

DIGITAL HERITAGE 2025

8 – 13 September 2025

Siena, Italy

Congress Chairs & Co-Chairs

Stefano Campana (University of Siena)

Daniele Ferdani (CNR ISPC)

Holger Graf (Fraunhofer IGD)

Gabriele Guidi (Indiana University)

Sofia Pescarin (CNR ISPC)

Fabio Remondino (FBK)

Scientific Chairs

Livio de Luca (CNR)

Maria Roussou (University of Athens)

Roberto Scopigno (CNR ISTI)

Publication Chair & Co-Chair

Gabriele Guidi (Indiana University)

Zackary Hegarty (Indiana University)

Poster Chairs

Hasan Kutlu (Fraunhofer IGD)

Selma Rizvic (University of Sarajevo)

Expo Chairs

Daniele Ferdani (CNR ISPC)

Sarah Kenderdine (EPFL)

Augusto Palombini (CNR ISPC)

Social Media Chair

Laura Travaglini (CNR ISPC)

Proceedings Production Editor

Dieter W. Fellner (Graz University of Technology, Austria)

Sponsored by EUROGRAPHICS Association

This work is subject to copyright.

All rights reserved, whether the whole or part of the material is concerned, specifically those of translation, reprinting, re-use of illustrations, broadcasting, reproduction by photocopying machines or similar means, and storage in data banks.

Copyright ©2025 by the Eurographics Association
Postfach 2926, 38629 Goslar, Germany

Published by the Eurographics Association
–Postfach 2926, 38629 Goslar, Germany–
in cooperation with
Institute of Visual Computing at Graz University of Technology
and
Fraunhofer Austria, Graz

ISBN 978-3-03868-277-6

The electronic version of the proceedings is available from the Eurographics Digital Library at
<https://diglib.eg.org>

Track 1 – Documentation, Preservation, Monitoring and Restoration

Digital Tools for Monitoring Heritage at Risk

- | | |
|-------------|---|
| dh.20253266 | Novel Documentation and Identification Methods for Combating Illicit Trafficking of Cultural Goods - ENIGMA Pilot Case Studies
<i>Charalampos Georgiadis, Nick M. L. Mols, and Chris Vastenhoud</i> |
| dh.20253067 | Under Fire Heritage of Ukraine: some insights from early damage assessment activity
<i>Marco Nebbia and Gai Jorayev</i> |
| dh.20253226 | Corpus-Based SKOS Development for Underrepresented and Endangered Ukrainian Epigraphic Heritage
<i>Hamest Tamrazyan and Emanuela Boros</i> |
| dh.20253384 | Monitoring Cultural Heritage in the Nagorno-Karabakh Conflict: The Mission and Methods of Cultural Heritage Watch (CHW)
<i>Adam T. Smith, Ian Lindsay, Lori Khatchadourian, and Husik Ghulyan</i> |
| dh.20253387 | Hidden Heritage: The E-FORESTER Project as a New Opportunity to Search for Relics of Past Human Activities in Forests
<i>Włodzimierz Rączkowski, Monika Konatowska, Paweł Rutkowski, and Adam Młynarczyk</i> |
| dh.20253185 | Low-Cost LiDAR Sensors for the Survey of Underground Cultural Heritage: applications on the Siena Bottini (Italy)
<i>Gioele Rossi, Paolo Ceccotti, Maria Elena Di Troilo, Fabio Gabbrielli, Marco Giamello, Enrico Tavarnelli, and Antonio Tizzani</i> |

Predictive Analysis, AI, Simulation, and Novel Computational Methods

- | | |
|-------------|--|
| dh.20253312 | 3D Autonomous Agents for Virtual Heritage
<i>Zackary Hegarty and Gabriele Guidi</i> |
| dh.20253126 | A cathedral of spatialised annotations portraying the multidisciplinary study of Notre Dame de Paris
<i>Roxane Roussel, Livio De Luca, Anais Guillem, and Florent Comte</i> |
| dh.20253389 | The RePAIR Project: Datasets for archaeological and restoration studies in Pompeii
<i>Gabriel Zuchtriegel, Maria Antonella Brunetto, Elena Gravina, Maria Cristina Napolitano, Francesca Simona Ricciardi, Alessandra Zambrano, Marina Khoroshiltseva, Luca Palmieri, Marcello Pelillo, Sebastiano Vascon, Gur Elkin, Ofir Itzhak Shahr, Yaniv Ohayon, Nadav Alali, and Ohad Ben-Shahar</i> |
| dh.20253376 | A Knowledge Graph for Andean Ritual Heritage: Structuring the Chunchada Dance in Honor of the Virgin of Rosario (Paucartambo, Peru)
<i>Dina Cornejo Meza, Javier Vera Zúñiga, and Carmen Gutiérrez Cuadros</i> |

- | | |
|-------------|--|
| dh.20253386 | Automated Detection of Prehistoric Tumuli in the Sahara: A Deep Learning Approach to Satellite Imagery
<i>Alessia Brucato</i> |
| dh.20253232 | A Preliminary Study of the Morphology and Spatial Distribution of Funerary Elements in the Southwestern Cemetery of Wadi al-Ma'awel, Oman
<i>Ana Sofia Meneses, Marco Solinas, M. Ramazzotti, and Massimo Musacchio</i> |

Digitization, Documentation, and Dissemination Workflows

- | | |
|-------------|---|
| dh.20253273 | 3D Technologies on the Underwater Archaeological Site of the Ancient Lighthouse of Alexandria (Egypt)
<i>Isabelle Hairy, Mohamed Abdelaziz, and Mohamed Elsayed</i> |
| dh.20253156 | Digitisation of the Plaster Casts of Lia and Rachele from the Tomb of Julius II by Michelangelo: Methodological Workflow for Data Collection and Photogrammetric Acquisition Processes
<i>Giulia Vaccari, Giovanni Grimaudo, Federico Niccolai, and Juri Ciani</i> |
| dh.20253322 | Epigraphy in Motion: Deciphering Armenia's Tapanakar Inscriptions via Mobile LiDAR
<i>Zachary Shord, Marley Roy, Zara Grigoryan, Anahit Yeghiazaryan, and Satenik Baghdasaryan</i> |
| dh.20253361 | Digital tools and conservation processes: Tomaso Buzzzi's staircase at Palazzo D'Azeglio in Turin
<i>Gerardo Bonito, Giulia Sammartano, Francesco Novelli, Filiberto Chiabrando, Giacomo Patrucco, and Xincheng Li</i> |
| dh.20253034 | Textile Photography with Pixel Shift Multi Shooting for Merdeka Textile Museum Archival Project
<i>Delas Santano, Maslisa Zainuddin, and Melissa Ann Marie James</i> |
| dh.20253017 | Cultural Heritage Dissemination Via Websites - Case Studies
<i>Stanislaw Piotr Skulimowski, Marcin Badurowicz, Kamil Zyła, and Piotr Tokarski</i> |

From 3D Models to Digital Platforms and Digital Twins

- | | |
|-------------|---|
| dh.20253309 | Hypothetical Reconstruction for the Conservation, Preservation and Valorisation of Cultural Heritage: the Kampanopetra Basilica in Salamis, Cyprus
<i>Marina Faka, Rahaf Orabi, Anastasia Tsagka, Andreani Papageorgiou, Valentina Vassallo, Sorin Hermon, and Nikolas Bakirtzis</i> |
|-------------|---|

dh.20253391	Visualization, Virtualization, and 3D Data Analysis in the Historical (Re) Construction of Household, Village, and Regional Landscapes: The Mount Amiata-Maremma Digital Heritage Project <i>D. Bigiotti, B. Baleani, Herbert Maschner, M. Nucciotti, and Stefano Campana</i>
dh.20253357	From HBIM to Digital Twins: An Interoperable Framework for Semantic Knowledge Integration and Dynamic Monitoring of Historic Buildings <i>Sabrina Becker, Laura Valderrama Niño, and Uwe Rüppel</i>
dh.20253090	Digital Recording of the Domus of Arianna in Pompeii: Toward a HBIM Platform for Site Management <i>Daniela Oreni, Dina Jovanovic, and Luigi Barazzetti</i>
dh.20253137	Low-Cost Digital Organization, Digitization and Valorization of Small Archives: The Jewish Archive of Pisa <i>Andrea D'Errico, Francesca Valentina Diana, Silvia Di Giovanna, Angelica Lo Duca, Andrea Marchetti, Manuela Moretti, and Mafalda Toniazzi</i>
dh.20253385	Filling the gap. The Challenge of loss and two outcomes of the Mapping Sacred Spaces Project <i>Ruggero Longo, Elisabetta Scirocco, and Manuela Gianandrea</i>
dh.20253276	Mediating Art History Data Models for Native Linked Data Construction using ResearchSpace <i>Alessandro Adamou and Polina Voronova</i>

Instrumental and Computational Approaches for CH Conservation and Restauration

dh.20253072	Digital Inpainting of Damaged Frescoes Using a Fine-Tuned Diffusion Model <i>Milena Smolka and Bogdan Smolka</i>
dh.20253084	Infrared Reflectography of the Madonna con Bambino, San Pietro Martire e San Giovannino by Lorenzo Lotto <i>Ilaria Improta, Maristella Marra, Sara Vitulli, Alessia Zaccaria, and Sabrina Peluso</i>
dh.20253242	Research on precise restoration of Thangka and Tibetan murals integrating contour drawing techniques <i>Mingxu Li</i>
dh.20253088	Preventive and planned conservation: an algorithm for the analysis and evaluation of degradation phenomena in Cultural Heritage <i>Ilaria Improta and Emanuela Lanzara</i>
dh.20253149	Survey and Digital Representation of the Statue of San Carlo Borromeo in Arona to Support Conservation Activities <i>Daniela Oreni and Luigi Barazzetti</i>

Track 2 – Policy, Standards, Ethics, and Education

From DH Theory and Principles to Innovative Practice: Participation, Training, and Access

- | | |
|-------------|---|
| dh.20253003 | A Grounded Theory Towards Intangible Architecture, A Systematic Review and Meta-analysis
<i>Nezam Haghiabi, Hasan Sajadzadeh, Mahdi Sharifi, and Hamidreza Babaali</i> |
| dh.20253007 | Project to Operationalize the Seville Principles
<i>Bernard Frischer and Víctor Manuel López-Menchero Bendicho</i> |
| dh.20253124 | From Data to Situated Knowledge: Designing Metadata for Plural and Participatory Cultural Heritage
<i>Simona Colitti, Margo Lengua, Sivia Gasparotto, and Elena Maria Formia</i> |
| dh.20253169 | Large Language Models for Museum Label Optimization: A Case Study on Ministerial Compliance and Cultural Accessibility in Galleria Sabauda's Flemish Collection
<i>Melissa Macaluso, Enrico Mensa, Anna Maria Marras, and Paola Pisano</i> |
| dh.20253382 | The Timeless Art of Special Effects: From Renaissance Stagecraft to Extended Reality
<i>Perla Gianni Falvo, Giovanni Valeri Manera, Michael Saari, and Gabriele Guidi</i> |
| dh.20253036 | Bridging Disciplines for Heritage Professionals: The H2IOSC Digital Training Platform (by CLARIN, DARIAH, E-RHIS and OPERAS)
<i>Antonina Chaban, Laura Benassi, Giulia Pedonese, Francesca Frontini, Roberta Ottaviani, Federico Boschetti, Alessia Spadi, Lucia Francalanci, Alessia Sconamiglio, Pietro Restaneo, and Jana Striova</i> |
| dh.20253310 | Enduring Memory: Participatory Digital Experiences for Exploring the Contemporary Past at Camp 65
<i>Daniele Mittica</i> |

Digital Heritage, Tourism, and Sustainability

- | | |
|-------------|---|
| dh.20253171 | Co-production in Digital Cultural Heritage: Bridging communication, Community, and Sustainability
<i>Beatrice Meo, Camilla Falivena, Alessandro Giosi, and Virginia Mondello</i> |
| dh.20253321 | Technology, Communication, and Sustainable Tourism: Exploring New Approaches for Heritage and Research
<i>Ivana Cerato, Federica Bonifazi, and Sofia Pescarin</i> |

- dh.20253283 | Heritage 5.0 - How emerging technologies can support SMEs innovation in Cultural Heritage
Valentina Apicerni, Silvia Liaci, and Antonia Gravagnuolo
- dh.20253272 | Reshaping Identities. How the Ugo and Olga Levi Foundation Navigates the Digital Age
Making Sense of Its Heritage
Elena Missaggia, Monica Calcagno, and Andrea Carlo Lo Verso
- dh.20253019 | Experimenting with Young Adults' Digital Engagement to Leverage Cultural Heritage as
Catalyst for Sustainable Development Goals: The Open Atelier Digital Competition
Gennaro Postiglione, Giulia Gerosa, Elena Montanari, and Lola Ottolini

Track 3 – Infrastructures, Dataspace, International Projects

Standards and Community-Driven Tools

- | | |
|-------------|--|
| dh.20253006 | Transforming Cultural Heritage Through Digital Innovation - Case Study of eKultura
<i>Jelena Rubic and Laura Šejic</i> |
| dh.20253115 | Early Stage of Community-Driven UI/UX Refactoring of the Open-Source ATON Framework
<i>Chiara Florise Amadei, Marcello Massidda, Sofia Menconero, Giorgio Gosti, and Bruno Fanini</i> |
| dh.20253189 | Designing and developing ICH Atlas: A Trend Identification Platform for Digital Valorization of Intangible Cultural Heritage
<i>Chiara Di Lodovico, Arianna Bertolino, Davide Spallazzo, Ilaria Bollati, and Greta Cappellini</i> |
| dh.20253253 | Broadening Data and Digital Skills within Communities to Access Digital Research Infrastructures
<i>Karina Rodriguez Echavarria and Myrsini Samaroudi</i> |

Infrastructures, Platforms and Digital Ecosystems

- | | |
|-------------|---|
| dh.20253167 | C3DHN - An evolutive French Ecosystem for heritage data preservation: methodology, technologies and community
<i>Florent Laroche, Sarah Tournon, Xavier Granier, Mehdi Chayani, Anthony Pamart, Bruno Dutailly, Matthieu Quantin, Valentin Grimaud, Sylvie Eusebe, and Olivier Marlet</i> |
| dh.20253041 | H/RADIOA: Recommended Approaches for the Development of Interoperable Open Semantic Artefacts in the Heritage Domain
<i>Erica Scarpa, Riccardo Valente, and Irene Rossi</i> |
| dh.20253369 | Determining a General CH Digitization Process Based on a Scoping Review
<i>Cindy Kröber and Sander Münster</i> |
| dh.20253292 | A Holistic Digital Ecosystem for Sustainable Cultural Heritage Management in Türkiye: National Museum Information System (MUES)
<i>Hakan Melih Aygün and Irmak Günes Yüceil</i> |
| dh.20253367 | Shared Data, Shared Practice, Shared Knowledge: Insights from Building NFDI4Culture's Federated Research Data Infrastructure for Cultural Heritage
<i>Torsten Schrade, Linnaea Söhn, Alexandra Büttner, Tabea Tietz, Jonatan Jalle Steller, Harald Sack, Etienne Posthumus, Oleksandra Bruns, Heike Fliegl, and Sarah Pittroff</i> |

dh.20253098	ChainPro - A Web3 Platform for Artists <i>Ferdinando Bosco, Vincenzo Croce, and Marcantonio La Franca</i>
dh.20253052	3D Digital Silk Road - the Project and Its Results Overview <i>Marek Milosz, Elzbieta Milosz, and Jerzy Montusiewicz</i>
dh.20253261	Rome Reborn: Status Report and Future of the Project <i>Bernard Frischer and Mohamed Abdelaziz</i>

Data Analysis, Datasets and Multimodal Approaches

dh.20253104	Spatialization, fusion and enrichment of Multimodal Imaging for Interdisciplinary Digital Heritage Studies <i>Anthony Pamart, Livio De Luca, and Philippe Veron</i>
dh.20253079	Introducing Sociodata in Virtual Museums: A Holistic Approach for Sustainable Development in Cultural Landscapes <i>Sharon Pisani, Alan Miller, Catherine Cassidy, Loraine Clarke, Iain Oliver, and Goncalo Gomes</i>
dh.20253381	Towards a Scientometric Understanding of Cultural & Digital Heritage: Multi Source Data Integration Pipeline & EC Funding Trends <i>Walter Ehrenberger and Sander Münster</i>
dh.20253317	I.PaC and semantic graphs to represent Italian Cultural Heritage <i>Margherita Porena, Margherita Bartoli, Luigi Cerullo, and Antonella Negri</i>
dh.20253150	Enhancing the study of historical figures through AI-powered interactive data visualizations <i>Giovanni Profeta, Joseph Cornelius, and Fabio Rinaldi</i>
dh.20253256	A Searchable Multimodal Dataset of Rococo-Era Ornamental Prints <i>Thomas Hudcovic, Ines Röckl, Julian Jachmann, and Gabriel Zachmann</i>
dh.20253040	From Black Books to Burners: Street Art as Cultural Heritage <i>Patrick Mcinerney and Kieran Cronin</i>

Track 4 – Acquisition and Digitization

Digitization and Technology

- | | |
|-------------|---|
| dh.20253158 | CultLab3D to CultArm3D - The first autonomous, robot-assisted, color-faithful 3D digitization technologies for cultural heritage collections
<i>Pedro Santos, André Stork, and Dieter W. Fellner</i> |
| dh.20253073 | Hacking Light in the Digitization of Archaeological Glass Vessels: the Quest for Geometric Rigor
<i>Vanessa Cornago Espuelas</i> |
| dh.20253025 | A Practical Inverse Rendering Strategy for Enhanced Albedo Estimation for Cultural Heritage Model Reconstruction
<i>Ruggero Pintus, Antonio Zorcolo, Alberto Jaspe-Villanueva, and Enrico Gobbetti</i> |
| dh.20253050 | Material Studies For Digital Heritage: Comparative Analysis of Geometric and Photometric 3D Representations
<i>Fabian Töpfer, Eliane Christ, Zhongyuan Yu, Lars Engeln, and Matthew McGinity</i> |
| dh.20253128 | Evaluating the Impact of Lighting Conditions on Photogrammetric Acquisition of Cultural Heritage
<i>Federico Gangi, Malik Umair Shafqat, and Gabriele Guidi</i> |

Digitization Tools and Applications

- | | |
|-------------|---|
| dh.20253306 | Bringing Stones to Life: The First Digital 3D Library of Ancient Armenian Gravestones
<i>Aleksei Andrianov, Garegin Muradyan, Zhanna Andrianova, and Narine Sarvazyan</i> |
| dh.20253174 | Unsupervised Colorization and Diffusion-Based Virtual Try-On for Ottoman Heritage Preservation
<i>Zeynep Akant, Elman Ghazaei, and Selim Balcisoy</i> |
| dh.20253285 | "Out There," Anywhere: Digital Proxies for Threatened Cultural Heritage Sites and Structures
<i>Eva Deisa, Sarah Tucker, Alex Kinnaman, and Todd Ogle</i> |
| dh.20253301 | Level-of-Detail Digitization of High Ceilings in Virtual Reality
<i>Jacob Edwards, Stephen D. Laycock, Thomas Roebuck, YingLiang Ma, and Cheng Wang</i> |
| dh.20253008 | UAV survey and large-scale digitization. Avenues for making visible the massive data on the archaeological landscape of the Lovo massif (DRC)
<i>David Lo Buglio, Michel Lefèvre, Geoffroy Heimlich, and Clément Mambu Nsangathi</i> |

- dh.20253366 | Drone-Based Magnetic Survey: Testing a New Approach for Archaeological Prospection
Alessia Mandorlo, Iacopo Nicolosi, Roberto Carluccio, Lorenzo Conti, Lorenzo Lambiase, Samuele Fantini, Giancarlo Morelli, Giancarlo Pastura, Giuseppe Ceraudo, and Stefano Rl. Campana
- dh.20253144 | Comparing MVS and Gaussian Splatting for the 3D Reconstruction of Reflective and Texture-less Cultural Heritage Artifacts
Paolo Clini, Roberto Pierdicca, Romina Nespeca, Renato Angeloni, and Laura Coppetta

Digitization and Segmentation

- dh.20253047 | 2D and 3D Semantic Segmentation for Interpreting and Understanding 3D Heritage Spaces
Ahmad El-Alailiyi, Gabriele Mazzacca, Ashkan Alami, Nazanin Padkan, Narges Takhtkeshha, Francesco Fassi, and Fabio Remondino
- dh.20253075 | Comparing OCR Pipelines for Folkloristic Text Digitization
Octavian M. Machidon and Alina L. Machidon
- dh.20253026 | Acquisition and digitization of large scale heritage scenes with open source project <https://github.com/MapsHD/HDMapping>
Janusz Bedkowski, Marcin Matecki, Michal Pelka, Karol Majek, Tresya Fitri, and A. Kostrzewa
- dh.20253113 | ArTLLaMA: Adaptating LLaMA to Performative Art Applications
Elisa Passone, Federico Borazio, Claudiu Daniel Hromei, Danilo Croce, and Roberto Basili
- dh.20253170 | Towards interdisciplinary approaches combining AI and 2D/3D: Designing a digital environment for the virtual reconstruction of a lost medieval church using a historical ontology
Florent Laroche, Ambre Vilain, Mathis Vauxion, and Elouarn Le Chenadec

Digitization Case Studies

- dh.20253348 | Sun Stones Chronicles: Enriching the Bornholms Museum Brightest Artifact Collection through 3D Scanning and Semantic Web Technologies
Nicola Lercari, M. Nicolás Caretta, Bruno Sartini, Yiming Du, Josephine Bergman, and Dario Calderone
- dh.20253326 | Virtual Reconstruction and Digital Twin of the Royal Monastery of San Benito of Sahagún: A Strategy for the Documentation, Conservation, and Dissemination of Lost Heritage
David Marcos Gonzalez, Daniel López-Bragado, Jesús San José-Alonso, Juan José Fernández-Martín, José Martínez-Rubio, and Antonio Alvaro-Tordesillas

- dh.20253071 | Immersive RockArt: When rock carvings meet photogrammetry and computer graphics
Daniele De Luca, Maria Chiara Liguori, Antonella Guidazzoli, Elisa Mariarosaria Farella, Fabio Remondino, Tiziana Cittadini, and Markus Loeffler
- dh.20253164 | Spatial random access to explore heritage site using spherical video
El Mustapha Mouaddib, Guillaume Caron, and Aرسالane Zarghili
- dh.20253351 | Geometric Modeling for Immersive VR Exploration of Underground Heritage: Matera's Hypogeum Case Study
Brigida Bonino, Daniela Cabiddu, Mattia D'Alonzo, Katia Lupinetti, Michela Mortara, and Simone Pittaluga
- dh.20253053 | 3D Digitalization of Wooden Churches - Techniques and Challenges During Preservation Efforts
Marcin Badurowicz, Stanislaw Piotr Skulimowski, Jerzy Montusiewicz, and Tomasz Szymczyk

Track 5 – Analysis and Interpretation

Semantics-driven Interaction with Digitized Heritage

- | | |
|-------------|--|
| dh.20253099 | Procezo: Data Processing Services for 3D Analytics
<i>Giorgio Gosti, Sofia Menconero, Chiara Florise Amadei, and Bruno Fanini</i> |
| dh.20253166 | Prompting Meaning: Optimizing Prompt Engineering for Architectural Point Cloud Interpretation
<i>Marina Paolanti, Nikhil Muralikrishna, Lucrezia Gorgoglione, and Roberto Pierdicca</i> |
| dh.20253298 | IBE meets AIR: a framework for structured archaeological reasoning and digital reconstruction
<i>Danilo Marco Campanaro, Paola Derudas, Mikkel H. Thomsen, Brendan Foley, and Federico Nurra</i> |
| dh.20253180 | Innovative Approaches through 3D Survey and Virtual Technologies for the Geometric and Semantic Fruition of Built Heritage Sites on the Web
<i>Manuela Aricò, Souhir Cherif, Marcello La Guardia, and Mauro Lo Brutto</i> |
| dh.20253280 | NL-2-SPARQL: Ontology-Based Natural Language Querying over 3D Point Cloud Knowledge Graphs
<i>Matteo Codiglione and Fabio Remondino</i> |
| dh.20253200 | Acting Like an Expert: Analyzing Eye and Movement Behavior when Exploring Archaeological Artifacts
<i>Maxime Dumonteil, Théophane Nicolas, Marc J.-M. Macé, Valérie Gouranton, Yan Leguedois, and Ronan Gagne</i> |

Analysing and Documenting the Creation Process, Evolution and Context

- | | |
|-------------|--|
| dh.20253042 | Palazzo della Loggia According to Luigi Vanvitelli: a Digital Reconstruction
<i>Silvia De Matteis</i> |
| dh.20253031 | Creative Processes of the Visual Arts and Generative AI. Correspondences between Michelangelo and Sebastiano Del Piombo in the Flagellation of Christ Ideation
<i>Costanza Barbieri, Paolo Clini, Ramona Quattrini, Paolo Pieruccini, and Mirco D'Alessio</i> |
| dh.20253083 | Identification of Violin Reduction via Contour Lines Classification
<i>Philémon Beghin, Anne-Emmanuelle Ceulemans, and François Glineur</i> |

- | | |
|-------------|---|
| dh.20253243 | 4D Data Organization and Alignment atWorld Scale
<i>Sander Münster, Jonas Bruschke, Dávid Komorowicz, Rebecca Debora Preßler, and Vaibhav Rajan</i> |
| dh.20253362 | Perin del Vaga, His Workshop and Patterns of Fresco Painting in the Farnese Tower cycle through Multiple Non-Invasive Analyses
<i>Giulia Iorio, Noemi Zappalà, Valerio Graziani, Luca Tortora, and Costanza Barbieri</i> |

Analysing and Documenting Digitized Assets

- | | |
|-------------|---|
| dh.20253035 | Outside the Wall: Some Applications of TagLab for Semantic Segmentation in Archaeological Practice
<i>Diego Ronchi, Elisabetta Di Virgilio, Samira Mele, Matteo Lombardi, Daniele Ferdani, and Domenica Dininno</i> |
| dh.20253105 | HBIM Modelling Techniques Applied to Gothic Architecture: Insights from the Founder’s Chapel at the Monastery of Batalha
<i>Gabriel Sugiyama, Hugo Rodrigues, and Fernanda Rodrigues</i> |
| dh.20253177 | A Scan-to-BIM Approach for the Preservation of the Architectural and Archaeological Heritage: the Digitisation of the Complex of San Nicolò Regale in Mazara del Vallo (Italy)
<i>Manuela Aricò, Marcello La Guardia, Mauro Lo Brutto, and Giorgio Mineo</i> |
| dh.20253300 | Reinterpreting Guaraní Heritage: Additive Manufacturing for Digital Heritage Strategies for Architectural and Cultural Reconstruction
<i>Florencia Ramirez and Nadja Gaudillière-Jami</i> |
| dh.20253146 | Enhancing Cultural Heritage with Generative AI: A Comparative Framework for the Evaluation of 3D Model Accuracy and Visual Fidelity
<i>Emanuele Balloni, Marina Paolanti, Jacopo Uggeri, Primo Zingaretti, and Roberto Pierdicca</i> |
| dh.20253354 | Solar Panels on Historic Roofs? A Digital Tool for Assessing Sensitive Roof Areas
<i>Yasmin Loeper, Christoph Palmen, and Markus Gerke</i> |
| dh.20253251 | Preserving the Sacred In Situ: A Scalable Model for Hybrid Religious Heritage Documentation
<i>Arnaud Schenkel, Carla Muyle, Henry-Louis Guillaume, Jeroen Reyniers, Valentine Hendriks, Lowie Vercruysse, Koen Janssens, and Olivier Debeir</i> |

Analysing and Documenting Sites and Landscapes

- | | |
|-------------|---|
| dh.20253080 | Mapping Pausania: A GIS-Based Reconstruction of the Laconian Landscape
<i>Marco Cornaglia, Sebastian Barzaghi, and Alessandro Iannucci</i> |
|-------------|---|

- | | |
|-------------|---|
| dh.20253175 | Intra-site Spatial Analysis at Sambuco Cave: Testing Digital 3D Approach for the Interpretation of Upper Palaeolithic Behavioural Strategies
<i>Giovanna Pizziolo, Carlo Tessaro, Matteo Faraoni, Gaia Mustone, and Attilio Galiberti</i> |
| dh.20253205 | High-Resolution LiDAR for Archaeological Prospection in Mediterranean Forested Landscapes: Insights from Two Case Studies in Italy
<i>Giuseppe Prospero Cirigliano, Gabriele Mazzacca, Fabio Remondino, Paolo Liverani, Gianluca Cantoro, Giorgio Pocobelli, Herbert Maschner, and Stefano Campana</i> |
| dh.20253244 | Building Height Assessment for Heritage Site's Surroundings using 3D-GIS Multiple Scenarios
<i>Janjira Sukwai and Nattasit Srinurak</i> |
| dh.20253227 | Digital Exploration of the Hydrosystems of the Haut Adour (French Pyrenees)
<i>Davide Gherdevich, Laurent Costa, Eric Mermet, Fabien Cerbelaud, Aurelia Desplain, and Richard Sabatier</i> |

Extracting Knowledge from Digitized Assets

- | | |
|-------------|--|
| dh.20253069 | An Open-Source Workflow for Handwritten Character Recognition
<i>Silvano Imboden, Antonella Guidazzoli, Giorgia Cardano, Luca Mattei, Federico Andrucci, Deanna Shemek, Rossella Pansini, Fauzia Albertin, and Maria Chiara Liguori</i> |
| dh.20253133 | From Scanned Pages to Semantic Graphs: Scalable Methods for Extracting Historical and Cultural Knowledge Across Heterogeneous Texts
<i>Piotr Malak, Agnieszka Letowska, and Jan Wodzinski</i> |
| dh.20253178 | Voxels for Finite Element Analysis of Cultural Heritage objects
<i>Sara Gonizzi Barsanti, Erika Elefante, and Ernesto Nappi</i> |
| dh.20253359 | Advancing Armenian Inscription Recognition
<i>Gevorg Nersesian, Narine Sarvazyan, and Suren Khachatryan</i> |
| dh.20253119 | The IlluminAI project: a deep neural network and immersive visualization system to enhance illuminated manuscripts
<i>Valeria Minisini, Giorgio Gosti, and Bruno Fanini</i> |

Track 6 – Visualization and Interaction

XR Platforms and Frameworks for Cultural Engagement

- | | |
|-------------|--|
| dh.20253049 | HERIX: An integrated platform for creating Immersive, Interactive and Liquid eXtended Reality experiences for Cultural Heritage
<i>Manuel Fortunato Drago, Emanuele Marino, Sara Serratore, Antonio Lagudi, Loris Barbieri, and Fabio Bruno</i> |
| dh.20253130 | FRAMES: A Platform for Constructing Immersive and Multimodal Extended Reality Exhibitions
<i>Vasileia Eirini Pitikaki, Emmanouil Troulis, Asterios Leonidis, Maria Korozi, and Constantine Stephanidis</i> |
| dh.20253240 | OpenLIME: An open and flexible web framework for creating and exploring complex multi-layered relightable image models
<i>Federico Ponchio, Fabio Bettio, Fabio Marton, Ruggero Pintus, Leonardo Righetto, Andrea Giachetti, and Enrico Gobetti</i> |
| dh.20253252 | User Driven Augmented Reality Registration for Urban Digital Twin Heritage Visualization
<i>Bernhard Öder and Sophie Jörg</i> |

Visual Archives and Historical Imagery in VR

- | | |
|-------------|---|
| dh.20253121 | Stereo Spectacular: Reviving the Universal Exposition of 1867 in Virtual Reality through Historical Stereoscopic Photographs
<i>Dhruva Gowda Storz, Samy Mannane, Tonia Ramogida, Toussain Cardot, and Sarah Kenderdine</i> |
| dh.20253142 | Real-Time Rendering of Old Glass Panes
<i>Alexander Josse, Quentin Huan, François Rousselle, and Christophe Renaud</i> |
| dh.20253176 | Representation of Meta-Paradata for H-BIM Models in WebGIS: Paving the Way Towards '3D Scientific Models'
<i>Alessandra Spreafico, Mohammadreza Mehdizadeh, Erica Casareto, Filiberto Chiabrando, and Cristina Della Coletta</i> |
| dh.20253313 | Swiss Echoes: An immersive and embodied exploration of a national broadcasting archive
<i>Giacomo Alliata, Loïc Serafin, André Rattinger, and Sarah Kenderdine</i> |

Digital Heritage Research: History, Archaeology, and Virtual Reconstruction

- dh.20253173 | Between technical history, industrial archaeology, Digital Humanities and Virtual Reality: A digital corpus of a former industrial site under rehabilitation: the case of CAP 44
Florent Laroche, Matthieu Quantin, William Plessis, Jean-Louis Kerouanton, Sophie Audoux, and Soazig Duchene
- dh.20253316 | Prague Astronomical Clock - Virtual Presentation
Sven Ubik, Oldrich Linhart, Jirí Kubišta, Petr Skála, David Knespl, Jirí Mašek, and Jakub Rocek

Accessibility and Inclusive Engagement

- dh.20253349 | Tactile Embroidery Reproduction Exploiting Machine Vision for Visually Impaired Engagement
George P. Jenkinson, Myrsini Samaroudi, and Xavier Aure Calvet
- dh.20253023 | Exploring Anamorphoses in Immersive Virtual Reality on the Web: Design and Challenges of the Anamorphic Gallery of Anamorphoses (AnGA)
Sofia Menconero, Chiara Florise Amadei, Giorgio Gosti, and Bruno Fanini
- dh.20253082 | Full-fledged Virtual Exploration of Sacred Spaces
Desislava Paneva-Marinova, Zsolt László Márkus, Tibor Szkaliczki, Maxim Goynov, György Szántó, Detelin Luchev, Miklós Veres, Radoslav Pavlov, Zsolt Weisz, Lilia Pavlova, Patrik Martonosi, Attila Hidán, and Konstantin Rangochev

Immersive and Interactive VR/AR Experiences in Cultural Heritage

- dh.20253213 | Augmented Reality Workflows and Prototype Tools for Museums
Fadilah Arief and Erik Malcolm Champion
- dh.20253265 | Cultural VR for the elderly: setting up the experience
Angeliki Antoniou, Stella Sylaiou, George Lepouras, Anastasios Theodoropoulos, and Maria Kyriazi
- dh.20253340 | ARise: an Augmented Reality Mobile Application to Improve Cultural Heritage Resilience
Angelica Urbanelli, Marina Nadalin, Mario Chiesa, Rojin Bayat, Massimo Migliorini, and Claudio Rossi
- dh.20253344 | Co-Designing XR Exhibits: Insights from a Domain Expert Workshop on UI and Interaction Features for Cultural Heritage
Tiago Nunes, Armanda Rodrigues, and Nuno Correia

Reconstructing the Past

- dh.20253016 | Remaking Lost Communities in Virtual Cultural Landscapes
Junyu Zhang, Miriam Sturdee, Alan Miller, Iain Oliver, and Jacquie Aitken
- dh.20253044 | Rediscovering Mural Paintings: Experiencing Medieval Art as Originally Conceived Through Historical Light Simulation
Imanol Munoz-Pandiella, Manvir Kaur-Singh, Carles Bosch, Carlos Andujar, and Xavier Pueyo
- dh.20253062 | From Site to Story: A Virtual Archaeology Project in Arzachena (Sardinia, Italy)
Daniele Ferdani, Bruno Fanini, Diego Ronch, Alfonsina Pagano, and Augusto Palombini
- dh.20253202 | Reconstructing Gladiator Combat: A Multisensory Virtual Reality Training Environment
Ronan Gaugne, Stéphane Salvan, Ewen Cazuc, Valérie Gouranton, and Charles Pontonnier

Digitization and 3D Visualization for Heritage Accessibility

- dh.20253065 | Modern Digitization and 3D Visualization Technologies for Virtual Access to Hard-to-reach or Perished Historical Sites
Piotr Tokarski, Marek Milosz, and Jacek Kesik
- dh.20253279 | Spatiando con gli Occhi: Delivering an Interactive 3D Reconstruction of 17th-Century Rome
Joanna Mundy, John Halbert, and Ian Burr
- dh.20253342 | ESILab: An efficient software for immersion and exploitation of large point clouds
El Mustapha Mouaddib, Jordan Caracotte, Dorian Kempf, Noël Villette, and Thibault Potin

Narratives, Multimodality, and Emotional Engagement in Heritage

- dh.20253107 | Riding the Hippogriff: a VR Exploration of Orlando Furioso Epic Poem
Annalisa Mombelli, Elisa Silva, Gianluca Genovese, Fabrizio Bondi, and Roberto Montanari
- dh.20253045 | Evaluating the role of video within multi-sensory cultural experiences
Stamatia Ladikou and Anastasia Chourmouziadi
- dh.20253234 | Reinterpreting Heritage Site Through Collective Memory and Augmented Reality - The Case of Nanjing's Great Bao'en Temple
Yimeng Chen, Mingdong Song, and Yuying Li
- dh.20253353 | Bridging Psychological Distance from Climate Change through Experiential Learning within Heritage Organisations
Maria Andrei, Sonja Heinrich, Jason Jacques, Iain Oliver, Sharon Pisani, Alan Miller, and Richard Bates

AI and Generative Techniques for Heritage Reconstruction

- | | |
|-------------|---|
| dh.20253011 | GenAI-Based Reconstruction of Prehistoric Remains
<i>Juan A. Barceló and Endoxia Tzerpou</i> |
| dh.20253085 | A multimodal approach to 3D modelling of Spanish cultural heritage buildings for visualization and management based on generative AI and geospatial data
<i>Miguel Antonio Barbero-Álvarez, Javier Rodríguez Peña, Cristian Olmedo Ferrero, and Marina A. Álvarez Alonso</i> |
| dh.20253282 | Bringing the Gonzaga Equestrian Heritage to Life: AI-Enhanced VR Storytelling for Cultural Dissemination
<i>Zhou You, Daniele Treccani, and Andrea Adami</i> |
| dh.20253238 | Integrating Artificial Intelligence in the Design of Interactive Experiences. An Overview for Digital Cultural Heritage Practitioners
<i>Manuele Veggi</i> |

Storytelling and Interpretation in Digital Heritage

- | | |
|-------------|---|
| dh.20253214 | Contextualism and Music Annotation: Exploring the Role of Digital Storytelling about a Composer's Life on Music Perception
<i>Dimitra Petousi, Lori Kougioumtzian, Akrivi Katifori, Maria Boile, Katerina Servi, Yannis Ioannidis, Vera Kriezi, Valia Vraka, Stefania Merakos, and Alexandros Charkiolakis</i> |
| dh.20253268 | Beyond Street Signs: Ethical and Situated Cultural Storytelling using AI and Extended Reality
<i>Marina Toumpouri, Marios Constantinides, Václav Milata, Sophia Ppali, Lampros Alexopoulos, and Fotis Liarokapis</i> |
| dh.20253220 | 360° Virtual Tours at the National Roman Museum. Making Culture Heritage Participatory, Accessible, and Personalized
<i>Eliana Maria Torre, Antonella Poce, Diana Andone, and Marius-Cosmin Tătaru</i> |
| dh.20253203 | The Secret of Bastet: Integrating VR and 3D Printing for the Study and Exhibition of a Cat Mummy
<i>Ronan Gaugne, Jérémy Lacoche, Odile Hays, Théophane Nicolas, and Valérie Gouranton</i> |

Track 8 – Digital Technologies for Colour

PERCEIVE: Exhibiting the "Unexhibitable"

dh.20253350	Perceptive Enhanced Realities of Coloured Collections through AI and Virtual Experiences <i>Sofia Pescarin, Birgitte Aga, I. Y. Arteaga Kiyomoto, Cristiana Barandoni, Federica Bonifazi, Beatrice G. Boracchi, Lucia Burgio, Ivana Cerato, Irina Ciortan, Arthur Clay, Bruno Fanini, Gemma Chiara Fedon, Daniele Ferdani, Holger Graf, Jon Y. Hardeberg, Donata Magrini, Marcello Massidda, Paschalis Panteleris, Giorgos Papadopoulos, Marios Pitikakis, I. C. A. Sandu, S. N. Sinha Neil, P. Siozos, S. Sotiropoulou, S. Spotti, P. Stavroulakis, L. Travaglini, G. Trumpy, and M. Veggi</i>
dh.20253147	An Atlas-based Approach for Appearance-aware Virtual 3D Restoration and Simulation of Fading in Fugitive Textiles <i>Saptarshi Neil Sinha, Irina M. Ciortan, Tom Kneiphof, Paul Julius Kühn, Brenda Doherty, Lucia Burgio, Richard Palmer, Catarina Pinto, Laura Martel, David Buti, Letizia Monico, Reinhard Klein, Arjan Kuijper, and Michael Weinmann</i>
dh.20253102	Interactive and immersive discovery of diagnostic processes on multi-layered 3D collections on the web: the MuLaX tool <i>Bruno Fanini, Marcello Massidda, Daniele Ferdani, Federica Bonifazi, Donata Magrini, Roberta Iannaccone, and Cristiana Barandoni</i>
dh.20253061	Text2Autochrome: Text guided autochrome synthesis using generative models <i>Paul Julius Kühn, Saptarshi Neil Sinha, Duc Anh Nguyen, Robin Horst, Arjan Kuijper, and Dieter W. Fellner</i>
dh.20253314	What can a historic black and white photograph tell us about the original colours of a painting? A case study on Edvard Munch's the Scream (1910?) <i>Panagiotis Siozos, Irina Crina Anca Sandu, Petros Ioannis Stavroulakis, and Sophia Sotiropoulou</i>
dh.20253108	Implementing Curiosity Hooks and Caring Practices in the Reconstruction of Lost Polychromy: Design Prototypes for Interactive Experiences. <i>Federica Bonifazi, Manuele Veggi, Marcello Massidda, Daniele Ferdani, and Sofia Pescarin</i>
dh.20253148	Designing Authentic Digital Experiences <i>Samuele Spotti, Federica Bonifazi, Marcello Massidda, Sofia Pescarin, and Laura Travaglini</i>

Track 9 – Collaborative Cloud for CH (ECHOES)

Collaborative Cloud for CH (ECHOES SESSION)

- | | |
|-------------|--|
| dh.20253188 | Application of LiDAR Sensors for the Reconstruction of the Production Techniques of Artificial Conglomerate Blocks: the Case of the Maconi Tower - Siena (Italy)
<i>Gioele Rossi, Jacopo Bruttini, Stefano Camporeale, Fabio Gabbrielli, Marco Giamello, and Enrico Tavarnelli</i> |
| dh.20253194 | Designing a Virtual Museum Ecosystem for the Cloud
<i>Alan Miller, Catherine Cassidy, Sharon Pisani, Maria Andrei, Junyu Zhang, Sarah Kennedy, Iain Oliver, Jacquie Aitken, Ray Williams, and Vanessa Martin</i> |
| dh.20253278 | Straniere: a Digital Archive on the Reception of non-European Arts and Cultures in Italy (1945-2000)
<i>Caterina Toschi, Livia de Pinto, Biancalucia Maglione, and Rachele Zanone</i> |
| dh.20253302 | Smart Collection Ingestion in the European Cultural Heritage Cloud: Toward Scalable, Semantically Enriched, Interoperable Cataloguing
<i>Paolo Ongaro, Sam Habibi Minelli, Daniele Duranti, Naomi Poli, Martina Rossi, Daniele Ugoletti, Rubino Saccoccio, and Alberto Raggioli</i> |
| dh.20253160 | The IMPULSE Project: Advancing Immersive Digitization for Sustainable Digital Cultural Heritage Integration within ECCCH.
<i>Lorela Mehmeti, Margherita Ascari, Valentina Gianfrate, Zaneta Zeglen, Dimitris Charitos, and George Anastassakis</i> |
| dh.20253358 | The collaborative Basilica Iulia Project: A Digital Knowledge Ecosystem for Integrated Archaeological Research
<i>Emanuel Demetrescu, Tommaso Ismaelli, Simone Berto, Sara Bozza, Giacomo Casa, Marika Griffo, Rachele Manganelli del F , and Eleonora Scopinaro</i> |
| dh.20253325 | Towards the Definition of the Heritage Digital Twin Ontology for the European Collaborative Cloud for Cultural Heritage
<i>Maria Theodoridou, Florian Hivert, Athina Kritsotaki, B atrice Markhoff, Martin Doerr, and Sorin Hermon</i> |

Track 10 – H2IOSC Project Development (H2IOSC SESSION)

H2IOSC Project Development

dh.20253009	Prototyper: a web3D platform for collaborative design and simulation of hybrid museum exhibitions <i>Marcello Massidda, Bruno Fanini, and Sofia Pescarin</i>
dh.20253055	Shaping a Web3D framework for different scientific communities: ATON as a service in H2IOSC <i>Bruno Fanini, Giorgio Gosti, Chiara Florise Amadei, and Sofia Menconero</i>
dh.20253210	The Illuminated Manuscripts pilot project: a hub dedicated to the interdisciplinary study of ancient codices, integrated into the DigiLab-IT platform <i>Eva Pietroni, Alessandra Chirivì, Matteo Greco, Andrea Pandurino, Alberto Bucciero, Alessandro Lupinacci, Romano Aloisi, and Marco Cozza</i>
dh.20253236	StoneVerse: Models and Methods in Cultural Heritage. The Open-Science Platform for Reproducible Modelling of Stone Decay <i>Elia Onofri, Sofia Bizzarro, Sandro Tassa, Michela Czech, and Gabriella Bretti</i>
dh.20253258	Estimating Cultural Heritage Processes Using Approximate Bayesian Computation <i>Paola Stolfi, Elia Onofri, and Gabriella Bretti</i>
dh.20253320	Merging Knowledge and Tools in Heritage Science and Digital Archaeology. Practices from H2IOSC WP2 <i>Giacomo Mancuso, Alessandra Caravale, Antonio D'Eredità, and Paola Moscati</i>

Track 12 – Digital Technologies for CHANGES

Digital Technologies for CHANGES (CHANGES SESSION) - Part 1

- | | |
|-------------|--|
| dh.20253051 | Designing Augmented Reality Storytelling in Historical Palaces: The Royal Palace of Caserta as a Case Study
<i>Roberta Presta, Yulia Tikhomirova, Francesca Nicolais, Leonardo Chiechi, Roberto Montanari, and Gianluca Genovese</i> |
| dh.20253117 | Flexible, Integrable and Accessible Digital Tools for a Dynamic and Adaptive Experience of Museum Environments. The CHAMELEON project
<i>Federica Maietti, Ursula Thun Hohenstein, Loreno Arboritanzza, Marco Medici, Stefano Settimo, Davide Borra, Stefano Santo Sabato, Ornella De Curtis, Giovanni Serafini, Andrea Perez, Chiara Parisi, Silvia Zanazzi, and Giorgio Poletti</i> |
| dh.20253255 | 3D Digitisation for Geological and Paleontological Specimens: Challenges and Solutions
<i>Luisa Ammirati, Alice Bordignon, Federica Collina, Francesca Fabbri, Daniele Ferdani, Maria Felicia Rega, and Mattia Sullini</i> |
| dh.20253334 | A Virtual Gallery Platform for Exploring Cultural Heritage collections and Practicing Digital Curatorship in a University Context
<i>Roberta Presta, Chiara Tancredi, Marianna Cuomo, Roberto Montanari, and Gianluca Genovese</i> |
| dh.20253043 | Multi-scalar Risk Mapping of Climate Change Impacts on Outdoor Tangible Cultural Heritage: the Case Study of Tortona, Italy
<i>Angelo Figliola, Adriano Ruggiero, Alberto Calenzo, Andrea Canducci, Livia Calcagni, and Alessandra Battisti</i> |
| dh.20253060 | PALEOTWIN. A Platform for Creating Integrated Digital Experiences: the case study of the Collezione di Geologia "Museo Giovanni Capellini"
<i>Michela Contessi, Davide Borra, Stefano Santo Sabato, Diego Mammo Zagarella, Giuliana Benvenuti, Chiara Caruso, Annalisa Managlia, and Roberto Balzani</i> |
| dh.20253153 | Supervised Models to Support Investigations of Ancient Coins
<i>Luca Naso, Lavinia Sole, Andrea Patti, Francesco Armetta, Fabrizio Lo Celso, Wladimiro Carlo Patatu, and Maria Luisa Saladino</i> |

Digital Technologies for CHANGES (CHANGES SESSION) - Part 2

- | | |
|-------------|--|
| dh.20253066 | Morphosyntactic Variation in Italian and Romansh Dialects: The Manzini & Savoia (2005) Corpus Within Project CHANGES
<i>Greta Mazzaggio, Carlo Zoli, Neri Binazzi, Luca Andrea Ludovico, Mael Vittorio Vena, M. Rita Manzini, and Leonardo Maria Savoia</i> |
|-------------|--|

- | | |
|-------------|--|
| dh.20253221 | Beyond Participation: A Quadruple Helix Approach to Digital Cultural Heritage and Inclusive Stakeholder Engagement
<i>Aelita Skarzauskiene, Monika Mačiulienė, and Kristina Kovaitė</i> |
| dh.20253331 | Small Codes: a platform for digital resources and tools for minority languages and dialects
<i>Carlo Zoli, Greta Mazzaggio, and Neri Binazzi</i> |
| dh.20253033 | Digital technologies for the "Grazia Deledda" Literary Park in Galtellì (NU): the 3D virtual reconstruction of Pontes Castle
<i>Nicola Mariniello, Federica Giacomini, Sara Obbiso, Francesco Sicilia, Antonio Sanna, Alessandro Iannucci, and Giuliana Benvenuti</i> |

Digital Technologies for CHANGES (CHANGES SESSION) - Part 3

- | | |
|-------------|---|
| dh.20253048 | Evaluating Zero-Shot Monocular Depth Estimation Models for Tactile Rendering of Paintings
<i>Roberto Magherini, Michaela Servi, Francesco Buonamici, and Rocco Furferi</i> |
| dh.20253118 | "There was a scribe, a priest and a thief". Testing the potential of language models for the creation of curatorial narratives in an archaeological museum
<i>Enrico Mensa, Chiara Fulfaro, Flavia Fubini, Andrea Bottino, Riccardo Antonino, Enrico Ferraris, and Rossana Damiano</i> |
| dh.20253151 | Community Landscape Archaeology and Digital Technologies for Heritagization and Memorialization Processes
<i>Luigi Magnini, Marco Paladini, Martina Bergamo, Jacopo Paiano, Bendetta De Rossi, Monica Calcagno, and Diego Calaon</i> |
| dh.20253375 | Formalising cultural heritage metadata with a multidisciplinary approach: enriching the CHANGES workflow for enhancing a museum collection about ceramics through a FAIR digitisation process
<i>Arianna Moretti and Madeleine Daste</i> |
| dh.20253336 | HERIFORGE Polish Hub As Digital Heritage Growing XR Community
<i>Marta M. Swietlik and Gabriela Manista</i> |
| dh.20253363 | A Summarization and Analysis of Methodologies for Creating Interactive and Lifelike Historical Characters Based on MetaHuman
<i>Victor Yuan and Alan Miller</i> |

Track 13 – Phygital Worlds & XR in Cultural Heritage (XRsalento SESSION)

Phygital Worlds and XR in Cultural Heritage

dh.20253086	Scenting Heritage: Real-Time Olfactory Augmentation <i>Tonia Ramogida and Sarah Kenderdine</i>
dh.20253181	From Interpretation to Immersion: XR and the Transformation of Fashion Heritage Story-telling <i>Eleonora Stacchiotti</i>
dh.20253267	ArtifactVM: Exploring Culturally Meaningful Presentations and User Interactions in Virtual Museums <i>Jiachen Liang, Yue Li, Xueqi Wang, Yuexin Yao, Richard Koeck, and Hai-Ning Liang</i>
dh.20253304	A Comparative Study of Virtual and Mixed Reality Blended Environments for Interacting with the Physical World During Virtual Guided Visits <i>Michele De Bonis, Huyen Nguyen, and Patrick Bourdot</i>
dh.20253270	Digital Technologies for Tangible and Intangible Heritage: a Preliminary Study for the Museum of Contemporary Art in San Cesario di Lecce <i>Carola Gatto, Laura Corchia, Giorgia De Giuseppe, Federica Faggiano, Ileana Riera Panaro, and Lucio Tommaso De Paolis</i>
dh.20253319	Real Time Photogrammetry in Cultural Heritage Applications <i>Cagin Torkut, Devrim Akca, Armin Gruen, and Gerhard Kemper</i>

Track 14 – Play, Learn, Explore (Serious Games Society – GALA SESSION)

Modern Technologies for Serious Gaming in Cultural Heritage

- dh.20253295 | Comparing VR and AR in Cultural Heritage Active Learning: A Study Based on the Stimulus-Organism-Response Model and the Engagement Theory
Jiayi Zhao, Jiachen Liang, Yue Li, Cheng Zhang, and Yiping Dong
- dh.20253186 | Designing Personalized Cultural Heritage Serious Games through Gamification, AI and Augmented Reality
Federico Martusciello, Antonio Bucchiarone, and Henry Muccini
- dh.20253247 | Digging through the Virtual Sand of Time: Development and Evaluation of Hetepheres Tomb VR
Kevin Körner, Luca Dreiling, and Peter Der Manuelian
- dh.20253377 | Characterization of Games Technologies for Learning in the Context of Intangible Cultural Heritage
Marcos E. Zúniga-Solórzano, Ramon Fabregat, and Teodor Jové
- dh.20253015 | Female Rulers of Medieval Balkans - gamified VR experience
Selma Rizvic, Bojan Mijatovic, Dusanka Boskovic, Aya Ali Al Zayat, Jelena Andjelkovic Grasar, Niall O Hoisin, Belma Ramic-Brkic, and Emir Durmisevic

Game Design Methods and Applications

- dh.20253327 | Promoting Positive Attitudes Through Narrative-Driven Digital Heritage Games
Lukáš Kolek, David Šosvald, Fernanda Flores, and Jasminko Halilovic
- dh.20253297 | Understanding User Experience in Serious Games: The Role of Narratives, Game Design and Player Background
Stavroula Ntoa, Anastasia Ntagianta, Fernanda Flores, Jasminko Halilovic, Lukáš Kolek, Lucie Formánková, Lisley Viraphong, Emilie Divoy, Petra Cernoušková, Petros Selekos, Konstantinos C. Apostolakis, Stefania Stamou, and Constantine Stephanidis
- dh.20253131 | Exploring and preserving Underwater Cultural Heritage through Play and Learning: the case study of CREAMARE
Fabio Bruno, Marco Cozza, Alessandro Cozza, Salvatore Isabella, Raffaele Peluso, Paola di Cuia, Ervin Silic, Felipe Cerezo Andreo, Carlota Pérez-Reverte, Angelos Manglis, Vasiliki Drouga, Barna Petrányi, Daniel Poulet, Roberto Rotondo, and Barbara Davide

dh.20253303	A Serious Game Strategy from Coastal Leisure to Cultural Discovery of an Archaeological Museum. The "Ozan1982" Application. <i>Irene Muci, Manuele Veggi, Alessandra Marasco, Alberto Bucciero, Sofia Pescarin, and Samuele Spotti</i>
-------------	--

Explorative Approaches for History

dh.20253215	Engaging History Through Play: The Potential of Digitally-Enhanced Tabletop Role Playing Games for Promoting Historical Empathy in Museums <i>Georgia Koutiva, Katerina Servi, Akrivi Katifori, Dimitra Petousi, Maria Boile, Yannis Ioannidis, Evangelos Papoulas, Myrsini Pichou, Foteini Tsitou, Elena Kitta, Eirini Savvani, and Foteini Fragkaki</i>
-------------	---

dh.20253305	Engaging with History: Towards an Interactive Experience of the 1562 Auto de Fe of Maní (Yucatan, Mexico) <i>Antonio Rodríguez Alcalá, John F. Chuchiak, Zoraida Raimúndez Ares, Maria Felicia Rega, Hans B. Erickson, and Luis Díaz De León</i>
-------------	--

dh.20253287	A historiographical method for video games. The proof of concept in the analysis of the game This War of Mine (11 bit studios) and its counterpart Sarajevo's Siege cultural heritage <i>José Júlio Schulz Melo</i>
-------------	---

dh.20253257	Exploring Saudi Arabian Traditions Through Roblox Puzzles For Children <i>Alaa Aljurais and Erik Champion</i>
-------------	---

Institutions



**UNIVERSITÀ
DI SIENA**
1240



**FONDAZIONE
BRUNO KESSLER**



Fraunhofer
IGD



INDIANA UNIVERSITY
LUDDY SCHOOL OF
INFORMATICS, COMPUTING, AND ENGINEERING

Sponsors



GLOBAL DIGITAL
HERITAGE



Next-gen Archaeological Survey Technology



DH was supported by the following EU-funded projects



Perceptive Enhanced Realities of Colored collEctions
through ai and Virtual Experiences



Main Tracks Chairs

1. Documentation, Preservation, Monitoring & Restoration

- *Stefano Campana – University of Siena, Italy*
- *Violette Abergel – CNRS, France*
- *Costanza Miliani – CNR ISPC, Italy*

2. Policy, Standards, Ethics, and Education

- *Angeliki Chrysanthi – University of the Aegean, Greece*
- *Alessandra Marasco – CNR ISPC, Italy*

3. Infrastructures, Dataspace, International Projects

- *Dimitri Kotzinos – Cergy Paris University, France*
- *Anaïs Guillem – CNRS MAP, France*
- *Bruno Fanini – CNR ISPC, Italy*

4. Acquisition and Digitization

- *Pedro Santos – Fraunhofer IDG, Germany*
- *Martina Hoffmann – National Library of Switzerland, Switzerland*
- *Fabio Remondino – FBK (Fondazione Bruno Kessler), Italy*

5. Analysis and Interpretation

- *Michela Spagnuolo – CNR IMATI, Italy*
- *Martijn van Leusen – University of Groningen, Netherlands*
- *Nicolo dell'Unto – Lund University, Sweden*

6. Visualization and Interaction

- *Karina Rodriguez Echavarria – University of Brighton, United Kingdom*
- *Maria Economou – University of Glasgow, United Kingdom*
- *Ruggero Pintus – CRS4, Italy*
- *Angeliki Antoniou – University of West Attica, Greece*

Special Tracks Chairs

8. Digital Technologies for Colour (EU Project PERCEIVE)
 - *Catlin Langford – Victoria and Albert Museum, United Kingdom*
 - *Donata Magrini – CNR ISPC, Italy*
9. Collaborative Cloud for CH (EU Project ECHOES)
 - *Emanuel Demetrescu – CNR ISPC, Italy*
 - *Sorin Hermon – Cyprus Institute, Cyprus*
10. Humanities and cultural Heritage Italian Open Science Cloud (EU Project H2IOSC)
 - *Riccardo Colella – CNR ISPC, Italy*
12. Digital Technologies for CHANGES (EU Project CHANGES)
 - *Silvio Peroni – University of Bologna, Italy*
 - *Ivan Heibi – University of Bologna, Italy*
13. Phygital Worlds & XR in Cultural Heritage (XRsalento)
 - *Lucio Tommaso De Paolis – University of Salento, Italy*
 - *Carola Gatto – University of Salento, Italy*
14. Play, Learn, Explore (GAMES and Learning Alliance, GALA)
 - *Chiara Eva Catalano – CNR IMATI, Italy*
 - *Francesco Bellotti – University of Genoa, Italy*
 - *Kevin Körner – University of Tübingen, Germany*

Honorary Chairs

Paolo Carafa – Professor of Classical Archaeology (University of Rome “La Sapienza”, Italy)

Valéry Freland – Aliph Foundation (Switzerland)

Mario Hernandez – Vice-President of the International Society for Digital Earth (ISDE)

Pascal Lievaux – Directorate-General for Heritage and Architecture, Ministry of Culture (France)

Paolo Liverani – Professor of Ancient Topography (University of Rome, Italy)

Martin Millett – Emeritus Laurence Professor of Classical Archaeology, University of Cambridge and President of the Society of the Antiquaries of London (UK)

Costanza Miliani – Director of the Institute of Heritage Science, National Council of Research Institute (Italy)

Emanuele Papi – Director of the Italian School of Archaeology at Athens (Greece)

National Committee

Andrea Arrighetti – History and Cultural heritage (University of Siena)
Roberto Bartalini – History and Cultural heritage (University of Siena)
Stefano Bertocci – Architecture (University of Florence)
Giovanna Bianchi – History and Cultural heritage (University of Siena)
Luca Bombardieri – Philology and Literary Criticism (University of Siena)
Elisa Bruttini – Superintendence Siena, Arezzo, Grosseto, Ministry of Culture
Stefano Camporeale – History and Cultural heritage (University of Siena)
Cristina Capineri – Social, Political and Cognitive Sciences (University of Siena)
Emanuela Carbé – Philology and Literary Criticism (University of Siena)
Angela Cerasuolo – History and Cultural heritage (University of Siena)
Giuseppe Ceraudo – Cultural Heritage (University of Salento)
Carlo Citter – History and Cultural heritage (University of Siena)
Fabio De Ninno – History and Cultural heritage (University of Siena)
Roberto Ferrari – Museo Galileo
Enrico Giorgi – Department of History and Cultures (University of Bologna)
Marco Gori – Information Engineering and Mathematics (University of Siena)
Anna Guarducci – History and Cultural heritage (University of Siena)
Nicola Labanca – History and Cultural heritage (University of Siena)
Federico Lenzerini – Political and International Sciences (University of Siena)
Alessandro Linguiti – Philology and Literary Criticism (University of Siena)
Ruggero Longo – History and Cultural heritage (University of Siena)
Giancarlo Macchi – History and Cultural heritage (University of Siena)
Maria Luisa Marchi – Cultural Heritage (University of Foggia)
Patrizia Marti – Social, Political and Cognitive Sciences (University of Siena)
Mirco Modolo – Dept. History and Cultural heritage (University of Siena)
Stefano Moscadelli – History and Cultural heritage (University of Siena)
Michele Pellegrini – History and Cultural heritage (University of Siena)
Pierluigi Pellini – Philology and Literary Criticism (University of Siena)
Giovanna Pizziolo – History and Cultural heritage (University of Siena)
Antonio Pizzo – Director of the Escuela Española de Historia y Arqueología en Roma (EEHAR)
Domenico Praticchizzo – Information Engineering and Mathematics (University of Siena)
Luca Quattrocchi – History and Cultural heritage (University of Siena)
Giacomo Maria Salerno – Social, Political and Cognitive Sciences (University of Siena)
Gionata Salvietti – Information Engineering and Mathematics (University of Siena)
Giuseppe Scardozzi – CNR ISPC (Italy)
Marcello Spanu – Humanities (Roma Tre)
Francesco Vincenzo Stella – Philology and Literary Criticism (University of Siena)
Federico Ugolini – History and Cultural heritage (University of Siena)
Luca Verzichelli – Social, Political and Cognitive Sciences (University of Siena)
Enrico Zanini – History and Cultural heritage (University of Siena)

Flexible, Integrable and Accessible Digital Tools for a Dynamic and Adaptive Experience of Museum Environments.

The CHAMELEON project

F. Maietti^{1*}, U. Thun Hohenstein^{2,3}, L. Arboritanz¹, M. Medici⁴, S. Settimo⁴, D. Borra⁵, S. S. Sabato⁶, O. De Curtis³, G. Serafini², A. Perez², C. Parisi^{2,3}, S. Zanazzi², G. Poletti²

¹ University of Ferrara, Department of Architecture, Ferrara, Italy

² University of Ferrara, Department of Humanities, Ferrara, Italy

³ Museum of Palaeontology and Prehistory, Ferrara, Italy

⁴ Inception Srl, Ferrara, Italy

⁵ No Real Interactive Srl, Torino, Italy

⁶ MediaSoft Srl, Galatina, Lecce, Italy

Abstract

The project CHAMELEON - Adaptable, integrable and accessible digital tools for a dynamic and adaptive use of museum environments, is focused on the Piero Leonardi Museum of Palaeontology and Prehistory, part of the Museum System of the University of Ferrara. The aim is to develop a set of digital tools for documenting, enhancing, sharing and narrating the museum palaeontological and anthropological collections. Starting with the conceptualization of a new digital exhibition system, the accurate 3D digital acquisition of more than thirty objects have been performed. The fossils were selected considering their state of preservation, relevance and scientific representativeness, and the need to be linked to an augmented set of information. The survey, carried out through structured-light handheld 3D scanner and digital photogrammetry, is the result of a methodological assessment highlighting the critical-interpretative and documentation opportunities that digitisation offers. The application design and development includes IT configurations aimed at managing content and virtual experiences. Responsive design, standard metadata, and open APIs support an inclusive user experience embedded in the IT architecture through applications for Semantic XR Museum, Semantic XR Avatar, 360° AR Experiences, frontside AR Experiences, and VR Experiences in specific settings. The overall outcome is a "chameleonic" repository able to manage on-line all the multimedia contents associated with the fruition and storytelling of tangible and intangible information.

CCS Concepts

• **Computing methodologies** → Computer Graphics; • **Information Systems** → Data Management Systems; Information Storage Systems;

1. Introduction

CHAMELEON aims to develop digital tools for documenting, enhancing, sharing and narrating museum heritage, with a particular focus on science and natural history museums. The project is grafted into Spoke 4 of the CHANGES project [BBB*24], and focuses on one of the case studies identified as "core" for its importance within palaeontological and anthropological collections: the Piero Leonardi Museum of Palaeontology and Prehistory, part of the University of Ferrara's Museum System (hence SMA). Since 2013, the Museum has launched a digitisation campaign experimenting with different ways of acquiring the collections to create educational pathways and modernise exhibition content [FBT*13; TPT*21; PT24]. Digitisation was mainly aimed at non-displayed and medium-sized exhibits, leaving out more composite specimens such as complete large vertebrate skeletons and complex fossils. CHAMELEON's main objectives are based on the use of digital tools to enhance the museum and its collection, addressing different needs and users. The first objective is to increase accessibility and knowledge (both onsite and remotely), maximising the openness to the general public. The project will also enable the museum's managers and curators to update the information system related to the fossil collections and to create adaptable visits and exhibitions. In order to achieve these goals, the project started with the accurate digital acquisitions of more than 30 objects selected on the basis of a preliminary educational and communicative design of the

Museum. The palaeontological remains were carefully selected, taking into account their state of preservation, their scientific relevance and representativeness, as well as the need to link them to an augmented set of information.

The survey, carried out using a handheld structured-light 3D scanner and digital photogrammetry, is the result of a methodological assessment that highlights the critical interpretation and documentation possibilities offered by digitisation. The collaboration of the two Departments of Architecture and Humanities and the Piero Leonardi Museum of Palaeontology and Prehistory of the University of Ferrara, together with the technical partner Inception has been crucial in this respect. In fact, the aim is indeed to obtain semantically enriched 3D models, enhancing the levels of information linked to the metric-morphological data, according to current standards and Open Data, pursuing inclusion and accessibility.

The application design and development, led by technical partner MediaSoft, includes a back-end configuration module that allows exhibitors to define the content and behaviour of both the visitor experience and the virtual experience. MediaSoft is also designing and developing the Digital Asset Management module, Augmented Reality (AR) applications, and the scalable local cloud infrastructure hosting the entire system. The software platform is based on responsive design, standard metadata, and open APIs. The user experience design, by No Real Interactive, is embedded in the IT architecture of applications, and includes five main tools:

* Corresponding Author

Semantic XR Museum, Semantic XR Avatar, 360° AR Experiences, frontside AR Experiences, and Virtual Reality (VR) Experiences in specific settings. The overall outcome is a “chameleonic” repository able to manage online all the multimedia contents associated with the fruition and storytelling of tangible and intangible information. Dynamic digital paths are based on semantic associations and can be reconfigured by the end user, increasing engagement and interactivity with the Museum heritage [DFC23]. The repository is accessible from different interfaces to allow multiple digital fruitions, and applications are adaptable and integrable, exploiting the potential of virtual paths to create new forms of knowledge narration and to broaden critical-interpretative analyses of cultural heritage.

2. The research context

The context of the CHAMELON project is the Piero Leonardi Museum of Palaeontology and Prehistory (hence MPPPL). It is part of the SMA of the University of Ferrara, founded in 2007, which brings together the University's museums and historical-scientific collections. It is located at Palazzo Turchi di Bagno (Fig. 1), which houses the MPPPL, the Exhibition Hall, and the Botanical Garden and Herbarium. It also includes the “Giovanni Tumiatì” Anatomical Museum, and the scientific collections of historical interest located in the Departments (CISFIS and the Ancient Navarra Pharmacy). The richness of the SMA represents a great potential as it is an archive of knowledge and historical-naturalistic evidence to be exploited [Lor01]. This heritage, spread over several historic-architectural sites and only partially accessible today, fits well into an overall project of new and renewed accessibility of exhibition spaces and collections.



Figure 1: Main facade of Palazzo Turchi di Bagno, entrance to the Piero Leonardi Museum of Palaeontology and Prehistory.

The MPPPL was founded in 1964 by Professor Piero Leonardi, the first Chair of Geology at the University of Ferrara. The materials that make up the museum are the result of an intense activity of collection, acquisition and exchange that has continued over time. In addition, staff and students brought rocks and fossils to the Institute on every excursion and their return from conferences. Professor Leonardi himself donated his private collection to the museum when he retired. The exhibition section is entirely housed in the rooms of the *piano nobile* of the Palazzo Turchi di Bagno, along Corso Ercole I d'Este. The exhibition is divided into four main sections: Palaeontology of Vertebrates (Fig. 2), Human Palaeontology and Prehistory (Fig. 3), Palaeontology of Invertebrates, and Historical Geology.

The initial exhibition was mainly intended for university teaching, but since the late 1970s, the growing interest in natural sciences in compulsory education has led to a constant and increasing demand for the use of the museum. The building is currently used by the staff of the University of Ferrara and for temporary exhibitions on the ground floor, while the permanent exhibition is temporarily closed to the public, following the earthquakes that hit Emilia in 2012. However, it is possible to study the museum's collections by appointment or visit the exhibition rooms for small groups.



Figure 2: View of the room housing the Vertebrate Palaeontology section.



Figure 3: View of the room showing the Human Palaeontology and Prehistory section.

As a result, the museum has had to rely heavily on digital strategies [BTTP19; SBT21]. These current limitations on the permanent exhibition accessibility make it even more relevant to design a digital repository enhancing the collection through a reorganisation of the information and documentary sources and creating a set of digital interfaces for different uses, associating in-depth information content with the digital replicas of the exhibits.

2.1. The Museum and the deposited collections

Palaeontological and archaeological excavations carried out by the University of Ferrara have significantly increased the quantity and the scientific value of the museum's objects. Concerning the invertebrate collections, the most important

[PB01] are: holotypes and paratypes of new species of foraminifers, molluscs, brachiopods from the Permian, Triassic, Lower Jurassic and Palaeogene of the Southern Alps; a collection of bivalves from the Lithothys facies, unique in the world for the wealth of specimens isolated from the rock, some of which exceptionally also show the original microstructures of the shells (Lower Jurassic); a rich collection of Triassic molluscs from the Dolomites and Hungary; a collection of ammonites from the Lower Jurassic and Lower Cretaceous of the Meridional Alps; calcareous coralline algae from the Paleogene and Neogene of Veneto and other Italian and foreign localities.

Among the most important vertebrate collections are:

- the fossil fish from the Pesciaia di Bolca, the famous Tertiary deposit in the Lessini Mountains (VR), known since the 16th century for the extraordinary preservation and abundance of its remains;
- the holotype of a large marine reptile from the Middle Jurassic-Early Cretaceous of Italy, in particular the largest specimen so far preserved from the metriorincoid group;
- two original skulls of *Lystrosaurus*, perhaps the only ones in Italy, from the Triassic period in South Africa;
- the Pleistocene collection of remains from the Settepolesini di Bondeno deposit (Ferrara), the study of which has made it possible to document, for the first time in Italy, the faunal population and fossil biocenosis of the mammoth steppe-taiga and woolly rhinoceros of the Po Valley during the last glaciation;
- the palaeontological and archaeological collections of several Pleistocene deposits in caves or rockshelters (i.e. Grotta del Broion, Riparo Tagliente, Riparo Villabruna, and others), which represent the most significant archaeological deposits for the chrono-stratigraphic reconstruction of the Recent Quaternary in northern Italy;
- a large batch of faunal remains from several Pleistocene deposits in Sicily, which document the evolutionary phenomenon of insular dwarfism and gigantism.

3. Methodological framework for the creation of digital exhibitions and applications

The objectives of the core case study on the Leonardi Museum are multiple, and can be summarised as follows:

- To increase accessibility (physical and virtual) through virtual routes, maximising openness to the public for different users through an inclusive approach;
- To activate a 3D digitisation process systematising what already digitised and focusing on exhibition and critical-interpretative opportunities that digitisation can offer;
- To apply a semantic approach to the models [MDM*20], enriching the levels of information associated with the metric-morphological data, according to current standards and with a view to Open Data / Semantic Web;
- To set up a platform and related VR and AR applications to make museum contents explorable;
- To activate a network with other Museum Systems or places of interest (e.g. archaeological excavations) for digital content sharing;
- To update the ICCD catalogue, in line with the ArCo project, and the Italian Ministry of Culture (MiC) Digital Library, including 3D and 4D (spatial-temporal) models.

3.1. User Experiences and target users

Starting from these purposes, the design process was divided into four main actions: application design, digital use design, inclusive use design, and gamified use design. The applications setting up started from the semantic mapping and identification of the objects to be digitised, describing the IT architecture (Fig. 4) for managing the flow of data to/from the central repository (e.g. client-server), defining the hardware required for the creation and use of the prototypes being developed, and considering the quantity and quality of the data to be managed. The hardware included all identified devices that could be used by each target user. A major part was the design of the software 'layer' (middleware) to connect the repository with the application prototypes, and the design of a 'chameleon-like' repository, able to:

- manage online all the multimedia assets that can be associated with a tangible or intangible museum object, including 3D replicas, audio-video clips, dialogues with avatars, information for users with different types of disabilities, etc.;
- enable to design dynamic digital visitor paths, i.e. based on semantic associations configurable by museum curators (e.g. to support temporary physical exhibitions or to create temporary online virtual exhibitions);
- allow the reconfiguration of the created itineraries by the end users (oriented and facilitated action), in order to adapt visits and increase their involvement.

The aim is to create a single repository accessible from "n" interfaces, different in form and function, allowing multiple digital uses supported by semantics that can be reconfigured at will [MMF21]. Such a repository fully meets the need to include not only the fruition of 3D models but of any other multimedia asset; and to create WebXR applications for exhibited objects, as a container for the virtual replicas [FDB*22], and related data and metadata, accessible through effective interfaces in the exploration of the 3D models via web browser. The identification of target users (curator, general user, specific user, disabled user, etc.) and expectations from the proposed experiences, and the analysis of the User Journey led to development of the User Experience (UX), described by means of graphical schematisations highlighting possible actions, criticalities (such as over-inoculation, loops, etc.), limits and freedoms granted to the user by correlating them with the combinatory potential offered by the "chameleon-like" repository.

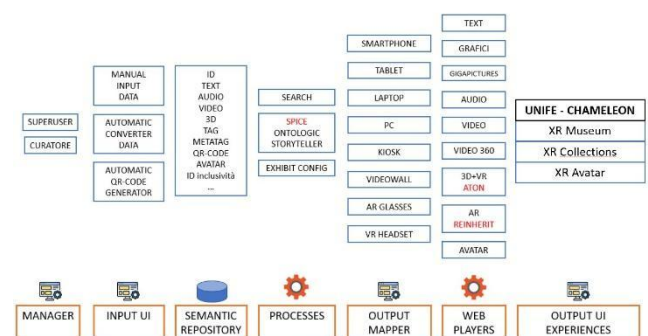


Figure 4: CHAMELEON IT architecture.

The user interface is designed specifically for each prototype, including functionality, graphical appearance, multi-device responsiveness, and accessibility. The design of an inclusive

digital use is necessary both when the digital is considered to support a visit to a real museum, and when the museum (with its multiple declinations) is virtual. The “chameleon-like” repository will also allow disadvantaged users to configure their own path. Considering the game as a mode of cultural access not exclusively for children, a specific task to plan how to introduce ‘gamified’ logics in the production of digital fruition paths was introduced. Starting from the analysis of gaming best practices for museum context (style, time, rewards, correlation with the objects on display, etc.), the aim is to describe at least a gamified application to be structured on the semantic repository and applied in the different prototypes. This task is also in line with the Spoke 4 partnership willingness to develop a gaming activity that includes all the core case studies.

3.2. The semantic repository

The semantic repository allows the online management of all multimedia assets, the design of new experience paths by the curator, and their reconfigurability. It includes:

- The “semantic editor”, an intuitive configuration back end based on a drag and drop interface that allows the curator to create experiences, and user interfaces. Content is managed by populating the repository.
- The “Semantic XR Museum” prototype for browser-based use of digital experiences through the user's own device, remote use of AR and VR, generic, gamified and inclusive paths. In addition to applications for exploring object models with augmented content, two immersive environments are also included.
- The “Semantic AR Collections” prototype enables the marker-based AR experience on the display case, which can be activated by QR code. This application is realised through the creation of thirty prehistoric animals.
- The “Semantic XR Avatar” prototype enables the experience of dialogue with a conversational AI avatar that can be accessed via a web browser with a smartphone connected to the Internet.

3.3. Semantic XR Museum and Avatar

Digital use is via the web and focuses on the “Leonardi collection”, which contains all the digital objects in the repository. It will be accessed via an online web browser so that digital itineraries can be realised in situ or anywhere in the world via the users' mobile devices (Fig. 5).

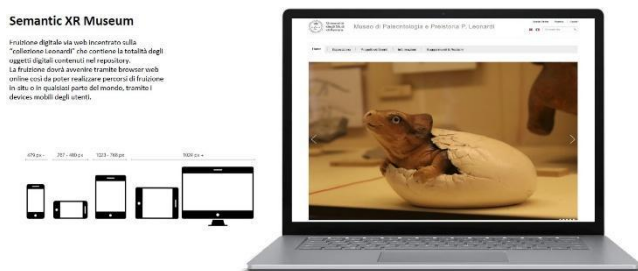


Figure 5: CHAMELEON responsive fruition via mobile devices.

The avatar is the museum guide, more targeted to children or a young audience. Three dialogues are planned, one for each of the two permanent rooms on the first floor and one in anticipation of the temporary exhibition to be set up on the ground floor. Each dialogue can be activated with a QR code. On the screen of the

smartphone, in portrait position, the avatar will appear in the upper part (Fig. 6), while the lower part will host the initial instructions, the written answers, the suggestions to the questions (which can also be clicked on for maximum inclusiveness), and the button to activate the microphone.

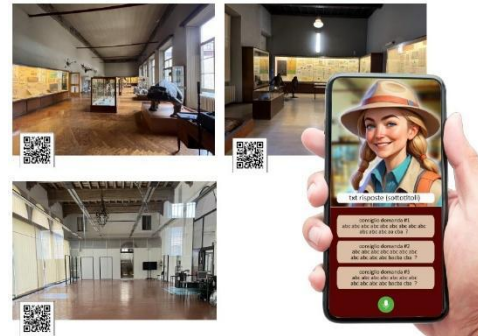


Figure 6: View of a possible Avatar prototype.

3.4. AR experiences

A 360-degree AR experience is designed for exhibits in individual showcases. Thanks to a maximum of four QR codes of approximately 15x15 cm placed on the four sides of the showcases, it will be possible to activate the AR exploration of the selected animals (Fig. 7). Scanning the QR code, the system launches the 3D reconstruction of the animated animal's body. At the bottom of the screen there will be the name of the animal and the button to activate the Information Tab, which will switch to the consultation mode of the digital object. The Information Tab will allow to read info and to explore the animal in real time in 3D. The Navigation Menu allows to close the tab, select the language and accessibility options, and come back to the AR view.

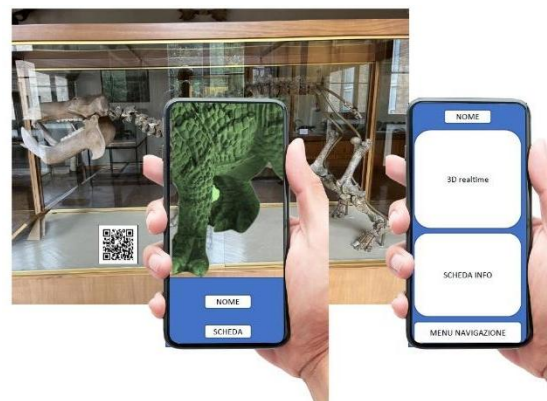


Figure 7: Sample visualisation of a 360° AR experience.

The frontal AR experience is provided for artefacts in wall cases. By framing the QR code of about 5x5 cm placed near the object, it will be possible to access the information of the corresponding digital object (Fig. 8) and in particular:

- Common name and Scientific name,
- Curiosity,
- Narrative Text 1,
- Narrative Text 2 (Fact Sheet),
- Alternative Text (e.g. for children),
- Interactive 3D model (if available),
- QR code for vocal readers (inclusivity).

At the bottom, the Navigation Menu will allow to close the tab (for another scan), choose the language and select accessibility options.



Figure 8: Sample view of a frontal AR experience.

3.5. VR experience in settings

The VR experience in settings is designed for at least two locations: one in the offshore, deep-water setting of a Jurassic sea (Tethys Ocean), mainly represented by deposits from the province of Verona and the Asiago Plateau, (Vicenza), and one for the setting called Settepolesini (Fig. 9), taking its name from the location near Bondeno, in the province of Ferrara. This experience can be enjoyed by smartphones tablets, and VR by scanning a QR code located in one of the exhibition rooms (or on the web or on external signage). The user will be able to explore in 360° the changing natural environment and the fauna that lived there by scanning three historical periods in the Settepolesini area: the Last Glacial, the Late Glacial, and the Contemporary (Roman era). The Jurassic marine environments, on the other hand, present extinct pelagic fauna in an underwater environment, with the possibility of accessing details and insights on the selected animals. The technology will be chosen when the first tests can be carried out using a smartphone. Possible choices are Play 3D real-time, and Play of a video generated from the 3D scenario. The Play 3D real-time function includes an ATON scenario (or similar) in which the following will be played: spherical/cubic image of the historical period; animation loop of the animals that will be arranged all around the user (so as to reduce the computational burden); audio of the narrated voice and subtitles; accompanying graphics (timeline).



Figure 9: Sample view of a VR experience in a 360° setting (*Last Glacial Fauna found in the excavations at Settepolesini di Bondeno, drawn by Busetto*).

Moreover, temporary exhibitions will be able to benefit from the outputs of the CHAMELEON project thanks to the use of the Avatar with the display of the QR code at the entrance; the use of a Digital Web Exhibition created with the exhibition configurator, accessible via browser (PC, laptop, smartphone) at the http address generated by the system, where the user can navigate through the digital objects and interact with the available 3D models.

4. Semantic mapping and 3D digitisation of museum objects

The development of the project action related to the digitisation of museum exhibits to obtain 3D models was anticipated by a careful analysis of the methodological approach and semantic mapping for the enrichment of models with information content. The careful analysis of the needs for narration through digital applications was developed according to the semantic-informative approach, while semantic mapping allowed the preparation of models for information enrichment.

The first phase involved the analysis of the museum context, both in terms of the characteristics of the exhibition halls and of the displayed objects. The University of Ferrara, through the joint work of the two departments (Architecture and Humanities), developed the overall methodological framework, defining the objectives for the different users and analysing the best reference practices. The joint work between the partners made it possible to define survey methodologies, enhancing the museum's needs.

The selection of exhibits to be digitised was guided by criteria of scientific, historical and narrative relevance, in line with the project's objectives. Firstly, specimens of central importance to the museum were selected as representatives of a collection able to tell the story of the area studied and its natural context. Secondly, special attention was paid to specimens with taphonomic characteristics and fossilisation or conservation processes of exceptional interest, which offer an important opportunity for study and valorisation through digitisation. The selection was also guided by the narrative purpose of the project: the specimens were identified to reconstruct significant thematic environments, such as the landscape of Settepolesini or deep-sea ecosystems, in order to create immersive and informative paths that make complex and scientifically relevant content accessible to the public. More than 30 specimens have been collected according to these criteria, with the possibility of adding other objects from the collection to the Museum's digital assets in the future.

4.1. 3D digitisation procedures

The digital acquisition of the specimens (34 objects) focused on the most representative and relevant items. The use of advanced digitisation techniques made it possible to fulfil the need for high-quality and accurate 3D models, but also to open up new interpretative and documentation opportunities, enriching the information levels associated with each object. Two three-dimensional survey methods were selected: structured light scanning and photogrammetry [AFGG21].

The handheld structured light scanner, which uses projections of light patterns onto the surface to be scanned, is a 3D scanning technology that combines the principle of triangulation with light projection, allowing precise and detailed measurement of surfaces. It is therefore particularly effective in gathering qualitative and quantitative information about the geometry of the object, making it ideal for surveying complex shapes. The decision to use a handheld scanner, i.e. a portable scanner, lies

precisely in its mobility, which allows the operator to move freely around the object to be scanned, unlike fixed scanners that require a stable support. In addition to ease of use and, consequently, reduced scanning times, its freedom of movement offers greater possibilities for detecting objects that, due to their size or fragility, cannot be moved from their original location.

The laser scanner used is the Einscan PRO HD with 0.2 mm resolution. The surveyed objects were scanned by rotating the instrument around them, starting from the front and proceeding to the back, when possible (Fig. 9). Afterwards, with the use of the EXscan software, a complete textured model was processed using the scanner's onboard camera. The final result was an .OBJ file with textures in .JPEG format.

Despite the freedom of movement given by its portability, the use of the laser scanner was not very effective for some artefacts due to the small size of the object combined with the very complex geometric characteristics. For this reason, and to capture textures as best as possible, the digital photogrammetry (or Structure from Motion - SfM) was chosen for a set of objects [KMR21]. Photogrammetry is a surveying technique based on the analysis of photographs taken from different angles, which is significant in capturing information on the colours and textures of surfaces, which can be used to improve the visual appearance of 3D models [FMR*22].

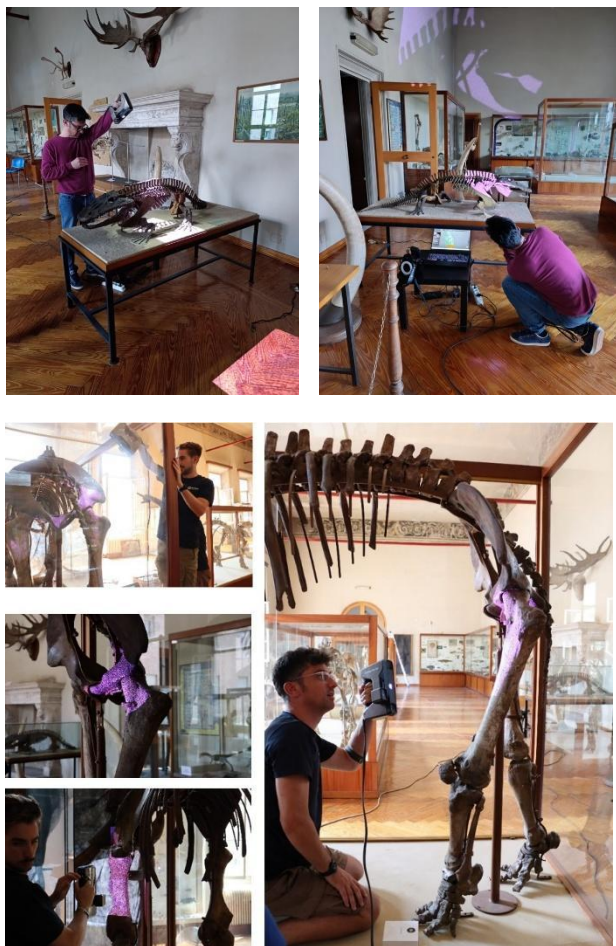


Figure 9: 3D survey phases by structured light laser scanner.

Although laser scanner surveying can provide much higher accuracy in terms of geometry and a higher point density, photogrammetry has the advantage that the camera can be moved more freely and does not necessarily require the use of a fixed support [FMG*22]. The camera used for photogrammetry is the Sony A7 r5 full frame 60 megapixel model with fixed 50mm macro lens and ring flash. The objects to be surveyed were photographed starting from the front and progressing with several shots along the main axes, thus making a rotating movement with the camera around the object (Fig. 10).



Figure 10: Views of the set for photogrammetric survey.

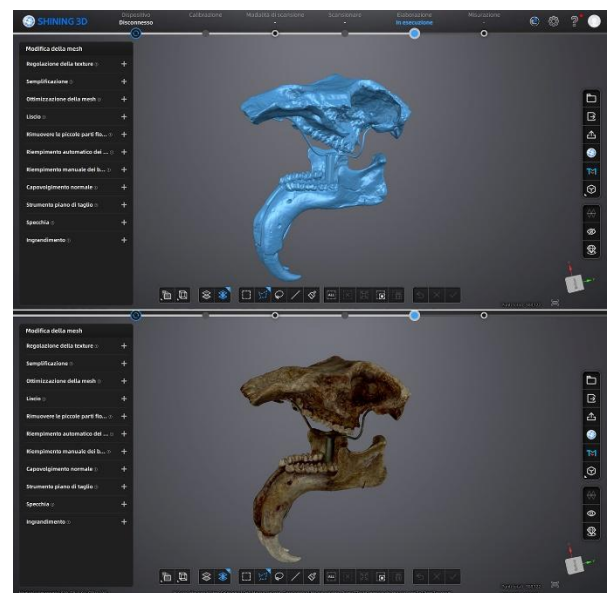


Figure 11: Steps in the processing of the 3D model of the *Deinotherium*. Top, solid model, above, textured model.

It was then possible to scale it using GCPs (Ground Control Points) of known coordinates. The four viewpoints - front, side and front - (two for objects with simpler geometry) made it possible to completely cover the surface of the object in order to obtain 3D models without gaps.

The controlled light of the flash and the fixed lighting set allowed the creation of a complete texture without chromatic aberrations (Fig. 11-12). The software used for the photogrammetric project is Agisoft Metashape with final outputs in .OBJ format and texture in .JPEG format.

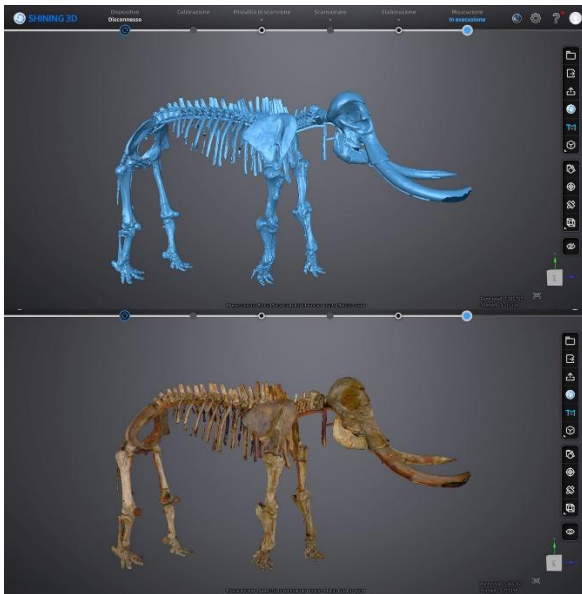


Figure 12: Sicilian elephant 3D model processing.

The 3D digitisation through digital photogrammetry has been performed by arranging a specific set. Objects were placed on a support within a fixed lighting set. In order to obtain the complete digital object, some photos were taken by rotating around the object, placed on a target, allowing easier recognition and merging of the different parts of the object during the data.

Wherever possible, a combination of the two methods was chosen as the surveying method (Fig. 13), combining the geometric accuracy of the laser survey with the quality of the photogrammetric textures of the SfM models (Figg. 14-15).

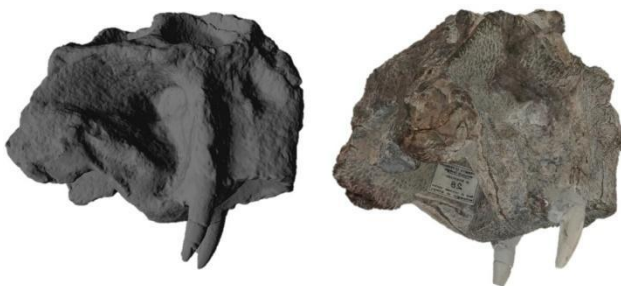


Figure 13: 3D model of the therapsid *Lystrosaurus*. On the left, the laser scanner model, on the right, the textured model.

5. The cataloguing of the museum specimens

For each specimen selected for digitisation, a dedicated repository of cataloguing details has been created. Access to these datasheets integrates the digital enhancement of the museum's exhibit, allowing visitors to gain insights and more detailed information about the selected specimens.

Each datasheet has been divided into three macro-sections based on the nature and use of the specimens it contains:

- SIGEC analytical fields, including the data reported in the SIGEC sheets of the specimens, together with the catalogue information.

- Additional fields, including information such as the scientific name, informative texts, data on the characteristics of the fossil organism in life as reported in the scientific literature, the place where the specimen was recovered, the method of its acquisition by the MPPPL, and its location in the exhibition room.
- Each specimen datasheet is also accompanied by a text transcribed into spoken audio for the visually impaired and neurodivergent people, using inclusive and accessible language. These texts have been written according to the principles of accessibility and inclusion, in particular by adopting the European "Easy-to-Read" guidelines [Inc09] to ensure that the information is easy to read and understand for all users.
- Particular attention has been paid to linguistic clarity, readability (including for users with dyslexia), and the removal of cognitive barriers, aimed at enabling independent and equal access to the Museum's information content. The descriptions simplify complex concepts without compromising scientific accuracy, and include detailed accounts of the physical characteristics of the objects, their position within the exhibition space, and their historical and scientific significance. Although intended for a non-specialist public, these fields provide bibliographic references for academic users.
- Functional fields and taxonomy, including the data useful for indexing the specimen in the database and in search engines.

This repository has a dual function: a purely cataloguing function for the museum's users, and a didactic function for visitors who are interested in more detailed information about the specimens on display.

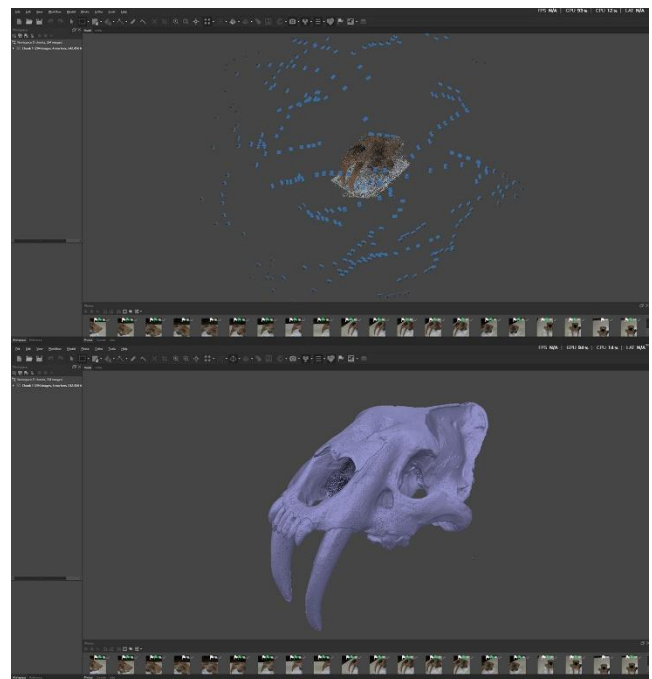


Figure 14: Above, development of the 3D model of the *Smilodon* by positioning the photos through tie points in Agisoft Metashape software. Below, wireframe model.

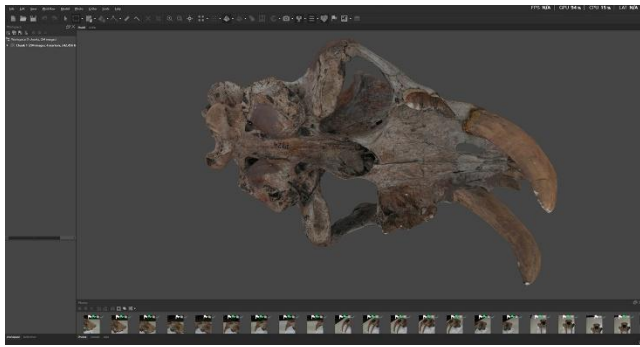


Figure 15: Processing of the 3D textured model of the Smilodon via Metashape through 294 photos by a full-frame camera.

The specimens' classification follows the most updated palaeontological and zoological studies, thus providing the reader with a modern and accurate understanding of the material on display. The scientific information is made accessible to the public using a simplified, yet specific and technical language, so as not to detract from the learning experience. Narrative text sections offer more informative insights and curiosities about the selected specimen, such as details of its anatomy, of its original time period and its kin. Among the additional fields, one will document the object's history from its recovery to its acquisition by the museum, depending on the availability of relevant information. This addition will promote virtual links with other museums, collections, individuals, and archives that have direct or indirect links with the artefact, thus fostering a network of relationships and information that will clarify its historical narrative, encompassing both its formation and acquisition up to the present day. Furthermore, linking the datasheet to the corresponding 3D model will facilitate the integration of various materials of historical and cultural significance, including the museum's archival documentation. The use of digital tools will not only enhance and display the museum's heritage but will also create new opportunities for research and development in a dynamic and interdisciplinary framework. Therefore, the selection of the fossil specimens to be analysed and the development of a specific cataloguing of the associated data were guided by an overall methodological approach aimed at enhancing not only the individual find, but the entire historical and cultural heritage of the MPPPL. The data thus collected, selected, and edited in this way, once digitised, will form the semantic backbone of the 3D models, leading to the creation of an implementable digital system for different users, linking different levels of information to specific IT applications.

6. Fruition design for an interactive museum

Within the framework of CHAMELEON, prototypes of 'Semantic XR Museum' [PCd*23], 'Semantic AR Collections', and 'Semantic XR Avatar' are being developed, including the IT architectures composed of the semantic repository and user interfaces, usable with different devices depending on the specific objective (virtual exhibitions, AR, conversational avatars).

6.1. State of the Art and best practices

The design of the applications started with a state-of-the-art analysis of the system infrastructure for interactive museum applications [MSR*25], based on the integration of technologies such as Artificial Intelligence (AI), AR, VR, and digital asset management systems. These solutions are designed to enhance the

visitor experience [AZF*25], support the preservation of cultural heritage, and increase overall accessibility. In particular, the main components of a typical infrastructure were analysed, i.e. digital asset management, solutions that allow organising, describing and storing content in a scalable way, supporting metadata customisation and access control, and improving the user experience [APM*21]. AR and VR applications and interactive tours explore artefacts and historical environments [BPP*23], making the museum experience more engaging and educational. AI can analyse large amounts of data and enrich visitor interaction. Multi-channel experiences, thanks to digital platforms combining physical and virtual, enable hybrid activities that engage both on-site and remote visitors, increasing the educational and cultural reach.

Best practices for the system architecture of interactive museum applications [PPFd21] aim to ensure scalability, efficiency, accessibility, and an engaging user experience. The main guidelines include: a scalable and modular architecture through cloud services, separate microservices for content management, data analysis, and interactive rendering; integration with immersive technologies (AR/VR) with support for devices such as viewers and smartphones; multi-sensory interactivity combining audio, video, and haptic feedback to make the visit more immersive. In addition, responsive interfaces work on desktops, mobile devices, museum kiosks and viewers to create applications that allow virtual access to museums [PPBF21], with online guided tours and 3D explorations of collections ensuring maximum accessibility and inclusiveness. Systems for archiving, cataloguing and disseminate digital resources such as high-resolution images and 3D reconstructions, through standards such as IIIF (International Image Interoperability Framework) and the integration of APIs (for collaboration between museums and with external developers) ensure standardised metadata sharing. In addition, sustainability principles are considered through measures to minimise energy consumption, and aspects of security and maintenance.

6.2. The architecture of the CHAMELEON project

Based on the requirements of the project, the infrastructure (system and physical) already available, and the goal of open-source, it was decided to implement a client-server infrastructure that does not rely on a cloud but on a single server installed locally and with the possibility of being reached from the outside through devices, applying secure and efficient communication protocols such as REST APIs, and open-source frameworks and libraries, to allow for future scalability. The choice was made to develop the applications in Node.js, taking advantage of its large community of developers and its extensive open-source library [FG24]. For authentication, the JWT Token authorisation protocol was chosen. The main components of the system infrastructure are the Frontend Configurator, i.e. the interface for the administrator user or designer who configures content and templates, which dialogues with the Backend Configurator to manage the data saved in the database and any connected devices through HTTP protocols for fast data transfers. The Database contains the configured data and makes it accessible to the backend, using a document database (such as MongoDB) for flexible management of multimedia data or configurations. The output devices are AR/VR visualisers for immersive experiences. The connection to the backend allows configurations or interactive settings to be uploaded for display in VR or AR viewers, while QR Codes enable fast interaction between mobile devices and the platform. In terms of visualisation, the VR visualiser is managed by an API backend via Aton, a framework for VR experiences, connected to

3D objects and advanced configurations; the AR visualiser is based on AR.js, a JavaScript framework accessible via browser and used on mobile devices for experiences connected to 3D objects or other configured content.

6.3. Semantic repository and configurations

Within the scope of the project, it was decided to use a NoSQL database, which does not require a rigid schema like relational databases, allowing different types of data (structured, semi-structured and unstructured) to be managed in the same database. Document-based databases represent documents in JSON format. Each document can have different fields without the need for structural changes, data can be added or modified quickly, complex data can be represented and documents can be accessed and written quickly. Furthermore, the use of a NoSQL database offers advantages in the programming workflow, especially for applications that require scalability, flexibility and high performance. It can have a natural integration with REST APIs since the JSON format integrates directly with APIs and frameworks; it also provides a natural mapping of objects that, in applications, can be saved directly without complicated conversions. By filling in an Excel file containing information required to populate the database, the data can be automatically imported into the web application. The curator's configuration, to create and manage the museum exhibits, and the visualisations for visitors have been designed considering all relevant aspects for museum applications, including the use of Aton [FFD*21], an open source framework based on Node.js and Three.js designed, developed and co-ordinated by VHLab, CNR ISPC to create Web3D/WebXR apps interacting with cultural heritage objects and 3D scenes on the Web. Aton adopts a 'develop once, deploy everywhere' approach, requiring no installation for end users, with its front-end automatically adapting to the device (mobile, desktop/kiosk or immersive XR). This modular framework offers a simple yet powerful API to manipulate graphics, customise event management for rich interactions and much more, along with a scalable rendering system with responsive interfaces [MMB*22]. Regarding the AR framework, considering the search for primarily open source solutions, it was decided to use the AR.js library, which is particularly suitable for mobile devices and works on both desktops and smartphones.

7. Conclusions

The expected impacts of the project concern, in particular, the increase of the knowledge of the important heritage preserved in the Leonardi Museum, the increase of the visibility of the collections both for scientists and for citizens, young people, schools, and the involvement of the widest number of categories of users. The applications will lead to a consequent increase in the number of physical visitors who go to the museum spaces, also through the organisation of specific visits and special openings, with the possibility of using digital applications designed for greater "on-the-spot" fruition. Another important expected result concerns digital access to the museum's collections through digital storytelling paths. A key role is played by the increase in knowledge of the Ferrara SMA and its collections, a reorganisation of the preserved objects, the definition of a database consisting of a set of digitised objects, expandable and integrable, with semantic features to enrich the information level in addition to the geometric-formal data. It is therefore expected that the digital applications developed by the project will increase public participation, make the exhibition more visible and sustainable, encourage a critical approach to knowledge both by curators and experts who can use the scientific content, and by

citizens and specific users such as young people, schools, scientists, etc., increasing accessibility, inclusiveness and participation. The creation of the repository of digital models and data configured to integrate different interfaces allows multiple digital uses supported by semantics that can be reconfigured at will, according to its adaptive nature and the creation of multiple user interfaces. The project is indeed designed to be shareable and replicable, providing for the systematisation of digital contents (3D models of objects, ICCD data sheets where available, internal database developed by the Department of Humanities on the information content of the objects preserved at the Leonardi Museum, etc.), and the use of open formats and open platforms/repositories, through a replicable workflow, optimised for natural history and scientific museums, providing a data aggregation tool for research/in-depth analysis that can constitute a best practice at national level, providing for the creation of a set of technologies reusable in similar contexts.

Acknowledgements

The CHAMELEON project is developed within the framework of the PE CHANGES Programme - Cultural Heritage Active Innovation for Sustainable Society (PE0000020) - NRP Mission 4 Component 2 Investment 1.3, Funded by the European Union – NextGenerationEU, Spoke no. 4 (CUP J33C22002850006). Authors thanks the SABAP per la città metropolitana di Bologna e le province di Modena, Reggio Emilia e Ferrara for allowing the digitisation.

References

- [APM*21] ANGELONI, R., PIERDICCA, R., MANCINI, A., PAOLANTI, M., TONELLI, A.: Measuring and evaluating visitors' behaviors inside museums: the Co. ME. project. *SCIRES-IT-SCientific RESearch and Information Technology*, 11(1), 167-178, 2021. DOI: [10.2423/i22394303v11n1p167](https://doi.org/10.2423/i22394303v11n1p167).
- [AFGG21] APOLLONIO, F. I., FANTINI, F., GARAGNANI, S., GAIANI, M.: A photogrammetry-based workflow for the accurate 3D construction and visualization of museums assets. *Remote Sensing*, 13(3), 486, 2021. DOI: [10.3390/rs13030486](https://doi.org/10.3390/rs13030486).
- [AZF*25] APOLLONIO, F.I., ZANNONI, M., FANTINI, F., GARAGNANI, S., BARBIERI, L.: Accurate Visualization and Interaction of 3D Models Belonging to Museums' Collection: From the Acquisition to the Digital Kiosk. *ACM Journal on Computing and Cultural Heritage*, 18(1), 1-25, 2025. DOI: [10.1145/3704812](https://doi.org/10.1145/3704812).
- [BBB*24] BALZANI, R., BARZAGHI, S., BITELLI, G., BONIFAZI, F., BORDIGNON, A., CIPRIANI, et al.: Saving temporary exhibitions in virtual environments: The Digital Renaissance of Ulisse Aldrovandi–Acquisition and digitisation of cultural heritage objects. *Digital Applications in Archaeology and Cultural Heritage*, 32, e00309 (2024). DOI: [10.1016/j.daach.2023.e00309](https://doi.org/10.1016/j.daach.2023.e00309).
- [BPP*23] BANFI, F., PONTISSO, M., PAOLILLO, F. R., ROASCIO, S., SPALLINO, C., STANGA, C.: Interactive and immersive digital representation for virtual museum: VR and AR for semantic enrichment of Museo Nazionale Romano, Antiquarium di Lucrezia Romana and Antiquarium di Villa Dei Quintili. *ISPRS International Journal of Geo-Information*, 12(2), 28, 2023. DOI: [10.3390/ijgi12020028](https://doi.org/10.3390/ijgi12020028).
- [BTTP19] BERTOLINI, M., THUN HOHENSTEIN, U., PASINI, A., POLETTI, G.: Il Museo Universitario di Paleontologia e

- Preistoria “P. Leonardi”: divulgazione e nuove tecnologie per un museo a porte chiuse. *Museologia Scientifica Memorie*, 20, pp. 194-197.
- [DFC23] DEMETRESCU, E., FANINI, B., COCCA, E.: An online dissemination workflow for the scientific process in CH through semantic 3D: EMtools and EMviq open source tools. *Heritage*, 6,2 (2023), 1264–1276. DOI: [10.3390/heritage6020069](https://doi.org/10.3390/heritage6020069).
- [FG24] FANINI, B., GOSTI, G.: A new generation of collaborative immersive analytics on the web: Open-source services to capture, process and inspect users’ sessions in 3d environments. *Future Internet*, 16(5) (2024) 147. DOI: [10.3390/fi16050147](https://doi.org/10.3390/fi16050147).
- [FDB*22] FANINI, B., DEMETRESCU, E., BUCCIERO, A., CHIRIVI, A., GIURI, F., FERRARI, I., DELBARBA, N.: Building blocks for multi-dimensional WebXR inspection tools targeting cultural heritage. *International Conference on Extended Reality* (2022). pp. 373–390, Cham: Springer.
- [FFD*21] FANINI, B., FERDANI, D., DEMETRESCU, E., BERTO, S., D’ANNIBALE, E.: ATON: An open-source framework for creating immersive, collaborative and liquid web-apps for cultural heritage. *Applied Sciences*, 11(22), 11062, 2021. DOI: [10.3390/app112211062](https://doi.org/10.3390/app112211062).
- [FMR*22] FARELLA, E. M., MORELLI, L., RIGON, S., GRILLI, E., REMONDINO, F.: Analysing key steps of the photogrammetric pipeline for Museum artefacts 3D digitization. *Sustainability*, 14(9), 5740, 2022. DOI: [10.3390/su14095740](https://doi.org/10.3390/su14095740).
- [FMG*22] FARELLA, E. M., MORELLI, L., GRILLI, E., RIGON, S., REMONDINO, F.: Handling critical aspects in massive photogrammetric digitization of museum assets. *Int. arch. photogramm. remote sens. spat. inf. sci.*, 46, 215-222, 2022. DOI: [10.5194/isprs-archives-XLVI-2-W1-2022-215-2022](https://doi.org/10.5194/isprs-archives-XLVI-2-W1-2022-215-2022).
- [FBT*13] FERIOTTO, C., BIANCARDI, M., THUN HOHENSTEIN, U., LEONFORTE, A., BREDA M.: Cloud computing for Cataloguing and valorization of the Cultural Heritage. Experimentation of the LiveBase platform for the fast development of cataloguing. *Proc. Digital Heritage 2013*, 2, pp. 103-106. DOI: [10.1109/DigitalHeritage.2013.6744738](https://doi.org/10.1109/DigitalHeritage.2013.6744738).
- [Inc09] INCLUSION EUROPE: Information for all: European standards for making information easy to read and understand. Brussels 2009. ISBN 2-87460-110-1. Available from: https://www.inclusion-europe.eu/wp-content/uploads/2017/06/EN_Information_for_all.pdf [accessed Jul 8 2025].
- [KMR21] KARAMI, A., MENNA, F., REMONDINO, F.: Investigating 3D reconstruction of non-collaborative surfaces through photogrammetry and photometric stereo. *Int. arch. photogramm. remote sens. spat. inf. sci.*, 43, 519-526, 2021. DOI: [10.5194/isprs-archives-XLIII-B2-2021-519-2021](https://doi.org/10.5194/isprs-archives-XLIII-B2-2021-519-2021).
- [Lor01] LORIGA C.: Verso un Museo delle Scienze. Orto Botanico, Musei e collezioni storico-scientifiche dell’Università di Ferrara. *Annali dell’Università di Ferrara*, volume speciale, 2001.
- [MDM*20] MAIETTI, F., DI GIULIO, R., MEDICI, M., FERRARI, F., ZIRI, A. E., TURILLAZZI, B., BONSMAS, P.: Documentation, processing, and representation of architectural heritage through 3D semantic modelling: the INCEPTION project. In *Impact of Industry 4.0 on Architecture and Cultural Heritage* (pp. 202-238), 2020. IGI Global Scientific Publishing. DOI: [10.4018/978-1-7998-1234-0.ch009](https://doi.org/10.4018/978-1-7998-1234-0.ch009).
- [MMB*22] MAIETTI, F., MEDICI, M., BONSMAS, P., LERONES, P. M., FERRARI, F.: Digital technologies towards extended and advanced approaches to heritage knowledge and accessibility. In *Handbook of Research on Implementing Digital Reality and Interactive Technologies to Achieve Society 5.0* (pp. 295-317), 2022. IGI Global. DOI: [10.4018/978-1-6684-4854-0.ch014](https://doi.org/10.4018/978-1-6684-4854-0.ch014).
- [MMF21] MAIETTI, F., MEDICI, M., FERRARI, F.: From semantic-aware digital models to augmented reality applications for architectural heritage conservation and restoration. *Disegnarecon*, 14(26), 17-1, 2021. DOI: [dx.doi.org/10.20365/disegnarecon.26.2021.17](https://doi.org/10.20365/disegnarecon.26.2021.17).
- [MSR*25] MARRA, A.C., SUDANO, F., RAO, A., CALZONA, V., GUIDO, A.: Promotion of Paleontological Heritage: Case Histories from Southern Italy. *Heritage*, 8(3), 100, 2025. DOI: [10.3390/heritage8030100](https://doi.org/10.3390/heritage8030100).
- [PPFd21] PAGANO, A., PIETRONI, E., FERDANI, D., D’ANNIBALE, E.: User experience (UX) evaluation for MR cultural applications: The CEMEC holographic showcases in European museums. *Applied System Innovation*, 4(4), 92, 2021. DOI: [10.3390/asi4040092](https://doi.org/10.3390/asi4040092).
- [PT24] PARISI, C., THUN HOHENSTEIN, U.: Educate about environmental and cultural sustainability through prehistoric collections. The case of the Museum of Palaeontology and Prehistory “Piero Leonardi” of the University of Ferrara, Italy. *Bull. Mus. Anthropol. préhist.* Monaco, 63, (pp. 23–28), 2024.
- [PPBF21] PIETRONI, E., PAGANO, A., BIOCCA, L., FRASSINETI, G.: Accessibility, natural user interfaces and interactions in museums: the IntARSI project. *Heritage*, 4(2), 567-584, 2021. DOI: [10.3390/heritage4020034](https://doi.org/10.3390/heritage4020034).
- [PB01] POSENATO R., BROGLIO A.: Museo di paleontologia e Preistoria. In: LORIGA C. (ed), *Verso un Museo delle Scienze. Orto Botanico, Musei e collezioni storico-scientifiche dell’Università di Ferrara*. Annali dell’Università di Ferrara, 2001.
- [PCd*23] PESCARIN, S., CERATO, I., D’ANNIBALE, E., FANINI, B., FERDANI, D., et al.: Hybrid XR Collaborative and Guided Experiences in Cultural Heritage: Brancacci POV Prototype. In GCH (pp. 157–161), 2023. DOI: doi.org/10.2312/gch.20231171.
- [SBT21] SCATÀ, L., BERTOLINI, M., THUN HOHENSTEIN, U.: Virtual tour e fotogrammetria 3D applicati al Museo universitario di Paleontologia e Preistoria P. Leonardi. *Museologia Scientifica Memorie* (pp. 39–45), 2021.
- [TPT*21] THUN HOHENSTEIN, U., PASINI A., TARTER A., MESSANA, C., SCALCO, A., SCALI, F., et al.: Education, dissemination, and new technological approaches for a museum opened behind closed doors: the University Museum of Palaeontology and Prehistory “P. Leonardi”. In: D. Delfino and V. Nizzo, *Understanding and Accessibility of Pre-and Proto-Historical Research Issues: Sites, Museums and Communication Strategies*. UISPP Proceedings Series, 17, pp. 59–69, 2021.