

JOINT INTERNATIONAL CONGRESS

ARQUEOLÒGICA 2.0  
9<sup>TH</sup>

&

GEORES  
3<sup>RD</sup>

PROCEEDINGS

Digital Twins for  
Advanced Cultural Heritage  
Semantic Digitization

Online - Valencia  
26-28 April 2021



UNIVERSITAT  
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## *Congress UPV*

Proceedings of the ARQUEOLÓGICA 2.0 - 9th International Congress & 3rd GEORES - GEOmatics and pREServation  
Lemma: *Digital Twins for Advanced Cultural Heritage Semantic Digitization*.

ARQUEOLÓGICA 2.0 - 9th International Congress on Archaeology, Computer Graphics, Cultural Heritage and Innovation.

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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 21<sup>st</sup> 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 9<sup>th</sup> ARQUEOLÓGICA 2.0 & 3<sup>rd</sup> 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-Mencheró (Global Digital Heritage)  
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2.0 & 3<sup>rd</sup> GEORES,  
Valencia (Spain).  
26–28 April 2021

## Contents

### Long scientific papers

THE DIGITAL TRANSFORMATION OF THE MUSEO EGIZIO .....	1
<i>D. Mezzino, F. V. L. Lori</i>	
YEDI KULE - MONUMENT ROAD RACE: THE CONSTRUCTION OF THE 3D MAPPING ANIMATION OF THE OLD CITY OF THESSALONIKI, GREECE .....	8
<i>E. S. Georgiou, N. Lambrinos</i>	
THE ETRUSCAN CITY GATES OF PERUGIA: GEOMATIC TECHNIQUES FOR THE DOCUMENTATION AND STUDY OF AN URBAN HISTORY HERITAGE.....	15
<i>F. Radicioni, P. Matracchi, A. Stoppini, G. Tosi, L. Marconi</i>	
HBIM FOR RESTORATION WORK AND MONITORING OF COMPLEX ARCHITECTURES: THE FAMILY CHAPEL OF RAMÓN PERES Y ROVIRA IN CASTELLÓN DE LA PLANA (SPAIN).....	29
<i>G. Bertacchi, F. Juan-Vidal, L. Cipriani</i>	
AN INTERACTIVE 3D APPLICATION OF A HOUSE FROM THE XVI CENTURY IN SAN CRISTÓBAL DE LAGUNA AS A CASE STUDY FOR THE DISSEMINATION OF CULTURAL HERITAGE.....	39
<i>I. Sánchez-Berriel, A. González-González, F. Pérez-Nava, C. Meier, J. Pérez-Morera, C. R. Hernández-Alberto</i>	
DIGITAL CULTURE, UMWELT AND ALETHEIA AN ONTOLOGICAL INTRODUCTION.....	47
<i>A. Pasqui</i>	
AN INTEGRATED APPROACH AIMED AT THE PROTECTION OF CULTURAL HERITAGE: FROM THE GEOMATIC SURVEY TO HBIM AND AR REPRESENTATION OF VILLA PISANI (STRA, ITALY) .....	55
<i>M. Monego, S. Maioli, M. Salvalaggio</i>	
BIM DESIGN LEAD FOR RESTORATION OF SHIPWRECK MUSEUM IN KYRENIA CASTLE IN CYPRUS .....	63
<i>C. Biagini, F. Capparelli, G. Verdiani</i>	
CRITERIA AND TOOLS TO CATALOGUE BRICK-MASONRY VAULTS. THE GIS-DATABASE OF FRAME, A FASCE AND PLANTERIAN VAULTS BETWEEN THE 16TH AND 18TH CENTURY IN NORTHERN ITALY .....	71
<i>C. Stanga</i>	
VOCABULARY ALIGNMENT FOR SHARING ARCHITECTURAL CONSERVATION DATA.....	79
<i>M. Acierno, D. Fiorani, A. Velios</i>	
VIRTUAL TERRESTRIAL LASER SCANNER SIMULATOR IN DIGITAL TWIN ENVIRONMENT .....	85
<i>D. Popovas, M. Chizhova, D. Gorkovchuk, J. Gorkovchuk, M. Hess, T. Luhmann</i>	
CONSIDERATIONS AND QUESTIONS DERIVED FROM THE APPLICATION OF A SCAN-TO-BIM MODELING PROCESS OF A HISTORICAL PUBLIC BUILDING .....	93
<i>F. Guzzetti, K. L. N. Anyabolu, F. Biolo, L. D'Ambrosio</i>	
THREE-DIMENSIONAL SURVEY AND MATERIAL CHARACTERIZATION OF THE TEMPIO-MASSERIA DEL GIGANTE IN CUMAE.....	101
<i>R. Amore, F. Carandente</i>	



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CONGRESO INTERNACIONAL DE ARQUEOLOGÍA E INFORMÁTICA GRÀFICA. PATRIMONIO CULTURAL E INNOVACIÓ

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AN INTEGRATION OF NON-DESTRUCTIVE TECHNIQUES (SFM–GPR–TLS) AS A VIRTUAL TOOL FOR ARCHAEOLOGICAL STRATEGY: THE CASE OF THE ROMAN SITE OF THE PLAZA DE LA MORERÍA IN SAGUNTO (SPAIN).....	108
<i>F. Buchón-Moragues, J. Benedito, F. García, J. M. Melchor</i>	
COMPARISON OF THE PHOTOGRAPHY, RADIOGRAPHY AND PROCESSED IMAGES IN THE STUDY OF METALLIC PIECES FROM ARCHAEOLOGICAL SITES.....	118
<i>J. A. Madrid, E. Yahaghi, J. M. Melchor, A. Movafeghi</i>	
INFORMATIVE MODELS OF CULTURAL HERITAGE. THE “UNFINISHED” CHURCH OF BRENDOLA.....	127
<i>E. Sorbo, G. Spironelli</i>	
GENERATIVE NETWORKS FOR POINT CLOUD GENERATION IN CULTURAL HERITAGE.....	134
<i>R. Pierdicca, M. Paolanti, R. Quattrini, M. Martini, E. S. Malinverni, E. Frontoni</i>	
QANATS AS AN ENDANGERED TRADITIONAL HYDRAULIC HERITAGE. AN INTEGRATED METHODOLOGY FOR DOCUMENTING, RESTORING AND REUSING AN ANCIENT IRANIAN QANAT.....	142
<i>P. Branduini, F. Zaina, F. Zavvari, Y. Nabati Mazloumi</i>	
BIM INTEROPERABILITY: OPEN BIM-BASED WORKFLOW FOR HERITAGE BUILDING INFORMATION MODELLING (HBIM). A MULTIDISCIPLINARY APPROACH BASED ON ADVANCED 3D TOOLS AND EXCHANGE FORMATS.....	159
<i>J. A. Bonini, A. Mandelli, S. M. de Gennaro, F. Banfi</i>	
THE RECONSTRUCTION OF A DYNAMIC INVENTORY MODEL TOWARD SHARED HBIM LIBRARIES FOR VAULTED SYSTEMS.....	170
<i>A. Turrina, D. Attico</i>	
DOCUMENTATION OF A COMPLEX CULTURAL HERITAGE ASSET WITH INTEGRATED GEOMATIC SURVEY: THE MONTANARO BELL TOWER.....	177
<i>L. Teppati Losè, F. Chiabrando, F. Novelli, G. Patrucco, S. Perri</i>	
AN INFORMATIVE TOOL FOR THE PRESERVATION OF THE WOODEN ENCIRCLING TIE ROD OF THE DOME OF SANTA MARIA DEL FIORE, IN FLORENCE.....	185
<i>S. Celli, F. Ottoni</i>	
THE ROLE OF EXTENDED REALITIES IN HERITAGE BUILDINGS REPRESENTATION.....	193
<i>A. Khalil, S. Stravoravdis</i>	
STUDY ON QUALITY IN 3D DIGITISATION OF TANGIBLE CULTURAL HERITAGE.....	206
<i>D. Pritchard, T. Rigauts, F. Ripanti, M. Ioannides, R. Brumana, R. Davies, E. Avouri, H. Clifflen, N. Joncic, G. Osti, M. Toumpouri</i>	
DETECTING AND MAPPING FLASH FLOODING WITH SYNTHETIC APERTURE RADAR (SAR) SATELLITE DATA: THE METAPONTO PLAIN CULTURAL LANDSCAPE CASE STUDY.....	212
<i>M. Gabriele</i>	
CANOSSA CASTLE: THE IMPORTANCE OF A CRITIC AND AWARE PLAN OF INTERVENTIONS FOR CONSERVATION AND PREVENTION OF CULTURAL HERITAGE.....	223
<i>M. Catellani, L. Ferrari, E. Zanazzi</i>	
INTEGRATION OF COMPLEX 3D MODELS INTO VR ENVIRONMENTS: CASE STUDIES FROM ARCHAEOLOGY.....	232
<i>J. Gorkovchuk, D. Gorkovchuk, T. Luhmann</i>	





ARQUEOLÒGICA 2.0

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Valencia (Spain).  
26–28 April 2021

MENSIOCHRONOLOGICAL TECHNIQUES FOR TIMBER ELEMENTS: LIMITS AND SPECIFICITIES THROUGH A CASE STUDY .....	238
<i>A. Grimoldi, A. G. Landi, E. Zamperini</i>	
DEVELOPMENT OF AN INTEGRATED BIM-GIS MANAGEMENT TOOL FOR MAINTENANCE PLAN OF HISTORICAL HERITAGE.....	247
<i>I. Bonfanti, E. Colucci, V. De Ruvoa M. Del Giudice, S. Fasana, E. Iacono, A. M. Lingua, F. Matrone, G. M. Ventura, M. Zerbinatti</i>	
3D GIS FOR A SMART MANAGEMENT SYSTEM APPLIED TO HISTORICAL VILLAGES DAMAGED BY EARTHQUAKE.....	255
<i>A. Gorreja, F. Di Stefano, F. Piccinini, R. Pierdicca, E. S. Malinverni</i>	
THE LAST DECADE DEVELOPMENT OF PROJECT DATA MANAGEMENT THROUGH THE BIM.....	261
<i>F. Di Stefano</i>	
TECHNIQUES OF GEOMATICS AND SOFT COMPUTING FOR THE MONITORING OF UNSAFE BUILDINGS.....	267
<i>E. Bernardo, G. Bilotta</i>	
DIGITAL TWINS: COMBINED SURVEYING PRAXIS FOR MODELLING.....	275
<i>C. M. Bolognesi, M. Signorini</i>	
A HYBRID MODEL FOR THE REVERSE ENGINEERING OF THE MILAN CATHEDRAL. CHALLENGES AND LESSON LEARNT .....	281
<i>F. Spettu, S. Teruggi, F. Canali, C. Achille, F. Fassi</i>	
ENHANCING AND MANAGING DATA AND DIGITAL COMPETENCIES FOR ARCHITECTURE TEACHING AND TRAINING IN THE FIELD OF PROTECTION OF HERITAGE.....	292
<i>N. Lombardini, C. Achille, C. Tommasi, E. Fioretto</i>	
PARAMETRIC PARADIGMA: EXCEPTIONAL COFFERED CEILING ARCHITECTURE VS HBIM.....	300
<i>O. Rosignoli, B. Scala, D. Treccani, A. Adami, L. Taffurelli, S. Scandurra, L. Fregonese</i>	
TLS AND IMAGE-BASED ACQUISITION GEOMETRY FOR EVALUATING SURFACE CHARACTERIZATION.....	307
<i>G. Patrucco, S. Perri, A. Spanò</i>	
MULTI-SCALE AND MULTI-DOMAIN APPROACHES FOR CULTURAL TERRACED LANDSCAPES.....	317
<i>E. I. Parisi, J. Tyc</i>	
MONITORING LANDSCAPE DEGRADATION IN MEDITERRANEAN AREAS INTEGRATING MEDALUS AND REMOTE SENSING FOR FRAGILE ARCHEOLANDSCAPE PLANNING: THE BASILICATA CASE STUDY .....	325
<i>M. Gabriele, R. Brumana, M. Previtali, A. Cazzani</i>	
ACCESSIBILITY TO UNDERWATER CULTURAL HERITAGE: THE INTERACTIVE WEB NAVIGATION OF THE ROMAN SUBMERSED VESSEL OF CALA MINNOLA.....	335
<i>A. Scianna, G. F. Gaglio, M. La Guardia</i>	
GEOMATICS ADVANCED IMAGE-BASED TECHNIQUES FLANKING ARCHAEOLOGICAL RESEARCH. A NOTEWORTHY AREA IN THE NORTHERN NECROPOLIS OF HIERAPOLIS OF FRIGIA (TK).....	343
<i>L. Teppati Losè, A. Spanò, A. Anguissola</i>	
COMPARATIVE INVESTIGATION OF THE 3D REPRESENTATIONS OF THE HOLY AEDICULE OF THE TOMB OF CHRIST .....	354
<i>N. Tentoma, A. Georgopoulos, G. Tucci</i>	



ARQUEOLÒGICA 2.0

CONGRESO INTERNACIONAL DE ARQUEOLOGÍA E INFORMÁTICA GRÁFICA. PATRIMONIO CULTURAL E INNOVACION  
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2.0 & 3<sup>rd</sup> GEORES,  
Valencia (Spain).  
26–28 April 2021

READING INTEGRITY IN THE LANDSCAPE: METHODS' COMPARISON ON TICINO AREA .....	363
<i>P. Branduini, M. Previtali, E. Spinelli, M. Tagliabue</i>	
PARAMETRIC GENERATION IN HBIM WORKFLOWS FOR SLAM-BASED DATA: DISCUSSING EXPECTATIONS ON SUITABILITY AND ACCURACY .....	374
<i>G. Sammartano, M. Previtali, F. Banfi</i>	
TOWARDS AN INTEGRATED DESIGN METHODOLOGY FOR H-BIM .....	389
<i>E. Pellis, A. Masiero, G. Tucci, M. Betti, P. Grussenmeyer</i>	
RESTORATION, REPRESENTATION, PROJECT: A DIALOGUE-LIKE APPROACH FOR THE COMPSA PALIMPSEST .....	399
<i>B. G. Marino, R. Catuogno, R. Marena</i>	
THE COMPLEX OF SANTA CROCE IN RAVENNA AS A CASE STUDY: INTEGRATION OF 3D TECHNIQUES FOR SURVEYING AND MONITORING OF A HISTORICAL SITE .....	408
<i>G. Bitelli, E. Barbieri, V. A. Girelli, A. Lambertini, E. Mandanici, E. Melandri, D. S. Roggio, A. Santangelo, M. A. Tini, S. Tondelli, A. Ugolini</i>	
CARE OF ANCIENT HUMAN REMAINS. CONSERVATION AND MANAGEMENT WITH 3D MODELING AND DBMS .....	414
<i>E. Dellù, A. Sciatti</i>	
THE TAORMINA THEATER: THE DIGITAL SURVEY SYSTEM OF KNOWLEDGE OPEN IN TIME.....	427
<i>G. Di Gregorio</i>	
HOW WERE THE TAPESTRIES IN THE SALA DI SATURNO OF PITTI PALACE ARRANGED? GEOMATICS AND VIRTUAL REALITY FOR ART CURATORS .....	436
<i>G. Tucci, V. Bonora, A. Conti, L. Fiorini</i>	
INTEGRATING LASER SCANNING AND GEO-MECHANICAL SURVEY IN CONSERVATIVE RESTORATION; THE CASE OF FIRST WORLD WAR'S CIMA GRAPPA MILITARY SHRINE, ITALY .....	443
<i>F. Mugnai, P. Farina, G. Tucci</i>	
FRESCO PHOTOGRAMMETRY: DOCUMENTING THE IMPERIAL CULT CHAMBER AT LUXOR TEMPLE .....	449
<i>O. Murray</i>	
COPERNICUS EARTH OBSERVATION FOR CULTURAL HERITAGE.....	459
<i>A. Agapiou, V. Lysandrou, B. Cuca</i>	
SPACE-BASED APPLICATIONS FOR BUILT CULTURAL HERITAGE: EXPERIENCE OF COPERNICUS4REGIONS PUBLICATION .....	467
<i>B. Cuca, R. Brumana</i>	
SANTA MARIA NOVA (VIA APPIA ANTICA, ROME), II – XX A.D. ARCHAEOLOGY OF ARCHITECTURE OF A LONGLIFE BUILDING.....	474
<i>L. Oliva, F. R. Paolillo, S. Roascio</i>	



ARQUEOLÒGICA 2.0

CONGRESO INTERNACIONAL DE ARQUEOLOGÍA E INFORMÁTICA GRÁFICA, PATRIMONIO CULTURAL E INNOVACION  
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26–28 April 2021

## Works in progress

DOCUMENT MANAGEMENT FOR ARCHITECTURAL HERITAGE RESTORATION AND ITS APPLICATION IN THE MONASTERY OF SAN MILLÁN DE LA COGOLLA (LA RIOJA).....	483
<i>J. Korro, P. Acosta, F. Pinto, J. M. Valle, A. Zornoza-Indart</i>	
TOWARDS ONLINE 3D ARCHIVE OF HISTORICAL SITE: THE TURIN 1911 WORLD'S FAIR .....	487
<i>A. Spreafico, C. Della Coletta</i>	
CLOUD DATA SHARING AND EXCHANGE OF HBIM PROJECTS FOR ARCHAEOLOGY: POSSIBLE SOLUTIONS AND PROPOSALS .....	491
<i>F. Diara, F. Rinaudo</i>	
ARTIFICIAL INTELLIGENCE APPLIED TO MULTISPECTRAL IMAGERY FOR FLUVIAL MACROPLASTICS DETECTION.....	495
<i>I. Cortesi</i>	
ENGINEERING THE ARCHAEOLOGICAL RESEARCH: SUBMILLIMETRIC CT SCAN OF ANCIENT EGYPTIAN ARTIFACTS.....	498
<i>S. Galli</i>	
ANALYSIS OF HISTORICAL EVOLUTION AND PRESENT STATE OF CONSERVATION OF REGIO VII, INSULA 14 IN POMPEII .....	501
<i>A. Capobianco, S. Gagliolo, S. Pallecchi, D. Sguerso</i>	
3D TECHNOLOGIES IN CYPRIOT PREHISTORIC ARCHAEOLOGY AND HERITAGE: THE ERIMI USER EXPERIENCE .....	504
<i>F. Dolcetti, L. Bombardieri</i>	
ALGORITHMIC MODELLING PROCESSES IN SCAN-TO-BIM WORKFLOWS .....	508
<i>R. Argiolas</i>	
PRE- AND SELF-CALIBRATION OF UNDERWATER CAMERAS FOR PHOTOGRAMMETRIC DOCUMENTATION OF ARCHAEOLOGICAL SITES .....	512
<i>A. Calantropio, D. Rissolo, E. Kovacs</i>	
MYTHOPOIESIS AND COLLECTIVE IMAGINATION IN VIDEOGAMES .....	515
<i>A. Piano, E. Ilardi, A. Ceccherelli</i>	
POINT CLOUD PROCESSING FOR URBAN ACCESSIBILITY MANAGEMENT IN HISTORIC CONTEXT .....	519
<i>D. Treccani, A. Adami, L. Díaz-Vilariño</i>	
THE ARCH OF AUGUSTUS IN AOSTA: DATA AND ANALYSIS REUSE FOR A CONSERVATION PROJECT .....	522
<i>A. Adami, L. Appolonia, B. Scala</i>	
MANAGEMENT OF ARCHAEOLOGICAL HERITAGE THROUGH TICS IN MUSEUMS. THE CASE OF THE ARCHAEOLOGICAL MUSEUM OF BURRIANA (CASTELLÓN) .....	526
<i>J. M. Melchor-Monserrat, J. Martínez-Uso, J. Alcaide-Marzal</i>	
FROM THE DOCUMENT'S LIFE CYCLE TO THE MONUMENT'S LIFE CYCLE: THE CASE OF THE DE MURTAS BARRACK IN CAGLIARI.....	530
<i>A. Agus, D. R. Fiorino</i>	
USE OF A NOVEL, LOW-COST 3D CT-SCAN VIEWER BY THE HOYO NEGRO PROJECT, QUINTANA ROO, MEXICO .....	534
<i>J. C. Chatters, W. O. Adams Jr, D. Arano Recio, D. Rissolo, H. Barba Meineke</i>	



Proceedings of the joint  
international event  
9<sup>th</sup> ARQUEOLÒGICA  
2.0 & 3<sup>rd</sup> GEORES,  
Valencia (Spain).  
26–28 April 2021

MIXED REALITY FOR THE MONUMENTAL HERITAGE. A FIRST TEST .....	538
<i>S. Teruggi, F. Fassi</i>	
AN EXPERIMENTAL WORKFLOW FOR THE VIRTUAL RECONSTRUCTION OF ANCIENT STATUES.....	542
<i>L. Fazio, M. Lo Brutto</i>	
INTEGRATION OF DIGITAL ACQUISITION TECHNIQUES FOR THE MANAGEMENT OF CULTURAL HERITAGE: THE ARCHAEOLOGICAL PARK OF THE VIA LATINA AND VIA APPIA ANTICA TOMBS .....	546
<i>S. A. Cugno, F. Fantini, F. Juan-Vidal, S. Rinaldi</i>	
DIGITIZING TO RE-DISCOVER: THE CASE STUDY OF THE ROMAN CITY-GATE IN ALTINUM, ITALY .....	550
<i>C. Balletti, E. Delpozso</i>	
MAPPING MONUMENTS' STONE WEATHERING USING LOW-COST MULTISPECTRAL TECHNOLOGIES AND IMAGE PROCESSING.....	555
<i>E. Adamopoulos, F. Rinaudo</i>	
HBIM AND WORKSITE SIMULATION: FIRST EXPERIMENTS.....	558
<i>O. Rosignoli</i>	
A HERITAGE INFORMATION SYSTEM FOR MULTISCALE ANALYSIS FOR THE WORLD HERITAGE SITE OF CUENCA, ECUADOR .....	562
<i>V. Heras, P. Ochoa, A. Delgado</i>	
CANTÓN NABÓN CULTURAL HERITAGE GEOPORTAL IMPLEMENTATION: FIRST STEPS .....	566
<i>A. Collado, G. Mora-Navarro, P. Rodas, V. Heras, J. L. Lerma</i>	
DIGITAL SURVEY AND RECEPTION STRUCTURES FOR A VIRTUAL FRUITION: THE CASE STUDY OF THE HYPOGEUM OF CALAFORNO (RAGUSA).....	569
<i>G. D'Agostino, M. Figuera, G. Rodonò</i>	
 <b>Extended Abstracts</b>	
SIMULATION OF PAST PROCESSES THROUGH LINEAR PROGRAMMING. THE CASE OF THE DISTRIBUTION OF SUPPLIES DURING THE SIEGE OF BILBAO IN 1874 .....	574
<i>Á. Rodríguez Miranda, P. Ferreira-Lopes, G. Martín, J. Korro</i>	
A WEB APPLICATION TO GEOLOCATE THE CURRENT CITY OF SAN CRISTOBAL DE LA LAGUNA IN A XVI CENTURY MAP .....	575
<i>F. Pérez-Nava, I. Sánchez-Berriel, A. Pérez-Nava, V. Gutiérrez-Rodríguez, J. Pérez-Morera</i>	
PARAMETRIC APPROACH TO THE RECONSTRUCTION OF TIMBER STRUCTURES IN CAMPANIAN ROMAN HOUSES .....	576
<i>L. Sbrogiò</i>	
DOCUMENTATION AND ENHANCEMENT OF A ROMAN WATERMILL WITH ALL ITS STRUCTURAL ELEMENTS .....	577
<i>J. García-León, J. A. González-García, P. E. Collado-Espejo</i>	
DIGITAL EARTHQUAKE-DAMAGED BUILDING USING HBIM, COMMON DATA ENVIRONMENT(CDE) AND EXTENDED REALITY (XR): THE CHURCH OF SAN FRANCESCO IN ARQUATA DEL TRONTO.....	578
<i>F. Banfi, R. Brumana, A. G. Landi, M. Previtali, F. Roncoroni, C. Stanga</i>	



Proceedings of the joint  
international event  
9<sup>th</sup> ARQUEOLÒGICA  
2.0 & 3<sup>rd</sup> GEORES,  
Valencia (Spain).  
26–28 April 2021

AUTOMATIC MASKS GENERATION FOR THE DIGITIZATION OF A WOODEN COLLECTION OF MAQUETTES USING DEEP LEARNING .....	579
<i>G. Patrucco, F. Setragno</i>	
FINE TUNING AND DATA AUGMENTATION TECHNIQUES FOR SEMANTIC SEGMENTATION OF HERITAGE POINT CLOUDS.....	580
<i>F. Matrone, M. Martini</i>	
LOST GEOMETRIES - A METHODOLOGY FOR THE DIGITAL RECONSTRUCTION OF HISTORIC ARCHITECTURAL RUINS .....	581
<i>S. Fallica, R. Garozzo, C. Santagati</i>	



*Proceedings of the joint  
international event  
9<sup>th</sup> ARQUEOLÒGICA  
2.0 & 3<sup>rd</sup> GEORES,  
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Long scientific papers



## THREE-DIMENSIONAL SURVEY AND MATERIAL CHARACTERIZATION OF THE *TEMPIO-MASSERIA DEL GIGANTE* IN CUMAE

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### Abstract:

The following paper describes the work carried out from a University exercise of the Restoration Lab of the Architecture Department of the University of Naples Federico II. The work reflects the results of a Three-dimensional survey and metric characterisation of the 'Tempio-Masseria del Gigante', in Cumae, in the Naples province, to elaborate an architectural restoration project. This is a rural building from the XVIII century, built and extended by incorporating the rests of the cell of an ancient temple from the Flavian Age, located at the eastern border of Cumae lower city's Foro, that was called 'del Gigante' (of the Giant), since a large Jupiter's bust was found in its proximities. Well known in the world of antiquarian dealers, it was pictured in many drawings and landscape paintings since the end of the XVII century and the first half of the XVIII, the Masseria Temple is taken into exam had been acquired by the public domain only at the end of 1990, so only after this period, the first archaeological investigations were made. Afterwards, between 1996 and 2002, conspicuous restoration and securing works were made. Today the structure is used as a temporary deposit for archaeological findings and it's among the buildings included in a wider restoration and re-functionalization project that has been proposed by the Campi Flegrei Archaeological Park and that is now about to start. The research work proposed is part of the preparatory analysis phase for the design of restoration work and has consisted of survey made with photo-modelling techniques with direct survey operations and it aimed to identify the construction methodologies and the degrading phenomena in place, with special regards to the identification of the ancient parts of the Temple, of those pertaining the conversion in a farmhouse and, lastly, those realised during the restoration works. The constant reference between the results of the three-dimensional survey performed and those of the comparative analysis of historical iconography and the graphs and photos examined, has allowed reconstructing the history of the ancient and recent transformations of the building in order to define an integrated knowledge framework, necessary for the definition of suitable conservative strategies.

**Keywords:** cultural heritage, restoration, 3D reconstruction

### 1. Introduction

During the last century, the archaeological excavation operations made in Cumae's lower city were focused in the Foro's eastern sector, that brought to light the Capitolium, the Thermal Baths, the ruins of the southern buildings and of the so-called Temple with the Portico (Maiuri, 1927; Maiuri, 1958; Barrella, 2019). The Masseria del Gigante Temple wasn't involved in systematic archaeological research until 1994. Since that date, thanks to the *Kyme* project of the Federico II University, essays and surveys have been made, allowing the identification of the number of ancient structures of the Temple, without removing those of the more recent farmhouse (Gasparri & Greco, 2007; Gasparri & Greco, 2009). Following this investigation, restoration and securing works were made between 1995 and 2003. Unfortunately, these haven't been followed by a suitable

re-functionalization of the complex, with the result that today only a few areas are used as a deposit of archaeological findings and the overall preservation of the building is mediocre. Recently the *Campi Flegrei Archaeological Park* has started a public call for projects called Restoration, securing and enhancement of the archaeological sites of Cumae's lower city, which is currently being awarded and that implies, among many actions, the re-functionalization of the *Tempio-Masseria del Gigante*. Taking this into account, the following paper, elaborated during the activities of the Restoration Lab of the Architecture Department of the University of Naples Federico II, after a historical framing, illustrates the results from the survey made at the *Tempio-Masseria del Gigante*, done with photo-modelling techniques integrated with direct measurements. The work has been designed with a precise objective: identifying the surviving parts of the ancient temple, those pertaining the

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conversion in a farmhouse and those realised during the restoration works made recently, always relying on previous studies on the matter. All this to recreate the scheme of the material documents and traces that today characterise this important and multi-layered monument and its decaying state.

The survey and documentary research carried out, in a logic of continuous integration and osmosis, have made it possible to highlight and consider the infinite diversity of the elements that make up the masonry of the Temple-Masseria and to record the traces that history has imprinted on its subject; an interweaving of knowledge that is indispensable to direct the restoration project in an effectively conservative vision, able to preserve the material authenticity of what remains, also taking due account of the needs of material integration to ensure its stability and use.

## 2. Cumae Archaeological Park

The Archaeological evidence of Cumae are among the most ancient between those known in the Campi Flegrei area (Caputo, Morichi, Pane, & Rispoli, 1996; Valenti, 2016). The Euboic column of Kyme was founded in the second quarter of the VIII century BC, within an area where the primitive Oscan town existed, made of nuclear residential settlements spread on the Cumaeian plain and at the Acropolis' foothill. Modelled on the greek city structure, it was relevant during the Early Archaic age, extending its hegemony from the Licola plain to Miseno. Similarly, to *Pithekoussai*, on the Island of Ischia. Kyme had a central role in the maritime trade. In 421 BC it was conquered by the Samnites, who dominated it for about a century, until 334 BC when it became *colonia sine suffragio* of Rome. Following the transformations from the Samnites Era, further alterations were made during the Roman domination. The sacred buildings and the walls were largely transformed: the area of the ancient agorà was transformed in the city Foro, that would suffer several transformations during the centuries. In its shape, traceable back to the Imperial Age, it was characterised by the presence of a large rectangular and colonnaded square, paved with limestone and on which all the main monuments of the city were facing, such as the *Tempio con Portico* and the *Capitolium*, the *tabernae* and the commercial spaces. The colonnade was articulated on two levels, with a first-order supported by Doric columns and a second one with Ionic columns.

Later, Octavian Augustus commissioned important engineering works to Agrippa and Cocceio Aucto in order to enhance the military role of the whole area of the Campi Flegrei: were so realised the Roman Crypta, the Cocceio Cave and the Sibilla Cave, that linked the portal area of Cumae to the Avernum and from there to the Portus Iulius in Lucrino. During the Flavian Age the road Domitiana and the majority of the city structures were built. Following the Fall of the Roman Empire, years of decadence and neglect ensued. Since the III century AD until the Middle Age, a series of flooding's radically changed the consistence of Cumae's lower city that after the following raising of the walking surfaces was transformed into a productive area destined to artisanal activities and for the processing of glass and metal. (Gasparri & Greco, 2007; Gasparri & Greco, 2009). During the Byzantian era a cocciopesto road was built, to cross the foro's square horizontally, in order to reach the Northern side of the

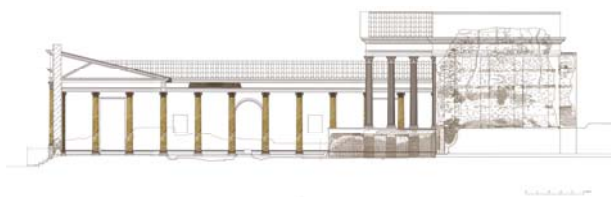
Capitolium. In those same years several calcare (limestone klin) were made: the most majestic one was located near the foro, including part of the so-called 'sillana room'. During the late ancient era the lime production became a very profitable activity thanks to the great amount of raw materials that were taken from the marble coatings and statues, still present in the Foro. During the same time, the main temples of the Acropolis from the Greek era were transformed into Paleochristians basilicas; the Roman Crypta and the Sybilla Cave were used to establish places of worship and burials (Maiuri, 1934).

## 3. The archaeological structures and the hypotheses on its original articulation

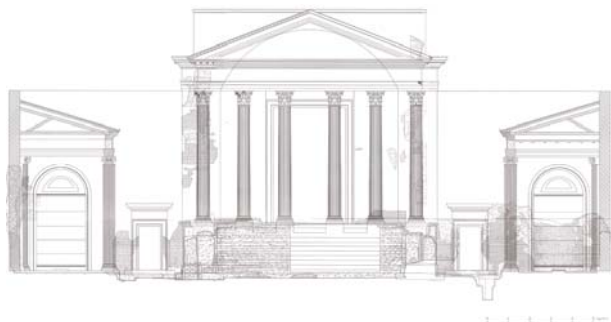
The analysis of the ancient structures found, partly incorporated and reused in the rooms of the Masseria, partly re-emerged during excavation campaigns carried out at the beginning of the 21<sup>st</sup> century, and integrated with that of the marble finds recognized as belonging to the same complex, have allowed the archaeologist Flavia Coraggio to elaborate a hypothesis for the reconstruction of the temple and its decorative part. According to the reconstruction of the aforementioned scholar, it is a temple located within a sacred enclosure consisting of a three-armed portico, probably dedicated to Vespasian. The internal scanning of the space responds - according to the model of the Forum of Augustus - to an accurate tripartition distributed on the longitudinal axis, that is a large vestibule accessible from three entrances, the uncovered courtyard and, finally, the sacred building raised on a podium (Coraggio, 2007; Coraggio, 2013).

The temple was oriented along the east-west axis and was divided into a hexastyle pronaos with two columns on the sides, accessible by a flight of eleven steps; the last two steps are interrupted by the foundation plinths of the colonnade. Since the width of the cell exceeded that of the pronaos, Coraggio hypothesized that they were made up of two disjoint bodies, also treated differently from the point of view of the surface covering (Figs. 1, 2, & 3). The podium was covered with marble, while the external volume of the *peribulum* was finished with a layer of *cocciopesto*; in elevation, the pronaos was covered in marble, while the walls of temple cell were covered in plaster. The three porticoed arms enclosed only the pronaos, leaving the outside temple cell at the *peribulum*. On the opposite side of the portico there were the three entrances that allowed access. The columns stood on composite attic bases and was made of smooth stems of *cipollino* marble, whose rhythm is documented by the trachyte foundation blocks, surmounted by composite capitals. The entire monumental complex is built in mixed masonry consisting of *opus reticulatum* and *opus latericium*. The cell of the temple, in particular, was characterized by the presence of *opus reticulatum* with tooting of latericium, as well as by walls in *opus vittatum mixtum* with alternating applications of parallelepiped blocks and bricks. Horizontal bands of *opus latericium* run along the walls, without a precise design (Coraggio, 2013).

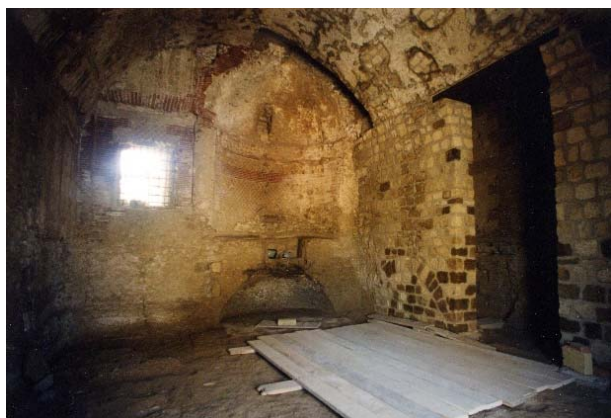




**Figure 1:** Tempio-Masseria del Gigante, Cuma. Longitudinal section according to the reconstructive hypothesis of F. Coraggio, in Coraggio (2007), annexe L.



**Figure 2:** Tempio-Masseria del Gigante, Cuma. Pronaos prospectus according to the reconstructive hypothesis of F. Coraggio, in Coraggio (2007), annexe I.



**Figure 3:** Tempio-Masseria del Gigante, Cuma. The apse before the restoration work 1994, photos by R. Morichi.

#### 4. The Temple-Masseria dei Giganti

Literary sources testify that statuary and epigraphic material was found in the ancient settlement of Cuma as early as the Middle Ages (De Filippis, 1996a; 1996b). However, only from the beginning of the seventeenth century were undertaken specific excavation activities, with the aim of recovering valuable ancient materials. The *Tempio-Masseria* owes its name to the discovery in its vicinity of the so-called 'Giant' of the Palace: the torso of the colossal acrolithic statue of Jupiter, which was originally located in the nearby Capitolium. Among the many rural buildings built in the area on partially emerging ancient ruins (Caputo, 2015), the *Tempio-Masseria del Gigante* has been for centuries a significant architectural emergence and an immediate topographical point of reference for the entire area of ancient Cuma, represented in many paintings and performances of travellers and scholarly.

As the view by Filippo Morghen showed, at least until 1740, the barrel vault of the cell was perfectly preserved,

as well as the lacunars: only a few years later, probably following a fire, it collapsed (Figs. 4, 5).



**Figure 4:** Morghen F., *Parete anteriore del precedente Tempio di Giove nella via di Cuma*. In Morghen 1814, tav. 28.



**Figure 5:** Morghen F., *Parte posteriore d'un tempio nella via dell'antica Cuma: da molti creduto sacro a Giove*. In Morghen 1814, tav. 27.

Then it was realized a new vault. It was set on the original wall to the north and on a new wall parallel to the original one, to the south, since the ancient one was no longer considered safe. This led to a significant reduction of the ancient volume. Throughout the eighteenth and nineteenth centuries, there were many discoveries and thefts of precious marble from the area of the forum: we will have to wait for Prince Leopoldo Borbone, Count of Syracuse, who was the first one on showing interest in recording the first systematic archaeological searches. They started right from the Temple-Masseria, of which part of the structures of the enclosures and its entrances were brought to light. Subsequently, and throughout the twentieth century, the *Tempio-Masseria* was volumetrically enlarged by the owners and actually nobody really cared about studying it. The interest of the scientific community of the time was entirely directed to the major excavations in the western sector of the Forum (Figs. 6, 7).

#### 5. The three-dimensional survey

After completing the necessary historical documentary investigations, synthetically described here, the work carried out consisted of surveying the complex with the photo modelling technique, integrated with direct measurements of the construction details. The three-dimensional survey carried out benefited from pre-existing topographic measurements which made it

possible to verify the degree of accuracy that was very high. 233 photographic shots from drone have been used, georeferenced by GPS antenna. These photos were taken according to three distinct shooting plans at different heights, made all around the building and then subsequently treated with a three-dimensional photo modelling program. Once aligned with the photos, there was a first cloud of the rough points that we proceeded to clean up manually. Subsequently, a dense cloud was generated and, from this, a three-dimensional polygon mesh from which the orthophotos of the elevations were extracted. From the three-dimensional model (Figs. 8, 9, 10, & 11), various section plans were obtained and exported to additional computer-assisted drawing programs, to elaborate plans and sections. For the completion of these graphs, a series of direct surveys have been carried out, room by room. In particular, the survey of many construction details and individual masonry parts of the interior rooms and some sample areas outside was carried out, also to verify the correctness of the photo modelling process.



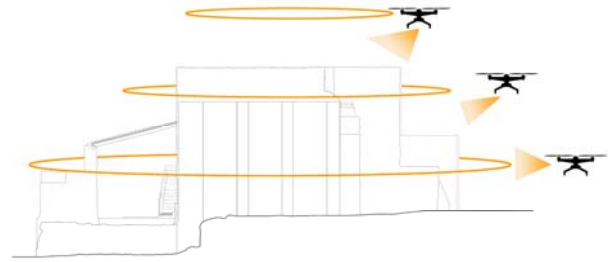
**Figure 6:** Tempio-Masseria del Gigante, Cuma. Archivio fotografico Mann, 3073, ex C165, 1938 in Valenti 2016, p.108.



**Figure 7:** Tempio-Masseria del Gigante, Cuma. View of the north-west corner before the restoration work 1994, photos by R. Di Re.

The graphic and photographic documentation produced was subsequently compared with the pre-existing one, made before the restoration works implemented. We proceeded, therefore, to identify the effective consistency of the consolidation and integration works completed and

to evaluate their impact on the overall conservation of the archaeological artefact.



**Figure 8:** Tempio-Masseria del Gigante, Cuma. 3D model. The flight phases of the drone.



**Figure 9:** Tempio-Masseria del Gigante, Cuma. 3D model. View from the northeast.



**Figure 10:** Tempio-Masseria del Gigante, Cuma. 3D model. View from the northwest.



**Figure 11:** Tempio-Masseria del Gigante, Cuma. 3D model. View from the southeast.

## 6. Some considerations on recent restoration work

That said, the comparison between the current state of The Temple-Masseria and the one prior to its restoration - that was possible to obtain by the historical-iconographic investigation, the three-dimensional surveys and the direct observation of the monument - leads to a series of critical observations on what has been accomplished. That is, about the nature and the number of wall integrations carried out and about the quality of the additions of new structural and functional elements, both in architectural terms and in terms of durability. The wall integrations performed, for example, were excessive (Figs. 12, 13, & 14). Let's take for example what was done to consolidate the remains of the southern wall of temple cell. Probably due to structural necessity, the whole original wall was covered by a new wall structure: that was, by a physically-mechanical standpoint, a 'distinguished' and 'compatible' integration, but at the same point also irreversible and invasive.



Figure 12: Tempio-Masseria del Gigante, Cuma. 3D model. View from the southwest.

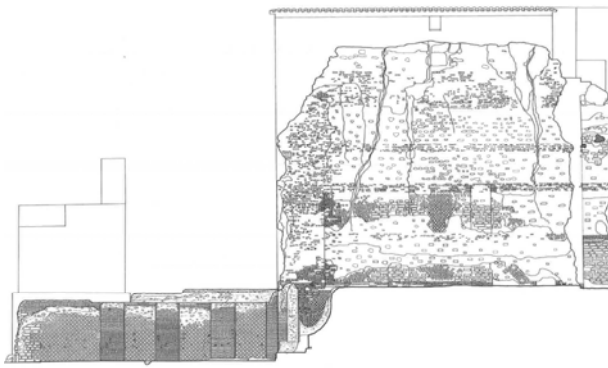


Figure 13: Tempio-Masseria del Gigante, Cuma. South prospectus, before restoration work, in Coraggio (2007), annex F.

The typologies of consolidation of the vaults and wooden floors cannot be fully shared, because of the techniques based on reinforced concrete that do not guarantee instead the complete physical-mechanical compatibility of the additions with the existing structures (Fig. 15). Unfortunately, the rigour of the archaeological explorations and the richness of the revealed schedule has not been followed by consolidation and integration

works that respect the authentic consistency of the complex. At this point, it seems legitimate to ask if it could have been possible to have adopted alternative solutions, in order to give more regard to the ruins of the walls and their stratifications or, at least, of being less invasive. Other misgivings are about the choices related to the finishing works (Figs. 16, 17, & 18). Fixtures, handrails, railings, gratings, walls and so on have been made in ways and shapes that only respond to functional needs, renouncing any attempt to make a connection between the ancient and contemporary element. This was, in our opinion, an incomprehensible choice, which assumes the belief that in the archaeological field what needs to be added must be anonymous and devoid of all those qualities that are not so strictly related to the functionality. This point is flatly denied by the fact that, a little less than twenty years after their realization, these elements are the ones that more than the others have suffered a rapid degradation process. Furthermore, we can't ignore the lack of a clear purpose of the use of the complex has led to a general 'aging' of all the parts, old and new, due to lack of maintenance.



Figure 14: Tempio-Masseria del Gigante, Cuma. South prospectus, before restoration work 1994, photos by R. Di Re.

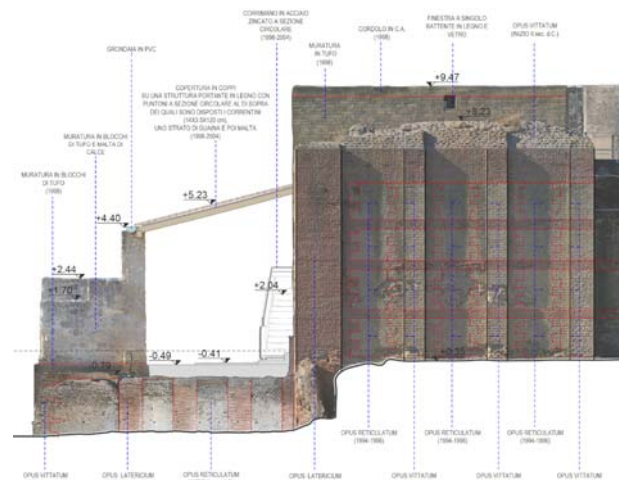


Figure 15: Tempio-Masseria del Gigante. South facade. Classification of the masonry typologies.



**Figure 16:** Tempio-Masseria del Gigante. The metal handrail of the staircase.



**Figure 17:** Tempio-Masseria del Gigante, Cuma. The grid for collecting rainwater on the terrace.



**Figure 18:** Tempio-Masseria del Gigante, Cuma. The floor in putrelles and wood.

## 7. Conclusions

The essays, studies, and archaeological surveys of such stratified monuments as the one in question allow us to

reveal complex and articulated palimpsests, which tell us about millenary events through the overlapping and integration of the walls. However, it is an extremely fragile *palinsesto*: ensuring its safeguarding requires that immediately after the archaeological studies, we proceed - with the same care and attention - to identifying suitable restoration interventions necessary to guarantee its conservation and protection. Therefore, to the structural and conservative fragility of archaeological structures it must be answered with recognizable and limited additions "to the minimum that will be necessary to guarantee the conservation of the monument and restore the continuity of its forms" (art. 15 Charter of Venice). From here the need to operate in a synergistic and multidisciplinary manner. All the skills of the archaeologist must put beside those of the restorer architect and of all the specialists who - within a clear framework of skills and roles - may be able to provide useful information to achieve the aforementioned objectives

The resulting design and executive choices, in addition to being distinguishable and limited, in order to do not irremediably alter the authenticity and the fragrance of the archaeological data, must also be characterized by effective durability over time, otherwise, they would be useless. To these, which are prerogatives that are generally found for all maintenance and restoration interventions in archaeological areas, for structures such as the Tempio-Masseria del Gigante in Cuma, it is also necessary to add formal and functional integration operations, to ensure them an appropriate and conscious use and a respectful consideration of the stratifications detected. In these cases, in addition to revealing all the layers (strata), reading their sedimentations and recognizing their structures, their age and their consistency, it is also necessary to design all the additions necessary for their use and their formal reconfiguration, if necessary. And this, not to the detriment of this or other structures, but with the aim of making it readable as much as possible, in the full awareness that each design act that will be carried out will represent another text that will be added to the existing ones, inevitably determining a new order.

Within these methodological premises, the investigation and research carried out for the realization of this work reinforce the conviction that only an interdisciplinary approach is the tool to increase the fertile hermeneutic circle necessary to guarantee authentic conservation of historical materials and to define conservative strategies and enhancement of cultural heritage both in the architectural historical and archaeological fields. Three-dimensional photomodelling techniques represent, in this framework of investigations, an extraordinarily useful and fast tool of knowledge that, when engaged in a broader process of cognitive deepening, can provide results of great importance to reveal the complexity of the values kept in the ancient masonry of archaeological monuments.

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