POLITECNICO DI TORINO
Repository ISTITUZIONALE

Representation Challenges: Searching for New Frontiers of AR and AI Research

Original
Representation Challenges: Searching for New Frontiers of AR and AI Research / Giordano, Andrea; Russo, Michele; Spallone, Roberta. - ELETTRONICO. - (2022), pp. 9-18. [10.3280/oa-845-c190]

Availability:
This version is available at: 11583/2972021 since: 2022-10-03T17:42:28Z

Publisher:
Franco Angeli

Published
DOI:10.3280/oa-845-c190

Terms of use:

This article is made available under terms and conditions as specified in the corresponding bibliographic description in the repository

Publisher copyright

(Article begins on next page)

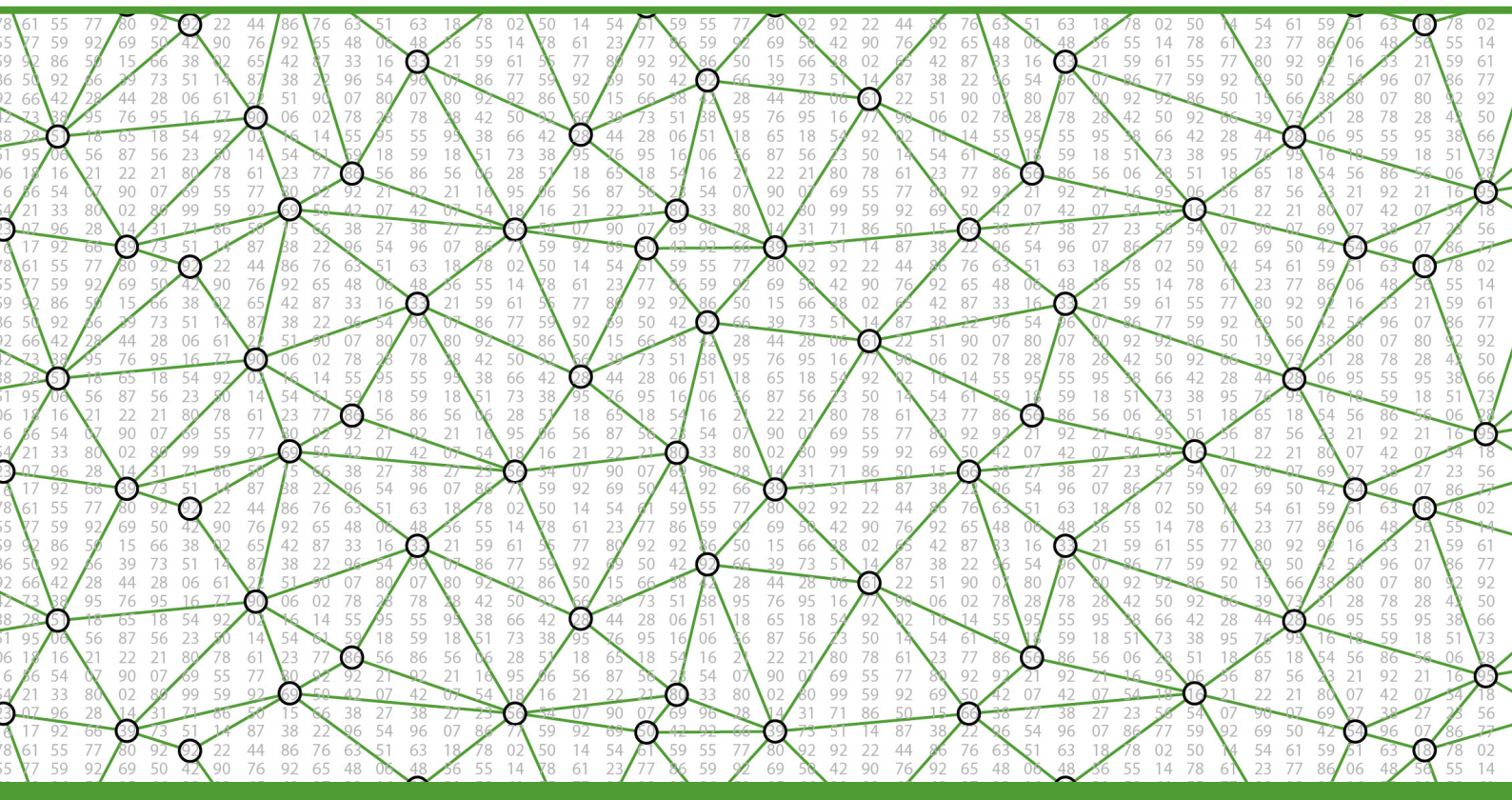
16 April 2024

REPRESENTATION CHALLENGES

New Frontiers of AR and AI Research for Cultural Heritage and Innovative Design

edited by

Andrea Giordano
Michele Russo
Roberta Spallone



FrancoAngeli OPEN ACCESS

diségno

diségno

the Series of the UID – Unione Italiana per il Disegno

director Francesca Fatta

The Series contains volumes of the proceedings of the annual conferences of the Scientific Society UID – Unione Italiana per il Disegno and the results of international meetings, research and symposia organised as part of the activities promoted or patronised by UID. The topics concern the Scientific Disciplinary Sector ICAR/17 Drawing with interdisciplinary research areas. The texts are in Italian or in the author's mother tongue (French, English, Portuguese, Spanish, German) and/or in English. The international Scientific Committee includes members of the UID Scientific Technical Committee and numerous other foreign scholars who are experts in the field of Representation.

The volumes of the series can be published either in print or in open access and all the authors' contributions are subject to double blind peer review according to the currently standard scientific evaluation criteria.

Scientific Committee

Marcello Balzani *Università di Ferrara*
Paolo Belardi *Università di Perugia*
Stefano Bertocci *Università di Firenze*
Carlo Bianchini *Sapienza Università di Roma*
Massimiliano Ciammaichella *Università IUAV di Venezia*
Enrico Cicalò *Università di Sassari*
Mario Docci *Sapienza Università di Roma*
Edoardo Dotto *Università di Catania*
Maria Linda Falcidieno *Università di Genova*
Francesca Fatta *Università degli Studi Mediterranea di Reggio Calabria*
Andrea Giordano *Università di Padova*
Elena Ippoliti *Sapienza Università di Roma*
Alessandro Luigini *Libera Università di Bolzano*
Francesco Maggio *Università di Palermo*
Caterina Palestini *Università di Chieti-Pescara*
Rossella Salerno *Politecnico di Milano*
Alberto Sdegno *Università di Udine*
Roberta Spallone *Politecnico di Torino*
Graziano Mario Valenti *Sapienza Università di Roma*
Chiara Vernizzi *Università di Parma*
Ornella Zerlenga *Università della Campania Luigi Vanvitelli*

Members of foreign structures

Marta Alonso *Universidad de Valladolid, ETS Arquitectura - Spagn*
Atxu Amann y Alcocer *ETSAM Universidad de Madrid (UPM) - Spagna*
Matthew Butcher *UCL Bartlett School of Architecture - Inghilterra*
Eduardo Carazo *Universidad de Valladolid - Spagna*
João Cabeleira *Universidade do Minho Escola de Arquitectura: Guimarães, Braga, Portugal*
Alexandra Castro *Faculdade de Arquitetura da Universidade do Porto - Portogallo*
Angela Garcia Codoner *Universidad Politécnica de Valencia - Spagna*
Pilar Chías *Universidad de Alcalá - Spagna*
Noelia Galván Desvaux *Universidad de Valladolid, ETS Arquitectura - Spagna*
Pedro Antonio Janeiro *Universidade de Lisboa - Portogallo*
Gabriele Pierluisi *Ecole nationale supérieure d'architecture de Versailles*
Jörg Schröder *Leibniz Universität Hannover*
Carlos Montes Serrano *Universidad de Valladolid - Spagna*
Jousé Antonio Franco Taboada *Universidade da Coruña - Spagna*
Annalisa Viati Navone *Ecole nationale supérieure d'architecture de Versailles*

Graphic design and cover by Enrico Cicalò and Paola Raffa

This volume is published in open access format, i.e. the file of the entire work can be freely downloaded from the FrancoAngeli Open Access platform (http://bit.ly/francoangeli-oa).
On the FrancoAngeli Open Access platform, it is possible to publish articles and monographs, according to ethical and quality standards while ensuring open access to the content itself. It guarantees the preservation in the major international OA archives and repositories. Through the integration with its entire catalog of publications and series, FrancoAngeli also maximizes visibility, user accessibility and impact for the author.

Read more:
http://www.francoangeli.it/come_pubblicare/pubblicare_19.asp

Readers who wish to find out about the books and periodicals published by us can visit our website www.francoangeli.it and subscribe to our "Informatemi" (notify me) service to receive e-mail notifications.

REPRESENTATION CHALLENGES

New Frontiers of AR and AI Research for Cultural Heritage and Innovative Design

edited by

Andrea Giordano
Michele Russo
Roberta Spallone

FrancoAngeli OPEN ACCESS

Scientific Committee

Violette Abergel
MAP UMR 3495 CNRS/MC, Marseille

Salvatore Barba
Università degli Studi di Salerno

Marco Giorgio Bevilacqua
Università degli Studi di Pisa

Stefano Brusaporci
Università degli Studi dell'Aquila

Pilar Chías
Universidad de Alcalá

Francesca Fatta
Università degli Studi di Reggio Calabria

Andrea Giordano
Università degli Studi di Padova

David Lo Buglio
Université Libre de Bruxelles

Alessandro Luigini
Libera Università di Bolzano

Michele Russo
Sapienza Università di Roma

Cettina Santagati
Università degli Studi di Catania

Alberto Sdegno
Università degli Studi di Udine

Roberta Spallone
Politecnico di Torino

Victoria Szabo
Duke University

Scientific Coordination

Andrea Giordano
Università di Padova

Michele Russo
Sapienza Università di Roma

Roberta Spallone
Politecnico di Torino

Editorial Committee

Giulia Flenghi
Sapienza Università di Roma

Fabrizio Natta
Politecnico di Torino

Michele Russo
Sapienza Università di Roma

ISBN printed edition: 9788835127307
ISBN digital edition: 9788835141945

Peer Reviewers

Marinella Arena
Università Mediterranea di Reggio Calabria

Salvatore Barba
Università di Salerno

Marco Giorgio Bevilacqua
Università di Pisa

Cecilia Bolognesi
Politecnico di Milano

Stefano Brusaporci
Università dell'Aquila

Francesca Fatta
Università Mediterranea di Reggio Calabria

Andrea Giordano
Università di Padova

Massimo Leserri
Università di Napoli "Federico II"

Stefania Landi
Università di Pisa

Massimiliano Lo Turco
Politecnico di Torino

Alessandro Luigini
Libera Università di Bolzano

Pamela Maiezza
Università dell'Aquila

Domenico Mediati
Università Mediterranea di Reggio Calabria

Cosimo Monteleone
Università di Padova

Michele Russo
Sapienza Università di Roma

Cettina Santagati
Università di Catania

Alberto Sdegno
Università di Udine

Roberta Spallone
Politecnico di Torino

Marco Vitali
Politecnico di Torino

The texts as well as all published images have been provided by the authors for publication with copyright and scientific responsibility towards third parties. The revision and editing is by the editors of the book.

Patronage

Cover image: Michele Russo

Copyright © 2022 by FrancoAngeli s.r.l., Milano, Italy.

This work, and each part thereof, is protected by copyright law and is published in this digital version under the license *Creative Commons Attribution-NonCommercial-NoDerivatives 4.0 International* (CC BY-NC-ND 4.0)

By downloading this work, the User accepts all the conditions of the license agreement for the work as stated and set out on the website
https://creativecommons.org/licenses/by-nc-nd/4.0

Index

7
Francesca Fatta
Preface

9
Andrea Giordano, Michele Russo, Roberta Spallone
Representation Challenges: Searching for New Frontiers of AR and AI Research

Keynote Lectures

21
Pilar Chías, Tomás Abad, Lucas Fernández-Trapa
AR Applications: Wayfinding at Health Centres for Disabled Users

29
Roberto D'Autilia
Cultural Heritage between Natural and Artificial Intelligence

35
Francesca Matrone
Deep Semantic Segmentation of Cultural Built Heritage Point Clouds: Current Results, Challenges and Trends

47
Camilla Pezzica
Augmented Intelligence In Built Environment Projects

55
Gabriella Caroti, Andrea Piemonte, Federico Capriuoli, Marco Cisaria, Michela Belli
"Divina!" a Contemporary Statuary Installation

AR&AI Heritage Routes and Historical Sources

65
Marinella Arena, Gianluca Lax
St. Nicholas of Myra: Reconstruction of the Face between Canon and AI

73
Greta Attademo
Perspective Paintings of Naples In Augmented Reality

81
Flaminia Cavallari, Elena Ippoliti, Alessandra Meschini, Michele Russo
Augmented Street Art: a Critical Contents and Application Overview

89
Giuseppe D'Acunto, Maddalena Bassani
The via Annia in Padua: Digital Narratives for a Roman Consular Road

97
Marco Fasolo, Laura Carlevaris, Flavia Camagni
Perspective Between Representation and AR: the Apse of the Church of St. Ignatius

105
Eric Genevois, Lorenzo Merlo, Cosimo Monteleone
Filippo Farsetti and the Dream of a Drawing Academy in Venice

113
Sara Morena, Angelo Lorusso, Caterina Gabriella Guida
AR to Rediscover Heritage: the Case Study of Salerno Defense System

121
Fabrizio Natta, Michele Ambrosio
AR for Demolished Heritage: the First Italian Parliament in Turin

129
Alessandra Pagliano
Between Memory and Innovation: Murals in AR for Urban Requalification in Angri (SA)

137
Barbara E. A. Piga, Gabriele Stancato, Marco Boffi, Nicola Rainisio
Representation Types and Visualization Modalities in Co-Design Apps

145
Paola Puma, Giuseppe Nicastro
Media Convergence and Museum Education in the EMODEM Project

153
Giorgio Verdiani, Pablo Rodriguez-Navarro, Ylenia Ricci, Andrea Pasquali
Fragments of Stories and Arts: Hidden and not so Hidden Stories

161
Ornella Zerlenga, Rosina Iaderosa, Marco Cataffo, Gabriele Del Vecchio, Vincenzo Cirillo
Augmented Video-Environment for Cultural Tourism

AR&AI Classification and 3D Analysis

171
Salvatore Barba, Lucas Matias Gujski, Marco Limongiello
Supervised Classification Approach for the Estimation of Degradation

179
Giorgio Buratti, Sara Conte, Michela Rossi
Proposal for a Data Visualization and Assessment System to Rebalance Landscape Quality

187
Devid Campagnolo
Point Cloud Segmentation for Scan to BIM: Review of Related Tecniques

195
Valeria Croce, Sara Taddeucci, Gabriella Caroti, Andrea Piemonte, Massimiliano Martino, Marco Giorgio Bevilacqua
Semantic Mapping of Architectural Heritage via Artificial Intelligence and H-BIM

203
Giuseppe Di Gregorio, Francesca Condorelli
3DLAB SICILIA and UNESCO-VR. Models for Cultural Heritage

211
Sonia Mollica
Connection & Knowledge: from AR to AI. The Case of Sicilian Lighthouses

219
Andrea Rolando, Domenico D'Uva, Alessandro Scandiffio
Image Segmentation Procedure for Mapping Spatial Quality of Slow Routes

227
Andrea Tomalini, Edoardo Pristeri
Real-Time Identification of Artifacts: Synthetic Data for AI Model

AR&AI Museum Heritage

237
Fabrizio Agnello, Mirco Cannella, Marco Geraci
AR/VR Contextualization of the Statue of Zeus from Solunto

245
Paolo Belardi, Valeria Menchetelli, Giovanna Ramaccini, Camilla Sorignani
MAD Memory Augmented Device: a Virtual Museum of Madness

253
Massimiliano Campi, Valeria Cera, Francesco Cutugno, Antonella di Luggo, Paolo Giulierini, Marco Grazioso, Antonio Origlia, Daniela Palomba
Virtual Canova: a Digital Exhibition Across MANN and Hermitage Museums

261
Maria Grazia Cianci, Daniele Calisi, Stefano Botta, Sara Colaceci, Matteo Molinari
Virtual Reality in Future Museums

269
Fausta Fiorillo, Simone Teruggi, Cecilia Maria Bolognesi
Enhanced Interaction Experience for Holographic Visualization

277
Isabella Friso, Gabriella Liva
The Rooms of Art. The Virtual Museum as an Anticipation of Reality

285
Massimiliano Lo Turco, Andrea Tomalini, Edoardo Pristeri
IoT and BIM Interoperability: Digital Twins in Museum Collections

293
Davide Mezzino
AR and Knowledge Dissemination: the Case of the Museo Egizio

301
Margherita Pulcrano, Simona Scandurra
AR to Enhance and Raise Awareness of Inaccessible Archaeological Areas

309
Francesca Ronco, Rocco Rolli
VR, AR and Tactile Replicas for Accessible Museums. The Museum of Oriental Art in Turin

317
Alberto Sdegno, Veronica Riavis, Paola Cochelli, Mattia Comelli
Virtual and Interactive Reality in Zaha Hadid's Vitra Fire Station

325
Luca J. Senatore, Francesca Porfiri
Storytelling for Cultural Heritage: the Lucrezio Menandro's Mithraeum

333
Marco Vitali, Valerio Palma, Francesca Ronco
Promotion of the Museum of Oriental Art in Turin by AR and Digital Fabrication: Lady Yang

AR&AI Building Information Modeling and Monitoring

343
Fabrizio Banfi, Chiara Stanga
Reliability in HBIM-XR for Built Heritage Preservation and Communication Purposes

351
Rachele A. Bernardello, Paolo Borin, Annalisa Tiengo
Data Structure for Cultural Heritage. Paintings from BIM to Social Media AR

359
Daniela De Luca, Matteo Del Giudice, Anna Osello, Francesca Maria Ugliotti
Multi-Level Information Processing Systems in the Digital Twin Era

367
Elisabetta Doria, Luca Carcano, Sandro Parrinello
Object Detection Techniques Applied to UAV Photogrammetric Survey

375
Maria Linda Falcidieno, Maria Elisabetta Ruggiero, Ruggero Torti
Information and Experimentation: Custom Made Visual Languages

383
Andrea Giordano, Alberto Longhin, Andrea Momolo
Collaborative BIM-AR Workflow for Maintenance of Built Heritage

391
Valerio Palma, Roberta Spallone, Luca Capozucca, Gianpiero Lops, Giulia Cicone, Roberto Rinauro
Connecting AR and BIM: a Prototype App

399
Fabiana Raco, Marcello Balzani
Built Heritage Digital Documentation Through BIM-Blockchain Technologies

407
Colter Wehmeier, Georgios Artopoulos, Federico Mario La Russa, Cettina Santagati
Scan-To-Ar: from Reality-Capture to Participatory Design Supported by AR

AR&AI Education and Shape Representation

417
Raffaele Argiolas, Vincenzo Bagnolo, Andrea Pirinu
AR as a Tool for Teaching to Architecture Students

425
Giulia Bertola, Alessandro Capalbo, Edoardo Bruno, Michele Bonino
Architectural Maquette. From Digital Fabrication to AR Experiences

433
Michela Ceracchi, Giulia Tarei
The Renewed Existence in AR of Max Brückner's Lost Paper Polyhedra

441
Serena Fumero, Benedetta Frezzotti
Using AR Illustration to Promote Heritage Sites: a Case Study

449
Francisco M. Hidalgo-Sánchez, Gabriel Granado-Castro, Joaquín María Aguilar-Camacho, José Antonio Barrera-Vera
SurveyingGame: Gamified Virtual Environment for Surveying Training

457
Javier Fco. Raposo Grau, Mariasun Salgado de la Rosa, Belén Butragueño Díaz-Guerra, Blanca Raposo Sánchez
Artificial Intelligence. Graphical and Creative Learning Processes

Representation Challenges: Searching for New Frontiers of AR and AI Research

Andrea Giordano
Michele Russo
Roberta Spallone

We have come to the second collection of essays that originated under the aegis of Representation Challenges and that, by reintroducing the combination of Augmented Reality (AR) and Artificial Intelligence (AI), explores its new frontiers.
The ambitious goal of this second step of the debate triggered during REAACH-ID Symposium 2020 was to go beyond the fundamental census of the research carried out by Representation scholars in Italy and to explore the new boundaries that, after just one year, AR and AI mark in the fields of cultural heritage and innovative design, opening to international studies. This goal has been fully achieved and surprisingly surpassed, thanks to the lymph provided by new proposals and new scholars, which we hope – at least in a small part – to have contributed to fuel and stimulate.
One of the advantages of the structure of REAACH-ID Symposium is that the research topics proposed during the two-day meeting are discussed and refereed by the members of the scientific committee and the committee of reviewers, who provide guidelines and stimuli for ongoing research and ask for clarifications and insights concerning those already completed. The volume of essays presented here is the outcome of the debate and enrichment that the research has received because of this process. For this reason and as the cutting-edge topics addressed require, the outcomes published here result as up to date as possible.
The international Symposium took place online on 12 and 13 October 2021, managed by the Zoom platform of the University of Padua.

doi.org/10.3280/oa-845-c190

The related abstracts were peer-reviewed and divided into 38 oral and 25 video presentations. This division wanted to preserve the duration of the event (two days) giving to everyone the opportunity to present their research. The sessions were introduced by the Keynotes lectures: Pilar Chías (University of Alcalá), Tomás Abad (University of Alcalá), Lucas Fernández-Trapa (Hochschule Koblenz), Roberto D'Autilia (Università degli Studi Rome Tre), Giuseppina Padeletti (CNR-ISMN), Patrizia Grifoni (CNR-IRPPS), Francesca Matrone (Politecnico di Torino), Camilla Pezzica (Cardiff University), Gabriella Caroti (Università di Pisa), Andrea Piemonte (Università di Pisa), Federico Capriuoli (ACAS 3D Soluzioni Digitali - Università di Pisa), Marco Cisaria (ACAS 3D Soluzioni Digitali - Università di Pisa), Violette Abergel (MAP Laboratory - Lyon - Marseille). The video presentations were uploaded before the beginning of the conference on a dedicated YouTube channel and shared with all Symposium participants. In addition, the final recordings of the event

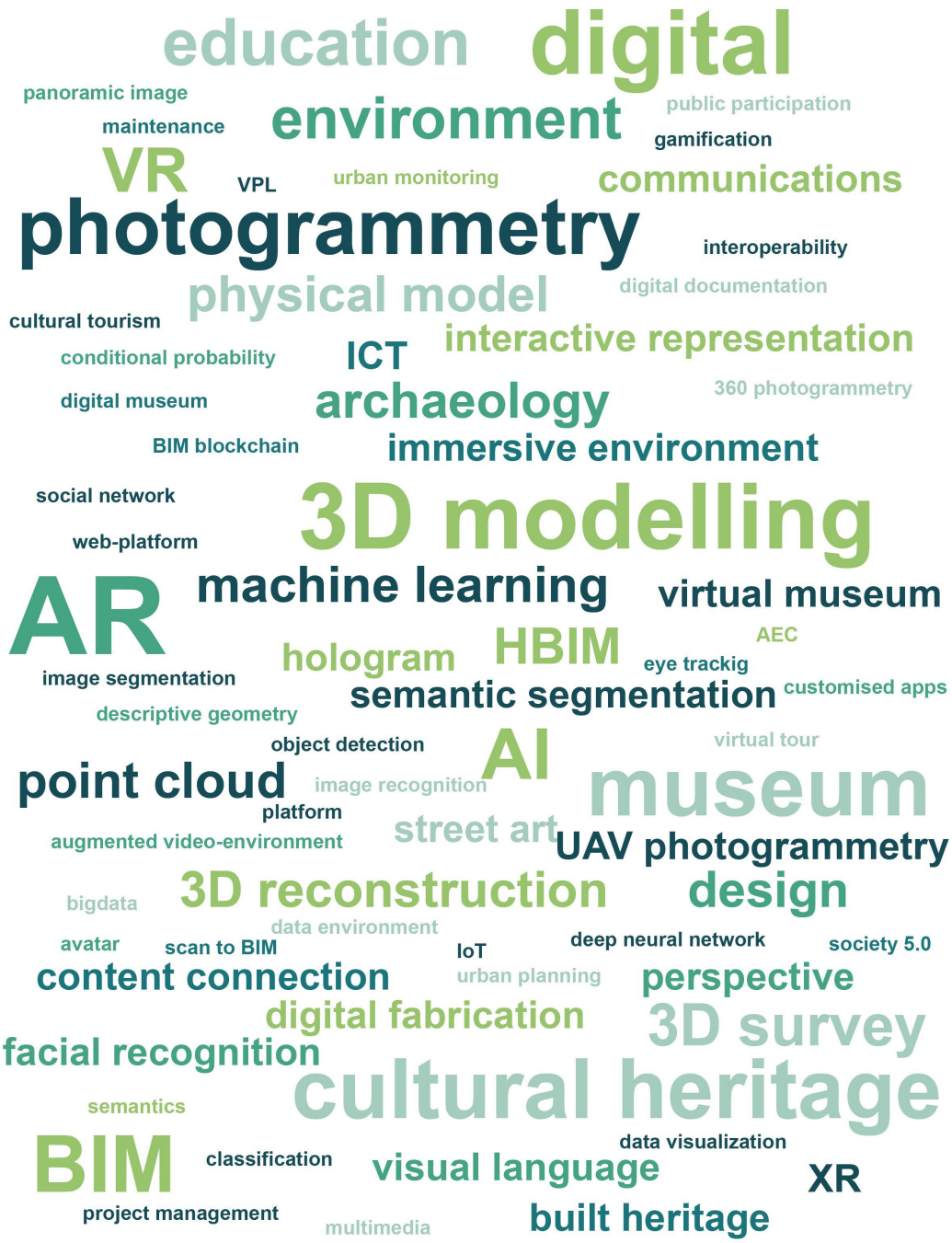


Fig. 1. Word clouds of the book keywords.

were uploaded on the same channel, available to all registered participants for the event.
A demo session collected videos with demonstrations of the experiments conducted on a continuous loop.
From the initial 63 proposals, there are 49 research papers selected and presented in the current volume, with a total number of 148 authors. There is also the presence among the authors of figures not from academia but industry and museums. In addition to the 49 essays, there are 5 keynotes reports, the preface by Francesca Fatta, and the present introductory essay by the editors of the book.
Following the double-blind peer-review of the final papers, the contributions were classified according to five macro-groups: AR&AI heritage routes and archival sources, AR&AI classification and 3D analysis, AR&AI museum heritage, AR&AI building information modelling and monitoring, and AR&AI education and shape representation.
We feel it is relevant to note that, many of the issues addressed in the essays in this volume, developed in the early months of the current year, 2022, correspond to those listed in the final report "Study on quality in 3D digitization of tangible cultural heritage: mapping parameters, formats, standards, benchmarks, methodologies, and guidelines" (VIGIE-2020-654; https://digital-strategy.ec.europa.eu/en/library/study-quality-3d-digitisation-tangible-cultural-heritage), financed by the European Commission, Directorate-General of Communications Networks, Content & Technology. This report, published in April 2022, is the outcome of research conducted by the consortium formed by one tenderer, the Cyprus University of Technology (CUT) and a group of expert subcontractors. This project deals with a field of interest, i.e., the movable and immovable tangible cultural heritage, circumscribed from that proposed by our initiative (which also ranges over intangible heritage and project monitoring and management). Vice-versa, VIGIE-2020-654 makes a broad exploration of heritage digitization, including the concepts of complexity and quality, with a focus on standards and formats, but without neglecting to broaden the look at 3D digitization technologies to the world of Architecture, Engineering & Construction (AEC). In the last section of the report, devoted to the "Forecast Impact of Future Technological Advances", individual points of attention in convergence with the REAACH-ID Symposium topics are, among others: Extended Reality (AR, VR, MR), Metaverse, 5G and the Continued Advancement of Mobile Technologies, BIM, HBIM, HHBIM, Digital Twin, Artificial Intelligence/Machine Learning, and Blockchain Technologies.
The analysis of the keywords chosen by the authors of this volume to represent the content of their research brings out the expected interests concerning digital technologies, primarily AR and AI, as central themes of the call, and their relationships with digital acquisition methodologies (photogrammetry and UAV photogrammetry), of interpretive and informative visualization (BIM, H-BIM, 3D modelling, VPL, digital fabrication, and mapping), of visual communication (VR, immersive environment, interactive representation, and hologram). In addition, several application areas appear (cultural heritage, museum, education, archaeology, street art, urban, built heritage, and virtual museum), and practices related to AI, machine learning and semantic segmentation.
Still other terms, at present mentioned with less intensity, seem likely to foreshadow new challenges of representation, opening up new areas of research and application.

AR&AI Heritage Routes and Archival Sources

This theme is central to the Representation discipline. The great potential of immersive and interactive visualization methods to promote understanding and reading of the existing emerges in the field. The research area develops different approaches according to the scale of application. At the urban scale, Barbara Piga, Gabriele Stancato Marco Boffi & Nicola Rainisio propose state of the art on web-based and mobile applications for collaborative processes in urban planning. The research highlights how two-dimensional representations and non-immersive visualization modes characterize such participatory processes. Remaining in the urban sphere, Ornella Zerlenga, Rosina Iaderosa, Marco Cataffo,

Gabriele Del Vecchio & Vincenzo Cirillo propose a series of reflections on the relevance of smart glasses for the tourist-cultural sphere. They highlight how such devices can be a resource for disseminating and "augmented" enhancement of diffuse cultural heritage.
At the architectural scale, it is interesting to mention two other types of research focused on using AR/VR technologies to represent architectures that no longer exist or have never been built. In the first case, Fabrizio Natta & Michele Ambrosio present a reconstructive digital modeling and AR visualization of the hall of the First Italian Parliament in the courtyard of Palazzo Carignano in Turin, which now no longer exists. The study starts by interpreting documents, archival drawings, and historical studies. These sources are also essential for the second project, proposed by Eric Genevois, Lorenzo Merlo & Cosimo Monteleone. It is devoted to the virtual reconstruction of the never realized "Accademia del Disegno" in Venice by Filippo Farsetti. The primary purpose is to give the palace new "digital" life, promoting and disseminating Venice's artistic and architectural heritage. Moving from the main urban architectures to the minority ones, Giorgio Verdiani, Ylenia Ricci, Andrea Pasquali, & Pablo Rodriguez-Navarro propose an AR-based system to make the traces of these architectures more evident and accessible in the center of Florence. Their research proposes exploring the historic Florentine center that recalls this secondary connective and cultural fabric, crucial for understanding the entire architectural-urban system. Staying on the topic of minority architecture, Sara Morena, Angelo Lorusso & Caterina Garbiella Guida's contribution addresses the issue of the protection and enhancement of lesser-known heritage. Specifically, a tower of the coastal defense system is explored, showing how technologies and the significant development of digitization contribute positively to the accessibility and visibility of this type of heritage.
The image recognition topic related to drawings, paintings, and frescoes is particularly relevant in the 2021 edition of REAACH-ID, providing specific information or suggesting cultural routes. Alessandra Pagliano presents a re-edition of the "Augmenting Angri" research, showing the use of AR as a tool for urban art enhancement and local population engagement. The study proposes the interaction of physical murals with overlaid digital content. Besides, Flaminia Cavallari, Elena Ippoliti, Alessandra Meschini & Michele Russo discuss the theme of democratization and physical decay of street artworks as pillars to preserve during the digital representation process. The research, which proposes some AR applications in Rome related to the figure of Anna Magnani, shows how AR allows achieving the delicate balance between real and digital, enhancing both specificities. Greta Attademo also reworks a 2020 research theme, proposing the definition of a geo-coded map of urban paintings and their use in AR on the graphic image of Naples. As in the previous contribution, weaknesses and strengths in using AR are critically highlighted. The city's iconography conveyed through images is close to that of decorative apparatus and frescoes. On this topic, Marinella Arena & Gianluca Lax reworked a 2020 project, developing an AI-based protocol for reconstructing the missing parts of the Byzantine frescoes of the Church of St. Nicholas. The research has the dual purpose of proposing digital restorations and initiating a formal and symbolic analysis of Byzantine iconography for communication to a broad audience. Staying on the topic of image analysis and underlying geometric constructions, Marco Fasolo, Flavia Camagni & Laura Carlevaris propose a way of applying AR for the communication of architectural perspectives. The study analyzes the decorations of the presbytery and the apse of the Church of Sant'Ignazio in Rome by Andrea Pozzo, promoting the understanding of perspective technique and highlighting the effect of spatial expansion on the architectural environment.
A final declination of the topic focuses on museum routes. Paola Puma & Giuseppe Nicastro repurpose the 2020 EMODEM project to interface virtual and physical space and make the museum experience more visitor-centered, interactive and personalized. The study updates the scientific progress of the research. In the same area, Giuseppe D'Acunto & Maddalena Bassani propose a study and enhancement of artifacts preserved at the Archaeological Museum of Padua. The research specifically addresses the problems related to the graphic restitution of the finds and the possible implementation of their communication through digital tools.

AR&AI Classification and 3D Analysis

The automatic or semi-automatic classification of consistent elements, regardless of scale and according to specific semantic orders, remains a challenging area of experimentation. Its importance is mainly related to the possibility of better handling large amounts of 2D/3D data and optimizing the modeling and representation steps. One of the most relevant passages is defined by the Scan-to-BIM process. Devid Campagnolo proposes a critical state of the art on the topic, analyzing the current trends in the automation of this process. The study highlights the most used approaches and methodologies, providing a point of view that helps to understand better future developments.
At the urban scale, two contributions focus on the topic of the landscape. At the theoretical level, Michela Rossi, Sara Conte & Giorgio Buratti analyze the territory as a complex system. It can be represented through AI models highlighting spatial settlement patterns and developing tools to rebalance the human-landscape relationship. On the other side, Andrea Rolando, Domenico D'Uva & Alessandro Scandiffio investigate the segmentation of spatial images for mapping some types of routes in the Lombardy-Molise territory. The research validates a possible complementary and valuable analysis process in territories where thematic geospatial data are unavailable.
At the architectural scale, data optimization becomes essential to address the issue of a virtual representation. Giuseppe Di Gregorio & Francesca Condorelli illustrate the 3DLAB Sicilia project aimed at enhancing some UNESCO sites through the 3D acquisition, modeling, and visualization with VR, AR, and wall VR systems. The theme of visualization is also addressed by Sonia Mollica, who proposes a study on the use, enhancement, and understanding of Sicilian lighthouses. Through AR and AI, a network of connections between semantic and ontological data is shown to facilitate reading these particular architectures, deepening their relationship with the territory.
Specific use of 3D point cloud segmentation and classification application facilitates conservation and restoration processes. In this field, Valeria Croce, Sara Taddeucci, Gabriella Caroti, Andrea Piemonte, Massimiliano Martino & Marco Giorgio Bevilacqua start from the 3D photogrammetric virtual reconstruction of the Church of the Carmine in Pisa. The study proposes an AI-based classification method that allows digital models of the existing architectural heritage to be semi-automatically characterized in terms of material mapping and state of degradation, simplifying the scan-to-BIM process. Remaining in materials mapping, Salvatore Barba, Lucas Matias Gujski & Marco Limongiello present a study to classify geomaterials. They start from image acquisition by UAV and photogrammetric processing. The study presents a supervised classification method based on orthoimage processing, examining is the "Broken Bridge" between the provinces of Avellino and Benevento.
Finally, at the museum level, Andrea Tomalini & Edoardo Pristeri go deep into the classification topic applied to collections of elements to optimize their management, maintenance, and dissemination. The research proposes the construction of specific datasets with low-budget tools and testing algorithms for recognizing and labeling cultural heritage objects.

AR & AI Museum Heritage

In the museum field, as in other places of culture that provide for the on-site enjoyment of works, collections, performances, projections, etc. the very recent period of the Covid19 pandemic, with the consequent reduced mobilities, closures, and access restrictions, has entailed the massive recourse to modes of communication that have tended to be homologated, which have taken the form of virtual tours and video footage of curator-led visits, more rarely in digitization of art-works made available on web-based viewers, immersive and/or interactive experiences of virtually reconstructed spaces and objects.
The large number of contributions – whose subject matter is museum heritage, outdoor and indoor – may suggest that a significant number of scholars in the disciplines of representation have proposed or have been called upon to offer original and innovative solu-

tions in this regard, aimed, conversely, on the one hand, at bringing the public back to the places of art and making them enjoy immersive and interactive experiences based on digital applications, and on the other hand, at proposing immersive, interactive experiences and original digital applications aimed at creating new links between real and virtual spaces.
The work of Fabrizio Agnello, Mirco Cannella & Marco Geraci creates a double link between the Statue of Zeus, an archaeological artefact housed at the Salinas Museum in Palermo, and the archaeological site of Solunto, where it was found. In the pipeline developed by the scholars, digitization of the site and the statue by laser scanning and panoramic photographs processed with structure from motion technology, modelling and markerless AR experience converge.
The research by Paolo Belardi, Valeria Menchetelli, Giovanna Ramaccini & Camilla Sorignani builds a synergy between AI and AR on the delicate topic of the musealization of psychiatric hospitals, with an experiment related to the Santa Margherita hospital in Perugia. Starting from a single photograph of patients, a plug-in for Character Creator based on AI can generate in real time the somatic features for digital avatars. They are actors recounting their lives, reconstructed through archival documentation, within a virtual museum placed on social networks through an Instagram profile. A physical museum, planned to be installed within a disused gallery near the original site of the asylum, makes use of AR for an enriched immersive experience.
The collaboration between the Interdepartmental Research Center Urban/Eco of the University of Naples and the Museo Archeologico Nazionale di Napoli (MANN) is the framework for the proposal by Massimiliano Campi, Valeria Cera, Francesco Cotugno, Antonella di Luggo, Paolo Gulierini, Marco Grazioso, Antonio Origlia & Daniela Palomba aimed at the augmented, interactive and immersive fruition, through AR and VR, of sculptures by Antonio Canova temporarily loaned by the Hermitage Museum in St. Petersburg to the Neapolitan museum.
Immersivity, interactivity and simulation constitute the key features of the intervention by Maria Grazia Cianci, Daniele Calisi, Stefano Botta, Sara Colaceci & Matteo Molinari, who realize a reconstruction of the Pavilion 2B of the former Mattatoio di Testaccio in Rome as a virtual environment for digital exhibitions. To the digitally reconstructed virtual environment are added the different exhibition proposals and in the space, enjoyed in immersive mode, a kind of "augmented virtual reality" is realized.
Fausta Fiorillo, Simone Teruggi & Cecilia Maria Bolognesi explore the possibility of broadening hologram table capabilities of interaction by developing a custom-designed experience to interact with the 3D point cloud coming from the digital survey of the basilica of Santa Maria delle Grazie in Milan. The holographic visualization can help understand and represent the morphologically complex building and its transformations, while, by customizing the hologram table interface, many data can be added, and the point cloud works as an informative model with associated other relevant information.
Isabella Friso & Gabriella Liva, in light of the continuing pandemic situation, propose the implementation of a virtual museum inside Gino Valle's room of Università Iuav di Venezia. It fulfils the functions of research, didactics, and alternative information, without aspiring to replace the real museum, but working alongside it in the revitalization of cultural objectives and contributing to the success of educational action.
Aiming to improve the management of museum buildings and collections, Massimiliano Lo Turco, Andrea Tomalini & Edoardo Pristeri propose the integration of IoT systems and BIM tools through the writing of flexible algorithms in the VPL (Visual Programming Language) environment. The authors set a computer architecture structured on three layers that collect, analyze, classify, and store environmental information. The first layer is a hardware interface (client) that collects the museum's environmental data and transmits it to the server (cloud or edge); the second layer acts as an interface for analyzing the collected data; the third layer stores locally the data processing to provide decision-making tools.
Davide Mezzino presents two experiences developed inside the Museo Egizio di Torino, in which the opportunities of AR technologies to implement the knowledge and dissemination of tangible and intangible aspects of the millennial historical objects preserved in the Mu-

seum are applied. The author discusses the role of digital strategies and, in particular, of AR in museum contexts aimed at preserving cultural identity and collective memory as well as interpreting and communicating their meanings to wide and heterogeneous audiences.
In the research of Margherita Pulcrano & Simona Scandurra XR systems for the use and dissemination of knowledge about the architectural Heritage are applied to areas that are currently inaccessible, i.e., the archaeological area below the Basilica of Santa Restituta. The methodological approach employs AR as a user-friendly tool that, through the involvement of the user in experiences implemented by multimedia content, allows to highlight unexplored aspects of the Heritage. In this way, it is possible to enjoy an otherwise inaccessible space, while maintaining a certain degree of relationship with physical reality.
Francesca Ronco & Rocco Rolli present a project aimed at the realization of accessible exhibition paths including multi-sensorial experiences in situ (tactile paths and AR experiences) in the Museum of Oriental Art in Turin (MAO), in the framework of the agreement between the Department of Architecture and Design of the Politecnico di Torino and the Fondazione Torino Musei, involving also Tactile Vision Onlus, for the enhancement of the MAO's heritage. Six stages of a knowledge path have been identified, including the museum's entrance hall and five artworks, the subjects of the digital survey, reconstructive modelling, prototyping of AR app and digitally fabricated models and replicas.
Alberto Sdegno, Veronica Riavis, Paola Cochelli & Mattia Comelli deal with the virtual reconstruction and virtual reality communication of the Fire Station designed by Zaha Hadid for the Vitra headquarters. In this regard the authors set up an application protocol that goes from the acquisition of graphic, photographic and documentary information of the architecture to be reconstructed, to low poly modelling, to the generation of specific textures, and lighting studies. Then the authors realize an effective immersive experience, allowing maximum freedom of movement and implementing the system with the programming of interactions.
A storytelling project based on AR experiences is at the centre of interest in Luca J. Senatore & Francesca Porfiri research. The first results of the ongoing digitization process of the collection inside the buildings of the Ostia Antica Archaeological Park in Rome, in particular, related to the case study of the Mithraeum of Lucrezio Menandro show how innovative digitization and data optimization technologies are compared with the immense heritage of the Park, animating the exhibition-interactive itinerary, creating digitally usable content through AR, reflecting on the opportunity of these technologies to create new forms of digital storytelling for use and knowledge.
In the same institutional framework, another project applied to the Museum of Oriental Art also proposes its promotion through crowdfunding, through the creation of the tactile replica and production of activating bookmarks of an AR experience, of Lady Yang, an artwork elected as the museum's mascot for 2021. Marco Vitali, Valerio Palma & Francesca Ronco are the authors of the project, which is being developed through SfM surveying, digital modelling, texturing, including philologically reconstructed colours, digital fabrication (via 3D printing for the tactile replica and raster engraving process of the laser printer for the bookmark), AR experience with the programming of a web-app that allows the digital model and related information to be visualized.
An archaeological artifact housed at the Salinas Museum in Palermo, and the archaeological site of Solunto, where it was found. In the pipeline developed by the scholars, digitization of the site and the statue by laser scanning and panoramic photographs processed with structure from motion technology, modeling and markerless AR experience converge.

AR&AI Building Information Modeling and Monitoring

This is another step of our challenge: the book here assembles a collection of essays that demonstrate the application of digital and interoperable procedures to a range of different circumstances. In fact, this methodological approach – to the fields of architectural/ engineering and urban heritage and new constructions – has resulted in new forms of

investigation, documentation and understandings as well as innovative approaches to the life cycle of the building also involving public facing and academic outcomes via multimedia visualizations. This compilation of papers serves as a moment to reflect upon the growth of this methodology, especially with regard to the application of emerging technologies.
In these topics, then, we can recognize the paper proposed by Fabrizio Banfi & Chiara Stanga that proposes a process and the advance of HBIM parameters skilled to communicate heterogeneous standards to support the building life cycle, starting from the survey campaign to the restoration and maintenance of the asset. The core is the improving of information sharing about earthquake-damaged buildings such as the San Francesco church in Arquata del Tronto, moving from for different types of users, digital devices and virtual experiences. The contribution of Rachele A. Bernardello, Paolo Borin & Annalisa Tiengo focuses on a procedure to communicate and enhance cultural heritage value. Combining them with digital strategies and methods, the core of the proposal is a methodology that implements BIM (Building Information Modeling) and CDE (Common Data Environment) concepts to build and organize information of paintings through connected databases, typically produced by multiple actors. Daniela De Luca, Matteo Del Giudice, Anna Osello & Francesca Maria Ugliotti propose an interesting research about challenging aspect of the scientific panorama. In fact, their contribution link and decline Augmented Reality and AI for a gradual scale analysis of artefacts contained in a building in an urban context of interest. Then, multi-level information processing system links the three-dimensional matrix with data collection, representation and visualization techniques – according to specific use cases – achieving the assisting communication processes both for the dissemination of knowledge and the accessibility and usability of data. The project presented by Elisabetta Doria, Luca Carcano & Sandro Parrinello propose an automated approach to the registration and monitoring of technological and architectural elements from considerable photography datasets. Starting from UAV photogrammetric close-range acquisitions of the roofs of the center of Bethlehem, the research gears dataset to train Deep Learning models on a Cloud Infrastructure handling model lifecycle from training to deployment, automating periodic operations to assist large scale monitoring and management of the areas, involving diverse teams and municipalities. The contribution of Maria Linda Falcidieno, Maria Elisabetta Ruggiero & Ruggero Torti proposes the experience of a productive partnership between the Architecture and Design Department (University of Genova) and Grandi Navi Veloci. The core is to set the visual perception of customer caring on board, with the issue of communicating data necessary in certain circumstances, such as in the often unspoken request for the reassurance of the user in the face of moments of unease or concern. Through AR, an interesting app configures elements that inform passengers about the protection and safety mechanisms that are not immediately perceptible. Then combining with AI, the app is able to guarantee involvement through the communication of messages tailored to specific situations. Andrea Giordano, Alberto Longhin & Andrea Momolo propose a research about a BIM-AR workflow to ensure the monitoring of the built heritage. Indeed, the application of AR might be an extension of the BIM since it allows during the on-site surveys' phases to add and update punctual information within the BIM model overcoming the traditional survey methods. Therefore, the proposed information models can performance as collaborative tools on behalf of public authorities and stakeholders utilization, achieving a proficient building management, also from a preventive perspective. The stimulating contribution of Valerio Palma, Roberta Spallone, Luca Capozucca, Gianpiero Lops, Giulia Cicone & Roberto Rinauro highlights current opportunities and limits of the the interaction between AR and building information modeling (BIM) technologies fully scalable. In this sense, the study intends to integrate immersive technologies and information modeling for the built space. The core is then the implementation of tools and processes to rapidly recognize the equipment present on telecommunication network sites and access the corresponding components on a digital information model. The output of the first phase of the project is an app prototype for mobile devices capable of showing a 1:1 scale AR representation on-site. The proposal of Fabiana Raco & Marcello Balzani enhances the problematic that there is redundancy,

multiplication, lack of transparency and disaggregation of data and information for the construction industry, with deleterious response in terms of time, cost, and quality of the project life-cycle management. The core of tis paper is the development of a TRL 4-5 ICT application that integrates Building Information Modeling and blockchain technologies, to digitalize procedures in the supply chain that guides better information flow transparency, knowledge-based organizations, and decision-making processes based on explicit ordered data. Colter Wehmeier, Georgios Artopoulos, Federico Mario la Russa & Cettina Santagati propose an impacting contribution centered on the Cantieri Culturali della Zisa, Palermo, part of a co-design workshop called Everyday Experiences and Heritage in South European Cities: Digital Tools and Practises. The proposed research contest is about methods in 3D scanning and augmented reality for public-inclusive architectural programs through rapid survey, accessible design tooling, and immersive visualization outcomes. The research core describes the benefits of pedestrian-operated 3D structure-from-motion survey for historic urban scenarios, implementing a cloud-based augmented reality app modified for accessible proposal creation and visualization.

AR&AI Education and Shape Representation

With the contributions of this section, we have arrived at a time for deepening the academic training and coaching, involving a deeper embracing of digital-media circumstances. Traditional methodologies of architectural and urban history must remain the foundation of digital approaches, becoming part of the new scientific-methodological practice that digital applications offer. An ambitious enterprise – with varying expertise and multi-disciplinary backgrounds – that emerges from all the paper here offered, involving simple models or digital data, but rather creating dynamic interactive and interoperable displays that can show complex / new modes of education / communication. Then, new processes and codes for communicating knowledge-based visualizations have assumed a decidedly important role, proposing the capacity to present a more fully three-dimensional revelation and subsequent analysis of data than traditional publications might offer in certain contexts, also the everyday life. Is the case of the contribution of Raffaele Argiolas, Vincenzo Bagnolo & Andrea Pirinu that shows how Information and communication technology (ICT) are currently a basic part of training and educational activities. The aim is the improvement of an augmented reality application for accessing documentary sources used in the teaching of drawing disciplines in architecture courses at the University of Cagliari, involving students in the deeper study of the Castello district and its architecture, organized as an "access point" to the knowledge. The paper of Giulia Bertola, Alessandro Capalbo, Edoardo Bruno & Michele Bonino reflects on how, in the age of the immaterial, a plastic model is an apparatus still contemporary in the representation with the new digital tools of augmented reality (AR). In this context, the basic of the proposed research is the experimentation of the realization of two static scale models, through Digital Fabrication technologies, aiming to increase the accessibility to knowledge about the architectural project in an exhibition context. The developed methodology allows the user to obtain information about the architectural project not only through the real model but also through static and dynamic virtual models overlaid using the current AR technologies. Michela Ceracchi & Giulia Tarei propose the implementation of an Augmented Reality museum of mathematical-physical models specifically for educational purposes and capable of explaining mathematical and geometric principles. The main feedback is the interactive accessibility of Max Brückner's collection of polyhedra models. The achieved digital twins of the solids facilitate the illustrative contents, with a replica of paper mock-up, thus giving pedagogical importance to the mathematical models otherwise precluded during the exhibition in a showcase or preserved in storerooms due to restricted exhibition space. The proposal of Serena Fumero & Benedetta Frezzotti shows the educational and advertising mission pointed at reaching a wider audience, specifically targeting the youngest visitor's global effort to promote the museum site of the Precettoria of Sant'Antonio di Ranverso, property of the Fondazione

Ordine Mauriziano. This objective is carried out with the didactic experience of Techniques in Visual Arts course at the Libera Accademia d'Arte Novalia. The course develops the potentials offered by augmented reality, both as a way of dissemination the knowledge of the site, also addressing a younger audience with educational content. The interesting contribution of Francisco M. Hidalgo-Sánchez, Gabriel Granado-Castro, Joaquín María Aguilar-Camacho & José Antonio Barrera-Vera describes the first evolving phases of a tool designed to support field-training sessions in topographic survey learning courses, also involving gamified simulator. Then the proposed research experience emphasizes how the mixture of software and hardware under a unified criterion oriented to the virtualization and gamification can significantly improve the learning process of practical land surveying. The paper of Javier Fco. Raposo Grau, Mariasun Salgado de la Rosa, Belén Butragueño Díaz-Guerra & Blanca Raposo Sánchez improves a fascinating experience about the connection between creative processes and artificial intelligence in the field of graphic expression. The authors then underline that this connection have to be intended not only as a substance of technological development but also as a solver of the articulation of logical / rational processes with creative/emotional ones. The experience is based on the teaching methods of drawing at the School of Architecture of Madrid and wishes to explore how these educational strategies allow the development of work habits promoting characteristics that can be used in other environments. Specifically, this experience, the dynamics of collective work between teachers and students has made it possible to establish the relationship between artificial intelligence and creative processes in teaching activities throughout the different phases of learning.

Authors
Andrea Giordano, Dept. of Civil, Environmental and Architectural Engineering, Uiversity of Padua, andrea.giordano@unipd.it
Michele Russo, Dept. of History, Representation and Restoration of Architecture, Sapienza University of Rome, m.russo@uniroma1.it
Roberta Spallone, Dept. of Architecture and Design, Politecnico di Torino, roberta.spallone@polito.it

Copyright © 2022 by FrancoAngeli s.r.l. Milano, Italy
Isbn 9788835141945