3b shows the Taula

called Vela Wells from the south west of the island while figure 3c shows the Taula called Sa Torreta from the north-east part of the island . In both cases as for the other 18 Taulas of Menorca the orientation of these sanctuaries corresponds to the rising and setting of a set of stars forming the Southern Cross at the time of the building of the taulas (between 1400BC and 800BC).

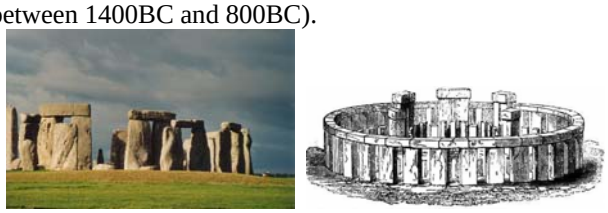

Fig. 1. Stonehenge : (a) the monument (b) reconstruction

(a) (b)

(c)

Fig. 2 : The Table des Marchands : (a) entrance ; (b) view from the inside chamber ; (c) view of the backstone from the entrance ; (d) view of the roof stone from the inside.

(a)

(b) (c)

Fig. 3 Menorca : (a) Es Tudon Naveta ; (b) Vela WellsTaula ; (c) Sa Torrata Taulas.

Other monuments under study are being found in America. In north America one of the famous example is the Big Horn Medicine Wheel (Wyoming, used around 1500-1740AD). It is a smaller wheel-shaped arrangement of stones in which certain piles of stones align with the rising and setting of the sun at the solstices, and with the rising points of several of the brightest stars. The Plains Indians build many Medicine Wheels across the western USA and Canada. In central and south America the studied monuments belong to the Maya or Azteque civilizations. For example one of the famous monument is the Mayan building now called El Caracol in the city of Chichen Itza (Mexico, built around 1000AD). It had a small room in the upper floor with oddly arranged, slit-like windows that appear to be aligned with sunset on the equinoxes, and with the the setting points of Venus and the bright star Achernar. The Maya had a written hieroglyphic language which has been decoded, and the writings confirm that the Mayan religion was keenly interested in astronomy, particularly the Sun and Venus. There are many archeoastronomical sites around the world, left from many cultures. Several key points are worth remembering :

(1) Most have ties to astronomy through the alignment of principal architectural features (significant stones, windows, doors, streets, etc.) with the rise and/or setting points on the horizon of the sun and/or moon at the solstices and equinoxes, or with bright stars or planets.

(2) At some sites, the astronomical links are more clearly intentional than at others, where evidence and interpretation is a matter of debate -- debates that may never be solved because there is little or no written or oral record left by the builders to indicate their true intentions.

(3) The prevalence of these sites indicates that astronomy was an important part of many cultures, either through religion, divination or timing the seasons.

B. Overview of the approach

In order to analyze and study the links between megalithic monuments and the sky at the various times these monuments has been erected (between 5000BC and 800BC) we propose a software approach that will allow to reconstitute the sky at megalithic times within landscapes surrounding a given site. In order to achieve this goal we propose to integrate both a GIS software and an astronomy software. In this paper we deal with MapInfo software [cc] and Starry Night Pro [bb] as astronomy software.

III. GENERATION OF 360° PANORAMIC VIEW USING A GIS

A. 3D Representations using MapInfo.

In order to be able to integrate realistic views of horizon in the Starry night pro software we need to generate a 360° panoramic view from a given point on the earth. This 360° view can be generated by composing a set of views using tools like MapInfo, ER Mapper or Vertical Mapper.

In Vertical Mapper for making 3D map, points are necessary with x,y,z coordinates. This program allows user to see the different perspective views of the terrain and zooming options. Also it allows user to scaling the map along the z axis.

It is part of natural human behavior to observe the (threedimensional) environment through an all-around view

over the partial or total horizon. The field of view of the single human eye is limited at 176°. Only by rotating the whole body a complete 360° panorama can be achieved. This methodology is used to compose the 360° view . By moving and rotating around the place you select on the GIS, you will be able to generate a set of pictures that after reconstruction will correspond to the desired 360° view. In 3D Perspective view of the Er Mapper software you manipulate the image as though it is an object in space. Thus, you move the image up and down while you remain in the same place. The functions for moving the image are the following :

Rotate round Y axis

Left mouse button—drag left or right

Rotate round X axis

Left mouse button—drag up or down

Rotate round Z axis

Left mouse button and plus the right mouse button (hold both down)—drag up or down

Zoom in (out)

Right mouse button—drag down (up) screen

Move

Right mouse button plus the left mouse button (hold both down)—drag

Vertical Mapper and Er Mapper thus supports the generation of true 3D perspective views. This gives users the ability to compose a MapInfo Map window of any vector, raster or textual entity that coincides with the spatial extents of the grid file and then drape the window onto a 3D representation of the grid surface. The end of the GIS software utilisation is the saving of the set of pictures corresponding to the 3D perspective views needed to compose a 360° panoramic view as described in the following section.

B. Instructions to generate a 3D view from a site

In order to generate a 3D view from a given point using MapInfo software we need to perform the following instructions :

- Click on …..
- …..
- ……
- ….;.

IV. INTEGRATION OF AN REALISTIC HORIZON IN A COMMERCIAL ASTRONOMY SOFTWARE

The integration of the previously generated 360° view leans on the writing of two components : (i) an 360° image component which has to be a photoshop [bb] file and (ii) a text component which is an accompanying text file of the previous one.

A. Composing a 360° view

We present how to compose a 360° panoramic view from a set of images obtained using a GIS as described above. The following tips for image processing make use of Photoshop, although other image editing programs can be used.

Step 1. Your raw images will look something like the ones below. The first step is to stitch them together to form a continuous panorama image whose ends match exactly. This is an important step and special care must be taken, otherwise seams will be visible in your final image.

Step 2. The image below shows a stitched 360º panoramic image. This is the most challenging step in creating your own custom landscapes for use in Starry Night.

Step 3. After the image is stitched, use the eraser tool - or a skillful hand with the magic wand and delete key - and remove the sky from your image. The sky is not required because Starry Night will simulate it.

Step 4. The next important step is to add an Alpha channel. Select your 'solid' horizon and add an alpha channel. The black represents 'no transparency' (so that your foreground is opaque) and the white represents '100% transparency' (so that your horizon's sky is transparent and Starry Night can fill it in for you.) Although optional, the Alpha channel allows you to only see the horizon in your final image.

Step 5. When you save the image, save it in “PSD” format.

B. Inserting realistic horizon in Starry Night

In order to be able to perform the link between the image file and the you have to write a set of lines with the general format:

<SN_VALUE name="XXXXX" value="XXXXX">. These lines allow you to change a number of properties for your photorealistic landscape. The most important lines are mentioned below :

- <SN_VALUE name="PanoName" value="YourHor">

You have ti indicate in the value slot name that describes your image. For example value="YoutHor". The name you choose will appear in the drop box in the Horizon Options window under Starry Night Pro.

- <SN_VALUE name="ImageFileName" value="YourHor.psd">

The name of the image you made and placed in the Horizon Panoramas folder. For example if you named your image YourHorrizon.psd”, set the value slot to **value="MyHorizon.psd"**. Both the image and text file must be located in the Horizon Panoramas folder.

- <SN_VALUE name="UseImageAlpha" value="Yes">

Set this value as yes if you added an Alpha channel.

The last operation to do is to both put the image and text files in the Horizon Panoramas folder of the Starry Night Pro Software.

V. VALIDATION OF THE APPROACH

In order to validate our approach we choose the area of Monte Revincu in the north of Corsica. The megalithic tombs both dolmens and cists which can be found in this area are associated with a famous oral legend of Corsica : “the legend of the Lurcu”.

A. Archaeological and anthropological context

This story is belonging to the North Corsica oral culture. It is a legend from the Nebbiu country and involves people from Santu Petru di Tenda village. The place of the legend is around a set of megaliths, which can be found near the Monte Revincu hill. The story as told by the people from Santu Petru di Tenda is described above. Near the place named Casta was living the Lurcu, a Sheppard, giant, Cyclops, with long hairs. He was living there alone with his mother. We have pointed out on the places where they were living as it is said in the legend coming from centuries and centuries by oral transmission. You can see in the picture that the two giants were living from Saleccia to Monte Rivincu and E purette. They were also going until I Teti and Capu Castincu (where there is a set of Menhirs). This giant was living in a house called u casarone. It is a dolmen whose picture is given in From the dolmen he was able to see Monte Ghjenuva hill (a sacred hill of the area). Another dolmen where was living his mother can be found 500m around the previous one. XX is a picture of this smaller one dolmen. The two dolmens are separated by a plateau named "Cima di Suarella" where a set of megaliths rectangular or circular structures can be found. In Fig.1 we present the northwest view from the plateau looking in direction of the Casa di u Lurcu. You can see on this figure the Monte Ghjenuva on the back.

Fig. 1. Northeastview from "Cima Suarella"

The giant was very clever. It is said that he knew everything that could be learned at the time. Furthermore he was very powerful so that the people from Santu Petru di Tenda village living near the place called Casta decided to kill him. But he was difficult to catch so that they had to draw the giant into a trap. There is a place near Bocca Pivanosa where the Lurcu was used to come to drink the water of a spring. At night they put a pair of shoes full of pitch in order to capture him. The next morning the Lurcu came to drink and tried the shoes. The people from the village took him easily because of the shoes he was not able to run away. They were going to kill him near the place where there was the water, when the Lurcu told them a secret in order not to be killed: how to do a special cheese (called Brocciu) with sheep milk. After telling them this secret, he was going to tell another secret: what to do with the rest of the milk when the Brocciu has been done. But the mother from the plateau shouted in Corsican language: "Ùn palisà, chì tantu sì mortu" that means "Don't tell them anything because in any case they are going to kill you". They killed both the Lurcu and his mother. They buried the Lurcu near Bocca Pivanosa and the mother near Bocca Murellu. People can find two stone chests.

B. First results obtained using the presented software approach

We spent several days to perform a careful GPS survey of the places of the story. Fig.2 gives the 3D representation we obtained using the MAPINOF GIS software.

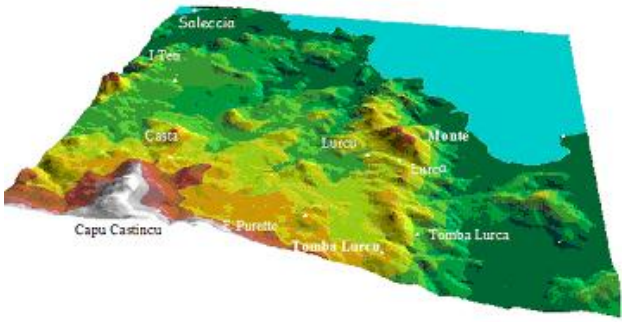

Fig.2. 3D representation of the legend using a GIS Software

Then we use the MAPINFO tools in order to generate a 360° panoramic view around the Orca dolmen.

By following the instructions described in section 3.A we have been able to generate a file containing a 360°panoramic view of the surrounding of the Orca dolmen. Then after a conversion using the Photoshop software we have been able to generate .psd file as described in 3.C. We then have been able to write an accompanying textfile as presented in 3.C

The result is presented in figure ww. We have been able to insert a realistic horizon in the Starry Night Pro software.

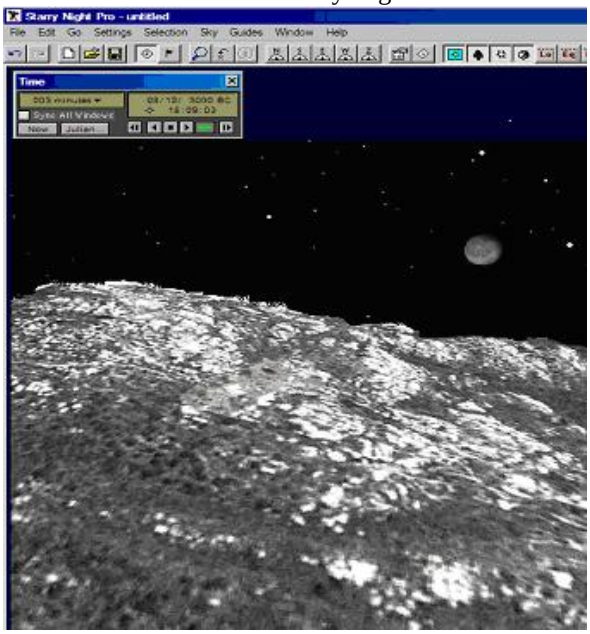

Fig.3. Realistic view of Moon rising above Monte Revincu 3000BC using Starry Night

The picture presents the simulation of the sky the 8 of December 3000 BC at 6:15 pm. You can see own to the

software the rising of the moon near the Monte Revincu as people could have seen it near the Orca Dolmen at this time. We have used this software approach to analyze astronomical event which happened in the are of Monte Revincu between 4200BC and 3000BC. We choose this two dates because the first one corresponds to the earliest datation of the cists in Monte Revincu while 3000BC corresponds to the datation of the dolmens. Of course we have been able to verify the orientations pointed out in previous papers and corresponding to : winter solstice, summer solstice, lunar major standstill. Furthermore astronomical events corresponding to potential target for the builders of the megaliths are been studied : minor lunar standstills and helical rising of Venus. Finally we have to point out that we discover using our software approach that the Halley comet was present above Monte Revincu in July 4200BC. Is it a reason for building the firsts Neolithic tombs under the shape of small cists? Of course the only way to scientifically verify such an hypothesis is to find a great numbers of megalithcs tombs associated with the Halley comet. Furthermore the possibility to simulate the sky and the astronomical events in the realistic landscape near megalithic sites allows to perform an anthropological study of the understanding of the sky at the time when the sites have been built.

VI. CONCLUSION

In this paper we describe a software approach allowing to integrate 360° panoramic view of an area within an astronomical software like Starry Night. We have validated this approach by performing simulation of the sky in a realistic horizon of the landscape around the megaliths of Monte Revincu.

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