



CONFERENCE PROCEEDINGS



2025 IMEKO TC26 INTERNATIONAL CONFERENCE ON

METROLOGY for ARCHAEOLOGY and CULTURAL HERITAGE

BERGAMO, ITALY

OCTOBER 15-17, 2025



CONFERENCE PROGRAM

Wednesday, October 15

Session 1.1 - Geomatics for Archaeology and Cultural Heritage: multi-source and multi-scale data integration and processing in research and applications

Room: Conference Hall "Alberto Castoldi"

- 1 Integrated Workflow for 3D modelling of Historic Architecture: A Multi-Sensor Approach**
Vincenzo Saverio Alfio (Polytechnic University of Bari), Domenica Costantino (Polytechnic University of Bari), Mathab Fallah (Polytechnic University of Turin), Alfredo Restuccia Garofalo (Polytechnic University of Bari), Massimiliano Pepe (University "G. d'Annunzio" of Chieti-Pescara) and Paolo Piumatti (Polytechnic University of Turin)
- 7 UAS-based capacity building for enhancing minor archaeology**
Joel Aldrighettoni (University of Bergamo) and Maria Grazia D'Urso (University of Bergamo)
- 14 High-Resolution Photogrammetric Survey of a Romanesque Mosaic Floor: A Comparative Analysis of UAS and a Custom-Built Acquisition System**
Barbara Fazion (Politecnico di Milano), Daniele Treccani (Politecnico di Milano), Andrea Adami (Politecnico di Milano) and Luigi Fregonese (Politecnico di Milano)
- 20 New discoveries at the Castello Sforzesco in Milan: an integrated approach through 3D modelling and GPR survey**
Maurizio Porcu (Codevintec Italiana s.r.l.), Francesca Biolo (Politecnico di Milano) and Franco Guzzetti (Politecnico di Milano)
- 26 Integrating geomatic high-detail surveying and thermography for the documentation of historical masonry**
Anna Forte (Università di Bologna), Francesca Trevisiol (Università di Bologna), Giulia Fiorini (Università di Bologna) and Gabriele Bitelli (Università di Bologna)
- 32 Underground Surveying of the Porticus Minucia as a Basis for the Georeferencing of a Fragment of the Marble Plan of Rome (Forma Urbis Marmorea)**
Valerio Baiocchi (Sapienza University of Rome), Alessandri Luca (sapienza Università di Roma), Marta Baumgartner (Soprintendenza speciale Archeologia, Belle Arti e Paesaggio di Roma), Diego Blanco (archeogeos s.r.l.), Alessandro Bosman (CNR IGAG), Andrea Guaglianone (Independent researcher) and Felicia Vatore (Sapienza Università di Roma)

Session 1.2 - Non-destructive imaging and interferometric techniques for cultural heritage diagnostics and metrology

Room: Room 6 - First Floor

- 37 Infrared and Terahertz Imaging for the Analysis of a Fresco Sample**
Emma Vannini (INO-CNR, University of Florence), Iliara Catapano (IREA-CNR), Alice Dal Fovo (INO-CNR), Valentina Di Sarno (INO-CNR), Alessandra Rocco (INO-CNR), Pasquale Maddaloni (INO-CNR) and Raffaella Fontana (INO-CNR)
- 42 2D and 3D optical techniques for manuscript analysis: diagnostics based on data integration**
Nicole de Manincor (University of Verona), Sara Mazzocato (University of Verona), Dumitru Scutelnic (University of Verona) and Claudia Daffara (University of Verona)
- 47 Shearography and 3D scanning for assessing the strip lining in the case study: Pericles observes Phidias's artwork on the Parthenon, by Gaspare Landi**
Chiara Saltarelli (CNR-ISASI), Vito Pagliarulo (CNR-ISASI), Maria Rosaria Vigorito (Suor Orsola Benincasa University) and Melania Paturzo (CNR-ISASI)

- 53 Preliminary Tests of Millimetric Crack Detection in Ancient Wall Paintings using a Terahertz Radar**
Fulvia Gennari (Istituto Italiano di Tecnologia), Andrea Campostrini (Istituto Italiano di Tecnologia), Agnese Babini (Istituto Italiano di Tecnologia), Raffaella Lamuraglia (Istituto Italiano di Tecnologia), Giancarlo Ruocco (Istituto Italiano di Tecnologia), Valeria Giliberti (Istituto Italiano di Tecnologia), Arianna Traviglia (Istituto Italiano di Tecnologia) and Michele Ortolani (Istituto Italiano di Tecnologia)
- 57 Multidisciplinary approach of conservation of the fistulae aquariae from the archaeological site of Baiae**
Paola Fenelli (University of Studies Suor Orsola Benincasa, Naples), Alessandro De Rosa (University of Studies Suor Orsola Benincasa, Naples), Paola Cennamo (University of Studies Suor Orsola Benincasa, Naples), Giorgio Trojsi (University of Studies Suor Orsola Benincasa, Naples), Massimo Rippa (Institute of Applied Sciences and Intelligent Systems “E. Caianiello” of CNR, Pozzuoli) and Enrico Gallochio (Ministry of Cultural Heritage and Activities (MIC), Archaeological Park of Campi Flegrei)
- 63 From Europe to the UAE: A Multidisciplinary Approach to Studying Islamic and Arabic Manuscripts on European Papers**
Nagmeldeen Hamza (Department of Antiquities and Museums Ras Al Khaimah, United Arab Emirates) and Islam Shaheen (Grand Egyptian Museum)

Session 1.3 - Integrated Methods, Theories and Applications For Structural Health Monitoring And Assessment Of Ancient Constructions - PART I

Room: Room 7 - First Floor

- 69 STRUCTURAL ASSESSMENT OF THE PROPYLAEA CHURCH ARCHAEOLOGICAL REMAINS IN JERASH (JORDAN) USING 3D DISCRETE ELEMENT MODELLING**
Florin Cristinel Stan (Roma Tre University), Stefano De Santis (Roma Tre University), Sara Fares (Roma Tre University) and Gianmarco de Felice (Roma Tre University)
- 75 From scan to H-BIM: towards an automated workflow for cultural heritage vulnerability assessment**
Pietro Meriggi (Roma Tre University), Antonio Napolitano (Roma Tre University), Alessio Pasquali (Roma Tre University) and Luca Bianchini Ciampoli (Roma Tre University)
- 81 Using GPR to support structural interpretation of collapsed archaeological sites**
Roberta Santarelli (Sapienza University of Rome), Alessandra Ten (Sapienza University of Rome), Luca Bianchini Ciampoli (Roma Tre University), Andrea Benedetto (Roma Tre University) and Fabio Tosti (University of West London)
- 87 Digital Twin for Railway Infrastructure and Historic Stations: State of the Art, Technological Architecture, and Development Perspectives**
Gianmarco Pireneo (Telematic University Pegaso), Francesco Fabbrocino (Telematic University Pegaso), Carlo Olivieri (Telematic University Pegaso), Andrea Miano (Telematic University Pegaso) and Hamidreza Alavi (University of Cambridge)
- 92 Planning tools for historic centres reconstruction. An overview of Central Italy 2016 earthquake**
Margherita Giuffrè (Consiglio Nazionale delle Ricerche) and Francesco Fazzio (Università degli studi di Perugia)

Session 2.1 - From Composition to Conservation: Advanced Diagnostic Techniques for the Study of Ancient, Modern and Contemporary Painting Surfaces

Room: Conference Hall “Alberto Castoldi”

- 98 In situ non-invasive analyses of the painting “Cristo in Trono” (Amalfi, SA, Italy)**
Antonio Faggiano (University of Salerno), Chiara Gallo (Istemi S.r.l.), Oriana Motta (University of Salerno), Carmine Napoli (Istemi S.r.l.), Eduardo Caliano (Istemi S.r.l.), Antonino Fiorentino (University of Milan), Enza Cobalto (Comune di Amalfi, Assessorato per cultura e beni culturali, eventi e tradizioni), Maria Ricciardi (University of Salerno) and Antonio Proto (University of Salerno)
- 103 Analyzing and studying ancient polychrome surfaces using advanced imaging techniques: Tracing Original Composition to Modern Intervention**
Islam Shaheen (Sapienza University of Roma - Grand Egyptian Museum), Nagmeldeen Hamza (Grand Egyptian Museum-conservation center) and Mohammed Ragab (Grand Egyptian Museum)

108 Characterization of two vases from Centuripe

Bianca Irene Carnesale (University of Milan), Giacomo Biondi (CNR, ISPC), Mario Colella (University of Pavia), Federica Giacobello (University of Milan) and Letizia Bonizzoni (University of Milan)

113 Spectroscopic Investigation of a 17th-Century Illuminated Parchment from S. Maria di Montalto Church (Messina, Italy)

Giuseppe Paladini (University of Messina), Francesco Caridi (University of Messina), Domenico Majolino (University of Messina), Lorenzo Pistorino (University of Messina), Paola Cardiano (University of Messina), Alessandra De Caro (Centro Regionale Progettazione e Restauro e per le Scienze Naturali ed applicate ai beni culturali), Gloria Bonanno (Centro Regionale Progettazione e Restauro e per le Scienze Naturali ed applicate ai beni culturali), Arcangela Valenti (Centro Regionale Progettazione e Restauro e per le Scienze Naturali ed applicate ai beni culturali), Enza Anna Passerini (Centro Regionale Progettazione e Restauro e per le Scienze Naturali ed applicate ai beni culturali), Giuseppe Sampino (Soprintendenza BB.CC.AA) and Valentina Venuti (University of Messina)

Session 2.2 - How To Preserve Outdoor Cultural Heritage: State-Of-Art, Challenges and New Perspectives

Room: Room 6 - First Floor

118 Practical solutions to the biodeterioration dilemma: activity of *Dittrichia viscosa* extracts and its specialized metabolites on standard organism *Raphidocelis subcapitata*

Alessandro De Rosa (University of Studies Suor Orsola Benincasa, Naples), Marco Morelli (University of Naples Federico II), Marco Masi (University of Naples Federico II), Alessio Cimmino (University of Naples Federico II), Andrea Carpentieri (University of Naples Federico II), Gaia Marzia Silvestre (University of Naples Federico II), Antonino Pollio (University of Naples Federico II) and Paola Cennamo (University of Studies Suor Orsola Benincasa, Naples)

124 An integrated approach to the study of the architectural features of the theatre of Tyndaris

Marco Sfacteria (University of Messina), Stefania Tuccinardi (University of Messina) and Marta Venuti (University of Messina)

129 In-situ investigation of mortar fragments from the theatre of the archaeological area of Tindari (Sicily, Italy) through DRIFT and u-Raman techniques

Giuseppe Paladini (University of Messina), Francesco Caridi (University of Messina), Domenico Majolino (University of Messina), Gabriele Lando (University of Messina), Paola Cardiano (University of Messina) and Valentina Venuti (University of Messina)

133 Multi-Technique Characterization of Mural Paintings at the Santa Maria Gratia Plena Church in Bruzzano Vetere (Calabria, Southern Italy)

Lorenzo Pistorino (University of Messina), Francesco Caridi (University of Messina), Giuseppe Paladini (University of Messina), Pasquale Faenza (G. Rohlfs Museum of the Calabrian Greek Language), Domenico Majolino (University of Messina) and Valentina Venuti (University of Messina)

Session 2.3 - Integrated Methods, Theories And Applications For Structural Health Monitoring And Assessment Of Ancient Constructions - PART II

Room: Room 7 - First Floor

138 Historic centers between reconstruction and recovery. Urban planning considerations on a post-earthquake survey in Amatrice and Accumoli

Francesco Fazio (University of Perugia)

144 Remote Sensing for Heritage Conservation and Structural Monitoring: The case of Wolvesey Castle, Winchester

Efcharis Balodimou (University of West London), Nicoletta Bianchini (University of West London), Tamsin Withers (English Heritage, Engine House), Laden Husamaldin (University of West London), Moein Motavallizadeh Naeini (University of West London), Tesfaye Tessema (University of West London) and Fabio Tosti (University of West London)

- 150 **Experimental investigation of a masonry arch subjected to an asymmetric concentrated vertical load and validation via static and kinematic limit analysis**
Mario Fagone (University of Florence), Tommaso Rotunno (University of Florence), Natalia Pingaro (Politecnico di Milano) and Gabriele Milani (Politecnico di Milano)
- 155 **Optimization of CVAE parameters for the damage assessment of historic masonry buildings**
Ivan Roselli (ENEA) and Domenico Palumbo (ENEA)
- 160 **Time and frequency domain analysis of Etruscan pottery magnified videos**
Vincenzo Fioriti (ENEA), Eugenia Verrigni Petrei Castelli (ENEA), Alessandro Colucci (ENEA) and Ivan Roselli (ENEA)

Thursday, October 16

Session 3.1 - Damage and Radiological Risk Assessment: Diagnosis and Monitoring for the Restoration, Preventive Conservation, Usability and Maintenance of Cultural Heritage

Room: Conference Hall "Alberto Castoldi"

- 166 **Mineralogical Analysis of Viterbo Tuff Using X-Ray Diffraction and Raman Spectroscopy**
Giuliana Faggio (University Mediterranea of Reggio Calabria), Francesco Caridi (University of Messina), Daniele Chiriu (University of Cagliari), Stefania Da Pelo (University of Cagliari), Michele Guida (University of Salerno), Giacomo Messina (Università Mediterranea di Reggio Calabria), Maurizio Ponte (Università della Calabria), Silvestro Antonio Ruffolo (Università della Calabria), Domenico Majolino (University of Messina) and Valentina Venuti (University of Messina)
- 171 **Role of consolidants for limiting the radon exhalation rate in building materials of historical and artistic interest**
Francesco Caridi (University of Messina), Daniele Chiriu (University of Cagliari), Stefania Da Pelo (University of Cagliari), Giuliana Faggio (Università "Mediterranea" Calabria), Michele Guida (Università degli Studi di Salerno), Giacomo Messina (Università degli Studi di Salerno), Maurizio Ponte (Università della Calabria), Silvestro Antonio Ruffolo (Università della Calabria), Domenico Majolino (University of Messina) and Valentina Venuti (Università degli Studi di Messina)
- 176 **Historical urban centers built in tuff and indoor radon exposure**
Simona Mancini (University of Salerno), Serpil Aközcan Pehlivanoğlu (Kirkklareli University), Natasa Todorovic (University of Novi Sad), Albina Cuomo (C.U.G.RI.), Domenico Guida (C.U.G.RI.) and Michele Guida (University of Salerno)
- 181 **Natural radioactivity content, radiological hazard and mineralogy evaluation of Pumice stone from Lipari, Sicily, Southern Italy: a case study**
Lorenzo Pistorino (University of Messina), Francesco Caridi (University of Messina), Giuseppe Paladini (University of Messina), Antonio Francesco Mottese (Università Mediterranea, Reggio Calabria, Italy), Domenico Majolino (University of Messina) and Valentina Venuti (University of Messina)
- 187 **Radon exhalation, natural radioactivity content and radiological hazard assessment for the Viterbo tuff stone: a case study**
Francesco Caridi (University of Messina), Daniele Chiriu (University of Cagliari), Stefania Da Pelo (University of Cagliari), Giuliana Faggio ("Mediterranean" University of Reggio Calabria), Michele Guida (University of Salerno), Giacomo Messina ("Mediterranean" University of Reggio Calabria), Maurizio Ponte (University of Calabria), Silvestro Ruffolo (University of Calabria), Domenico Majolino (University of Messina) and Valentina Venuti (University of Messina)

Session 3.2 - Chromatic Heritage: Exploring the Science of Pigments, Stones and Art Conservation - PART I

Room: Room 6 - First Floor

193 [INVITED] Natural ultramarine in the Roman context of Volsinii (Bolsena, Italy): a multianalytical characterization

Martina Bernabale (Sapienza University of Rome), Anna Candida Felici (Sapienza University of Rome), Pierfrancesco Atanasio (Sapienza University of Rome), Luca Buccini (Sapienza University of Rome), Daniele Passeri (Sapienza University of Rome), Marco Rossi (Sapienza University of Rome), Paolo Binaco (Museo Territoriale del Lago di Bolsena) and Danilo Dini (Sapienza University of Rome)

198 Intelligent Workflow for Real Time and Automated Analysis of Historical Pigments

Irene Ferrara (Università degli Studi di Catania, Italia), Paola Benedetta Castellino (Università degli Studi di Catania, Italia), Salvatore Gallo (Università degli Studi di Catania, Italia), Anna Maria Gueli (Università degli Studi di Catania, Italia), Giuseppe Politi (Università degli Studi di Catania, Italia) and Giuseppe Stella (Università degli Studi di Catania, Italia)

203 3D Fluorescence Mapping: A promising Technique for the Analysis of the Degradation of Pigments

Stefania Porcu (University of Cagliari), Michela Podda (University of Cagliari), Giovanni Brodu (University of Cagliari), Stefano Columbu (University of Cagliari) and Daniele Chiriu (University of Cagliari)

Session 3.3 - Multiscale And Multitemporal High Resolution Remote Sensing and Non-Destructive Testing For Archaeology And Monumental Heritage: From Research To Preservation - PART I

Room: Room 7 - First Floor

208 New results from the GPR surveys at the area surrounding the Basilica at S. Croce in Gerusalemme, (Roma, Italy)

Salvatore Piro (ISPC CNR)

213 Multidisciplinary approach for the stability analysis of a historical hypogeum in the municipality of Cisternino in the Itria Valley (Puglia, Southern Italy), aimed at a refunctionalization and valorization of the site

Maurizio Lazzari (CNR ISPC, Potenza), Davide Palma (Geophysics to GeoEngineering), Pierpaolo Moretti (Geophysics to GeoEngineering) and Valentina Leopizzi (Independent archeologist researcher, Lecce)

219 GPR survey at the archaeological site of Heloros (Noto, Sicily)

Davide Tanasi (University of South Florida), Rosa Lanteri (Parco archeologico di Siracusa, Eloro, Villa del Tellaro e Akrai), Vincenzo di Fiore (ISPC-CNR), Michele Punzo (ISPC-CNR), Daniela Tarallo (ISPC-CNR), Dora Francesca Barbolla (ISPC-CNR), Lara De Giorgi (ISPC-CNR), Ivan Ferrari (ISPC-CNR), Francesco Giuri (ISPC-CNR) and Giovanni Leucci (ISPC-CNR)

224 From Point Clouds to Cultural Landscapes: Open-Source Machine Learning Applications for Archaeological UAV LiDAR segmentation

Nicodemo Abate (CNR - ISPC), Antonio Minervino Amodio (CNR - ISPC), Maria Sileo (CNR - ISPC), Rosa Lasaponara (National Research Council - IMAA), Nicola Masini (CNR - ISPC), Gabriele Ciccone (CNR - ISPC) and Alessia Frisetti (CNR - ISPC).

229 Discovery and study of “S.S. Egypte” shipwreck using remote sensing techniques, off north harbour of Patras city, Greece

George Papatheodorou (University of Patras), Dimitrios Christodoulou (University of Patras), Xenophon Dimas (University of Patras), George Karelak (University of Patras) and Maria Geraga (University of Patras)

Session 4.1 - Old Solutions for New Problems: Innovative Multitechnical Strategies for Diagnostics on Peculiar Case Studies

Room: Conference Hall “Alberto Castoldi”

234 A matter of materiality: the use of multi-analytical methods for reinforcing urban heritage

Adi Sela Wiener (Bezalel Academy of Arts and Design, Jerusalem), Laura Medeghini (Sapienza University of Rome) and Gabriele Favero (Sapienza University of Rome)

240 Exploring the Application of Explainable Neural Networks for the Petrographic Classification of Ceramic Samples from the Levant

Sara Capriotti (Sapienza University of Rome), Alessio Devoto (Sapienza University of Rome), Donatella Genovese (Sapienza University of Rome), Silvano Mignardi (Sapienza University of Rome), Simone Scardapane (Sapienza University of Rome) and Laura Medeghini (Sapienza University of Rome)

246 Unlocking the Information Potential of Lake Pigments through SERS and Chemometrics

Adele Bosi (CNR-ISC), Camilla Marola (Sapienza University), Alessandro Ciccola (Sapienza University), Federico Marini (Sapienza University) and Claudia Fasolato (Sapienza University)

Session 4.2 - Chromatic Heritage: Exploring the Science of Pigments, Stones and Art Conservation - PART II

Room: Room 6 - First Floor

250 XRF and Raman Spectroscopic Study of Wall Polychromes in the Saltworks Castle in Wieliczka

Anna Klisińska-Kopacz (National Museum in Krakow), Pamela Grajny-Brzezińska (Cracow Saltworks Museum in Wieliczka), Tomasz Wilkosz (National Museum in Krakow), Michał Obarzanowski (National Museum in Krakow), Klementyna Ochniak-Dudek (Cracow Saltworks Museum in Wieliczka) and Julio M. del Hoyo Meléndez (National Museum in Krakow)

256 Quantitative approaches for Fiber Optics Reflectance Spectroscopy (FORS)

Ricardo Pedro Vicente Rojas (Sapienza University of Rome), Silvia Sotgiu (National Central Library of Rome), Véronique Cachia (National Central Library of Rome), Eugenio Delre (Sapienza University of Rome), Nicola Schiavon (Hercules Laboratory, University of Evora, Pal), Mauro Giustini (Sapienza University of Rome) and Mauro Missori (Institute of Complex Systems, CNR)

261 Multi-technique archaeometric investigation of a XVII century illuminated parchment belonging to the S. Maria di Montalto Church (Messina, Italy)

Giuseppe Paladini (University of Messina), Francesco Caridi (University of Messina), Domenico Majolino (University of Messina), Lorenzo Pistorino (University of Messina), Alessandra De Caro (Centro Regionale Progettazione e Restauro e per le Scienze Naturali ed applicate ai beni culturali, Italy), Gloria Bonanno (Centro Regionale Progettazione e Restauro e per le Scienze Naturali ed applicate ai beni culturali, Italy), Arcangela Valenti (Centro Regionale Progettazione e Restauro e per le Scienze Naturali ed applicate ai beni culturali, Italy), Enza Anna Passerini (Centro Regionale Progettazione e Restauro e per le Scienze Naturali ed applicate ai beni culturali, Italy), Giuseppe Sampino (Soprintendenza BB.CC.AA, Messina, Italy) and Valentina Venuti (University of Messina)

Session 4.3 - Multiscale And Multitemporal High Resolution Remote Sensing And Non-Destructive Testing For Archaeology And Monumental Heritage: From Research To Preservation - PART II

Room: Room 7 - First Floor

267 Archaeological Remote Sensing at the Villa of Sette Bassi: Vegetation Index Analysis with Pléiades Neo Imagery

Jessica Clementi (Sapienza University of Rome), Veronica Sanvito (Sapienza University of Rome), Stefano Roascio (Ministero della Cultura, Parco Archeologico dell'Appia Antica), Michele Reginaldi (Ministero della Cultura, Parco Archeologico dell'Appia Antica) and Paolo Mazzanti (Sapienza University of Rome)

273 Can Vandalism Reshape the Way We Perceive Cultural Heritage?

Fabrizio Terenzio Gizzi (CNR-ISPC), Cristina Cumbo (CNR-ISPC), Maria Rosaria Potenza (CNR-ISPC), Agata Maggio (CNR-ISPC), Antonio Minervino Amodio (CNR-ISPC) and Canio Alfieri Sabia (CNR-ISPC)

278 ERT geophysical survey for Landslide Risk Management in Coastal Areas: Case Studies of Brovinje and Havišće (Croatia)

Michele Punzo (ISPC-CNR), Dora Francesca Barbolla (ISPC-CNR), Giuseppe Cavuoto (ISPC-CNR), Vincenzo Di Fiore (ISPC-CNR), Daniela Tarallo (ISPC-CNR) and Giovanni Leucci (National Research Council).

282 Water leaks as a hidden risk to cultural heritage sites: application of the TEAMWIRE project and the geophysical challenges

Chiara Torre (University of Malta), Sebastiano D'Amico (University of Malta), Emanuele Colica (University of Malta), Julian Mamo (University of Malta), Lara De Giorgi (CNR-ISPC), Dora Francesca Barbolla (CNR-ISPC) and Giovanni Leucci (CNR-ISPC)

Session 5.1 - Monitoring techniques for cultural heritage damage assessment and control

Room: Conference Hall "Alberto Castoldi"

287 EO-based products for risk assessment of cultural and natural heritage against climate and pollution impact

Alessandro Sardella (CNR-ISAC), Ramiro Marco Figuera (SISTEMA GmbH), Stefano Natali (SISTEMA GmbH) and Alessandra Bonazza (CNR-ISAC)

292 Environmental monitoring of The Grotto of the Animals: a case study for the SENNSE IoT platform

Francesco Taurino (CNR - ISPC), Irene Muci (Università La Sapienza), Davide Zecca (CNR - ISPC), Cristiano Riminesi (CNR - ISPC), Grazia Tucci (Unifi, Firenze - Italia) and Alberto Bucciero (CNR - ISPC)

297 From Thermal Signatures to Conservation Insights: A Fixed Camera Network Approach for Heritage Structure Health Monitoring

Giandomenico Mastrantonì (Sapienza University of Rome), Jessica Clementi (Sapienza University of Rome), Antonio Molinari (Sapienza University of Rome), Ioannis Farmakis (Sapienza University of Rome) and Paolo Mazzanti (Sapienza University of Rome)

303 Multi-scale non-invasive techniques for assessing instability conditions: examples from the Val di Cornia parks system (Tuscany, Italy)

Tommaso Beni (University of Florence), Silvia Guideri (Parchi Val di Cornia S.p.A), Debora Brocchini (Parchi Val di Cornia S.p.A), Marta Coccoluto (Parchi Val di Cornia S.p.A), Diletta Borselli (University of Florence), Lorenzo Bonechi (National Institute for Nuclear Physics INFN), Sandro Gonzi (University of Florence), Irene Centauro (University of Florence), Anna Palamidessi (University of Florence), Vitaliano Ciulli (University of Florence), Raffaello D'Alessandro (University of Florence), Giovanni Gigli (University of Florence), Deodato Tapete (Italian Space Agency ASI), Veronica Tofani (University of Florence) and Silvia Bianchini (University of Florence)

309 Application of Digital Photogrammetry in Damage Mapping on Facades of Historical Buildings

Tallis Rubens (Universidade de São Paulo), Fabiana Oliveira (Universidade de São Paulo), Fabricio Costa (Oregon State University), Luciana Toledo (Pontifícia Universidade Católica de Campinas) and Ana Elisabete Jacintho (Pontifícia Universidade Católica de Campinas)

Session 5.2 - Advances and innovation in ancient building materials studies: interfacing Archaeology, Science, and Technology

Room: Room 6 - First Floor

315 Geophysical Survey in the Presbytery of Tarragona Cathedral

Albert Casas (Universitat de Barcelona), Josep M^a Macias (Institut Català d'Arqueologia Clàssica), Mahjoub Himi (Universitat de Barcelona), Andreu Muñoz-Virgili (Institut Català d'Arqueologia Clàssica), Aritz Urruela-García (Universitat de Barcelona), Andreu Muñoz-Melgar (Museu Diocesà de Tarragona), Albert Casas-Ponsatí (Universitat de Barcelona).

320 València la Vella (Spain) and Late Antique Mortars: A Regional Geochemical Approach

Manel Górriz I Villar (Universitat de València), Mirco Ramacciotti (Universitat de València), Iván Pérez Torralba (University of Valencia), Angel Morales Rubio (University of Valencia), Iván Fumadó-Ortega (Universitat de València), José María Macias Solé (Catalan Institute of Classical Archaeology), Albert Ribera (Catalan Institute of Classical Archaeology) and Gianni Gallelo (Universitat de València)

326 Multi-Technique Characterization of Mortars from Gammarth Villa (Tunisia)

Manel Górriz I Villar (Universitat de València), Mirco Ramacciotti (Universitat de València), Iván Fumadó Ortega (Universitat de València), Hamden Ben Romdhane (Institut National du Patrimoine, Tunis, Tunisia.), Angel Morales Rubio (University of Valencia) and Gianni Gallelo (University of Valencia)

- 333 **XRD and PCA analysis of historic mortars from the Venetian Fortress of Bergamo (Italy)**
Renato Pelosato (Università degli Studi di Bergamo), Isabella Natali Sora (Università degli Studi di Bergamo), Virna Maria Nannei (Università degli Studi di Bergamo) and Giulio Mirabella Roberti (Università degli Studi di Bergamo)
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Session 5.3 - General Session - PART I

Room: Room 7 - First Floor

- 339 **The Advent of Complex Metallurgy**
Yuval Goren (Ben-Gurion University of the Negev), Yotam Asscher (University of Haifa), Sarel Shalev (University of Haifa) and Danny Rosenberg (University of Haifa)
- 345 **Characterization of Early 20th Century Measurement Instruments: A Heritage Approach**
Emma Angelini (Politecnico di Torino), Margherita Bongiovanni (Politecnico Torino), Leila Es Sebar (Politecnico di Torino) and Federico Di Iorio (Fondazione Centro per la Conservazione ed il restauro dei Beni Culturali (La Venaria Reale))
- 351 **Preliminary Investigation into pre-Industrial Salt Production: an experimental approach**
Martina Sciortino (University of Trento), Alessia Santiglia (University of Milan), Monica Azzarone (University of Milan), Laura Magnano (Università Cattolica), Giorgio Baratti (Università Cattolica), Laura Santagostini (University of Milan) and Vittoria Guglielmi (University of Milan).
- 357 **Preserving the Past with Gamma Rays: Real Case Studies from the Montecassino Abbey Collection**
Beatrice D'Orsi (ENEA), Rocco Carcione (ENEA), Iliaria Di Sarcina (ENEA), Jessica Scifo (ENEA), Teresa Rinaldi (Sapienza University of Rome), Nicola Tangari (University of Cassino and Southern Lazio) and Alessia Cemmi (ENEA)
- 362 **Assessing material compatibility for restoration: An innovative approach to compare hydraulic properties of repair and historic mortars**
Salvatore Menta (University of Catania), Antonio Stroschio (University of Catania), Gaetano Ortolano (University of Catania), Roberto Visalli (University of Catania) and Cristina Maria Belfiore (University of Catania)
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Session 6.1 - Archaeobotany and Palynology as Tools for Reconstructing Past Biodiversity, Ecosystems, and Landscapes

Room: Conference Hall "Alberto Castoldi"

- 367 **Natural vs anthropogenic constraints address changes of plant biodiversity in Italy during the Holocene**
Cristiano Vignola (Sapienza University of Rome), Alessia Masi (Sapienza University of Rome) and Laura Sadori (Sapienza University of Rome)
- 372 **The Long-Term Human-Mediated Success of Olive Trees in the Central Mediterranean: A Multiproxy Perspective**
Laura Sadori (Sapienza University of Rome), Jordan Palli (University of Tuscia, Viterbo), Sabina Fiolna (Freie Universität of Berlin), Monica Bini (University of Pisa), Federico Cappella (Sapienza University of Rome), Adam Izdebski (Max Planck Institute, Jena, Germany, Jagiellonian University in Krakow, Poland, University of Warsaw, Poland), Alessia Masi (Sapienza University of Rome), Scott Mensing (University of Nevada, Reno), Lorenzo Nigro (Sapienza University of Rome), Gianluca Piovesan (University of Tuscia, Viterbo) and Giovanni Zanchetta (University of Pisa)
- 376 **Measuring Millennial Biodiversity with Pollen: Archaeo-Data from Southern Italy**
Eleonora Clò (University of Modena and Reggio Emilia), Anna Maria Mercuri (University of Modena and Reggio Emilia), Jessica Zappa (University of Modena and Reggio Emilia), Cristina Ricucci (University of Modena and Reggio Emilia), Lorenzo Braga (University of Modena and Reggio Emilia) and Assunta Florenzano (University of Modena and Reggio Emilia)
- 382 **ARBOREA – A new georeferenced database for plant macro-remains from archaeological sites in Central Italy**
Claudia Moricca (Sapienza University of Rome), Erasmo Di Fonso (Sapienza University of Rome), Rachele Nicolini (Sapienza University of Rome) and Laura Sadori (Sapienza University of Rome)

Session 6.2 - General Session - PART II

Room: Room 6 - First Floor

- 386 Biofilms on limestones specimens: laboratory tests implementing a non-destructive approach**
Davide Ripamonti (Università degli Studi di Milano), Emanuele Frabasile (Università Degli Studi di Milano), Alessia Marzanni (Università di Bolzano), Chao Gao (Norwegian University of Science and Technology), Chiara Bertolin (Norwegian University of Science and Technology), Villa Federica (Università degli Studi di Milano) and Nicola Gherardo Ludwig (Università degli Studi di Milano)
- 392 Multi-technical non-invasive analysis to prevent deterioration in varnish-coated oil-paintings**
Alice Dal Fovo (Istituto Nazionale di Ottica, CNR), Laura Maestro-Guijarro (Instituto de Química Física Blas Cabrera, CSIC), Paula Maria Carmona-Quiroga (Instituto de Ciencias de la Construcción Eduardo Torroja, CSIC), Raffaella Fontana (Istituto Nazionale di Ottica, CNR), Francesca Rosi (Istituto di Scienze e Tecnologie Chimiche, CNR), Martina Alunni Cardinali (ISTC-CNR, Perugia, Italy; Università di Perugia, Italy), Aldo Romani (Università di Perugia, Italy), Lucia Comez (Istituto Officina dei Materiali, CNR), Cristiano Riminesi (Istituto di Scienza del Patrimonio Culturale, CNR), Magdalena Iwanicka (Faculty of Fine Arts, Nicolaus Copernicus University in Toruń, Poland), Piotr Targowski (Institute of Physics, Faculty of Physics, Astronomy and Informatics, Nicolaus Copernicus University in Toruń, Poland), Magdalena Kowalska (Nicolaus Copernicus University in Toruń, Poland), Aggelos Philippidis (Institute of Electronic Structure and Laser, FORTH, Heraklion, Crete, Greece), Paraskevi Pouli (Institute of Electronic Structure and Laser, FORTH, Heraklion, Crete, Greece), Marta Castillejo (Instituto de Química Física Blas Cabrera, CSIC) and Mohamed Oujja (Instituto de Química Física Blas Cabrera, CSIC)
- 397 Mediterranean eustatic and climatic variations vs the Phoenician-Punic settlement/abandonment phases**
Alessandro Paladini (Independent archeologist researcher) and Maurizio Lazzari (CNR ISPC, Potenza)
- 403 Evolution of anthropic coastal landscapes and ground deformation in the Campi Flegrei caldera (southern Italy) since Roman times: insights from multi-technique surveys**
Claudia Caporizzo (Università Telematica Pegaso), Gaia Mattei (Università degli Studi di Napoli Parthenope), Pietro P.C. Aucelli (Università degli Studi di Napoli Parthenope) and Gerardo Pappone (Università degli Studi di Napoli Parthenope)
- 409 APPLICATION OF PARTICLE IMAGE VELOCIMETRY (PIV) TO DETECT THERMALLY-INDUCED AIRFLOWS IN ARTWORK DISPLAY CASES**
Barbara Marchetti (Università degli Studi eCampus), Matteo Moglie (Università degli Studi eCampus) and Francesco Corvaro (Università Politecnica delle Marche)

Friday, October 17

Session 7.1 - Vibroacoustic metrological characterization for archaeology and cultural heritage - PART I

Room: Conference Hall "Alberto Castoldi"

- 414 Minimization of environmental acoustic effects: an intangible design element of Greek theatres**
Fabrizio Barone (University of Salerno) and Marco Casazza (University of Salerno)
- 420 Vibroacoustic landscape and defensive network: metrology for the characterization of potential communication systems in Medieval Basilicata until the Longobard-Norman transition**
Rosa Fiorillo (University of Salerno), Marco Casazza (University of Salerno) and Fabrizio Barone (University of Salerno)
- 425 The Sound Emission of the Bell Tower of the Salerno Cathedral in Medieval Europe between Architectural Structure and Bell Construction Techniques**
Fabrizio Barone (University of Salerno), Rosa Fiorillo (University of Salerno) and Marco Casazza (University of Salerno)

- 430 **A Case Study of Road Traffic Noise Intrusion Simulation in an Italian Archaeological Site**
Claudio Guarnaccia (University of Salerno), Aurora Mascolo (University of Salerno) and Domenico Rossi (University of Salerno)
- 436 **The Roman Bridge on the Savuto River: understanding its dynamical structural behavior through the adaptive DFEM method**
Fabrizio Barone (University of Salerno), Salvatore Antonio Fornaro (Studio di Architettura Fornaro), Armando Di Maio (Studio di Architettura Di Maio, Napoli, Italy) and Marco Casazza (University of Salerno)

Session 7.2 - Virtual environments and Cultural Heritage: tools, new technologies, and future perspectives - PART I

Room: Room 6 - First Floor

- 442 **Gradient-Based Analysis of Vertical Displacements in Urban 3D LiDAR Models Using SAR Data**
Alessandro Di Benedetto (University of Salerno), Margherita Fiani (University of Salerno) and Salvatore Barba (University of Salerno)
- 448 **Cultural Heritage visualization through Generative AI: a Unity-based plugin for real-time 3D object creation**
Attilio Della Greca (University of Salerno), Ilaria Amaro (University of Salerno), Giovanni Nocerino (University of Naples Federico II) and Paola Barra (Parthenope University of Naples)
- 453 **Federated Digital Twins and XR for Cultural Heritage: A Collaborative Framework**
Gizealew Alazie Dagnaw (University of L'Aquila) and Henry Muccini (University of L'Aquila)
- 458 **Mobile games for the Revival of Archeological Parks in Campania: A Pilot Experience Bridging Virtual Environments and Cultural Heritage**
Francesco Colace (University of Salerno), Constanza Fiorella Duarte Petti (Universidad abierta Interamericana), Angelo Lorusso (University of Salerno), Michele Pellegrino (University of Salerno) and Domenico Santaniello (University of Salerno)
- 464 **Towards an Operational Protocol for Virtual Tours in Complex Cultural Sites: The Norman Castle of Aci Castello**
Paolino Trapani (University of Catania), Eleonora Pappalardo (University of Catania), Anna M. Gueli (University of Catania) and Filippo Stanco (University of Catania)

Session 7.3 - Advanced Metrological Approaches for the Study and Transmission of Prehistoric Material Culture

Room: Room 7 - First Floor

- 470 **High-Resolution 3D Digitization and Analysis of the Mesolithic Site of Latnija (Malta)**
Davide Tanasi (University of South Florida), Alex Fawbush (University of South Florida), Kaitlyn Kingsland (University of South Florida), Dario Calderone (LMU-Munich), Eleanor Scerri (Max Planck Institute of Geoanthropology), Nicholas Vella (University of Malta) and Huw Groucutt (University of Malta)
- 474 **Preliminary Results of the Integrated 3D Digitization of the Prehistoric Artifacts Exhibited at the Museum of Archaeology of the University of Catania**
Paolino Trapani (University of Catania), Marianna Figuera (University of Catania), Simona V. Todaro (University of Catania), Anna M. Gueli (University of Catania) and Filippo Stanco (University of Catania)
- 479 **Colourant pigments used for pottery decoration in Northeastern Africa during the Neolithic period: An analysis using Raman spectroscopy and Microscopy**
Sakura Sanada (Tokyo Metropolitan University, Graduate School of Humanities)
- 485 **RTI and virtualRTI: tools and methodologies for documenting prehistoric engraved artifacts**
Angelo Lorusso (University of Salerno), Michele Pellegrino (University of Salerno), Domenico Santaniello (University of Salerno) and Francesco Colace (University of Salerno)
- 491 **Digital Strategies for the Protection and Valorization of Prehistoric Landscapes: 3D Metrology at Cozzo del Pantano (Sicily)**
Davide Tanasi (University of South Florida), Alew Fawbush (University of South Florida), Stephan Hassam (Randolph Macon College) and Dario Calderone (LMU-Munich)

Session 8.1 - Vibroacoustic metrological characterization for archaeology and cultural heritage - PART II

Room: Conference Hall “Alberto Castoldi”

- 495 Geometry of a Medieval Town in the Context of Political Religious Governance of the Territory**
Fabrizio Barone (University of Salerno), Rosa Fiorillo (Università di salerno), Armando Di Maio (Studio di Architettura Di Maio, Napoli, Italy) and Marco Casazza (University of Salerno)
- 501 Non-invasive dating of historical church bells through vibroacoustic matching of musical temperaments**
Marco Casazza (University of Salerno), Rosa Fiorillo (University of Salerno) and Fabrizio Barone (University of Salerno)
- 506 A new protocol for the reconstruction of the auditory ambiance in Palaeolithic sites: first results from Grotta Paglicci (Apulia – Southern Italy)**
Jacopo Crezzini (University of Siena), Adriano Farina (University of Bologna), Enrico Armelloni (University of Parma), Riccardo Salvini (University of Siena), Annamaria Ronchitelli (University of Siena), Stefano Ricci (University of Siena) and Francesco Boschini (University of Siena)
- 511 Sensorial identity of ruins: Vibroacoustic features of the roofless medieval Chapel of Madonna del Fieno (Fisciano, Italy)**
Elide Nastri (University of Salerno) and Paolo Todisco (University of Salerno)

Session 8.2 - Virtual environments and Cultural Heritage: tools, new technologies, and future perspectives - PART II

Room: Room 6 - First Floor

- 515 Hidden Monuments Revealed: 3D Digitization of the Benedictine Monastery of Catania and its Stratified Spaces**
Simone Pio Barbagallo (University of Catania), Maura Fugazzotto (University of Catania), Lucrezia Longhitano (University of Catania), Roberta Occhipinti (University of Catania), Dario Allegra (University of Catania), Germana Barone (University of Catania), Paolo Mazzoleni (University of Catania) and Filippo Stanco (University of Catania)
- 520 Adaptive Immersive Experiences: Comparative Study on Villa Regina**
Liliana Cecere (University of Salerno), Francesco Colace (University of Salerno), Muhammad Khan (University of the West of England), Angelo Lorusso (University of Salerno), Domenico Santaniello (University of Salerno) and Carmine Valentino (University of Salerno)
- 526 Gamified AR and supervised AI for Cultural Heritage: The Amiternum Site Experience**
Federico Martusciello (Università degli Studi dell'Aquila), Henry Muccini (Università degli Studi dell'Aquila) and Alfonso Forgione (Università degli Studi dell'Aquila)
- 532 From Surveying Techniques to a 3D GIS Geodatabase**
Barbara Marana (University of Bergamo) and Giorgio Ubbiali (Diemme Strumenti)

POSTER SESSION

Room: University of Bergamo

- 538 How do climate change-driven renewable energy infrastructures affect the visual perception of landscapes? An exploratory empirical study**
Canio Alfieri Sabia (CNR ISPC), Maria Rosaria Potenza (CNR ISPC), Agata Maggio (CNR ISPC), Antonio Minervino Amodio (CNR ISPC) and Fabrizio Terenzio Gizzi (CNR ISPC)
- 543 Implementation of Management Facilitators in Historic Buildings: Integration of BIM and GIS for Pathology Monitoring**
Crislandy Kaline Barreiro Marques (Universidade Estadual de Campinas), Rafael Fernandes Dionízio (Universidade Estadual de Campinas) and Eloísa Dezen Kempter (Universidade Estadual de Campinas)

- 548 Tracing Construction Phases at the Roman Villa Horta da Torre (Fronteira, Portugal): Insights from mortars aggregates**
Mizuki Takahashi (University of Évora), Cristina Galacho (University of Évora), André Carneiro (University of Évora) and Patricia Moita (University of Évora)
- 553 Walls of the Castle of Alcácer do Sal – Contribution to the Study of Mortars in Military Architecture**
Maria Almeida (University of Évora), Maria Pinheiro-Alves (University of Évora), Patrícia Moita (University of Évora) and Cristina Galacho (University of Évora)
- 559 Protecting the Past, Shaping the Future. High School Students Test Nanocomposites on Archaeological samples**
Beatrice Calosso (ENEA), Rosaria D’Amato (ENEA), Valentina Nigro (ENEA) and Gaetano Terranova (ENEA)
- 564 An integrated approach for the systematic monitoring of the indoor air quality and microclimatology at churches located in the Central Mediterranean region**
Antonio Proto (University of Salerno), Francesca Cannizzaro (University of Messina), Maria Ricciardi (University of Salerno), Maria Letizia Amadori (University of Urbino), Jgor Arduini (University of Urbino), Oriana Motta (University of Salerno), Paola Donato (University of Messina), Alfred Micallef (University of Malta), Sebastiano D’Amico (University of Malta), Adriana Alescio (St John’s Foundation), Luigi Mondello (University of Messina) and Danilo Sciarrone (University of Messina)
- 569 Application of 3D Ultrasonic Tomography in Cultural Heritage: The Case of the Ustica Sculpture**
Alessandra Carollo (University of Palermo), Patrizia Capizzi (University of Palermo), Raffaele Martorana (University of Palermo), Marco Vincenzo Majani (University of Palermo) and Franco Foresta Martin (National Institute of Geophysics and Volcanology)
- 573 Integrated Geophysical Prospection at the Roman Villa of Agosta (Comacchio, Italy): first results**
Jessica Clementi (Sapienza Università di Roma) and Enzo Rizzo (Università di Ferrara)
- 577 Micro-geophysical investigations for structural diagnostics at Coratelli Mill**
Lara De Giorgi (ISPC-CNR), Dora Francesca Barbolla (ISPC-CNR) and Giovanni Leucci (ISPC-CNR)
- 582 ERT surveys at the Necropolis of Baucina (Palermo)**
Lara De Giorgi (ISPC-CNR), Dora Francesca Barbolla (ISPC-CNR) and Giovanni Leucci (ISPC-CNR)
- 587 Virtual reconstruction of the Ducal Palace of Oliveto Lucano (Basilicata, Italy)**
Maurizio Delli Santi (ISPC-CNR) and Massimiliano Passarelli (CNR - NANOTEC)
- 591 Post-earthquake structural assessment using Ground Penetrating Radar (GPR): preliminary insight for guidelines from literature review**
Antonio Minervino Amodio (Institute of Heritage Science (ISPC)), Giovanni Leucci (Institute of Heritage Science (ISPC)) and Fabrizio Terenzio Gizzi (Institute of Heritage Science (ISPC))
- 596 Dust Detector for Museum Environment Based on Raspberry-Pi**
Mariagrazia Leccisi (Università degli Studi Roma Tre), Giuseppe Schirripa Spagnolo (Università degli Studi Roma Tre) and Fabio Leccese (Università degli Studi Roma Tre)
- 602 The Theatre of Marcellus: between historical memory and digital innovation**
Roberto Barni (Sapienza Università di Roma), Marika Griffò (Sapienza Università di Roma), Carlo Inglese (Sapienza Università di Roma) and Simone Lucchetti (Sapienza Università di Roma)
- 608 Reconstructing Galileo’s Inclined Plane Experiments: Problems of Time Measurements.**
Giuseppe Schirripa Spagnolo (Università Roma Tre), Giorgia Satta (Università degli Studi Roma Tre), Federico Fina (Università degli Studi Roma Tre), Ilaria De Angelis (Università degli Studi Roma Tre) and Fabio Leccese (Università degli Studi Roma Tre)
- 614 Analysis of hypogea environments based on ambient vibration data: application to a case study on the Palatine hill**
Iolanda Gaudiosi (Consiglio Nazionale delle Ricerche), Maurizio Simionato (Consiglio Nazionale delle Ricerche), Daniel Tentori (Consiglio Nazionale delle Ricerche), Michele Livani (Consiglio Nazionale delle Ricerche), Salvatore Piro (Consiglio Nazionale delle Ricerche), Marco Mancini (Consiglio Nazionale delle Ricerche), Francesco Stigliano (Consiglio Nazionale delle Ricerche) and Massimiliano Moscatelli (Consiglio Nazionale delle Ricerche).

- 620 Historic Roofless Masonry Structures: The role of Environmental Factors that Contribute to Decay and Collapse**
Nicoletta Bianchini (University of West London), Efcharis Balodimou (University of West London), Tesfaye Tessema (University of West London), Laden Husamaldin (University of West London) and Fabio Tosti (University of West London)
- 626 Augmented Reality for Knowledge Transfer of Historical Masonry Vaulting Techniques**
Davide Prati (University of Bergamo), Orsolya Gaspar (Penn State University) and Vittorio Paris (University of Bergamo)
- 632 Structural Investigation through Digital Modeling of Two Domes by Ferdinando Crivelli**
Virna Maria Nannei (University of Bergamo), Vittorio Paris (University of Bergamo), Davide Prati (University of Bergamo), Monica Resmini (University of Bergamo) and Giulio Mirabella Roberti (University of Bergamo)
- 638 Multitemporal SAR data for prospection, monitoring and preservation of Cultural Heritage**
Antonio Corbo (Sapienza University of Rome), Antonio Napolitano (Sapienza University of Rome, Roma Tre University), Deodato Tapete (Italian Space Agency), Andrea Benedetto (Roma Tre University) and Alessandro Jaia (Sapienza University of Rome)
- 644 Spectroscopic and Micro-Elemental Analysis of some 20th-Century Paintings: Identifying Diagnostic Pigments**
Andrea Bergomi (Università degli Studi di Milano), Valeria Comite (Università degli Studi di Milano), Chiara Andrea Lombardi (Università degli Studi di Milano), Mattia Borelli (Università degli Studi di Milano), Giulia Galli (Università degli Studi di Milano), Gianluca Carabelli (Università degli Studi di Milano), Paola Fermo (Università degli Studi di Milano) and Antonino Fiorentino (Università degli Studi di Milano)
- 649 Optical methods for violin diagnostic**
Vito Pagliarulo (CNR-ISASI), Massimo Rippa (CNR-ISASI), Chiara Saltarelli (CNR-ISASI), Antimo Di Meo (CNR-ISASI), Dimitru Scutelnic (Dept. of Computer Science, University of Verona), Claudia Daffara (Dept. of Computer Science, University of Verona) and Melania Paturzo (CNR-ISASI)
- 654 Active Thermography Analysis of Wall Paintings in the Early Christian Basilica Complex of Cimitile (Italy)**
Antimo Di Meo (Institute of Applied Sciences and Intelligent Systems “E. Caianiello” of CNR, Pozzuoli (Na), Italy.), Maria Palma Recchia (Superintendency for Archaeology, Fine Arts and Landscape for the Metropolitan Area of Naples, Italy.) and Massimo Rippa (Institute of Applied Sciences and Intelligent Systems “E. Caianiello” of CNR, Pozzuoli (Na), Italy.)
- 659 3D modelling for the historical reconstruction of an archaeological site: the temple of Iuvanum**
Vincenzo Saverio Alfio (Polytechnic University of Bari), Domenica Costantino (Polytechnic University of Bari), Ahmed Kamal Hamed Dewedar (University “G. d’Annunzio” of Chieti-Pescara), Massimo Leserri (Polytechnic University of Bari), Caterina Montanaro (Polytechnic University of Bari), Donato Palumbo (University “G. d’Annunzio” of Chieti-Pescara), Massimiliano Pepe (University “G. d’Annunzio” of Chieti-Pescara) and Alfredo Restuccia Garofalo (Polytechnic University of Bari)
- 665 High-Resolution 3D Surveying to Support Museum Inclusiveness Strategies**
Gabriele Bitelli (Università di Bologna, DICAM), Anna Forte (Università di Bologna, DICAM) and Andrea Tirincanti (Museo del Territorio di Riccione)
- 671 Metal finds from the Etruscan site of Spina (Ostellato - FE - Italy), 2023 field: preliminary results**
Colin Ongari (University of Ferrara), Elena Marrocchino (University of Ferrara), Negar Eftekhari (University of Ferrara) and Carmela Vaccaro (University of Ferrara)
- 677 Medieval church bell sound generation for vibroacoustic landscape studies**
Marco Casazza (University of Salerno) and Fabrizio Barone (University of Salerno)
- 682 Hard vibroacoustic metrology for intangible cultural heritage: The case of church bells tuning**
Rosa Fiorillo (Università di Salerno), Marco Casazza (Università degli Studi di Salerno) and Fabrizio Barone (Università degli Studi di Salerno)
- 686 Preliminary results obtained by a non-destructive multi-analytical approach applied to a self-portrait by Giuseppe Sabatelli, son of Prof. Luigi Sabatelli professor at Brera Academy, and to an inscription by Natale Longoni on a shaving bowl lid**
Giulia Galli (University of Milan), Chiara Andrea Lombardi (University of Milan), Chiara Nenci (Accademia di Belle Arti di Brera), Carlo Mariani (Architect), Paola Fermo (University of Milan) and Valeria Comite (University of Milan)

- 691 **Geophysical data acquisition for a non-invasive diagnosis at the Convitto Palmieri in Lecce**
Dora Francesca Barbolla (ISPC-CNR), Lara De Giorgi (ISPC-CNR), Ivan Ferrari (ISPC-CNR), Francesco Giuri (ISPC-CNR) and Giovanni Leucci (ISPC-CNR)
- 696 **Integrating Historical Sources and Infrared Thermography for Detection of Seismic Damage in Architectural Heritage**
Fabrizio Terenzio Gizzi (CNR-ISPC), Edoardo Gherardi (CNR-IMAA), Maria Rosaria Potenza (CNR-ISPC) and Maria Sileo (CNR-ISPC)
- 700 **Tracking the research landscape of Infrared Thermography in Architectural Heritage: A Data-Driven View**
Fabrizio Terenzio Gizzi (CNR-ISPC), Maria Rosaria Potenza (CNR-ISPC), Maria Sileo (CNR-ISPC) and Antonio Minervino Amodio (CNR-ISPC)
- 706 **Geophysical survey in the area of aguglia d'agosta (Priolo Gargallo, Sicily)**
Lara De Giorgi (ISPC-CNR), Dora Francesca Barbolla (ISPC-CNR) and Giovanni Leucci (ISPC-CNR)
- 712 **Geophysical survey at the coastal tower of S. Caterina (Lecce, Italy)**
Lara De Giorgi (ISPC-CNR), Giancarlo De Pascalis (Università di Roma La Sapienza), Ivan Ferrari (ISPC-CNR), Francesco Giuri (ISPC-CNR) and Giovanni Leucci (ISPC-CNR)
- 716 **ERT survey at the Roman Bath in Sagalassos (Turkey)**
Lara De Giorgi (ISPC-CNR), Dora Francesca Barbolla (ISPC-CNR) and Giovanni Leucci (ISPC-CNR)
- 720 **THE ARCHAEOLOGICAL SITE OF ANGLONA (MT): GEOPHYSICAL SURVEYS TO UNDERSTAND THE SETTLEMENT DISPOSITION**
Lara De Giorgi (ISPC-CNR), Dora Francesca Barbolla (ISPC-CNR) and Giovanni Leucci (ISPC-CNR)
- 724 **Archeology of the future and the simulacrum for heritage As-Becoming solutions**
Fernando Birello de Lima (State University of Mato Grosso), Simone Helena Tanoue Vizioli (University of São Paulo), Luciana Paelas Mascaro (Federal University of Mato Grosso) and Amanda Kirchesch Castrillon Mendes (Federal University of Mato Grosso)
- 730 **Digital Built Heritage Representation and Documentation: A Systematic Mapping of Platforms and Hybrid Models**
Maisa Almeida (University of São Paulo), Marcela Noronha (Postdoctoral Fellow at the Faculty of Civil Engineering, Architecture and Urban Design, UNICAMP), Marcio Fabricio (Full Professor at the University of São Paulo, Architecture and Urbanism Institute (IAU USP)) and Alfonso Ippolito (Full Professor at the DSDRA, Sapienza University of Rome)
- 736 **The First 21st Century Comprehensive Restored Plan of Hadrian's Villa and its Metrological Analysis**
Michael Ytterberg (Drexel University)
- 742 **From Visual Perception to Automated Detection: Integrating NDVI, SCP, and AI for the Identification of Archaeological Surface Markers**
Filomena Papaleo (Università degli Studi di Genova) and Simone Giosuè Madeo (Università degli Studi di Genova)
- 747 **Application of Charged Particle Activation Analysis (CPAA) in archaeology**
Chaturvedula S. Sastri (Scientist (retired) - (Guest at CNRS-CEMHTI, Orleans, France)), Thierry Sauvage (CNRS, CEMHTI UPR 3079, Orleans), Olivier Wendling (CNRS, CEMHTI UPR 3079, Orleans), Aurélien Bellamy (CNRS, CEMHTI UPR 3079, Orleans), William Hate (CNRS, CEMHTI UPR 3079, Orleans), Paul Sigot (CNRS, CEMHTI UPR 3079, Orleans), Frédéric Foucher (CNRS, CEMHTI UPR 3079, Orleans) and Christian Humburg (Medical doctor)
- 753 **Multi-technique integrated analysis to discover the invisible on the Camponeschi Monument in L'Aquila**
Luisa Caneve (ENEA), Valeria Spizzichino (ENEA), Massimiliano Guarneri (ENEA), Federico Angelini (ENEA), Roberto Chirico (ENEA), Elena De Panfilis (GSSI) and Speranza Falciano (GSSI)
- 759 **Digital Heritage Conservation: The SENNSE IoT Platform as a Structured Approach for Cultural Heritage Monitoring Projects**
Davide Zecca (ISPC-CNR, Lecce, Italy), Irene Muci (Università La Sapienza, Rome, Italy), Francesco Valentino Taurino (ISPC-CNR, Lecce, Italy), Mohamed Ali Jaziri (ISPC-CNR, Lecce, Italy) and Alberto Bucciero (ISPC-CNR, Lecce, Italy)
- 764 **Modeling Memory: Ethical Reuse and AI Training with Archaeologist-Produced 3D Reconstructions**
Simone Pio Barbagallo (University of Catania), Davide Tanasi (University of South Florida) and Filippo Stanco (University of Catania)

- 769 **Digital Documentation and Virtual Accessibility of Prehistoric Artefacts: Case Studies from Sicilian Museums**
Dario Calderone (Ludwig Maximilians Universität, Munich), Davide Tanasi (University of South Florida), Enrico Greco (Institute for the Advanced Study of Culture and the Environment, University of South Florida, Tampa (FL), USA), Stephan Hassam (Randolph-Macon College, Ashland (VA), USA) and Madeleine Kraft (Digital Exploration, University of South Florida, Tampa (FL), USA)
- 774 **Preliminary findings from a non-invasive and micro-invasive multi-analytical study of the painting “Posa della Prima Pietra” by Ismaele Teglio Milla (1853)**
Paola Fermo (University of Milan), Valeria Comite (University of Milan), Chiara Andrea Lombardi (University of Milan), Mattia Borelli (University of Milan), Andrea Bergomi (University of Milan), Letizia Bonizzoni (University of Milan), Francesca Sabatini (University of Milano-Bicocca), Giulia Galli (University of Milan), Gianluca Carabelli (University of Milan) and Daniele Bolleri (University of Milan)
- 779 **Virtual Reconstruction of the Temple of Olympian Zeus in Syracuse: A Journey in the Metaverse between History and Technology**
Nicolò Di Marco (University of Catania), Elvia Maria Letizia Giudice (University of Catania) and Filippo Stanco (University of Catania)
- 784 **Surface Features of the Giovanni Rasori marble monument (1840, Milan): chemical characterization of degradation and past restoration interventions**
Andrea Bergomi (University of Milan), Paola Fermo (University of Milan), Chiara Andrea Lombardi (University of Milan), Michela Pirovano (Alma Mater Studiorum - Università di Bologna), Antonino Fiorentino (University of Milan), Mattia Borelli (University of Milan), Mario Colella (Università degli Studi di Pavia) and Valeria Comite (University of Milan)

From Surveying Techniques to a 3D GIS Geodatabase

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Abstract – Topographic surveys of buildings are usually performed with a variety of instruments and techniques. Then, dedicated software packages provide 3D metric models that can be enriched with a series of descriptive information. The user can choose between three different options: Building Information Modelling (BIM), Historical Building Information Modelling (HBIM) and 3D GIS Geodatabases.

Particularly regarding cultural heritage buildings, information is extremely heterogeneous.

Geographic Information System (GIS) software packages facilitate the creation of georeferenced 3D environments and geodatabases. This allows linking all the information to the referenced metric building; it is useful for its maintenance, restoration and management. The surrounding environment, to which it is closely connected, plays an important role.

This paper describes how we built a GIS geodatabase of two 3D-modelled apses of a small church in the province of Bergamo. All the available information was gathered and linked in a 3D GIS scene.

I. INTRODUCTION

Surveying buildings, with laser scanners and photogrammetric techniques, provides the input required to construct 3D building models and derive a variety of 2D information, such as vertical and horizontal sections and raster images detailing the building's description at different resolutions. These products are managed with the help of dedicated SFW packages.

Then, the digital description of a building can be achieved in different ways, through BIM (Building Information Modelling) [1], HBIM (Historic Building Information Modelling) [2] and 3D GIS geodatabases.

BIM applications are typically adopted for new buildings, describing their structural elements with a defined library of parametric objects, representing construction components that contain not only geometric attributes, but also information about the physical properties of the applied materials. They are useful across a building's entire lifecycle, starting from its project and construction [3].

HBIM stems from BIM, as a standardised library of parametric objects is insufficient for the complex and diverse architecture of cultural heritage buildings [4]. It is

useful for renovation, maintenance and conservation projects.

3D GIS geodatabases are collectors of heterogeneous information linked to 3D metric features inside GIS georeferenced scenes. In the case of heritage buildings and their ancient origin, they have undergone restoration, maintenance and interventions in time and also have a lot of related documentation which requires long and demanding research work. This material can be made by photos, projects, analyses and text documents of different origins and times. 3D GIS geodatabases become the most effective solution for storing all this heterogeneous material in a single environment and placing the referenced one in the proper spatial position. The advantage is also the possibility to make queries, define topological rules, enrich and update the collected information and add the products of new analyses and acquisitions. The spatial reference also becomes highly useful when considering the environment in which the building is located, and that deeply influences it with its changes and all kinds of phenomena occurring around it. This allows a better understanding of the building and to find the most suitable decisions for interventions, maintenance and restoration. This way, HBIM models and 3D GIS geodatabases represent the two faces of the same coin and their integration can be useful in many cases [5, 6].

It is also important to underline that the subject of BIM and GIS integration has been widely analyzed [7, 8, 9]. However, recently, a major step towards resolving this debate has been made thanks to a new partnership that allows users to integrate BIM products into GIS environments directly. Esri has partnered with Autodesk [10] to put GIS and BIM integration at the centre of construction projects. By accurately georeferencing BIM models, they are correctly placed in the real world. This alignment is essential for integrating BIM data with other geospatial data layers, such as maps, satellite imagery and environmental data [11].

The solution is provided by a relevant package called ArcGIS GeoBIM [12].

This is the first step, primarily focused on the project and management of buildings. However, in time, we hope to have new developments, also concerning a more complete and effective management of cultural heritage buildings and their heterogeneous information.

Going back to the digital description of a building, the first step, common to all three ways previously mentioned, is a topographic survey: surveying buildings, with laser scanners, GNSS receivers and photogrammetric techniques, provides the input required to construct georeferenced 3D building models and derive a variety of 2D information, such as vertical and horizontal sections and raster images detailing the building description at different resolutions. These products are managed with the help of dedicated SFW packages.

Drawing on previous studies [13 and mainly 14], this paper describes how it is possible to import a georeferenced 3D building model – in this case, of a cultural heritage building – into a GIS software package and establish connections between all the available information. This doesn't provide an HBIM model, but a 3D georeferenced geodatabase, into which all the building's information can be stored and linked to the structure under examination. This can be achieved by creating a geodatabase inside a 3D scene. Here, all the geometric information is referenced and therefore correctly placed, and the non-georeferenced information (such as images, texts, etc.) is linked via attribute tables to the corresponding geometric elements.

In the past, it was difficult to import and manage 3D models in GIS SFW packages, but this is now possible thanks to improved hardware and software.

Geographic Information Systems do not provide the advanced tools of BIM for modelling complex surface shapes of 3D objects. They allow, by now, only 3D basic elements to be edited, such as lines, points and simple 3D objects. On the other hand, GIS applications offer a major advantage: topological rules can be established among objects to evaluate their geometrical and spatial relationships. It is also possible to make queries. This way, the georeferenced 3D model of the building becomes a shell that, with the aid of a geodatabase, allows connecting, storing and updating all the available and new heterogeneous information.

Starting from these assumptions, this paper describes the steps followed to provide a 3D geodatabase of a test case: a small church in the province of Bergamo, which is called the Sanctuary of The Madonna dell'Olmo. The work was completed by taking the following steps: topographic surveys were performed, with varying instruments, and the survey data were processed. Three-dimensional georeferenced models were constructed and some 2D information (horizontal and vertical sections) was derived. Finally, a 3D GIS geodatabase was created in a suitable 3D GIS environment. The geodatabase collects all the referenced information and data without spatial reference, such as texts, images, etc.

Figure 1 outlines the steps required to complete the tasks mentioned above.

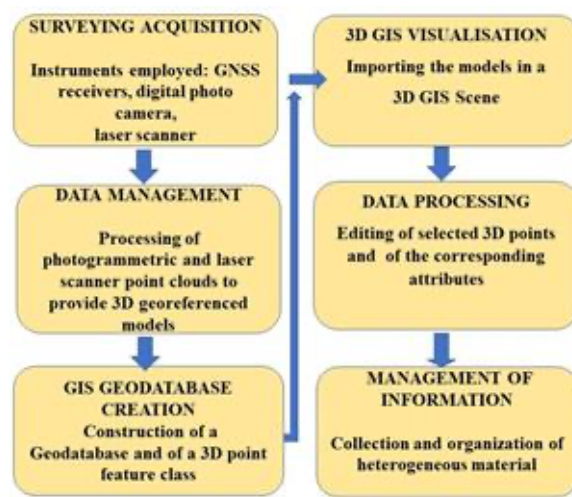


Fig. 1. Flowchart describing the steps taken in this work.

II. THE SANCTUARY OF THE MADONNA DELL'OLMO

The Sanctuary of the Madonna dell'Olmo, which dates to the fourteenth century, is in the southern part of the municipality of Verdellino, a village in the province of Bergamo [15, 16, 17]. The name of the church derives from an ancient legend about a miracle being performed by the Holy Mary through an elm tree once located in what later became the front yard of the church.



Fig. 2. The Sanctuary of the Madonna dell'Olmo.

The church, in Figure 2, was initially built in a rural area and then gradually absorbed by the industrial and residential settlement of Zingonia (around 1960), in the municipality of Verdellino. In 1400, the sanctuary already existed in its present form. It has not undergone major changes over the centuries.

In its outer part, there is a low wall that contains a grassy churchyard, a well, the rustic sacristy and a small bell tower. In the middle of the churchyard stands what remains of the secular elm (part of the trunk with a hollow inside), surrounded by a gate. Behind the elm tree is the entrance, preceded by a small porch that completely covers the façade. Inside, as shown in Figure 3, the sanctuary has a single nave divided into two bays by a pointed arch protruding from the wall.

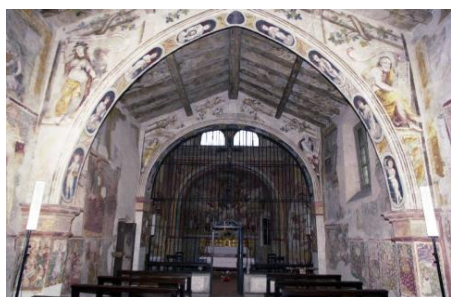


Fig. 3. The interior of the sanctuary [18].

A round arch leads into the presbytery, which has a rectangular plan with three small apses, a high altar and a minor altar on the right. The church is richly decorated with frescoes throughout its interior, on the ceilings, arches and walls. They have been painted in different periods by authors who are, unfortunately, unknown. These frescoes, which hold great historical value, earned the church a special grant in 1914, when the Superintendence of the Monuments of Lombardy declared that the Sanctuary of the Madonna dell'Olmo would be included among the national monuments of art [17].

Up to now, this sanctuary has been studied only from a historical and cultural point of view, and the existing documentation is limited to textbooks and images. Now, thanks to modern surveying techniques, it is possible to create thoroughly georeferenced geometric documentation of the building. This metric and referenced information will help facilitate the management of the building.

III. SURVEY AND DATA MANAGEMENT

All the instruments and software packages employed in this work and the resultant outputs achieved are summarized in Table 1.

Table 1. Instruments, SFW packages and outputs.

	Surveying	GIS
Acquisition Instruments	eSurvey E300 Pro GNSS receiver; Nikon D3300 reflex camera; Faro Focus Premium laser scanner	
Software Packages	Mercurio and Meridiana by Geopro; Scene by Faro; Riscan Pro by Regl; 3DF Zephyr by 3DFlow	ArcGISPro 3.1.3 by Esri
Resultant Outputs	3D Georeferenced Models	3D GIS Geodatabase

The outside of the church was surveyed using a Global Navigation Satellite System (GNSS) receiver, for

georeferencing, and other instruments. A laser scanner, with a camera mounted on board, was used to acquire information on the interior and exterior of the building, while a photogrammetric survey targeted the major and right lateral apses inside the church. The laser scanner was used to survey the complete interior area, but not some side areas of the exterior or the roof. Further surveys could then be performed to complete the missing information.

A GNSS eSurvey receiver, the E300 Pro, was employed [19] to identify a set of points that could serve as the basis for georeferencing the products of the laser scanner and camera. For the interior analyses, we focused on the right side and the major apses of the presbytery. The photogrammetric survey was carried out with a Nikon D3300 reflex camera [20] with a 24.2-megapixel sensor, and the images were taken at a resolution of $6,000 \times 4,000$ pixels. In addition, a Faro Focus Premium laser scanner with a 13-megapixel camera mounted onboard was employed in the survey project [21].

The data were processed using multiple software packages: Mercurio and Meridiana [22] by Geopro, Scene [23] by Faro, Riscan Pro [24] by Regl and 3DF Zephyr [25] by 3DFlow. They allowed us to build a georeferenced (WGS84 UTM32N) laser scanner 3D point cloud for the interior part of the building and two dense photogrammetric 3D point clouds for the two apses. These clouds were then aligned, and finally, with the use of meshes and textures, two 3D georeferenced models were produced. In Figures 4 and 5, we can see (in Zephyr) the final 3D georeferenced models of the right side and major apses of the presbytery section of the sanctuary.



Fig. 4. The right lateral apse.



Fig. 5. The major apse.

It is worth noting that the resolution of the final models was set to the highest possible level. It follows, for example, that, for the 3D model of the major apse, the mesh is of 3,838,878 triangles.

In addition to the georeferenced geometric information, i.e. the two 3D models and horizontal and vertical sections, we collected textual information and images. The whole complex of material was then uploaded into a GIS software. Hence, both the georeferenced and non-georeferenced material facilitated the construction of a 3D geodatabase of the building within a GIS 3D environment, called scene.

IV. A 3D GIS BUILDING GEODATABASE

At this point, we were working inside the SFW package ArcGISPro, version 3.1.3, made by Esri [26]. The aim was to store all the available heterogeneous information, connected with the building, in a geodatabase. This way, it would be possible to easily learn what data are already available, to plan to enrich them with new acquisitions, and evaluate possible maintenance interventions.

The imported files contain the following information:

- two 3D georeferenced models of the right side and major apses of the sanctuary;
- available photos, text and pictures and new georeferenced data, such as vertical and horizontal sections.

We decided to create a geodatabase and a 3D point feature class, to consolidate all the information within the GIS environment. The 3D files were then imported into a 3D scene to provide a geometric referenced vision of the two apses. Figure 6 shows the two models and the volumetry of the surrounding buildings (visualised at their real Orthometric height), in the municipality of Verdellino. This shapefile was downloaded from the Lombardy Geoportal [27]. A topographic basemap, provided by Esri, was chosen as the background.

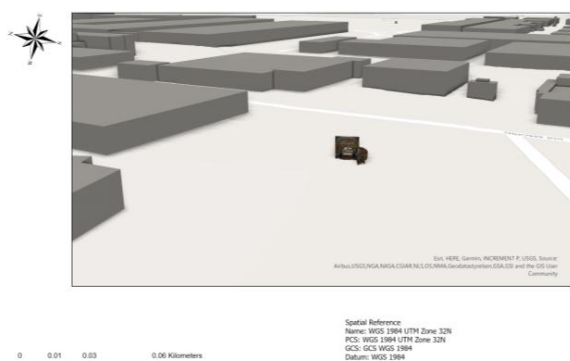


Fig. 6. The 3D referenced models in an ArcGISPro scene with the DBGT (Geo-Topographical Database) buildings.

Focusing, at first, on the major apse, an editing step allowed the selection of some points of interest and to link the corresponding information, such as images, texts and descriptions, inside the attribute table. Consequently,

these points could be easily identified and selected in the 3D scene by clicking on special symbols.

Figure 7 shows, for a selected point (in cyan) of the major apse, in the 3D scene, the corresponding pop-up window, with the relevant information stored in the attribute table. If there is a preview image, one can click on it and view an enlarged version inside an image editing program.

Then, for each selectable point, we also added, in the attribute table, three fields (columns) which store, in different folders, the corresponding available and new information. They are named Literature (for books, articles, papers, letters, etc.), Pictures (for paintings, images, pictures, photos, etc.) and Analyses (for plans, projects, interventions, restorations, etc.). Each folder can then be organised in subfolders, according to the variety and amount of the available and new information. It is important to collect, keep and update this information in case of future analyses and works.

Two-dimensional georeferenced information derived from the models, such as horizontal and vertical sections, can also be correctly placed in a 3D GIS scene.

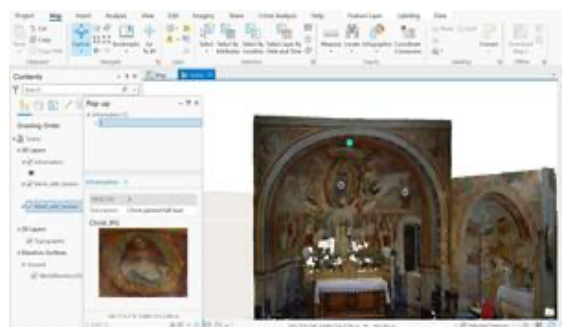


Fig. 7. The available information stored in an attribute table and linked to a selectable point on the 3D georeferenced model of the major apse, in an ArcGISPro scene.

V. DISCUSSION AND CONCLUSION

Thanks to the advantages offered by recent developments in survey instruments and software packages, it is nearly unthinkable to perform a building survey using only one type of instrument. The work described in this paper shows how the use of joint survey instruments and techniques can provide fast and thorough metric georeferenced information on a building.

Our goal was to create a 3D georeferenced geodatabase of a religious cultural heritage building. A GIS environment offers the advantage of providing a complete georeferenced description of a building's geometrical features, which can be enriched with associated heterogeneous information (texts, images, etc.). This is now possible, thanks to advancements in software and hardware. We have described how we were able to create a 3D geodatabase for two apses of the sanctuary.

The next step will be to enrich the database, following two different but parallel paths. The first will focus on the research, collection and reordering of all existing heterogeneous material that can be found. The second

will provide new georeferenced and non-georeferenced information, starting, for instance, with a survey of the exquisite ceiling frescoes of the two spans and the presbytery dome. This procedure will also be performed for the other frescoes on the walls, to build as many georeferenced 3D models as possible. These will then be connected to the geodatabase, with the corresponding information. As a further step, we plan to use a drone to acquire a comprehensive 3D georeferenced model of the building exteriors. Another task will be to perform a georadar survey of the floors inside the sanctuary and the outside areas at the front. It has been claimed, but not yet verified, that some hidden rooms and built areas could exist just below the sanctuary's interior and close to the premises.

As noted above, this will help to produce a 3D geodatabase, always updatable with both old and new data, that is useful for managing the building, for instance, by maintenance and possible restoration. Geographical referencing also facilitates the analysis of the influence and possible problems related to the surrounding environment, such as atmospheric phenomena, air quality, soil texture and geology, seismic events, etc. It is important to consider the close relationship between a building and its surroundings and only georeferenced information can help achieve this purpose. In fact, at the sanctuary we studied, an issue with water infiltration had recently damaged the dome. Work is underway to repair the church and prevent future damage.

Besides, GIS environments are extremely flexible, allowing work at different scales, according to requirements. This way, it is possible to focus on large-scale particulars, with a high Level of Detail (LOD), or to consider a wider environment, at small-scale, with a reduced Level of Detail.

The OGC standard CityGML defines five LODs, ranging from 0 to 4, which state the amount of geometric and semantic information provided to describe a building. At LOD0, a 3D edifice is represented by its simple 2D footprint and, finally, LOD4 defines the interior features of an architecturally detailed 3D model [28].

GIS applications typically address territorial issues at a small scale; however, when they focus on specific analyses of a building at a large scale, the level of detail plays an important role. For this reason, it is crucial to decide the priorities of a project. If the purpose, for instance, is the study of a building within its environment, the building LOD can be low; otherwise, if the work is focused on the analysis of the walls of a crypt, the LOD must be higher. As said, GIS environments offer the advantage of being extremely flexible and allow working at different scales.

According to these assumptions, a building survey is performed with different instruments, from drones to laser scanners, which provide 3D models at different resolutions.

It has to be remembered, anyway, that only the integration of BIM and GIS is the best approach for a

thorough description of a building, whose project and management are highly influenced by the surrounding environment. As seen above, this integration is now possible and, in time, it will hopefully evolve, also concerning the management of cultural heritage buildings and their legacy and new heterogeneous information.

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