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&

GEORES 3RD

PROCEEDINGS

Digital Twins for
Advanced Cultural Heritage
Semantic Digitization

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Congress UPV

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Preface

More than 10 years have passed since the first edition of ARQUEOLÓGICA 2.0 (International Congress on Archaeology, Computer Graphics, Cultural Heritage and Innovation) was held, in 2009. At that time, its promoter, Dr. Alfredo Grande, dreamed of creating a meeting place for all researchers and professionals who were experimenting with the application of new technologies in the field of archaeology. They were years of change and resistance, since part of the academic community considered these new lines of research as something secondary and residual, without connection to true scientific knowledge. People who worked in the field of virtual archaeology did so as isolated units, scattered across different regions and countries and with very little connection to each other. Although in the first decade of the 21st century the number of researchers working in this field had grown exponentially, there was a lack of spaces that would make it possible to make visible what was being done. Thus ARQUEOLÓGICA 2.0 was born, to fill those spaces for the Spanish case but with an international vocation. An open and inclusive congress where it was possible to know what other researchers from different countries were doing but also to forge new contacts and relationships to foster not only the virtual archaeology field but also the widening field of cultural heritage with collateral resources. A congress that favoured the emergence of new collaborations and projects. A congress to know that we were not working alone, encouraging new researchers to join the field of virtual archaeology.

In these years, this congress has evolved at the same time as the scientific discipline that today we call virtual archaeology. During this time, ARQUEOLÓGICA 2.0 has established itself as a meeting forum for professionals from different branches of knowledge. The congress has served to build in Spain and the rest of the world, a link between the latest technological developments and archaeological science. It has promoted the creation of the *International Principles of Virtual Archeology* (*Seville Principles*) that were ratified by ICOMOS in 2017. It has served as the basis for creating a scientific journal, *Virtual Archaeology Review* (VAR), which in 10 years has been positioned as one of the most important archaeology journals in the world, and which has allowed, and continues to allow, researchers from around the world to share their progress with the international scientific community in an open and free format.

ARQUEOLÓGICA 2.0 has also demonstrated its commitment internationally and in some editions, Marseille 2013 and Granada 2015, it has joined other similar congresses. This year, ARQUEOLÓGICA 2.0 once again demonstrates its ability to join forces, in this case with the close friendship of the GEORES (GEOmatics and pREServation) community. The previous two editions of GEORES in Italy capture the innovative spirit of the cultural heritage community. In the present edition of the virtual joint international event, the 9th ARQUEOLÓGICA 2.0 & 3rd GEORES 2021, deal with topics related to data acquisition, virtual archaeology, virtual architecture, conservation, cultural heritage, high-end digitization, advanced geomatics, preservation and restoration, through the event lemma, **Digital Twins for Advanced Cultural Heritage Semantic Digitization**. The power of technology, combined with deep understanding of heritage will definitely contribute to increase the scientific level of state-of-the-art technologies applied to safeguarding our heritage, trying to be useful to our society.

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The proceedings report about 87 contributions that have been peer-reviewed by an international scientific committee fully compromised with the advancement of technology. We would like to express our gratitude to the PhD Forum co-chairs, Nannina Spanò (POLITO), Giulia Sammartano (POLITO), Valentina Bonora (UNIFI), Mattia Previtali (POLIMI) & Roberto Pierdicca (UNIVPM), for their active compromise and excellent undertakings in this congress.

We want to express our gratitude to both the Organising Committee and the Scientific Committee for their compromise in the success of this virtual event during the COVID-19 pandemic era. Hopefully, the next editions will be in a face-to-face format. Last but not least, our gratitude to all the researchers and participants for their positive input that have allowed us to gather this excellent manuscript.

Prof. José Luis Lerma (UPV), Prof. Grazia Tucci (UNIFI), Prof. Raffaella Brumana (POLIMI) & Dr. Víctor M. López-Menchero (Global Digital Heritage)
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INTEGRATION OF DIGITAL ACQUISITION TECHNIQUES FOR THE MANAGEMENT OF CULTURAL HERITAGE: THE ARCHAEOLOGICAL PARK OF THE VIA LATINA AND VIA APPIA ANTICA TOMBS

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Abstract:

This study, still in its initial phase, aims to develop the knowledge of the ancient Tombs, through digital models of a selection of case studies belonging to the archaeological area of the Archaeological Park of the Tombs of Via Latina in Rome. A crucial role of the on-going research is the integration of current surveying technologies in combination with the interdisciplinary exchange of information with the managers of the archaeological site. This site - belonging to the *Archaeological Park of the Appia Antica* (MIBACT) - hosts one of the most important funerary complexes which currently presents an intact view of traditional features of the ancient Roman landscape. In addition to this, the complex preserves, along the cobbled road between the 3rd and 4th mile, the remains of the Via Latina which once connected the city of Rome with Capua (Rea, 1999; Montella, 2005; Cugno, 2020). Currently, in a stretch of about 450 meters, there are numerous tombs of various types, built between the Republican age and the early Middle Ages (Tazzi, 1998). The synergy resulting from the relationship between these converging landscape/architectural/archaeological components can be defined as "a synthesis of the visual element that insists on the space included in a single turn of the horizon" (Biasutti, 1962). The challenge of this project is to document and "represent" this specific case: the Landscape of the ancient Via Latina, with its complex reality of interrelation between the tombs, the archaeological areas (the so-called "*mansio*"; the early Christian basilica of S. Stefano Protomartire), the biotic elements, the historical center and the urban suburban network composed of the old roads that must coexist with the continuous expansion of the contemporary ones.

Keywords: 3D digital models, Via Latina, Imperial Roman Architecture, tombs, digital archaeology, cultural landscape, surveying

1. Introduction

The multifaceted system of the *Ager Romanus* and the cultural site of the Via Latina/Via Appia Antica is comparable to a living and dynamic structure and as such should be analysed. The key aspects that the research wants to address are those of digitization and documentation of Cultural Heritage. In fact, historical sites and monuments cannot be maintained only by using them passively, but by activating all the protection and conservation operations through direct and indirect interventions such as the use of the most advanced architectural survey techniques (laser scanner and photogrammetry) and the detailed study of their state of conservation. Therefore, careful digital documentation becomes a priority and the main objective is to develop an accurate three-dimensional documentation method able to record the current state and facilitating the original morphological aspect of this ensemble, as well as the planimetric organization and the archaeological remains that constitute the apparently most significant value. The problem of transposing in digital form the characteristics of the territory, urban sediments and details of archaeological relevance is not simple (Benedetti, Gaiani, & Remondino, 2010); previous studies aimed at creating innovative systems of acquisition have in fact deepened the theme of the representation of Cultural Heritage by developing a high level of knowledge both theoretical and practical. The on-going research, currently under development, is part of a PhD program in Survey, Management and Development of the Cultural Heritage of the Via Latina/Via Appia Antica (Rome) carried out in collaboration with the UPV (*UniversitatPolitècnica de València*) and UNIBO (*Alma Mater Studiorum - University of Bologna*), in collaboration with the *Archaeological Park of the Appia Antica* (MIBACT) and the *Soprintendenza Capitolina ai Monumenti*. The global Cultural Heritage is in fact what distinguishes and characterizes each single

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country (in this case Italy), in which it reflects itself and the whole community (Riegl, 2011). It is the concrete task of local and non-local communities to protect its historical, artistic, archaeological and landscape heritage, as well as to promote the widest possible dissemination of its history and knowledge; it is also a common duty to make every effort to accustom citizens to frequent the "Places of Culture" assiduously, in order to achieve civil and social growth. The Tombs of the Archaeological Park of the Via Latina (Fig. 1) (Rea, 1999; Montella, 2005; Cugno, 2020) are set in a landscape, cultural and urban context of great importance, the result of complex interactions between man and the natural environment (*Ager Romanus*), through which local communities self-represent themselves. Specifically, the cultural landscape of the Roman Campagna and the Via Latina must be studied starting from the value offered by their territorial structure and the analysis of the transformation of the urban context that surrounds them, so as not to neglect a double aspect: environmental on one side and historical/archaeological on the other. Indispensable, in such a delicate balance of elements, becomes the contribution of innovative methodologies for the diffusion and fruition of the knowledge of Cultural Heritage, such as the use of advanced digital tools (metric data acquisition), information technologies and modern information transmission channels for a correct communication and valorization of Digital Cultural Heritage (through *Virtual Reality* and *Augmented Reality* technologies). The study to be conducted therefore starts from the technological examination to understand the effects on the interpretation of a "set" carrying hybrid values, testing the limits of graphic production codes (2D and 3D) in the reproduction of entire portions of territory that allow total analysis in digital environments (Gaiani & Apollonio, 2015).

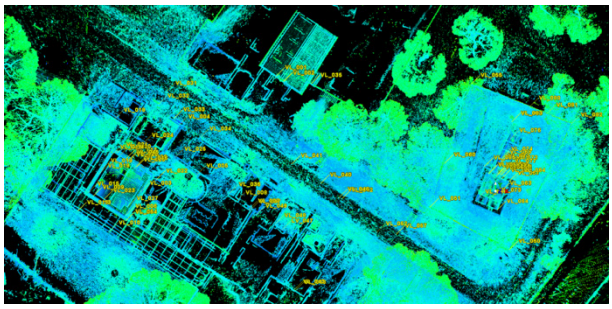

Figure 1: The Latin Tombs: plan view - *point cloud*.

2. Territorial and historical context

The Roman Campagna, in its general and more common meaning, does not correspond only to *Ager Romanus* nor to the Lazio Region, as it extends in the territories that historically belonged to the Etruscans. Its name does not derive from that of ancient Campania, which corresponds to the region of "*Terra di Lavoro*", but, as Tomassetti & Tomassetti (1910) remind us, from the rural state of this large portion of territory surrounding Rome. Historically, the *Suburbium* included a peripheral strip characterized by the presence of vines and vegetable gardens, beyond which the estates and farmhouses of the *Ager Romanus* developed: a marshy and unhealthy countryside, which remained, for a long period of time, very difficult to frame due to its extension and complexity. In addition to the geographical aspects of the *Ager Romanus*, of fundamental importance are the history and the infrastructural development of the two ancient and main roads: Via Latina and Via Appia Antica. In particular, the Via Latina was one of the oldest of the great suburban roads, thanks to which the Romans were able to exercise their political, military and commercial activity. Remembered by Strabone and Tito Livio as the link used between Rome and *Casilinum* during the first Republican Age, it was travelled by Hannibal in the Punic wars between Rome and Carthage. The Via Appia Antica intersects with the previous one in the road development, presenting similar construction characteristics, but it differs both in history and in the place of arrival (Brindisi). The testimonies of how the Romans faced death are still offered to us by the tombs thanks to which it is possible to understand the philosophy, uses and customs connected to the cult of death and the dead and which play a role of fundamental importance for the impact that this it was a subject in ancient society.

3. Tombs and the first survey

The first documentation campaign was carried out during August 2020 on tombs of the imperial age of the Via Latina (specifically the Calpurni and Valeri) and the Cenotaph of Annia Regilla (located in the Caffarella Park, between the 2nd and 3rd mile of the Via Appia Antica). Planned activities include further steps, in addition to the first documentation activity carried out by means of a Terrestrial Laser Scanner (*Faro Focus X 130*, measurement range between 0.6-130 m, 3D point accuracy of ±2 mm at 10 m). Once the situation allows it, a photogrammetric survey campaign is planned for the mapping of the facades, as well as the interiors of the buildings to be carried out with *SLR Cameras* and a campaign with *UAV* for the documentation of the roofs (Fig. 2). The digital modelling of these architectures allows morphological, constructive and structural understanding as it facilitates their complete and fluid exploration of various aspects. The pipeline (Guidi, Russo, & Beraldin, 2010) for the construction of reliable, optimized mesh models are split into the following stages:

1) Range map alignment in Leica Cyclone 9;
2) High definition 3D model construction through meshing in 3D System Geomagic;
3) Photogrammetric model construction and referencing with TLS data;
4) Mesh integration and optimization (quad-dominant re-meshing, parameterization, baking);
5) Texturing by means of frames re-projection onto parameterized mesh.

In this way a three-dimensional model was obtained that could then be used in the most flexible ways in the field of representation in a digital environment (Stylianidis, & Remondino, 2016). High definition models (Master models, high-poly models) will facilitate the achievement of a better knowledge of the site and of specific design features (2D and 3D) of buildings by means of reverse modelling techniques (Van Genechten, 2009). The aim of this phase is to obtain 2D-3D outputs such as the generation of orthographic images, sections, profiles, contour lines and finally the export through interactive visualization (such as *3dhop*). The extraction of reliable vectorial drawings are supposed to facilitate the dialogue

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with other professionals working on the site (archaeologists, restorers, etc.).

4. Discussion

In the framework of a complex reality that characterizes the survey of Cultural Heritage, the support of current analysis software in a digital environment is often considered a powerful tool available to operators because it allows versatility and interconnections with numerous information that can be obtained from architectures. The purpose of this section is twofold: firstly, to review the state of this field, discussing and characterizing different approaches to manage information on geometric models; secondly, to present in detail an innovative analysis proposed and evaluated in the framework of the Cultural Heritage applications of the Archaeological Park of Via Latina Tombs. At present, Digital Cultural Heritage is increasingly influencing the field of Cultural Heritage and the research/restitution of data concerning Architectural Heritage is undergoing a rapid transformation; moreover, the use of three-dimensional models, fundamental for restoration professionals and Public Administration bodies, allows the fast and multiple collections of metric information, the easy sharing of contents among users and their immediate reading (Apollonio, Gaiani, & Bertacchi, 2019).

Figure 2: Annia Regilla's Cenotaph: *front rendering*.

5. Conclusions

Thanks to the potential offered, technological innovation in the field of Cultural Heritage surveying can lead to their intelligent management and use, with the aim of transforming them into Smart Cultural Objects. This workflow could become a means to quickly and efficiently unite and share knowledge between public and private users, thus becoming an integrated method of analysis, interpretation, detection and archiving at the service of the protection, management and enhancement of the historical, artistic and archaeological heritage (by obtaining advanced data that take an active role in the restitution of the Via Latina Tombs). This analysis therefore starts from a recovery of those representation abilities that once synthesized the historical, topographical, morphological and chromatic knowledge of an environment and the surrounding territory such as the Via Latina and Appia Antica and their original qualities.

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