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## **2015 Digital Heritage**

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# **2015 Digital Heritage International Congress**

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# The Palmieri hypogeum in Lecce.

## From the integrated survey to the dissemination of contents

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**Abstract** - This paper describes a complete path of research, which, starting from analysis and restitution 3D, gets to the virtual exploration of Hypogeum Palmieri in Lecce, a monument of Messapian age (4th century BC) currently not visible by tourists, as it is located in the garden of a private home. This project is developed under the DICET, an Italian National Operative Program, that aims to define and produce innovative models, processes, and tools for the sustainable development of a smart territory by capitalizing on its cultural and environmental resources, and marketing their touristic offerings. The instrumental survey of the Palmieri hypogeum was executed using two different methods, laser scanner and digital photogrammetry, in order to get a high metric control of the monument and high-resolution textures for the sculpted friezes. The two different survey methods allowed a perfect porting on different outputs: the 3D real time visit on the web and virtual visit on portable devices. A stereoscopic animation, installed at the museum MUST (Historic Museum of Lecce) Lecce, provides an easy diffusion of the cultural message. The richness of the textures and the resolution of the models has allowed the study of the monument from a morphological and structural point of view. The virtual reconstruction contributes to read an unpublished part of monumental tombs in Messapian age. Thanks to a cinematic approach with a great scientific rigor, the historical competence of an ordinary visitor is now largely formed on information coming from these media, thus creating a great increase in the demand for products with a high technological content and popularising historical re-evocations and reconstructions of the past.

**Index Terms** - Palmieri, survey, laser scanner, virtual reconstruction, image-based, Lecce.

### I. AIMS OF THE RESEARCH

This work has been conceived from the need to document, reconstruct and make virtually accessible this important testimony of Messapian period, as part of the Smart Cities project called DICET. This project pursues the objective to define and produce innovative models, processes, and tools for the sustainable development of a smart territory by capitalizing on its cultural assets and environmental resources, and promoting and marketing their touristic offerings. From this

standpoint, procedures were developed to compile technical models for an efficient management of 3D and 2D resources, and to define best practices and methodical protocols for quality certification and process standardization, capable of fostering a cross-sector dialogue. The sites were identified on the account of a supply-and-demand analysis regarding a placement in the market of innovative models and services based on the creation of hyper-realistic digital models and virtual scenarios. Particular attention was given to those uses that permit greater visibility, protection, and conservation of cultural assets characterized by difficult access, vulnerability, seismic risk, hydro-geological risk, etc. In this frame, innovative models and tools were designed and developed for capitalizing on and exploiting cultural heritage, considered as an integrated and complex system designed as a holistic model strongly based on the use of ICT technologies.

Specifically, this paper discusses several issues related the survey, the representation and dissemination of 3D contents and the virtual visit of the Hypogeum Palmieri in Lecce, a monument currently not open to the public as it is located in the garden of a private house. The final outcomes are merged into different outputs: an application for iOS developed by the ISTI CNR of Pisa, an immersive application of real time 3D projected on a angular movie screen and a synthetic stereoscopic movie illustrating the peculiarities of the monument, both as regards the current status and for its probable ancient aspect.

### II. PALMIERI HYPOGEUM IN LECCE, HISTORICAL AND ARCHAEOLOGICAL INFORMATION

The Palmieri hypogeum in Lecce is still visible today in the garden of the Guarini Palace, located along the Via Palmieri, not far from the Duomo, in the heart of the city of Lecce. The hypogeum is one of the most remarkable examples of chamber tomb, not only in a Messapic context but more generally throughout the entire region of Apulia [1]. It is characterized by a elegant monumentality in its architectural structure and by the prominence given to sculptural decoration. The ancient Roman city of Lupiae was not the first urban incarnation of Lecce [2]. It was in fact preceded by an older settlement, which

from at least the second half of the 4th century B.C. formed an extended and organised urban centre. A local people, known as Messapians, constructed a city wall here, 5 metres thick, which surrounded an area of around 50 hectares and contained houses alternating with tombs.

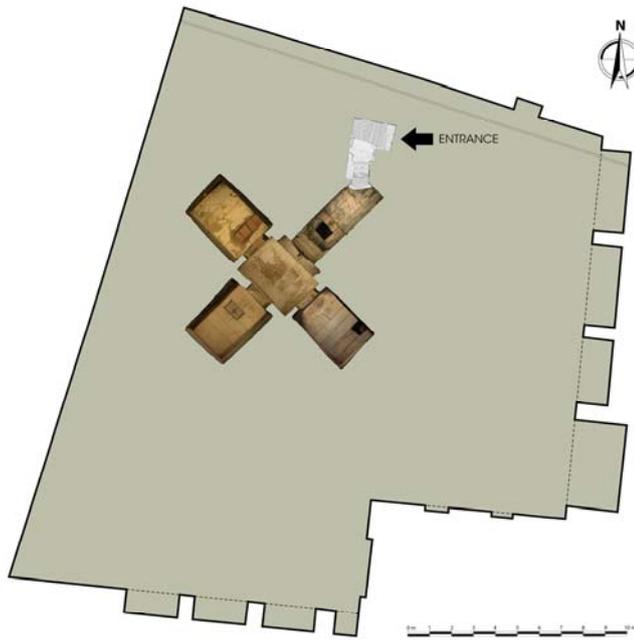


Fig. 1. The plan of hypogeum in in the garden of the Guarini palace.

And it is the *intra muros* presence of a complex monument such as the Palmieri hypogeum which clearly indicates the desire for social affirmation of a family who buried their dead in their home city and who would appear to have a clearly defined area dedicated to funerary purposes. Engineer Mario Micaella, who had an enthusiasm for local antiquities, discovered the Palmieri hypogeum in October 1912 [3]. The same year he published news of his discovery in the magazine *Apulia*. The tomb, emptied of its contents, may have been looted in the 16th century. Some inscriptions scratched on the walls of the *dromos* and cells have been dated to this period, and they record the names of important residents of Lecce. Excavated in the rock up to a depth of around three metres, the hypogeum shows a *dromos* comprising a stairway of 16 steps cut into the rock, emerging into an atrium from which it leads three cells laid out in a cross pattern, a unique feature in Messapia [4]. Today the tomb can be reached by a modern stairway that provides access from the garden of the Palazzo Guarini. The vestibule and the three cells are covered by a ceiling consisting of seven rows of limestone slabs.

The doors feature a Doric outline and are flanked by rectangular pillars topped with figured capitals sculpted in the rock [5]. Above the capitals is an architrave with a moulded cornice, showing signs of a hole for the door closing system, which today is no longer preserved. The cells show traces of an interesting pictorial decoration on the walls, divided into two areas: a lower section, dark coloured, of around 1 metre high, which also continues onto the doorjambs and ends with a

double stripe of red; and an upper section decorated with two rows of squares cut into the plaster and painted in red. Also still visible, fixed into the walls, are iron nails for offerings. Six composite capitals and two sculptural friezes are preserved in the tomb. The figural frieze is composed of two panels of roughly the same length, featuring a poorly preserved cornice on the upper edge which protrudes by around 10 cm, and it comprises an inverse groove, a row of ovolo shapes, a straight groove and a lath. Despite the moderate state of preservation, it is possible to gain a reasonably accurate understanding of the frieze: a battle between warriors on foot and on horseback. The figures are twenty in total, ten per panel; the first and last figures, however, are not participating to the battle.

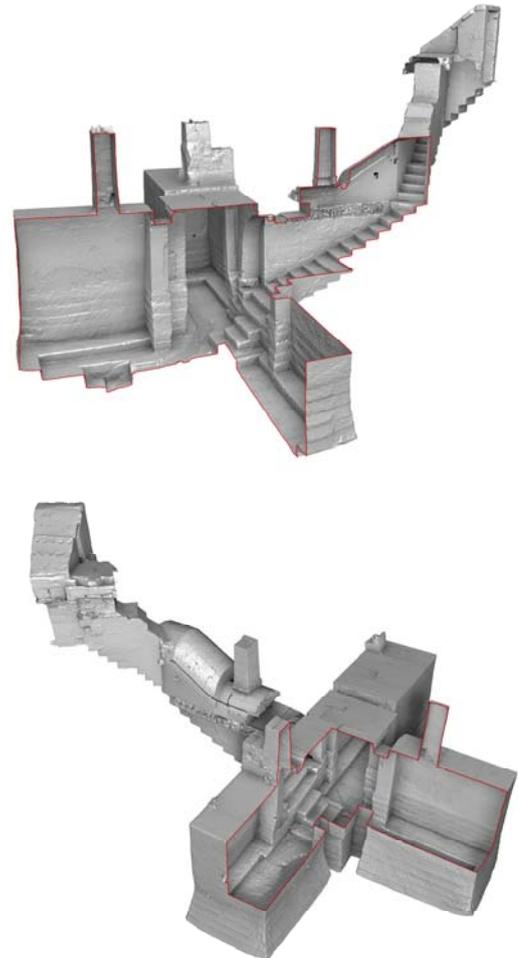


Fig. 2. Axonometric views without textures

The floral frieze, recessed into the opposite wall of the *dromos*, is formed of three panels and features a cornice similar to that of the figural frieze. The central panel shows a female face emerging from a bunch of seven acanthus leaves, wearing a *polos*, with hair parted on the brow in two bands, and stud earrings. Scholars' opinions are divided on the chronology of these remains, but it can be narrowed down to between the end of the 4th century and the first half of the 3rd century B.C.

This hypogeum is distinguished among the hypogea of Apulia and Messapia by its architectural importance and by the

social and funerary ideology of its sculptures; it seems to signify a strong separation between an exclusive dominant class, particularly near Taranto, and the rest of the population.

The Palmieri hypogeum is thus a symbol of an indigenous aristocratic clan which may have promoted the urban growth of the city. A *gens* which, in any case, survived until the 2nd century B.C., and whose vitality, manifested in the care given to the family tomb. This affords us a better understanding of the slow transformation that took place in the Apulia region and the ancient centres of the indigenous nobility from the second half of the 3rd century to the Social War [6].

monument, from the entrance to the garden to the burial chambers placed about 3 meters below, with a resolution appropriate to the architectural scale (about 4 mm of edge mesh). The scanning of the monument did not require special skills for the control of the accuracy, but has provided interesting elements for the reconstructive study.

From the technical point of view an interesting element is the use of the "Camera Mapping" technique, in order to obtain a realistic and metrically accurate 3D texture mapping of meshes acquired by laser scanner.

The 3D survey (using Leica ScanStation 2 laser scanner)



*Fig. 3. 3D restitution after the texture mapping process*

### III. INTEGRATED SURVEY AND 3D REAL TIME VISIT

The survey of the Palmieri hypogeum was executed using two different methods, laser scanner and digital photogrammetry, in order to obtain a high metrical control of the monument and a high resolution of textures for the sculpted friezes. The interior walls, although they are mostly characterized by low surface complexity, are carved into the bedrock and thus they present an irregular shape. Since the comprehension and the knowledge of the metrical morphology is the basis of any reconstructive hypothesis, it is important to have a basic study as precise as possible. For this reason, it was preferred a laser scanner survey that could reconstitute the entire

involved both the entrance corridor, characterized by an illustrated frieze running on the right and left hand side of the entrance stairs, plus four spaces that are radially distributed downstairs. During the same survey campaign, all the photographic shots required for a documentation of the state of conservation of surfaces and for further texture mapping tasks of 3D models, have been taken. Each picture has been conveniently treated with PTLens software of Tom Niemann. In this way, the distortions induced by the lenses have been filtered out. The 3D model has been subsequently optimized in order to achieve an advanced texture mapping, adopting some camera projection methodologies on multiple patches experimented on purpose and documented by our laboratory in recent years [7]. The correct mapping of the three-dimensional

model acquired through laser scanning is usually one of the most problematic issues in order to process the data and offer a verisimilar restitution of the artifact under study. The results of this method (see: <http://cipa.icomos.org/fileadmin/template/doc/PRAGUE/056.pdf>) are visible in the attached images, but the real utility of this technique in this project is related to the possibility to obtain a unique mesh with only three large textures applied in UVW mode. This has allowed an easy porting of the 3D model and an efficient management of high resolution textures (10000x10000 pixels) with classical LOD systems [9].

The most complex part of the hypogeum, from the point of the decorative volumes, are the two friezes set in the dromos and the capitals above the entrance doors of the three chambers. For these features, and in particular for the two friezes, it was carried out an image based survey. As briefly mentioned before, this choice has been justified by three reasons.

5DMKII, with 24 MP. The 3D models of the two friezes are very similar in terms of geometric resolution and associated textures. Both are calculated with Agisoft PhotoScan, using medium parameters of accuracy and moderate depth filter. It was not possible to calculate these models with higher parameters due to long waiting times, not compatible with the delivery of the work. However, it took a full coverage of the parts to be detected with photos taken in a way of moving a dolly camera, ie with large overlap between contiguous frames, to get a 3D model virtually indistinguishable from the real. How often it happens to ascertain, any deficit in the sub-millimetric definition of these models is compensated by the wealth of high-resolution textures. Thanks to UVW mapping, even the smallest details, such as surface scratches, small efflorescence, small holes, are well represented. About the management of native UVW, should be highlighted considerable management software for parts undercut and sides characterized by a complex plastic. As it is well known, the



Fig. 4. The figured frieze acquired by image-based techniques

The first is given by the resolution, surely higher than that obtained with time of flight laser scanner used for the walls. The second is given by the ease of use in complex environmental conditions with limited space and continuous dripping water coming from the external surface. The third, perhaps the most important, is given by the possibility to obtain a complete 3D model with texture correctly associated automatically with the corresponding 3D points. Considered the remarkable difficulty of the process of texturing based on "Camera Mapping" just described, that we had to use for mapping meshes obtained from laser scanner, the ability to get so expeditious and excellent model in a complete automatic way, with texture, is a great benefits for everyone, not negligible even for those using scanners with integrated camera. The particular nature of automatic generation of 3D models from photos are now widely discussed and used by non-specialists. In our experience it has been used a Canon

management of the mapping of these subjects involves a considerable engagement with software sometimes expensive and not always equally effective. Both models, with the actual length of about 3 meters by 2 meters high, were restituted with about 300 images from 24 MP each, at a resolution of 2.5 mm and 3 million of polygons in total. A resolution certainly not very high, but it is adequate to describe in detail the studied friezes. Moreover, the prerogative of each survey must be the final purpose and his effectiveness. As no survey can be perfect, we need a compromise and a purpose for the survey itself. This survey could go up the mesh definition, but for the purposes of a tourist use and a study of the figurative style would give redundant and superfluous data. Unnecessary and difficult to manage.

The figure 4 shows the 3D model of the figured frieze, with textures and phong shading mode. In this latter image you can appreciate both the level of detail of meshes and the amount of noise. In particular, as often happens for this type of restitution,

the noise level increases with the level of uncertainty of measurement. This is related to many factors, some internal, depending for example by the algorithm itself used by the software for the generation of 3D points. Among the external causes of noise generation, that are attributable to the operator or to the settings of shoots, we can certainly report three parameters at least. The first is related to ISO, this should be set to the lowest value, and otherwise high ISO values will induce additional noise to images. The second is linked to the quantity of images, and then the photo coverage. The third is, in our experience, due to the correct lighting of real scene. Good lighting produces, of course, best shooting conditions, taking the possibility of very low uncertainty in the identification of the individual pixels, the movement of which must be tracked in space, in accordance with the algorithm of structure-from-motion. In this work only LED lamps (6500 °K) were used for lighting.

application for iOS has been implemented. This application displays in real time the hypogeum Palmieri, using an interface based on the mobile iPad Air sensors. In particular, it uses the gyroscope for the virtual camera orientation and a touch interface for the movement within the 3D model. For the movement, a component was developed to implement a camera with a rail system, similar to the one previously added to 3DHOP, but optimized for the iOS. As previously said, this application is meant as 3D mode for the virtual tour of inaccessible contexts, possible with the current generation of devices. Furthermore, it has been experienced other forms of use of it, much more simple, which do not require special hardware equipments. In these applications, that could be called “semi augmented reality” and that are based on observable panoramas, the innovative element is the ability to connect the virtual reconstruction on the real context with an immediate dimensional and spatial feedback.



Fig. 5. Figured frieze: particular of 3d restitution

Thanks to this model, and with the fundamental contribution of the ISTI CNR of Pisa, an application has been tested for the creation of interactive multimedia presentations, aimed to allow the use of the monument on the web. The 3DHOP application is available at the URL: <http://vcg.isti.cnr.it/palmieri/>. The central component of the 3DHOP allows the navigation of the 3D model with the movement restricted on a path, as if the camera would be fixed on a rail. Navigation’s hotspots have been added moving the camera operated by the user within the 3D model of the hypogeum, with the result of an optimal real time navigation of the 3D data. In addition to the web application, a native

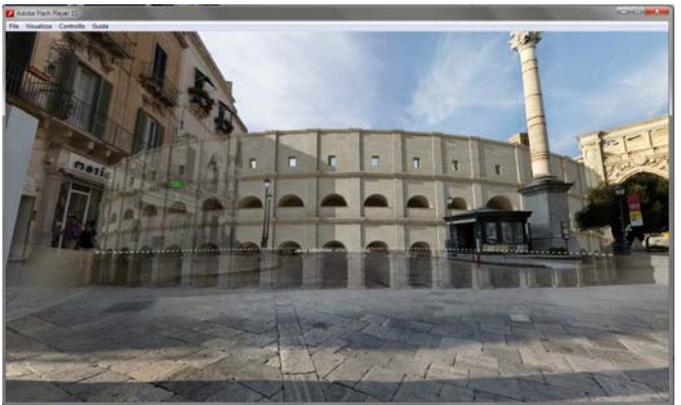


Fig. 6. The amphitheater of Lecce in the “semi augmented reality” app.



Fig. 7. The external view of reconstructed Plamieri hypogeum



Fig. 8. The reconstruction with cover. The hypogeum is completely hidden under the ground.

#### IV. RECONSTRUCTIVE STUDY AND COMMUNICATION ISSUES

The analysis based on the integrated survey has allowed us to formulate a reconstructive proposal of the monument, which gives a partially original reading of the monumental tombs in Messapian age. The study of the monument was started with the search for any traces of painting on the walls. a very important aspect, as recent discoveries testify to the widespread use of color also on grave goods and not just on architectural surfaces. The analysis carried out by means of video microscope and on samples taken from relevant areas, allowed us to identify only a few traces of red color on the boundary lines of the wall decoration in false ashlar-work.

A different treatment of the surface of the plaster, partly smooth and partly worked with an "orange peel" effect, gives to the parietal decorations a shallow plastic movement, with a simple red line of demarcation between the different blocks. The overview shows an unexpected sobriety of polychromies, played only on the effect of chiaroscuro given by the false ashlar-work and the red color of the walls of the *dromos*. The same colors are found on the figural frieze (red and white) and on the floral frieze (red, green and blue).

The second line of research has focused on the ancient upper plan of the rock. The upper edges of the blocks, covering the three burial chambers and the vestibule, are approximately at the same level. This level is about one meter higher of two friezes of the *dromos*, probably showing the external ancient floor level. As the original floor probably did not have a so strong height difference, it is possible that there were some elements necessary to make them even. The presence of a large block of coverage with an upper band slightly projecting on his

lateral vertical plane, can be interpreted as an *anathyrosis*, the typical shape of the contact surfaces of the building blocks in the Greek age, meant to obtain a better connection between contiguous blocks. These two elements suggest a complete coverage for the *dromos*, which similarly to the Macedonian prototypes give back the picture of a burial complex completely obliterated, but yet accessible only for new funeral depositions.

languages of digital media and new tools introduced by IT; the so-called digital humanities. This revolution is increasingly involving research bodies, museums and universities in communication initiatives, where the modern language introduced by new digital technologies is used to transmit historical-cultural contents, naturally with greatest scientific rigor [8].

Recent studies have shown that those museums that have



Fig. 9. Virtual reconstruction of burial chamber.

This and other peculiar aspects (the slopes of levels, the upper planes of the coverage blocks, the height of the ancient and modern level, etc.) are clearly observable in the indirect survey and shows their difficulty of reading with the traditional drawings used by early archaeologists of the century last. The dissemination of these results, as described above, aimed to different types of output, both on the web and on portable devices, but the medium that in our opinion offers the greatest chance of diffusion of cultural message is given by CG animation and the emotional narrative. In an age of horizontal diffusion of culture, to communicate means to use the language of the new media in the belief that the border between elite culture and mass culture is no longer as clear as it was. With this in mind, the role of virtual heritage also consists in transmitting information using the language of modern mass media and cognitive metaphors of video games and serious games, considering these as cultural paradigms for a form of communication that is freed from the classic rules of elite culture [7]. These new perspectives have determined the creation of numerous new disciplines alongside virtual heritage, which unite the traditions of humanistic studies to the

characterised their approach by using digital technologies and active public participation have had greater success in terms of visitor-numbers, and probably also a greater understanding of the cultural information being illustrated. Where communication has become an important component of the museum presentation and organisation, the museums have become home to a new way of conceiving cultural communication, and looking for new dynamics of social communication [8].

The introductions of new forms of communication, based on interactivity and emotional narration, are the most successful examples of the new methods available to contemporary museum studies. There is no doubt that everything that gravitates around virtual heritage can no longer avoid confronting the themes used by those who would raise awareness in the wider public, nor the new epistemological challenges that result from them. The historical competence of the average citizen is now formed largely by information that comes from the new media, thus creating a great increase in the demand for products with a high technological content, with the aim of popularising historical re-evocations and reconstructions of the past.

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