The 13th International Symposium on Virtual Reality, Archaeology and Cultural Heritage VAST (2012)
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Digital techniques for Etruscan Graves: the Etruscanning Project

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Abstract

Etruscanning is a project founded by the European Commission and it focuses on the investigation of new digitization and presentation techniques, in order to re-create the original context of the Etruscan graves. Several digital techniques have been applied for the stages of digitization, virtual restoration and reconstruction and communication. The possibility of working on two different tombs allows us to deep two specific approaches and to diversify the final real-time applications.

This project represents an interesting opportunity to create a concrete link between research and communication in the field of virtual museums, testing the effective impact in terms of cultural transmission, learning and appreciation both in non-linear narrative plots conception and in novel metaphors of interaction. From a technological point of view the most innovative result of the project is the implementation of natural interaction interfaces, allowing the public to move and interact with objects inside the virtual environment.

Categories and Subject Descriptors (according to ACM CCS): J.2 [Physical sciences and engineering]: Archaeology

1. Introduction and goals

Etruscanning 3D is a two years project founded by the European Commission in 2011 within the Culture 2007 framework, it focuses on the investigation of new digitization and presentation techniques, in order to re-create the original context of the Etruscan graves (in particular the Regolini Galassi tomb in Cerveteri and the tomb n.5 of Monte Michele in Veii). The consortium involves museums and research organizations from 3 European countries cooperating in digital acquisition, digital restoration, 3D reconstructions and final communication of Etruscan graves and collections through innovative VR systems. The possibility to collaborate directly with Museums represents a fantastic opportunity to create a concrete link between research and communication in the field of virtual museums, testing the effective impact in terms of cultural transmission, learning and appreciation both in non-linear narrative plots conception and in novel metaphors of interaction. From a technological point of view the most innovative result of the project is the implementation of natural interaction interfaces, allowing the public to move and interact with objects inside the virtual environment that means using only the body movements, instead of the traditional devices like joystick, mouse, console, keyboards [PRP*12]. These ones are still not so easy to use for a consistent part of the public. Such a development requires the creation of a new simple but powerful grammar of gestures that needs to be tested in museums in order to observe the public reaction, improve the system and make the communication between us/the real world and the virtual domain as easy as possible, immediate and natural, suitable for all the public [MD06].
We already presented a first well-working version of the VR application dedicated to the Regolini Galassi tomb in 2011 [Etr2011], in occasion of temporary exhibitions in the Netherlands (Amsterdam - Allard Pierson Museum and Leiden - Museum of Antiquities) and in Italy (Paestum-Archeovirtual). A second improved version has been implemented and presented in Genova (Science Festival, October 2012) and it will be installed for permanent use in Italian, Dutch and Vatican museums (Figure 1).

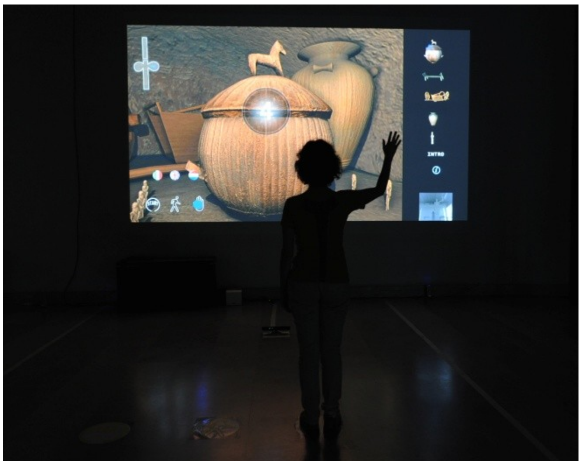

Figure 1: *VR installation with natural interaction interface*

Regolini Galassi tomb, located in Sorbo necropolis in Cerveteri, and the Monte Michele tomb in Veii (Figure 2), are both graves belonging to very important personages – princess and warrior-, dated at the half of the VII century BC and showing the orientalising influence in the style of

DOI: 10.2312/VAST/VAST12/129-136

their precious funerary goods. Today the tombs are empty as the artefacts are preserved in Italian Museum (Museo Gregoriano Etrusco in the Vatican Museum and Villa Giulia Museum), moreover they are not easily accessible for the public. The Regolini Galassi grave is usually closed but it can be opened on demand; on the contrary the tomb in Veii is open but out of the main touristic paths. By making 3D reconstructions of the tombs and of the objects which originally were found inside, we can reintegrate what is illegible, contextualize what is fragmented, isolated, re-creating the ancient contexts and putting back together cultural ties essential to the cultural understanding and transmission [Ant04]. A 3D reconstruction is not simply a digital replica of a real grave: we want to create an experience that can bring visitors inside the ancient Etruscan mind and culture [For08].

Beside the communicative aspect the process of digitization and virtual reconstruction revealed one more advantage. The creation of accurate 3D models, corresponding to the real dimensions of the tomb and its artefacts, allowed the archaeologist to simulate and verify the original setup of the funerary goods in relation to what different ancient iconographical and literary sources can suggest, comparing different solutions and hypotheses. This is the case of the Regolini Galassi grave: as the process of virtual reconstruction of this context tries to visualise the tomb at the moment it was closed, we have been forced to ask ourselves very practical questions regarding the placement of the objects and their original position, their original shape and colours. This was not so easy because when the priest Regolini and the general Galassi discovered the tomb in 1836, they didn't document it methodically and the same we can say for Grifi's and Canina's drawings, consequently much of the information on the exact location of the objects within the tomb was lost. We had to re-evaluate and re- interpret all of the available, unclear, sources to seek answers to difficult questions. It is clear that this case study is a powerful example of the use of 3D reconstructions as a research and interpretative tool and immersive visualization [HPP*11].

Figure 2: *actual state of Regolini Galassi Tomb*

The project started in 2011 and it will be concluded in April 2013. In the first year we focused on the Regolini Galassi Tomb, its digital survey, digitization and restoration of the object preserved in the Vatican Museums. The work in this case is nearby the conclusion. Since few months we have being working on the Monte Michele n.5 grave whose digitization process is still in progress. The pipeline adopted for the two tombs is quite similar for the stages of acquisition, elaboration and digital restoration. The differences will consists especially in the final goals of the applications, as the Regolini Galassi one focuses on narratives and storytelling, emotional involvement, bringing the users in the VII century BC, while in the case of Monte Michele grave we shall enhance the archaeological aspects.

2. Historical introduction about the graves

Although dated the same period, the two tombs are very different as concerning their spatial configuration and shape, the state of the conservation of their structure and of the objects. So they represent two interesting case studies to test how digital techniques can be applied for the digitization and restoration process and for final communication.

2.1 Regolini Galassi Tomb

The Regolini-Galassi tomb is one of the richest and most significant examples of the Orientalising period in Etruria. But its value is not only at aesthetic level. The formal aspects related to the funerary ritual and the symbolic elements that emerge from the analyses of individual furnishings and their association and arrangement have a revealing value about the entire complex ceremony that accompanied the Etruscans "princes" in life as in death.

The structure, partly carved into the rock and partly built with blocks, was covered by a monumental mound with a diameter of 48 m. A *dromos* (corridor), with functions of anti-chamber, allows to enter the inner chamber where the main burial stays. The two rooms were separated by a low wall that partially closed the passage, forming a ritual open window [CD99]. Two small elliptical rooms, called *cellae*, are carved on the sides of the antechamber. The cell on the right kept a large ceramic olla containing the remains of an individual cremation: relatively poor grave goods were located in this *cella*. In the left cell there were no any burial but grave goods of controversial identification. The inner chamber was reserved for a woman buried, of high rank that we can say of royal lineage. The rich personal collection consists of refined jewels, silverware and bronze pottery and fabrics decorated with golden plates [San08]. In the antechamber there were the funeral bed in bronze and opulent furnishings which have a ritual use and references to the practice of aristocratic banquet and power. This oldest tomb, dating between 675 and 650 BC, was later incorporated into a massive mound of larger diameter, including five other tombs (known as peripheral). It was used at least till the first half of the fifth century BC, probably from the same noble family.

The first publication of Regolini Galassi (after the preliminary report of the Grifi and Braun) is due to L. Canina which reproduces the first map with the disposition of the grave goods [Can1838]. The plant made by Canina was also used by L. Grifi in his book of 1841 [Gri1841]. Some differences in the location and characterization of the objects can be noticed: different sizes and even shapes

from the real for some objects, diverse location in the tomb, the size of the tomb itself is different from actual one.
The reconstruction here proposed is neither complete nor definitive, but it is an effort to find the most reliable solution and it shows what can be achieved with the latest digital techniques. It is based on the reinterpretation of the first documentation of the nineteenth century and therefore receives only part of the location of the grave goods finally proposed by L. Pareti in 1947 [Par47], [SB03].

2.2 Monte Michele Tomb n.5

In 1980, during excavations in a section of the Monte Michele necropolis at Veii, six chamber tombs with their grave goods still in situ were found. They are a small, separated group, which supports their interpretation as the property of a single family clan.
Tomb 5 was a princely tomb from the middle orientalising period, dated 670-650 BC. It is a chamber tomb, [Boi01] [BK11] approximately 4.5 by 4.5 metres square, with two small cellae (side chambers), accessed from the *dromos*, the entrance passage. It contained four interments, probably of members from the same family. Although this Monte Michele tomb did not display the wealth found in contemporary tombs at centres such as Cerveteri (*Caere*), it is one of the richest tombs to date in Veii.
In the left side chamber the skeleton of a child without grave goods was found on the ground.
In the right side chamber were the cremated remains of a man aged 18-20, identified as such from bone fragments in the ashes. These remains were contained in a large *stamnos* (a vessel for storing and mixing liquids).
In the large chamber there were two interments. To the left there was a woman, in the absence of bones identified as such from the grave goods, which chiefly comprised ceramics and feminine jewellery. The male interment in Tomb 5 was placed along the right side of the chamber, although its rich grave goods occupied almost the entire space. A cinerary urn made of sheet bronze in the form of an oblong "house" with sloping roof contained the cremated remains of a grown man. The urn stood on a rectangular wooden chest which must have formed part of a four-wheeled carriage, used during the funeral. Together with the vehicle from the Regolini-Galassi tomb, this is the only four-wheeled funerary carriage found to date in the Etruscan world.
The grave goods include aristocratic artefacts like a sceptre, weapons, spindle, precious jewels, ceramics, ornamental plates and banqueting service for scooping, pouring and drinking, iron implements used for preparing and roasting meat: gridirons, skewers, two knives and an axe, a small bronze food cart or trolley. Sophisticated examples of Veii's first bucchero production were also found.
Today the tomb is covered by a plate shelter but its access is open and it is often attended by the sheep. It is clear the process of deterioration of the archaeological remains if we compare the actual state of preservation with the photos taken in 1980 (Figure 3).
An accurate 3D digital documentation is very important not only for communication purposes but also to preserve the memory and to allow further studies and analyses in the future.

Figure 3: *the Monte Michele Tomb n. 5. a) photos just after excavation, 198; b) nowadays, 2012*

3. Digital acquisition, elaboration and optimization.

The transition from real to virtual is a relevant stage of the work because it gives the basis for subsequent processing of virtual restoration and 3D representation.
There are various methods for digitization and each one has positive and negative aspects. There are a lot of aspects which influence the choice of the most suitable method and they are connected with the available sources, the possibility of acquiring new information, the state of preservation of the objects, their complexity (materials, decorations, etc.), the expected results and end-user application (number of polygons, textures, etc). Sometimes we need to combine different approaches (3D scanner and computer graphic technique, manual modelling) to achieve the best result in terms of correctness, appearance and communicative impact.
Another important element to consider is the dimension and the requested accuracy for each object: the digitization method applied on the grave cannot be applied for a single object in the same way.
In particular, as concerning the digitization both of the objects and of the tombs we applied:
a) 3D digitization with TOF (time of flight) laser scanner;
b) multi-image photogrammetric system and dense stereo matching reconstruction;
c) manual modelling from drawings, photos, and acquired measures.

Sometimes different techniques have been applied and combined on the same object in different stage in order to obtain the best result.

Finally all the results of the digitization step have been optimized for real-time application. Indeed it requires models with a low number of polygons to guarantee a high speed of visualization. One of the most common techniques, for these models, is to keep high quality textures, as diffuse, bump and normal maps and an appropriate use of shaders to simulate all the details.

All these procedures have been used in the process of digitization of the tombs and of the objects. At the moment of this writing the majority of the examples refer to the Regolini Galassi case study, as it constituted the first step of the work. The digitization of the objects coming from Monte Michele tomb is still ongoing and it follows similar criteria.

The 3D model of the Regolini Galassi tomb has been obtained by means of a 3D time of flight laser scanner (Riegl LMS Z390i) keeping a resolution of about 6 mms. The workflow of laser-scanning technique is very well-known [GRB10]: positioning of reflective targets, scanning from several positions in order to minimize the holes in the point cloud, filtering of the point clouds to minimize the noise, registration in a single reference system and triangulation to obtain the mesh model. For the first stage of data processing we used RiSCAN Pro software, by Riegl, while, for all the other steps we worked with Meshlab.

The first result was a model of 8 million polygons. Because of the high number of polygons, the mesh had to be decimated in order to obtain a suitable model for real time application.

Anyway in this case the goal was to create an immersive application, in which the user can explore the tomb by using natural interaction interfaces. In terms of 3D modelling, this means that the polygonal resources must be highly optimized, which excludes the direct use of the original high resolution mesh obtained from the point cloud For this reason, another 3D model was built following the main shape of the laser scanner model as close as possible, excluding all grooves and surface imperfections. . This 3D model was obtained by using the backing texture technique in Autodesk Maya 2012. This tool allows to generate a very accurate normal map using a high-resolution model as source. In this way all the geometric detail can be stored in a texture file (normal map), which permits to have a simple mesh, looking the same as the high-resolution model.

This normal map was used as a base for the ortho-photomosaic reconstruction of the diffuse colour, to texture the mesh.

Following this workflow, a model composed of 750 polygons was obtained which, in the real time visualization, appears very similar to the model obtained from point triangulation (Figure 8).

It is necessary to put in evidence the high metrical accuracy we can be reached with laser scanner, but, on the other side, we have to consider some other aspects such us the difficulty of bringing the instrument into the tomb and the acquisition times that are long enough (two days for the Regolini Galassi tomb), especially compared to other techniques. As concerning data processing, there is no any protocol for filtering and triangulating points, so you must rely on the expertise of the operator and control the resulting model. It should be avoid to have a model with many polygons (many details, but too heavy in real time application) or too simple (very fast, but with little detail).

For all these reasons laser-scanner technology appears a good way to obtain a very detailed 3D database of the objects, from which to extract measures and information which are necessary to build the virtual model.

New photogrammetric systems, based on structure-from-motion and dense stereo matching, have been used for the digitization of objects in the graves [CDD*11]. For the objects of the Regolini Galassi Tomb and Monte Michele Tomb, the images have been acquired from different points all around the object, in order to have a complete description of it. Each point of the object has to appear at least in 3 images.

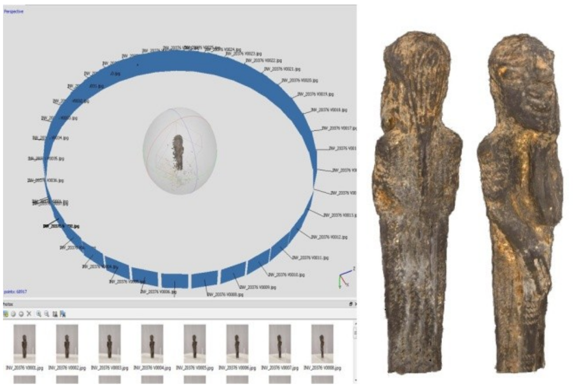

Figure 4: *3D model of a mourner statuette (right), obtained with Dense Stereo Matching (left)*

Many software, as 123D Catch by Autodesk (new version of Photofly), Arc3D Web Service and Photoscan by Agisoft, allow to orientate the images, to apply a bundle adjustment and finally to rebuild a virtual copy of the object which simply needs to be rescaled on its real dimensions and to be decimated.

This method allows to obtain a complete geometric representation of the object and of its texture at the same time. It has been applied for not reflective objects with a complex shape and that could not be acquired with laser scanner, since the Vatican Museum did not gave us the permission to use such an instrument. Dense stereo matching technique showed some problems for reflective objects, made of gold or silver, because the software cannot recognise the same points in different images (because of the different reflection). There were some problems also in the photographic acquisition of near black surfaces such, for example, bucchero pottery.

Among the items that have been completely digitized in this way, we mention the mourner statuette of the Regolini Galassi Tomb (Figure 4) or an unknown ivory base from the second tomb. In the case of the mourner statuette (12 cm high), the object was so complex that it was very difficult to take some measurements. There were no drawings so it was not possible to build the model by manual modelling. So we decided to apply dense stereo matching techniques.

We acquired 40 images of the Mourner statuette, with the same camera and focus length. The camera has been

rotated around the object in order to have a big overlapping area between subsequent photos. This guarantees to find a sufficient number of points to orientate images and to compute the model. The model, obtained by 123Dcatch, was decimated till 4600 triangular polygons and the texture, applied as a diffuse map, is a high resolution map of 2048 x 2048 pixels.
For this object the method has been successfully applied. I was possible to obtain 3D information from the pictures and to get to the final result without using other software.
In other cases this method has not been used to build the final 3D model, but simply to have more information about the object and to extract some profiles which have been used later to build an optimized handmade model. As in the case of structures acquired by means of laser scanner, dense stereo matching technique can be used also to store a 3D high resolution database of small objects.
The third method, manual modelling, has been used in different conditions:
- in case of objects with an accurate and trustworthy visual documentation (photos, drawings, measures)
- in case of objects for which it was not possible to obtain new images (e.g. because they are in the showcase),
- in case of objects with problems of reflection or with very complex details, difficult to digitize with more automatic techniques (for instance the ceremonial golden fibula, Figure 5).
It is evident than in these cases the result is mainly related to how the object is seen and perceived. For this reason the modeller tries to reconstruct the object according to the available documents, paying attention to the correct dimensions (acquired from literary sources or through new measurements taken by callipers) and to the aesthetic aspects.
The ceremonial golden fibula testifies the good results that can be achieved through the manual modelling. Also in this case we produced a high resolute model that was after reduced for real time implementation, using normal maps to simulate the original geometry.

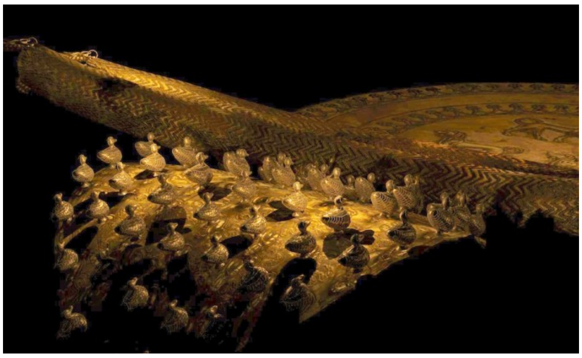

Figure 5: *the fibula (rendering).*

During the acquisition phase, some tests have been carried out to understand which method could guarantee the best results in some uncertain cases.
The second grave, Monte Michele n.5, is very different from the first one. It was completely dug in the ground. The space in the Regolini Galassi is very straight and narrow; instead in Monte Michele the grave is completely open because of the collapse of the ceiling.
So the Tomb of Veii has been acquired by laser scanner and photogrammetry and we compared the results of these two approaches. Each method has its strengths. Photogrammetry allows a very fast acquisition and the coverage of all parts of the tomb (photo coverage), while laser scanner guarantees a good geometric accuracy, but the acquisition is longer and harder in terms of logistics.

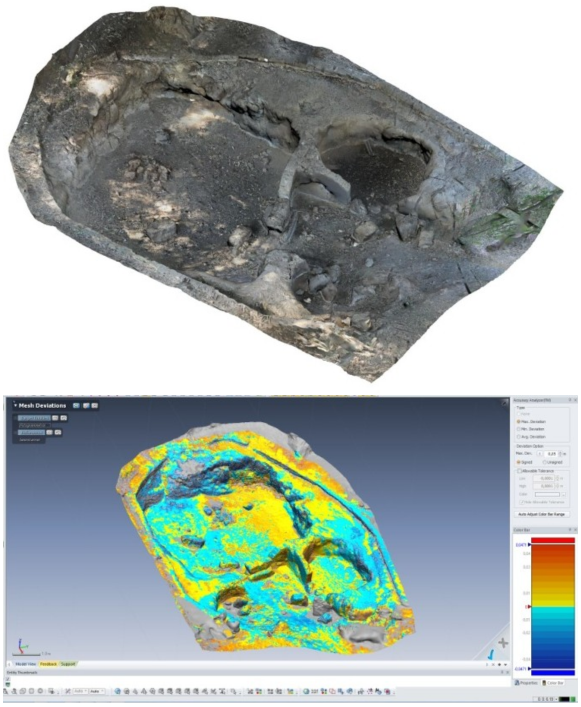

Figure 6: *tomb of Monte Michele n. 5: the textured model (a), the comparison between photogrammetric and laser-scanning model (b).*

The comparison between the two methods allows to determinate that in this case the photogrammetric model (made by Photoscan) is very accurate (standard deviation from the laser scanner model is about 5 mm) and complete, without the holes of the vegetation and the pile of the roof. Moreover it has also a texture map, built by the same photogrammetric software (Figure 6).
This experience on the tomb of Monte Michele has highlighted the good results that can be achieved with the techniques of dense stereo matching not only on small objects, but also on larger objects. The different size obviously entails a change in the pattern of acquisition of the photographs (no more “around the object”, but “from the inside”).
But we must pay particular attention to the object to be digitized. This tomb, consisting of tuff and not well preserved, it has no special decoration so we cannot evaluate the result of dense stereo matching on a very detailed surface.

4. Virtual reconstruction

The main goal of virtual restoration is to recreate the original state of the object. In the Etruscanning project, this practice has played an important role because it is the necessary step to show the public the most probable original configuration of an object or a space. The process of digital restoration has been coordinated by Daniel Pletinckx from Visual Dimension, one of the partner of the consortium, and it was completed by CNR, in Unity 3D.
It is clear that the process of virtual reconstruction demands different skills [Ple07]. It is necessary to use the digital tools to recreate the original configuration. But even more important is the process of knowledge that leads from the current state of the object to the reconstructive hypothesis. This process is essentially based on detailed observations and comparisons with other objects that are coeval, from the same place or with the same cultural influences.

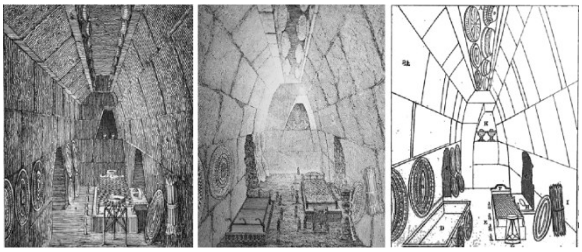

Figure 7: *reconstructions made by Grifi (1836), Canina (1837) and Hamilton (1838)*

Till now all the experiences of virtual restoration regards the Regolini Galassi Tomb and its objects.
As concerning the grave the actual state of preservation of the inside is not very different from the original one (even if probably it should be investigated with more attention, but this was not the aim of the project): we recreated only the two missing walls closing the inner chamber and the right cell, as documented in the historical and iconographic sources (Grifi, Canina, Hamilton) in Figure 7.
One of the most important steps is to recover the available sources and assess their reliability. The first descriptions of the tomb are all interpretations of the original state of the tomb and there were no drawings of the excavation.
The 3D model of the tomb and accurate digital copies of the objects (about 80 key objects), mainly from Musei Vaticani, have been put together in different spatial configuration.
The last hypothesis of spatial location of the objects ensures a spatial correctness and plausibility (Figure 8).
An important part of the virtual reconstruction is the digital restoration of the objects. Also in this case we used several techniques from manual modelling till the use of manually originated depth map.
The most interesting application regards engraved and embossed objects, with missing parts (for example a silver, gold-plated bowl from Musei Vaticani).
This bowl was broken due to the collapse of the *cella* roof of the tomb and is about 70 percent complete. The decoration consists of marching and horse riding soldiers in Egyptian style, and was created by engraving and embossing the silver bowl. Starting from the line drawing by the restorer we created a complete line drawing, mostly by copy-pasting the Figures, as the decoration is quite repetitive.

Figure 8: *final hypothesis for the location of the objects in the dromos (a) and in the cella (b) of the Grave*

The remaining missing parts were completed by symmetry and by comparing to a very similar bowl in the National Museum of Antiquities in Leiden, the Netherlands. This complete line drawing was used to simulate the different creation processes of engraving and embossing as different layers of a depth map, as a greyscale image in Photoshop.

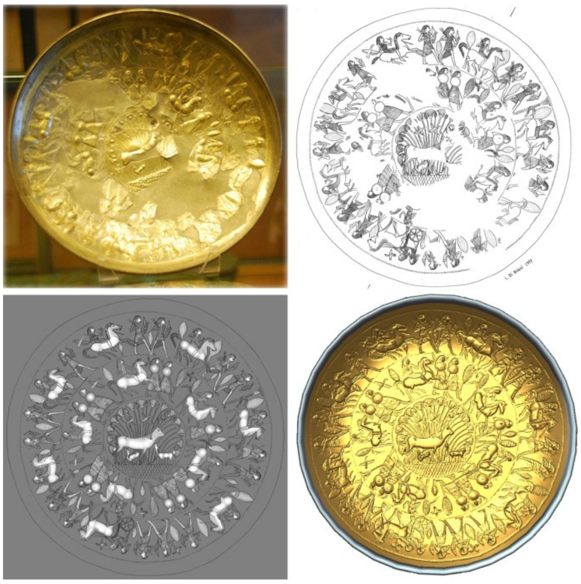

Figure 9: *digital restoration of incomplete gold-pl silver bowl: the physical restored bowl (a), the li*

The embossing was painted by hand in Photoshop, based upon detailed analysis of the object and simulating the way the artist was creating the embossing. The resulting depth map was turned into a normal map for efficient real time

visualisation. The can be fine-tuned in Photoshop when composing the layers, to match the original object as much as possible.
Several objects were digitally restored in this way. This yields not only a well-documented and easy digital restoration method, but provides also the opportunity to visualise the object efficiently in a real time system by converting the depth map into a normal map (see next paragraph). On the other hand, a depth map can also be used to create a detailed 3D model of the object, for example to make a physical replica of the restored object (Figure 9).

5. Optimisation for real-time visualisation and integration in Unity 3D

3D models elaborated with several technologies have been imported in 3D Studio Max in order to verify their geometrical quality and to make their final topology and texture mapping coordinates as perfect as possible. From 3D Studio Max, we exported each 3D model in .fbx format and we implemented it in Unity 3D real time engine. The latter has been used for the final visualisation in a VR environment, where storytelling, behaviours and natural interaction interfaces have been developed. In Unity 3D, the final editing and optimization of 3D contents has been obtained, especially in relation to the final rendering quality, materials, shaders, light mapping, occlusion maps, etc.
In fact, the great potential of the latest generation of video game engines, in terms of editing tools, has completely changed the traditional workflows. In the past, we used to finish and optimize the quality of our 3D models inside 3D graphic software (3D Studio Max, Maya, etc.), finally exporting them into the real time engine where they were directly managed at programming level. At present, the actual engines integrate proper editing and optimisation tools that allow complex materials authoring and shaders, global illumination, normal maps generation, occlusion culling, and light probes in order to have full control over the final result of the visualisation.
In the previous paragraphs, we explained how objects were digitised and digitally restored. Many objects have their details visualised in Unity 3D through normal maps that are generated during digitisation or as the result of the digital restoration.
Each object has been imported in Unity 3D following a convenient and rigorous hierarchical structure of the dataset without redundancies or dangerous duplications of data. In fact, in terms of optimization and fluidity, it is imperative to limit the draw calls number, as they influence the real time performances more than the number of polygons itself. The draw calls number is determined by the complexity of the material; each map is attributed to a specific channel of the material and corresponds to a draw call. At the end of the editing process each single object has been saved as a “prefab”.
Within the main scene, the whole scenario of the tomb has been recomposed: the prefabs are put in the right position and the successive behaviours are implemented at programming level (Figure 10).

Figure 10: *VR application with natural interaction interface: the navigation through the tomb (left) and the objects (right).*

6. VR and natural interaction interfaces

The public has the possibility to explore the virtual Regolini Galassi tomb, to get near the artefacts, to listen to narrative contents from the voices of the prestigious Etruscan personages buried inside to which such precious objects were dedicated. All this is possible moving in the space front of the projection, in the simplest and natural way. Some hotspots on the floor are used for the following functions:
1) hotspot Languages: choice of language
2)hotspot Exploration: free exploration, using arms for translation and rotation on xyz axes);
3) hotspot Selection and Storytelling: the storytelling will be referred to the objects staying in the area in which the user has stopped. Each object, when selected with the right hand, has a dedicated camera and spotlight; it can be animated while speaking.
4) *hotspot Start:* a short tutorial is given to the user in order to teach him how to interact inside the 3D space. This section includes also an historical introduction about the tomb.
This solution appears the best compromise, suitable for every kind of public: the users can immediately understand how it works without any frustration but feeling much more embodied in the 3D space. Moreover the user can find a balance between active interaction and relax listening to the stories. This solution not only makes the interaction amazing for the public but allows also people of every age and every “technical” skill to enjoy the virtual contents. The evocative storytelling in first person, the use of the lights that reveal the objects gradually, as soon as the space is penetrated, the physical involvement of the user produce an impression of strong sensorial immersivity. The system has been derived from the new generation of games, but for the first time, it has been applied to VR environments dedicated to Cultural Heritage (CH) and experimented with inside museums.
The application is built in Unity 3D and uses the Kinect sensor for motion capture.

7. Conclusion

The Etruscanning project aims at investigating the potentialities of new digitization techniques and innovative virtual reality systems for communication inside museums.

In this paper we presented the first results of the work, by a comparison of the different digitization technologies. We considered some examples in order to explain which are the most suitable approaches according to different objects and conditions of acquisition.
In the VR implementation based on natural interaction interfaces the crucial point is the capability, even if still at pioneer level, to establish relations and, therefore communications between natural and artificial worlds based on perceptive-sensor motor dynamics, instead of symbolic codes: gestures, proprioception, images, sounds, on which the original and much more evolved approach in human learning is based. This "embodiment" constitutes a new frontier of the communication and learning processes.
It is clear that this case study is a powerful example of the use of 3D reconstructions as a research and interpretative tool and immersive visualization. From this work it is evident that the digital work on the tombs, as for each archaeological case, needs a strict cooperation with historians, archaeologist and museum curators.

Acknowledgements

In this project, we appreciate Vincenzo Bellelli, CNR-ISCIMA for his help and support.
Etruscanning 3D is a project in the Culture Programme of the European Commission and is funded by its Executive Agency for Education, Audiovisual and Culture

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