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Western Han Dynasty Mural Tombs: from the Use of Integrated Technologies to the Cybermap

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The Virtual Museum of the Western Han Dynasty Project is a joint research between UC Merced, the Italian National Council of Research, and the Jiaotong University aimed at digitally documenting archaeological sites, artifacts and cultural relics of the Western Han Dynasty. The outcome of this process will be the creation of a virtual museum, based on collaborative environments, dedicated to the Western Han Dynasty. This project will integrate new archaeological datasets from fieldwork activities, monuments, and famous collections of artifacts. The use of integrated technologies will permit the reconstruction of the ancient landscape of the capital of the Dynasty –Chang'an–, funerary contexts and art and artifacts. One of the most important archaeological examples in Xi'an is represented by the paintings of the western Han mural tombs. Despite their cultural and historical importance they are at risk of being lost because of the critical conditions of plasters and colors. The murals show a very rich repertoire of subjects such as scenes of daily life, rituals and ascension to heaven. These examples of mural paintings contain a very complex interpretation code explaining the relations between life and death during the Western Han dynasty. A simple description of the subjects and also the 3D virtual reconstruction of the tombs are insufficient for approaching a correct cultural interpretation. In this paper we present a tentative analysis and communication of two mural tombs' iconography obtained through 3D virtual cybermaps. The use of cybermaps emphasizes the interpretation of the spatial connections (affordances) between the different scenes decorating the coffin chambers.

Keywords: 3D data collection, integrated technologies, 3D reconstruction, cybermap, communication, learning process.

1. Introduction

In 2008 the University of California Merced, School of Social Sciences, Humanities and Arts launched a multidisciplinary project in Xi'an (China), aimed at studying the Western Han Dynasty (206 BC-8 AD) in the light of the new archaeological discoveries.

The project, directed by Maurizio Forte, aimed to create a virtual museum, based on the reconstruction of sites, landscapes, and main artifacts collected in the major archaeological museums of the city (FORTE *et al*., 2010). An off line digital installation was also planned in two different locations: the Xi'an Jaotong University and the University of California Merced.

This paper will survey the principal technologies and methods used in the field, during two fieldwork campaigns (summer 2008 and 2009), for the documentation of monumental wall paintings tombs, archaeological sites, and artifacts (Figure 1). Moreover, we will feature the first 3D reconstructions and cybermaps obtained after the fieldwork data post-processing.

Figure 1: *Green Bamboo Garden (M1) mural tomb.*

The archaeological fieldwork mainly encompassed 3D documentation of tombs recently discovered, in the center and in the surroundings of the city. Much archaeological evidence has already been examined to develop the virtual museum, such as the landscape, the ancient city, the imperial mausoleums, other burial monuments, the art and artifacts. The reconstruction of the landscape has been carried out through DGPS

(Differential Global Positioning System); the monuments' data collection has been obtained using a time of flight laser scanner (Figure 2); a desktop triangulation 3D laser scanner has been used for the artifact data capture.

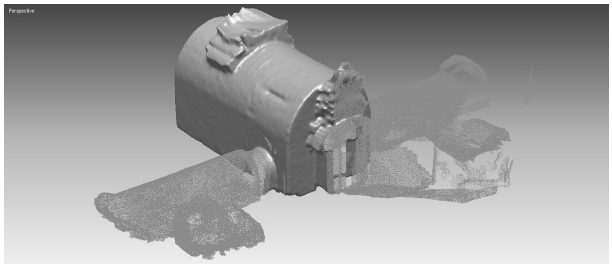

Figure 2: *Green Bamboo Garden (M1) mural tomb: point cloud obtained through laser scanner technique.*

The integrated use of technology was employed to collect as much information as possible for a complete reconstruction of the Western Han Dynasty, one of the most important archaeological periods in Chinese civilization. It is notable that the majority of Chinese people today are of Han descent.

Thanks to such digital technology, we can reconstruct different potential interpretations of the past, without touching and damaging its physical remains, or tangible heritage. At the same time it is also possible to describe the material culture´s symbolic meanings (intangible heritage), using different 3D digital tools, as cybermaps (a 3D graphic representation of contents and cultural elements inherent to the monument, archaeological site and artifacts), virtual immersive environments, 3D movies, etc.

High resolution is not fundamental to constituting a virtual museum; however, a high level of detail has been chosen in order to combine the communication purpose with the necessity to preserve this at risk heritage. Integrated technologies have permitted the preservation of archaeological remains. The issue of preservation is particularly important in Xi'an, with its rapid urban development. Every year archaeologists discover hundreds of monuments during emergency surveys in construction sites.

We have collected a very consistent amount of data, so far, sufficient for the creation of a digital 3D archaeological archive functional to the preservation, collaborative scientific analysis, and interpretation of that material culture.

2. The Western Han Dynasty Mural Tombs

Our research has been specifically addressed to the 3D reconstruction of two mural tombs: the Xi'an University of Technologies (M27) (Figure 3) and the Cuizhuyuan, also known as Green Bamboo Garden (M1) (Figure 4).

Figure 3: *Cuizhuyuan (M1) mural tomb: 3D model with high resolution texture applied.*

Figure 4: *Xi'an University of Technologies (M27) mural tomb: 3D model with high resolution texture applied.*

They are two of the few Western Han mural tombs discovered in the city.

M 27 is located on Leyou Plane, northwest of Yue Jiazhai village in the south suburb of Xi'an. It was discovered and excavated in 2004, and documented by the UC Merced and Italian CNR VHLabs in summer of 2008 (AA.VV., 2006; GALEAZZI *et al*., 2010). It is characterized by the following elements: a tunnel excavated directly in the ground, two side rooms where grave goods were preserved, and the main chamber. The orientation is South-North, as Chinese houses were traditionally positioned in that time. Through the tunnel, it is possible to have access to the three underground chambers that are all made of bricks. The side rooms are located at the end of the tunnel, before the main chamber gate. The tomb was dated by Chinese archaeologists at the end of the Western Han Dynasty (206 BC-9AD) thanks to a typological comparison with similar structures that were dated and to the bronze Wuzhu coins discovered inside the tomb. Based on the size of the tomb, the importance of the burial objects, and the paintings, the identity and status of the tomb owner has been assumed to be a governmental official during the Western Han Dynasty (LOEWE, 2006; CH'Ü T'UNG-TSU, 1972).

M1 was discovered and excavated in November of 2008, in the course of construction of the Cuizhuyuan

housing estate, together with three other Western Han tombs in the southern suburbs of the city of Xi'an, in the Shaanxi Province (XI'AN MUNICIPAL INSTITUTE, 2010). M1 is a vertical pit tomb very similar to M 27, with a long sloping passage and brick chambers: a tomb tunnel, a coffin chamber, a paved path, and two side chambers with accesses from the coffin one. Differently from M 27 the orientation is south-north. The tomb structure and burial objects suggest that the tomb was built in the late Han Dynasty as well.

The monument was digitally documented by the VHLabs in the summer of 2009, immediately after the Chinese archaeological campaign ended.

The mural tombs coffin chambers show a very rich repertoire of subjects, such as scenes of daily life, rituals and the ascension to heaven (HE XILIN, 2005). In spite of their importance, they are disappearing because of the critical condition of cluster and colors. Even though the mural tombs are closed to the public, the temperature and humidity controls, and completed anti-mold and anti-germ processing, the successful conservation of these paintings is still at risk. Moreover their removal from the walls and preservation inside a museum is impossible, because the medium is a very thin stratus of clay, directly applied on the bricks composing the structure.

These examples of mural paintings contain a very complex interpretation code explaining the relations between life and death during the Western Han dynasty.

The tombs' architecture and design reflect late Western Han Dynasty ideas, and the paintings partially narrate and describe this revolutionary historical moment period through visual narratives of scenes and themes.

The diffusion of Confucianism influenced the iconographic representation of this period and brought about the introduction of human figures (CHANG, 1983). Scenes of daily life are perfectly fused with pre-Han iconographic motives, as the soul journeys after death. This fusion of elements underlines an important moment of cultural transition in the Han period.

The scenes present in M27 are connected to four main themes (LOEWE, 2005: 38-43; HARDY *et al*., 2005: 5-6):

Daily life: symbolizes the social status of the owner, and testifies the introduction of Confucianism as the official imperial doctrine (LOEWE, 1970; 1982). The scenes are also symbols of earth and mortality. They are painted in the two lateral walls of the tomb. On the eastern wall there are hunting scenes underlying men activities; on the western one there are nightly activities as scenes of banquet, where women are maily represented (Figure 5).

Figure 5: *Xi'an University of Technologies (M27) mural tomb: scenes of daily life. Top: hunting scene; bottom: banquet scene.*

Ascension to heaven: on the northern wall (opposite to the entrance), the yuren stands waiting for the deceased for the immortal life transfer. The yuren is the means of this transfer. The trip symbolically starts from the entrance where, on the two sides, are guardian animals (tiger and dragon) defending the sacred place from intruders. It continues with the daily life scenes, then with yuren on the northern wall, and ends on the ceiling where the heaven is represented.

Five Phases: this path is designed on the ceiling, where the red bird, green dragon, black snake, white tiger, design a map themselves, being symbols of cardinal points. The path shape is circular, and it describes a continuous movement, defining a circular conception of time (eternal repetition).

Yin and Yang (KOHN, 2000): following this path the tomb can be divided in two triangles, where the vertexes are cardinal points: the South-East/North-East/South-West triangle represents the yang (light, male, day); the South-West/North-West/ South- East triangle represents the yin (dark, female, night).

In the subsequent M1 all the recognizable legacies from the past disappear in favor of newer motives: besides the introduction of human figures, for instance, constellations take the place of the four symbols of the cardinal points on the ceiling; the symbolic animal-guardians are substituted by male figures (Figure 6); the opposition night-day remains just on the ceiling; in the

lateral walls, in fact, the clear dichotomy between day/night, male/female, yin/yang, disappears in favor of a parade of people converging on the eastern wall, where a screen stands at the center.

The screen is a very important piece of furniture in a traditional Chinese house, because it divides the public space, where the owner receives guests, from the private part of the house. Clouds decorate the M1 screen, and they seem to symbolically recall the trip to the immortal life.

Figure 6: *The tombs guardians. Left: M27 green dragon of the east; right: M1 human figure.*

The paintings in the Xi'an University of Technology Mural Tomb are very innovative, because they stress the passage to the new state doctrines and philosophy. They are also more elegant than the one found in M1, and this element, together with the burial objects found inside the monument, seem to show that the owner of M27 had a social status higher than the owner of M1. In M27, in fact, ceramic vessels, jade funerary ornaments, coins and seals were found in association with remains of two lacquer wooden chariots. Both were rectangular in plane and had double shafts and single horse. Of these chariots only the lacquer pieces and the bronze ornaments remain, while the wooden part has deteriorated into powder. In M1 there were jade funerary ornaments, coins and vessels as well, but in the side chambers, instead of chariots, just two identical pots of considerable dimensions were found.

3. 3D data collection and 3D modelling

The 3D data collection of the two mural tombs was obtained using a Riegl LMS Z390i. This laser scanner allows acquisitions with an accuracy of 6 mm for a range of 1-400 m. The two monuments were scanned choosing a very high level of detail (8 mm). Very detailed point-clouds were obtained and they are of incredible value from a preservation standpoint and can have a considerable value also for communication purposes. With 3D models in a Virtual Reality environment, high resolution models can be difficult to manage and are often optimized in a pre-processing phase. However the level of detail should be preserved, because it could help the users of a virtual museum to better perceive the objects' composition. In fact the textures sometimes hide or render very complicated physical details in a virtual reconstruction. As one example, in the Maoling Museum (China), the tomb of the Han Emperor Wu Di (end of the 2nd cent. BC), located in Xingping County of Shaanxi Province, the stone carving "Horse trampling the Xiongnu" is preserved. It is made using a local stone with a very light yellow texture that partially obscures its perceived weight and volume. The point cloud alone, instead, shows that volume and stresses the importance of the work made by the artist/artisan who created the monument (Figure 7).

During the post-processing phase the point cloud data were filtered using filter noise, filter redundancy, smooth points, sample points, without losing sight of the metric accuracy of the final 3D model. In other words, the final model preserved the accuracy of 8 mm.

In a second phase two different triangulated point clouds were obtained for the tombs: one at high resolution for preservation purposes, one, optimized for its fruition in an immersive virtual environment. In the latter model the number of polygons is reduced, and the virtual reality engine performances can increase.

The acquisition of M1 was complicated by the fact that the vault of the tomb is supported by retaining structures that considerably increased the scanning time. In fact, more point clouds were needed to scan the entire surface of the monument, slowing down the post-processing phase.

Eventually the models were texturized. High resolution pictures were used to map the model with the 3D studio Max "unwrap modifier", a special tool that permits to apply the image directly on the mesh (GALEAZZI *et al*., 2008: 133-136). M 27 was texturized using different maps for a communication purpose: the first texture was obtained using the pictures of the tomb; the second using the drawings made by the Chinese archaeologists during the excavation phase, georeferencing them on the regular texture; eventually the archaeological drawings were overlapped with the regular texture.

The idea was to show different levels of perception of the monument. For M1 archaeological drawings were

not available, and it was not possible to create different perception levels. This is because the tomb was discovered in November of 2008, excavated and consolidated immediately after, and then documented in 3D. There was no time for archaeologists to work on the drawings.

The artifacts found inside the tombs have been digitally documented using two different techniques: in summer of 2008 M 27 grave goods data collection was obtained thanks to photomodeling technique. This technique permits a very easy and quick documentation, while it requires a long post-processing phase. The data collection, in fact, is possible with only the use of a digital camera. The 3D reconstruction of the artifacts takes place in the lab, where the pictures are aligned to obtain the final 3D model.

Figure 7: *Maoling museum, "Horse trampling the Xiongnu". Top: picture; bottom: point cloud.*

M1 grave good was acquired using the Next Engine, a desktop triangulation laser scanner. The scanning work was very challenging, because objects were manufactured using different kinds of materials - especially pottery, bronze, and jade. The jade was the most difficult to scan, because of its transparency and brightness.

The Next Engine permits a 3D scanning in high definition (HD technologies). It is, thus, possible to obtain an accuracy of 0.002 inches (about 50 microns), packing points finer than the accuracy spectrum (Figure 8).

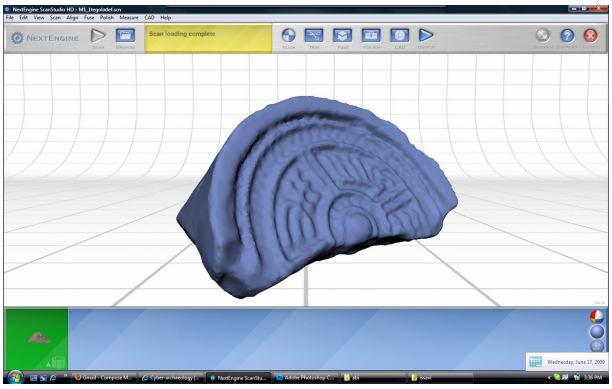

Figure 8: *M1 burial object. Model obtained using the Next Engine.*

The added value of this kind of hardware is the possibility to obtain the final 3D model with meshes and textures applied, without the need of post processing work. During the acquisition and copying process, in fact, the automated alignment of scan sets, the scans merge into single mesh model, the reduction of edge and noise artifacts, and the maintenance of higher quality points through oversampling. Moreover, a seven channel color capture for high accuracy generates a mapping of the final model characterized by the high resolution of textures. The result obtained was a RGB color model.

The process of the 3D desktop Next Engine is automatic; a manual alignment is necessary only with objects characterized by a very complex shape, but also in this case the procedure is simple and fast.

4. Interpreting and communicating Heritage: the cybermaps

A simple description of the subjects and also the 3D virtual reconstruction of the tombs are insufficient for approaching a correct cultural interpretation. For this reason cybermaps of the Xi'an University of Technology Mural Tomb (M 27) and the Cuizhuyuan (M1) have been created (Figure 9).

The idea of this work originates from the fieldwork. Visiting the monuments we immediately understood that there was a big difference in the conception and use of space for the paintings' narrative. We are in fact used to the representation of pictorial narratives per overlapping registers. When we entered inside the coffin chambers for the first time, we immediately perceived a cultural difference in the way the storytelling through the images. As Europeans we are in fact used to storytelling realized in a linear path per superimposed registers. In general there is a main focal point and all the figures converge to it in a linear path. Differently, here, the path is circular and in continuous movement. There is no one focal point.

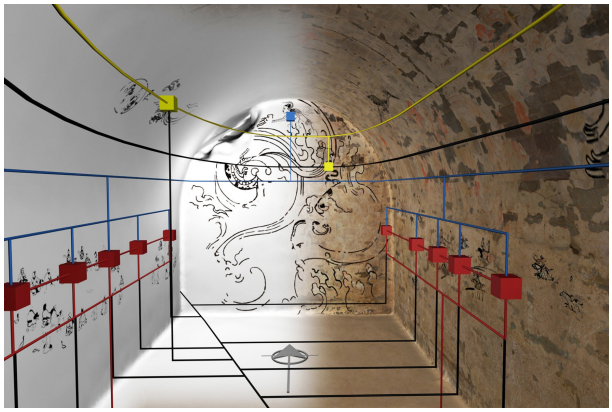

Figure 9: *Xi'an University of Technologies (M27) mural tomb: 3D Cybermap.*

As we began to think about the communication model for the tombs, we wanted to emphasize these cultural differences. And we started from this assumption: *Chinese people think the world is a circle; "westerners" that is a line. The Chinese believed in constant change, but with things always moving back to some prior state* (NISBETT, 2003: 5).

In the tombs, as previously stated, the paintings are composed on a white clay stratus which hides the material support, giving the sense of an immaterial whole with intangible boundaries: contents and frescos spatial relations.

Is the 3D modeling sufficient to show and explain the tomb´s iconographic complexity?

Both the simple description of the subjects and the 3D virtual reconstruction of the tomb are insufficient for approaching its correct cultural interpretation.

This is why the monument should be considered as a mindscape which needs a mindmap for people to decode it (BATESON, 1979; FORTE, 2002). Thus we created a cybermap to allow users to understand all the symbolic connections between scenes. The cybermap (or hypertextual map in three dimensions) is the graphic layout of a set of relations between each scene and its context (FORTE *et al*., 2002). Interacting with it, users are able to acquire information on the tomb iconographic apparatus. Thanks to an abstract code it is possible to represent a symbolic environment using different kinds of metadata.

We shouldn't forget that the material culture mediates between the cognition of people today and that of people in the past. Moreover, it reconciles the past to the present. In this case material objects carry the information across temporal and spatial discontinuities in the form of images. This process is not static.

The use of virtual-cyber mind maps emphasizes the interpretation of the spatial, religious and symbolic connections (affordances – GIBSON, 1979) of the different subjects and images decorating the vault and the walls of the tomb. Through this simulation process the potential semantic re-composition of the tomb creates new metaphors of learning and communication.

It is well known that the human brain responds directly to the inability to process all the visual elements of a scene simultaneously. As our eyes move from one point to another, they recreate a continuous narrative that is perceived by the brain as seamless whole (RATEY, 2002). This idea was developed, for example, by Vik Muniz in the exhibition "Rebus" at the New York MOMA museum. He arranged art and design objects from the MOMA's collection in a special order, and asked visitors to create a narrative from these artifacts (http://www.moma.org/visit/calendar/exhibitions/304).

According to this statement the cybermap acquires an added value. It guides visitors in a virtual tour, showing the main iconographic themes paths; therefore it helps people to recreate narratives, moving from one scene to another in the right sequence.

We are working on a complex system that includes meta-data. As a final result the cybermap will become interactive.

Conclusions

New technology allows scholars to re-conceptualize traditional models to document and archive archaeological findings. Starting from the 3D data collection on the fieldwork, and concluding with the creation of a 3D cybermap, we have demonstrated the added values of this new approach. We think that, increasing the number of perception levels of heritage through technologies, it is possible to improve the user's capacity to collect information, retain it and transform it in knowledge after a subjective interpretation (VARELA *et al*., 1991). The final aim of the project will be the creation of an immersive collaborative environment, where the cybermap will be interactive and linked to metadata such as visuals, images, textuals and videos.

With this research it has been proved that a high resolution data capture has a huge potential for preserving heritage that is at risk. It can also be helpful for communication purposes after an optimization. However the 3D model alone is not enough to show the original context of an ancient monument. Every archeological site, and every museum, needs infrastructures for the general public. At the same time a virtual environment needs digital tools for users to understand ancient codes and be able to reconstruct the context in every monument.

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Figure 10: *Cuizhuyuan (M1) mural tomb: 3D model with high resolution texture applied.*

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