Marta Racconta

A project for the virtual enjoyment of inaccessible monuments

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Abstract: As often happens, many monuments are affected, for various reasons, by an inevitable trouble: the artefacts preserved inside them until the discover have been brought into some museum, because (e.g.) the monumental structures had to be restored (in most cases with provisional works) in order to prevent their collapse. One consequence of this moving is the de-contextualization of the grave goods and the non-valorisation of monumental archaeological contexts. An effective solution for these issues can be achieved from the use of technologies that allow the virtual enjoyment of these monuments and the virtual set-up of the grave goods in their original contexts.

This paper presents the project "*Marta Racconta. Storie Virtuali di Tesori Nascosti*", co-financed by the *Fondazione Cassa di Risparmio di Puglia*, carried out by CNR-IBAM (Lecce, Italy) in order to provide the installation of a Virtual Platform in the National Archaeological Museum of Taranto (MARTA). The main purpose of this project is to make 'accessible' ancient monuments from the Greek Taras (the ancient Taranto) currently inaccessible to visitors. These are: the *Tomb of the Athlete of Taranto*, *Tomb of the Festoons*, and the *Hypogeum of the Gorgons,* was discovered some years ago in *Via Otranto.*

From a technological point of view, we have developed a Real Time 3D platform for a stereoscopic immersive visit, in which a navigation system with 'natural interface' was implemented, where the commands are executed with simple hand gestures. Through this technology, the visitor will have the opportunity to follow a path of integrated knowledge starting from heterogeneous contents, which will allow the access to historical and archaeological data, the archaeometric analyses and the spatial navigation within a hyper-realistic environment where it will be possible to interact with the three-dimensional structures, to query the Database and to explore, interactively, the funerary finds.

Keywords: virtual enjoyment, virtual visit, 3D reconstruction, inaccessible, laser scanning

Introduction

Immovable archaeological goods, dislike movable artifacts, usually cannot be transported in a museum. While movable artifacts, even if not relevant enough for being exhibited, at least are restored, classified, studied and kept, immovable artifacts meet a different fate. When not plundered before the excavation, they are separated from the precious objects they kept, in the best case roughly restored and often closed to visitors. Similar is the fate of those minor and less known sites, inaccessible for causes related to the impossibility to arrange a plan of public fruition. These sites, representing tiles of an unreadable mosaic of our ancient cities, are invested by serious issues related to monitoring their conditions, often compromised by a state of partial abandonment. The road map for solving some of the above mentioned problems is clearly represented by an intervention aimed to enhance the value of ancient structures, to disseminate their features and above all to give back their fruition to public.

Against this scenario, in 2004, a project of to digital promotion conceived for matching the need of re-opening, even virtually, some hypogeic monuments of the Greek necropolis of Taranto. The goal has been achieved thanks to financial support of Fondazione Cassa di Risparmio di Puglia that funded the project “Marta Racconta. Storie Virtuali di Tesori Nascosti”, aimed to make open and accessible, in the Museo ARcheologico Nazionale di TAranto (MARTA), some hypogeic funerary monuments of the ancient city of Taranto though a Virtual Reality installation. The visit is based on the production of 3D replicas of some Greek monumental tombs, where finds in display in MARTA were found, as architectural elements, ornamental sculptures, sets of grave goods). Just few of them are visible on site, while the majority being underneath private buildings is closed to the public. Since there were many monuments of Taranto with the features required by the project, the choice of focusing just on the hypogea has been taken basing on certain factors. Consequently, in partnership with the director of the Museo Archeologico Nazionale di Taranto, the following monuments have been chosen: The Twin Tombs in via Umbria (fig. 2), the Hypogeum of the Gorgons in via Otranto (fig. 1) and the Tomb of the Festoons in via Crispi. The last two hypogeic chamber tombs, since they show architectural and decorative characteristics (sculpture and painting) common to other Hellenistic monuments (4th-3rd century BC), are very interesting especially with regards to historical and archaeological aspects. Finally, it has to be taken into account that archaeological and archaeometric analyses and studies carried out on them help to enhance the knowledge ranging from building technique to funerary rituals in use in ancient Taranto. The system of virtual visit at the museum includes two different types of visit. The first is based on an active approach, centered on an application developed on VirTools of Dassault Systèmes, a stereoscopic commercial RealTime engine featuring a building blocks programming. This software, despite the choice of customized scripts, does not require any particular programming skill and it has been chosen for the high quality OpenGl output and reliability. The second option is based on a passive approach, a stereoscopic movie in computer animation where the three monuments are presented with an illustrative and appealing narrative

This choice is motivated by the need of offering to the public a diversified product, aimed to engage via the interactive exploration visitors familiar with IT tools but also to attract visitors with easy and user friendly communication tools not requiring any specific technological competence. In short, a complex product in which historical and archaeological knowledge is blended with modern techniques of computer animation and edutainment.

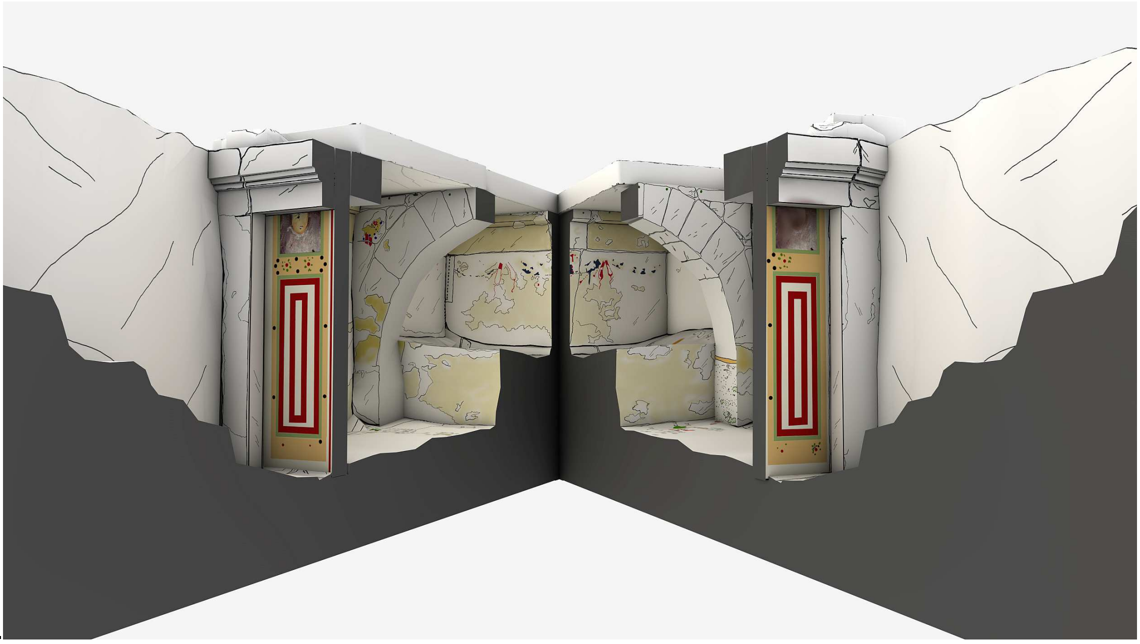

Fig. 1 – The Hypogeum of the Gorgons in via Otranto, Taranto. 3D reconstruction based on old drawings

Main goals of the research

The active virtual visit is centered on an immersive stereoscopic platform, controlled by natural (or transparent) interfaces, that means usable without pointing systems as mouse, keyboard and joystick. Obviously, the use of an interactive stereoscopic system requires an interactive 3D model, possibly metrically correct. On that model, further contents, to be used for the virtual fruition, the documentation or for the analysis of the current conditions of the monument, are linked. The morphological and architectural study of these hypogeic spaces presumes a explorative approach aimed to recognize building features and, since architectural elements cannot be beforehand simplified in planar and regular shapes, also and a metric survey as meticulous as possible avoiding any simplification. It could be useful to emphasize how significant the use of indirect survey, whose measurement is based on optical, mechanical or computer assisted devices, has been for passing the difficulties of a traditional direct survey, allowing to achieve accurate and precise results investing little time.

The experience on the Tomb of via Crispi pointed out that photogrammetry (indirect passive survey), despite the low costs for hardware, can be affected by the user during the calibration causing relevant residual errors if used without proper attention. This survey technique was used by the author during the previous analysis of 2003-2004, for his affordability and easiness of use in restricted spaces. The new survey of the chamber Tomb of via Crispi has been carried out via an indirect active method, with the use of a Leica ScanStation 2 time-of-flight laser scanner (fig. 3).

Fig. 2 – The Twin Tombs in via Umbria, Taranto. 3D reconstruction of actual state and virtual restoration based on the archaeometrical analyses.

Fig. 3 – The Tomb of via Crispi, survey carried out via laser scanning (final results).

Due to the morphological features of the monument object of the study and the limited working space, during the survey a pace point-to-point of 2 mm has been adopted, that is also the maximum precision value tested on this device. This parameter allowed to get a good resolution mesh (approximately 5M polygons), suited for the goals of the architectural survey but also it caused a certain complexity in the 3D model, that brought to post-processing solutions for a compatible decimation (1/10 of original resolution) with the RealTime platform. The 3D survey was carried out on the entrance corridor, built at the beginning of the last century, and the room called α or of the Festoons. During the same survey campaign, all the photographic shots required for a documentation of the conditions of the spaces and for further texture mapping tasks of 3D models have been taken. Each picture has been conveniently treated with PTLens software of Tom Niemann, for canceling the distortions induced by the lenses. The 3D model has been subsequently optimized for adjusting it to the requirements of an advanced texture mapping, adopting some camera projection methodologies on multiple patches (fig. 5) on purpose experimented in this project.
The correct mapping of the three-dimensional model acquired through laser scanning is usually one of the most problematic issues in the process of accurate and verisimilar restitution of an artifact. Often, some important works by laser scanning are presented as well as mere geometric shapes, with simple shaded views without any applied texture. Certainly a simplified presentation of reality, in which the chromatic values of the surfaces are essential elements for a correct reading of the conservation status, of the characteristics of the constituent materials, of superficial cracks and other micro detail characteristics, impossible to reproduce with a time-of-flight laser scanner. This technique is generally known and applied in Computer Graphics especially for making interactive 3D models from two-dimensional images, very useful for the conversion of two-dimensional paintings, frescoes, engravings, in 3D explorable scenes. The usefulness of this method is even more appreciated in mapping operations starting from photos. It is indeed known that

cylindrical, spherical or cubical projections are applicable only in specific cases and can never be used to overlap the photos directly on a scanned object. The planar mapping, in particular, projects the texture on the object according to the plane normal, the plane orientation and so the projection direction is chosen according to the necessities and the kind of the object to texturize, but this type of projection is not coincident with a camera take. In a lot of case studies is wrongly used precisely this technique to map complex objects, by assigning small parts of the scanned object to specific photo-textures, with poor results and obvious signs of stretching in the areas with a different angle projection. This means, strictly speaking, that the planar mapping could be applied just on a planar object with an ortho-rectified texture, according to the rules of the orthogonal projection. Each photographic image is rather a perspective view, with a point of view, a target point of the perspective, a visual field and deformations dependent on the quality and nature of the lenses. Then in theory, knowing exactly these four parameters and mapping the photographic images according to the perspective rules, that is the same Camera Mapping method, you can get a mapping with an almost perfect texture-3D model overlap (fig. 4).

Fig. 4 – The Tomb of via Crispi. An example of camera mapping texturing applied on 3D model.

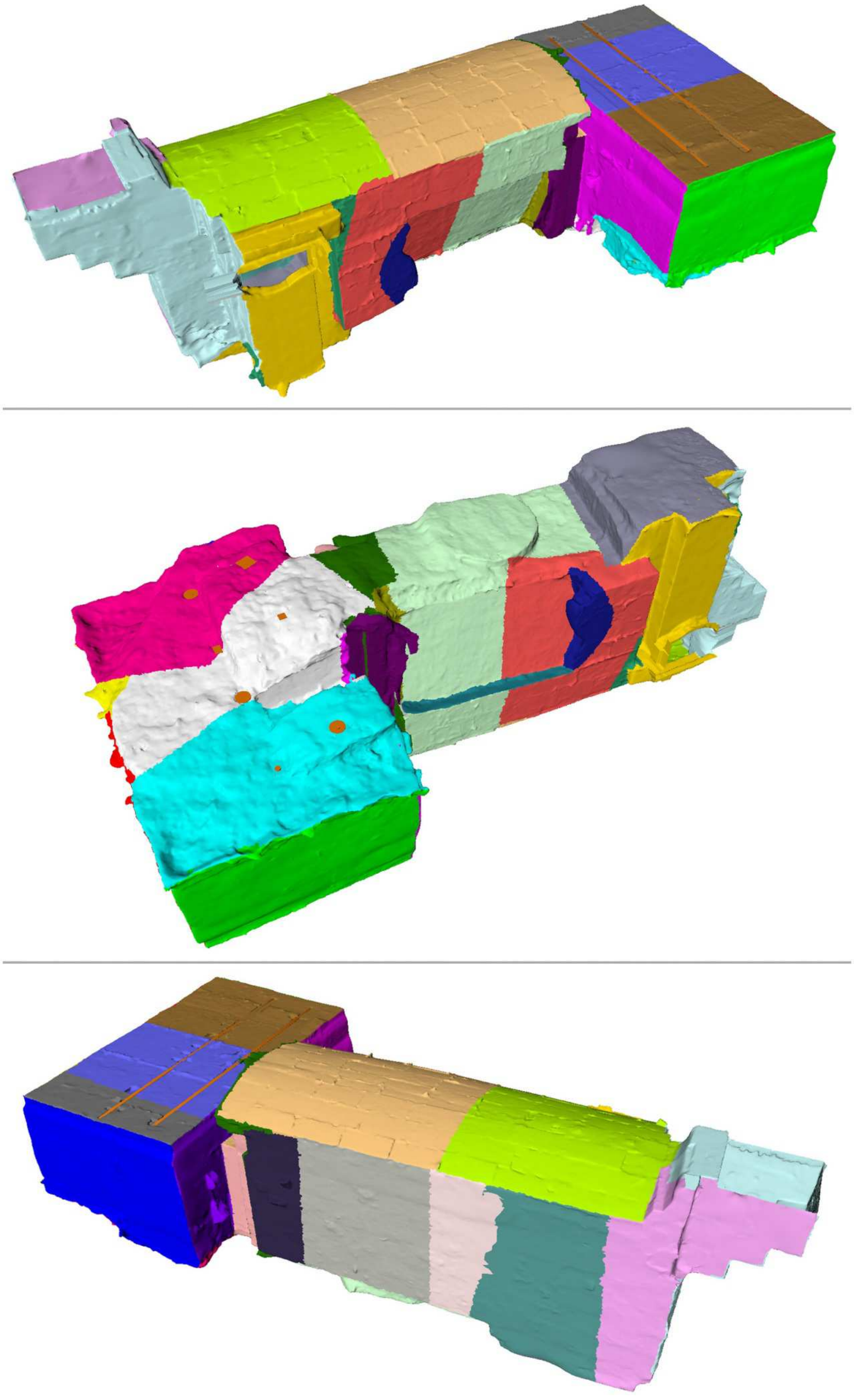

Fig. 5 – Subdivision of multiple patches necessary for the use of camera projection method

Fig. 6 – Color correction. A. original image with strong red dominance. B. Dominance removed in Adobe Photoshop.

This texturing process required considerable efforts for transforming a rough model produced by the laser scanner into a representation as naturalistic as possible in terms of metrics. Due to the particular light conditions of restricted spaces, an approach of chromatic correction of pictures has been applied though three steps: the first for eliminating strong color dominants (fig. 6), the second for eliminating differences of light intensity between diverse parts of the same picture, the third for getting gradual passages between

adjoining textures (texture blending). The sum of all these techniques produced a model without clear 'texture striations' and at the same time without visible joining points. Subsequently, single patches were canceled with a process of texture baking, calibrated on direct light, ambient occlusion and indirect light of radiosity. Final textures, UVW mapped after the baking process, were calculated with a resolution of 10.000x10.000 pixel. On them a further chromatic correction of the inner surfaces has been applied.
There are several criteria to establish with precision the camera position in a 3D scene. The first, widely experienced by the Information Technologies Lab of Lecce (ITLab), consists in the recognition of only the significant points of the scene with digital photogrammetric techniques, and then, after the orientation process, in the recovery of the camera positions of each shot after a patient work of restitution. However, this technique can produce also significant residual errors and lead to further uncertainty degrees in the research of the camera positions, moreover this technique, although it is classified as "low cost", requires a long processing time, which should be added to that one needed for the post-processing of point clouds.

Fig. 7 – 3D survey of Tomb of Via Crispi

The method used for this work is not automatic and requites a certain user skill. The research of the view point and of the camera airing point works as follow:

1. For the research of the airing point the center of the texture should coincide with the same correspondent point on the geometry. The search of this correspondence can be simple if the superficial morphological complexity easily allows the recognition. On the contrary, it is possible do find the point relying on vertex color.
2. Once established the center of the texture on the geometry, it is needed to assign a target to the camera in order it always points on it. After that, the view point of the camera has to be found. It can be easily found moving the camera all around the target in natural way if the distortions induced by the lenses were previously corrected.

Fig. 8 – 3D reconstruction of Tomb of Via Crispi (same point of view of previous figure).

The importance of this last working phase has not to be ignored, because the chromatic correction based on the research of the point of white and the point of black, is affected by the tonal extension of the image object of the study. It means that the more ample of the available selection of colors the more precise will be the correction, because it is offered a the research range within which the most bright 'real' point and the most dark 'real' point of the hypogeum fall. First of all, the system of RealTime visit of the Tomb of Via Crispi has been conceived as the tomb appears. For achieving it, during the rendering of scenes it is necessary to adopt certain expedients as to allow a visit as close as possible to the real perception of an in situ visit. For this goal, a crucial component is represented by the illumination of the virtual space and consequently by the establishment of the point of white of the textures. A neuter illumination and a point of white fixed for giving back chromatic values in their 'numeric' components gives as a result a correct vision in terms of colorimetry but distant from the direct perception of a real visitor. Because of that, the hypogeic space has been reproduced with a point of white of the textures based on the temperature of an incandescent lamp (3000 ^{o}K). This simple expedient, besides the use of light sources of area type, copied the light conditions used during the shooting.

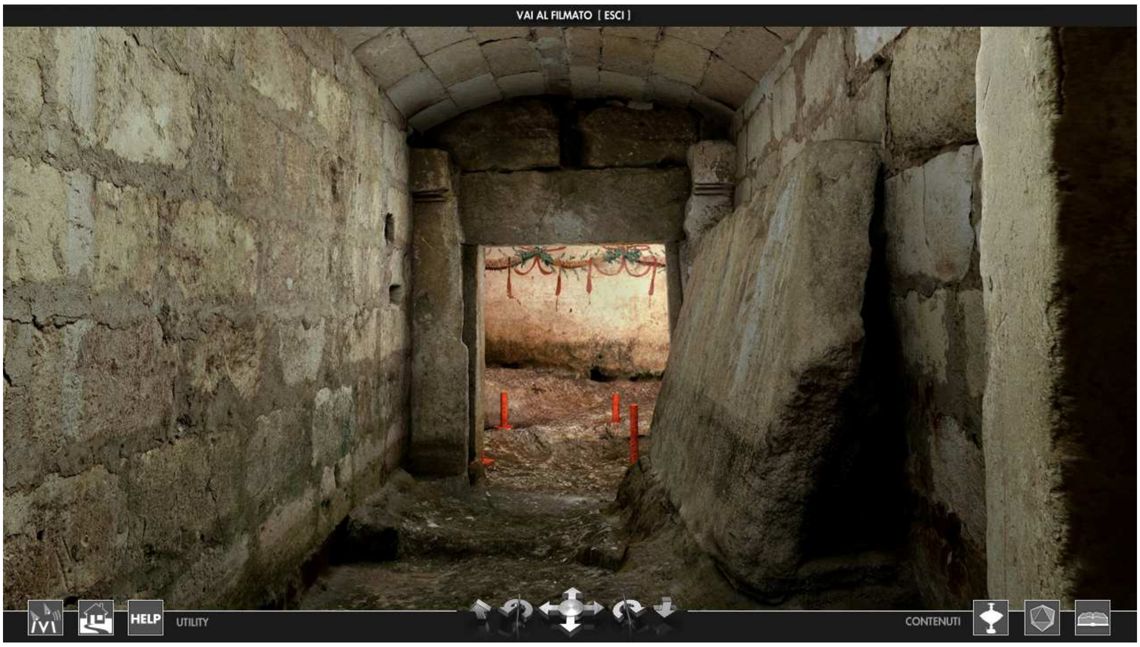

Fig. 9 – Screen-shot of real time 3D platform

Reconstruction of the Tomb of Via Crispi

To the virtual visit of the hypogeic structures ‘as they appear’ today, a CG reconstruction aimed to a diachronic reading of the monument and to a further comprehension of its transformations has been sided. In the CG environment, the internal structures of the Tomb of Festoons were reconstructed, as the now destroyed klinai with the grave goods on the top. All the inner surfaces have been restored to original color, rebuilt in the base of the analysis of the pigments, partly already carried out in 2004. The entire hypogeum has been rebuilt, but the RealTime visit will be limited only to the burial chamber. An overview of the tomb will be presented in a 3D stereoscopic movie, where with a narrative approach all the peculiar features of the monument and the funerary ritual of goods deposition will be illustrated. This task helps the user to reconnect the original context with the grave goods but it clarifies further the importance of this project as example of virtual museology.

Information materials on the Tomb of Via Crispi

The gathering of information materials is completed by a section on the available documentation for the tombs and the finds retrieved from them. In the visiting platform, archive documents, photographic and graphic data, archaeological notes about the grave goods and archaeometric analyses can all be consulted. To this end, excavation journals (transcribed for easier reading) and entries in the museum’s inventory book were reproduced; the grave goods were photographed; and the official tables for ‘Grave Goods’ and ‘Pigments’ of the paintings were compiled, together with the entries for samples and the results of archaeometric analyses. All this information increases the knowledge of the monument being studied, in addition to its faithful three-dimensional restitution, providing a form of “Enriched Reality” that the visitor can consult in line with their personal interests. Access to the links and the navigation itself in the 3D scenes is

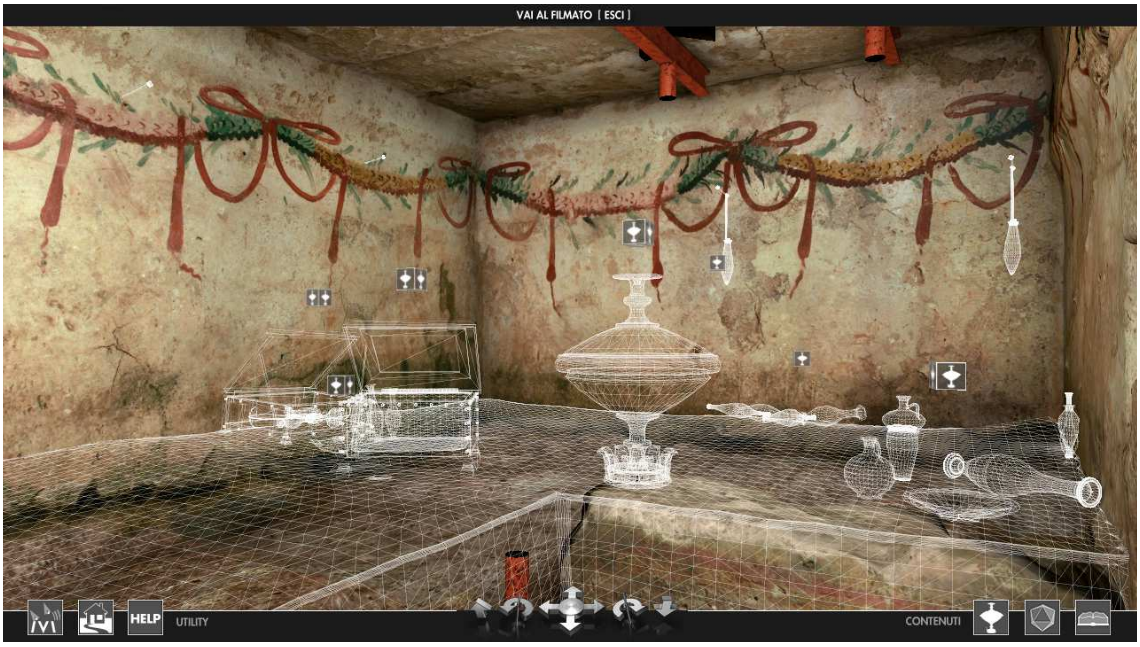

Fig. 10 – Screen-shot of real time 3D platform with wireframe grave goods

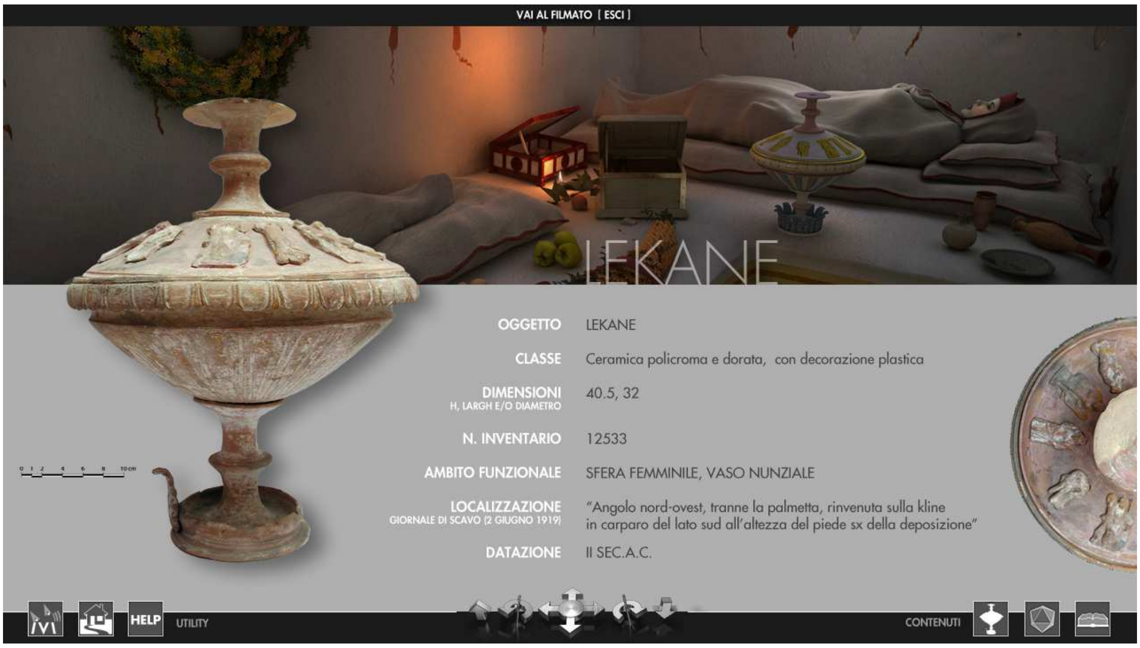

Fig. 11 – Screen-shot of real time 3D platform. Information materials

controlled by a natural interface managed by the Kinect for Windows free software. In their visiting itinerary, users can read transparent texts on the location of the grave goods, placed on the kline in accordance with the excavation data, and receive information on these objects. They can also compare them to the real display in the museum. Indeed, after the interactive stereoscopic experience, the visitor can watch an animated story (hence the name "Marta Racconta", MARTA narrates) in which the funerary object is framed in its ancient context but then placed in the museum showcase, with a single camera movement. The grave goods are thus perfectly contextualised, but also understood in terms of their functional and ritual value.

Fig. 12 – 3D reconstruction of Tomb of Via Crispi, view of the entrance.

Final remarks

The project 'MARTA Racconta' is an example of use of different technologies aimed to achieve the public fruition of a neglected and hidden heritage. The proposed techniques allow to visit monumental complexes with an high level of realism and simple and transparent interfaces both in active and passive modes. This product grants the possibility of consulting archive, historical, architectural and archaeometric data on a single platform in an interactive environment of

RealTime3D produced from a model obtained with an high level of precision and conceived as a serious 'container' on contents. We look forward that the blend of all these informative elements in a single platform, could represent the first step of a systematic phase of salvage of the entire necropolis buried underneath the modern city of Taranto and that tools like this could become dissemination tools of knowledge for that heritage risking to remain unknown.

Software used

- Cloud points processing: Leica Cyclone 6.5
- Optimisation/triangulation of meshes: Inus Rapid Form
- 3D Modelling and T. Mapping: Maxon Cinema 4D
- Removal of lens distortion: PTLens
- Rendering: Chaos Group VRay
- Net Render: Cinema4D Net Render
- Real time authoring: Dassault Systèmes Vir Tools
- Colour correction: Adobe Photoshop
- Gesture control: Kinect for Win NITE
- Film compositing: Adobe After Effects

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The SDK for Kinect is available on: http://www.microsoft.com/en-us/kinectforwindows/

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