POLITECNICO DI TORINO
Repository ISTITUZIONALE

AI+AR: Cultural Heritage, Museum Institutions, Plastic Models and Prototyping. A State of Art

Original
AI+AR: Cultural Heritage, Museum Institutions, Plastic Models and Prototyping. A State of Art / Vitali, Marco; Bertola, Giulia; Natta, Fabrizio; Ronco, Francesca - In: Representation Challenges. Augmented Reality and Artificial Intelligence in Cultural Heritage and Innovative Design Domain / Giordano A., Russo M., Spallone R.. - STAMPA. - Milano : FrancoAngeli, 2021. - ISBN 9788835116875. - pp. 59-63 [10.3280/oa-686.9]

Availability:
This version is available at: 11583/2926352 since: 2021-09-22T15:44:20Z

Publisher:
FrancoAngeli

Published
DOI:10.3280/oa-686.9

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)

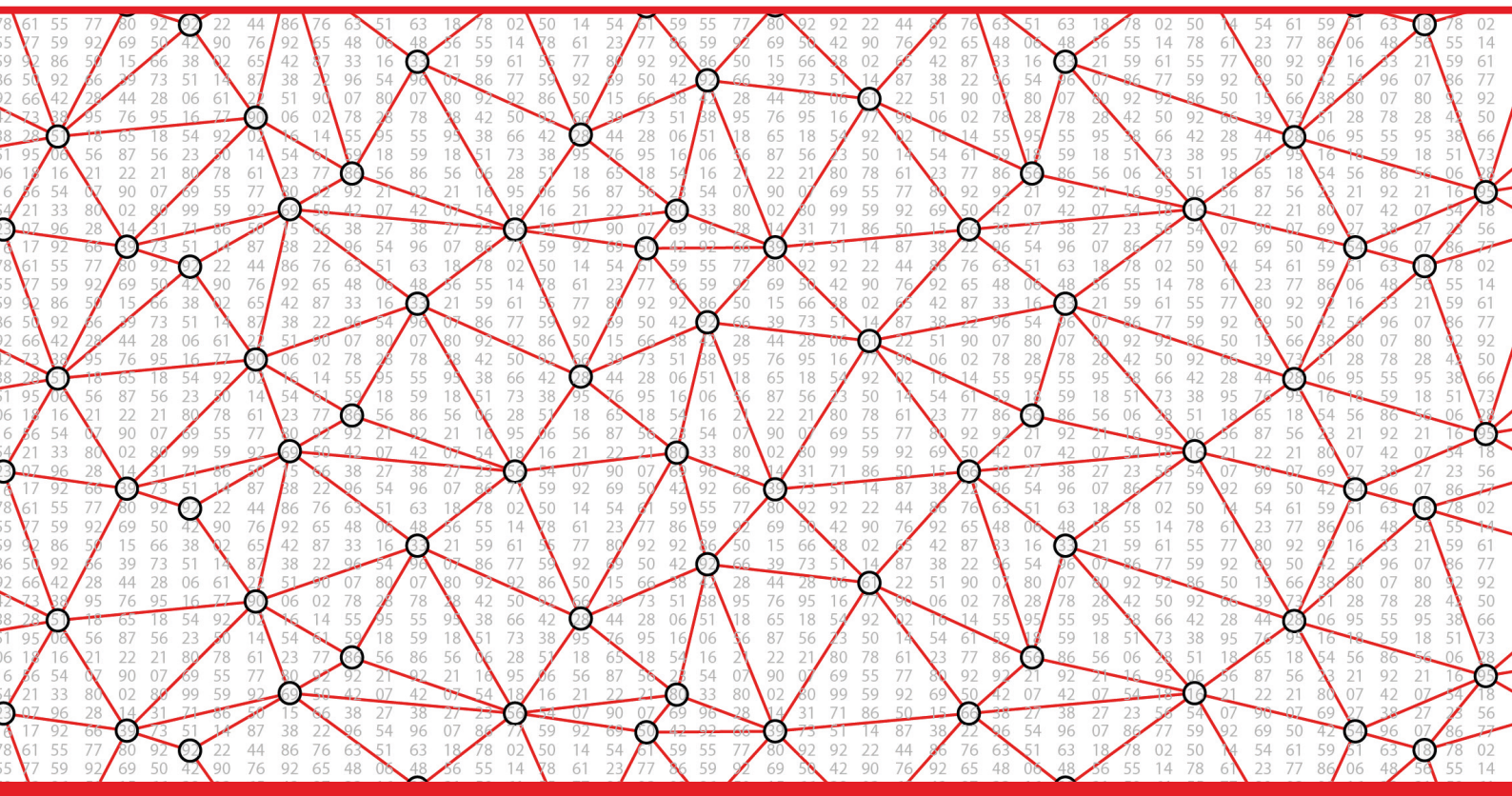
20 April 2024

REPRESENTATION CHALLENGES

Augmented Reality and Artificial Intelligence in Cultural Heritage and Innovative Design Domain

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

Giuseppe Amoruso *Politecnico di Milano*
Paolo Belardi *Università degli Studi di Perugia*
Stefano Bertocci *Università degli Studi di Firenze*
Mario Centofanti *Università degli Studi dell'Aquila*
Enrico Cicalò *Università degli Studi di Sassari*
Antonio Conte *Università degli Studi della Basilicata*
Mario Docci *Sapienza Università di Roma*
Edoardo Dotto *Università degli Studi di Catania*
Maria Linda Falcidieno *Università degli Studi di Genova*
Francesca Fatta *Università degli Studi Mediterranea di Reggio Calabria*
Fabrizio Gay *Università IUAV di Venezia*
Andrea Giordano *Università degli Studi di Padova*
Elena Ippoliti *Sapienza Università di Roma*
Francesco Maggio *Università degli Studi di Palermo*
Anna Osello *Politecnico di Torino*
Caterina Palestini *Università degli Studi "G. d'Annunzio" di Chieti-Pescara*
Lia Maria Papa *Università degli Studi di Napoli "Federico II"*
Rossella Salerno *Politecnico di Milano*
Alberto Sdegno *Università degli Studi di Udine*
Chiara Vernizzi *Università degli Studi di Parma*
Ornella Zerlenga *Università degli Studi della Campania "Luigi Vanvitelli"*

Members of foreign structures

Caroline Astrid Bruzelius *Duke University - USA*
Pilar Chías *Universidad de Alcalá - Spagna*
Frank Ching *University of Washington - USA*
Livio De Luca *UMR CNRS/MCC MAP Marseille - Francia*
Roberto Ferraris *Universidad Nacional de Córdoba - Argentina*
Glaucia Augusto Fonseca *Universidade Federal do Rio de Janeiro - Brasile*
Pedro Antonio Janeiro *Universidade de Lisboa - Portogallo*
Jacques Laubscher *Tshwane University of Technology - Sudafrica*
Cornelie Leopold *Technische Universität Kaiserslautern - Germania*
Juan José Fernández Martín *Universidad de Valladolid - Spagna*
Carlos Montes Serrano *Universidad de Valladolid - Spagna*
César Otero *Universidad de Cantabria - Spagna*
Guillermo Peris Fajarnes *Universitat Politècnica de València - Spagna*
José Antonio Franco Taboada *Universidade da Coruña - Spagna*
Michael John Kirk Walsh *Nanyang Technological University - Singapore*

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

Augmented Reality and Artificial Intelligence in Cultural Heritage and Innovative Design Domain

edited by

Andrea Giordano
Michele Russo
Roberta Spallone

FrancoAngeli OPEN ACCESS

Scientific Committee

Salvatore Barba
Università di Salerno

Marco Giorgio Bevilacqua
Università di Pisa

Stefano Brusaporci
Università dell'Aquila

Francesca Fatta
Università Mediterranea di Reggio Calabria

Andrea Giordano
Università di Padova

Alessandro Luigini
Libera Università di Bolzano

Michele Russo
Sapienza Università di Roma

Cettina Santagati
Università di Catania

Alberto Sdegno
Università di Udine

Roberta Spallone
Politecnico di Torino

Scientific Coordination

Andrea Giordano
Università di Padova

Michele Russo
Sapienza Università di Roma

Roberta Spallone
Politecnico di Torino

Editorial Committee

Isabella Friso
Università IUAV di Venezia

Fabrizio Natta
Politecnico di Torino

Michele Russo
Sapienza Università di Roma

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

ISBN printed edition: 9788835116875
ISBN digital edition: 9788835125280

Cover image: Michele Russo

Copyright © 2021 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
Francesco Fatta
Preface

9
Andrea Giordano, Michele Russo, Roberta Spallone
Representation Challenges: The Reasons of the Research

AR&AI theoretical concepts

23
Francesco Bergamo
The Role of Drawing in Data Analysis and Data Representation

29
Giorgio Buratti, Sara Conte, Michela Rossi
Artificial Intelligency, Big Data and Cultural Heritage

35
Marco Ferrari, Lodovica Valetti
Virtual Tours and Representations of Cultural Heritage: Ethical Issues

41
Claudio Marchese, Antonino Nastasi
The Magnificent AI & AR Combinations: Limits? Gorgeous Imperfections!

47
Valerio Palma
Data, Models and Computer Vision: Three Hands–on Projects

53
Alberto Sdegno
Drawing Automata

59
Marco Vitali, Giulia Bertola, Fabrizio Natta, Francesca Ronco
AI+AR: Cultural Heritage, Museum Institutions, Plastic Models and Prototyping. A State of Art

AR&AI virtual reconstruction

67
Alessio Bortot
Physical and Digital Pop–Ups. An AR Application in the Treatises on Stereotomy

73
Maurizio Marco Bocconcino, Mariapaola Vozzola
The Value of a Dynamic Memory: from Heritage Conservation in Turin

79
Antonio Calandriello
Augmented Reality and the Enhancement of Cultural Heritage: the Case of Palazzo Mocenigo in Padua

85
Cristina Càndito, Andrea Quartara, Alessandro Meloni
The Appearance of Keplerian Polyhedra in an Illusory Architecture

91
Maria Grazia Cianci, Daniele Calisi, Sara Colaceci, Francesca Paola Mondelli
Digital Tools at the Service of Public Administrations

97
Riccardo Florio, Raffaele Catuogno, Teresa Della Corte, Veronica Marino
Studies for the Virtual Reconstruction of the Terme del Foro of Cumae

103
Maurizio Perticarini, Chiara Callegaro
Making the Invisible Visible: Virtual/Interactive Itineraries in Roman Padua

AR&AI heritage routes

111
Marinella Arena, Gianluca Lax
Saint Nicholas of Myra. Cataloguing, Identification, and Recognition Through AI

117
Stefano Brusaporci, Pamela Maiezza, Alessandra Tata, Fabio Graziosi, Fabio Franchi
Prosthetic Visualizations for a Smart Heritage

123
Gerardo Maria Cennamo
Advanced Practices of Augmented Reality: the Open Air Museum Systems for the Valorisation and Dissemination of Cultural Heritage

129
Serena Fumero, Benedetta Frezzotti
The Use of AR Illustration in the Promotion of Heritage Sites

135
Alessandro Luigini, Stefano Brusaporci, Alessandro Basso, Pamela Maiezza
The Sanctuary BVMA in Pescara: AR Fruition of the Pre–Conciliar Layout

141
Alessandra Pagliano, Greta Attademo, Anna Lisa Pecora
Phygitalarcheology for the Phlegraean Fields

147
Andrea Rolando, Domenico D'Uva, Alessandro Scandiffio
A Technique to Measure the Spatial Quality of Slow Routes in Fragile Territories Using Image Segmentation

153
Giorgio Verdiani, Ylenia Ricci, Andrea Pasquali, Stéphane Giraudeau
When the Real Really Means: VR and AR Experiences in Real Environments

159
Ornella Zerlenga, Vincenzo Cirillo, Massimiliano Masullo, Aniello Pascale, Luigi Maffei
Drawing, Visualization and Augmented Reality of the 1791 Celebration in Naples

AR&AI classification and 3D analysis

167
Marco Giorgio Bevilacqua, Anthony Fedeli, Federico Capriuoli, Antonella Gioli, Cosimo Monteleone, Andrea Piemonte
Immersive Technologies for the Museum of the Charterhouse of Calci

173
Massimiliano Campi, Valeria Cera, Francesco Cutugno, Antonella di Luggo, Domenico Iovane, Antonio Origlia
CHROME Project: Representation and Survey for AI Development

179
Paolo Clini, Roberto Pierdicca, Ramona Quattrini, Emanuele Frontoni, Romina Nespeca
Deep Learning for Point Clouds Classification in the Ducal Palace at Urbino

185
Pierpaolo D'Agostino, Federico Minelli
Automated Modelling of Masonry Walls: a ML and AR Approach

191
Elisabetta Caterina Giovannini
Data Modelling in Architecture: Digital Architectural Representations

197
Marco Limongiello, Lucas Matias Gujski
Image–Based Modelling Restitution: Pipeline for Accuracy Optimisation

203
Federica Maietti, Marco Medici, Ernesto Iadanza
From AI to H–BIM: New Interpretative Scenarios in Data Processing

209
Michele Russo, Eleonora Grilli, Fabio Remondino, Simone Teruggi, Francesco Fassi
Machine Learning for Cultural Heritage Classification

215
Andrea Tomalini, Edoardo Pristeri, Letizia Bergamasco
Photogrammetric Survey for a Fast Construction of Synthetic Dataset

AR&AI urban enhancement

223
Giuseppe Amoruso, Polina Mironenko, Valentina Demarchi
Rebuilding Amatrice. Representation, Experience and Digital Artifice

229
Paolo Belardi, Valeria Menchetelli, Giovanna Ramaccini, Margherita Maria Ristori, Camilla Sorignani
AR+AI = Augmented (Retail + Identity) for Historical Retail Heritage

235
Fabio Bianconi, Marco Filippucci, Marco Seccaroni
New Interpretative Models for the Study of Urban Space

241
Marco Canciani, Giovanna Spadafora, Mauro Saccone, Antonio Camassa
Augmented Reality as a Research Tool, for the Knowledge and Enhancement of Cultural Heritage

247
Alessandra Pagliano
Augmenting Angri: Murals in AR for Urban Regeneration and Historical Memory

253
Caterina Palestini, Alessandro Basso
Evolutionary Time Lines, Hypothesis of an AI+AR–Based Virtual Museum

259
Daniele Rossi, Federico O. Oppedisano
Marche in Tavola. Augmented Board Game for Enogastronomic Promotion

AR&AI museum heritage

267
Massimo Barilla, Daniele Colistra
An Immersive Room Between Scylla and Charybdis

273
Francesco Borella, Isabella Friso, Ludovica Galeazzo, Cosimo Monteleone, Elena Svalduz
New Cultural Interfaces on the Gallerie dell'Accademia in Venice

279
Laura Carlevaris, Marco Fasolo, Flavia Camagni
Wood Inlays and AR: Considerations Regarding Perspective

285
Giuseppe D'Acunto
Augmented Reality and Museum Exhibition. The Case of the Tribuna of Palazzo Grimani in Venice

291
Giuseppe Di Gregorio
The Rock Church of San Micidiario of the Pantalica Site and 3DLAB VR/AR–Project

297
Elena Ippoliti
Understanding to Enhance, Between the Technical and Humanist Approaches

303
Gabriella Liva, Massimiliano Ciammaichella
Illusory Scene and Immersive Space in Tintoretto's Theatre

309
Franco Prampolini, Dina Porpiglia, Antonio Gambino
Medma Touch, Feel, Think: Survey, Catalog and Sensory Limitations

315
Paola Puma, Giuseppe Nicastro
The Emotion Detection Tools in the Museum Education EmoDeM Project

321
Leopoldo Repola, Nicola Scotto di Carlo, Andrea Maioli, Matteo Martignoni
MareXperience. AI/AR for the Recognition and Enhancement of Reality

AR&AI building information modeling and monitoring

329
Vincenzo Bagnolo, Raffaele Argiolas, Nicola Paba
Communicating Architecture. An AR Application in Scan–to–BIM Processes

335
Marcello Balzani, Fabiana Raco, Manlio Montuori
Integrated Technologies for Smart Buildings and PREdictive Maintenance

341
Fabrizio Banfi
Extended Reality (XR) and Cloud–Based BIM Platform Development

347
Carlo Biagini, Ylenia Ricci, Irene Villoresi
H–Bim to Virtual Reality: a New Tool for Historical Heritage

353
Fabio Bianconi, Marco Filippucci, Giulia Pelliccia
Experimental Value of Representative Models in Wooden Constructions

359
Devid Campagnolo, Paolo Borin
Automatic Recognition Through Deep Learning of Standard Forms in Executive Projects

365
Matteo Del Giudice, Daniela De Luca, Anna Osello
Interactive Information Models and Augmented Reality in the Digital Age

371
Marco Filippucci, Fabio Bianconi, Michela Meschini
Survey and BIM for Energy Upgrading. Two Case Study

377
Raissa Garozzo
A Proposal for Masonry Bridge Health Assessment Using AI and Semantics

383
Federico Mario La Russa
AI for AEC: Open Data and VPL Approach for Urban Seismic Vulnerability

389
Assunta Pelliccio, Marco Saccucci
V.A.I. Reality. A Holistic Approach for Industrial Heritage Enhancement

AR&AI education and shape representation

397
Maria Linda Falcidieno, Maria Elisabetta Ruggiero, Ruggero Torti
Visual Languages: On–Board Communication as a Perception of Customercaring

403
Emanuela Lanzara, Mara Capone
Genetic Algorithms for Polycentric Curves Interpretation

409
Anna Lisa Pecora
The Drawn Space for Inclusion and Communicating Space

415
Marta Salvatore, Leonardo Baglioni, Graziano Mario Valenti, Alessandro Martinelli
Forms in Space. AR Experiences for Geometries of Architectural Form

421
Roberta Spallone, Valerio Palma
AR&AI in the Didactics of the Representation Disciplines

427
Alberto Tono, Meher Shashwat Nigam, Stasya Fedorova, Amirhossein Ahmadnia, Cecilia Bolognesi
Limitations and Review of Geometric Deep Learning Algorithms for Monocular 3D Reconstruction in Architecture

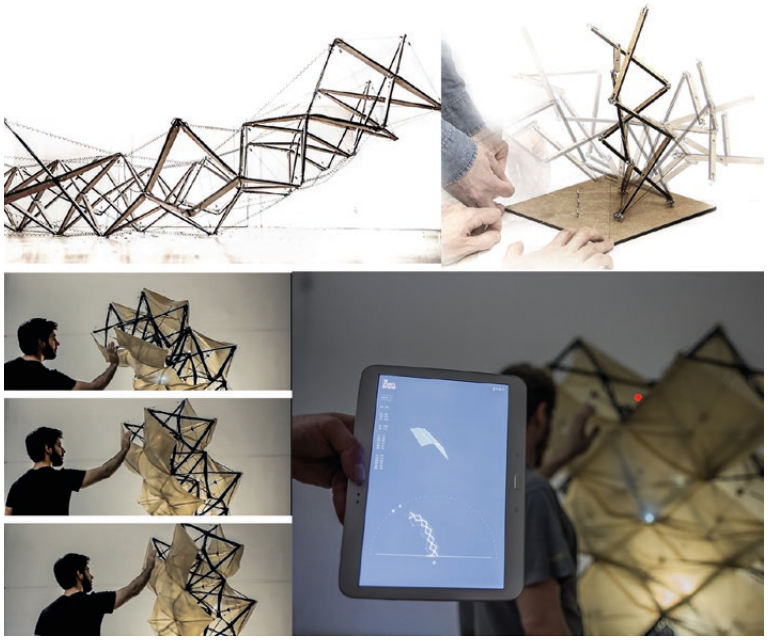
AI+AR: Cultural Heritage, Museum Institutions, Plastic Models and Prototyping. A State of Art

Marco Vitali
Giulia Bertola
Fabrizio Natta
Francesca Ronco

Abstract

The links between representation and artificial intelligence (AI) invade many fields of architectural research, recording continuous and significant advances: they require, on the one hand, a constant update of the state of the art and, on the other hand, careful consideration of the role of Representation in interdisciplinary research in this field.
The present contribution intends to investigate these intertwining in some of the most frequented research fields in recent years: the valorization and communication of Cultural Heritage and cultural tourism, the experiences in the museum field, the research on the role of the prototype within the processes of artificial intelligence applied to architecture.

Keywords
cultural heritage, museum, digital fabrication, artificial intelligence, augmented reality.



doi.org/10.3280/oa-686.9

Introduction (MV)

The intertwining of representation – in particular in its manifestations in the field of augmented reality (AR) – with artificial intelligence (AI) spans many fields of architectural research and registers in the contemporary world continuous and significant advances that require, on the one hand, a constant updating of the state of the art and, on the other hand, careful considerations on the role of Representation in interdisciplinary research in this field. The present contribution intends to investigate these connections in some of the most frequented fields in architectural research in recent years: research on the enhancement and communication of Cultural Heritage and cultural tourism, research on the most recent and innovative experiences in the museum field, research on the role of the prototype within the processes of artificial intelligence applied to architecture.
According to the most recent experiences conducted on the valorization and communication of Cultural Heritage, the most used tools to ensure its success range from the creation of cognitive maps to the development of AI technologies for the automatic digitization of cultural heritage, or the use of Deep Learning for the recognition of monuments and the construction of mobile apps.
In the museum field, artificial intelligence is increasingly used to develop different tools such as robots, chatbots, and websites, which allow analyzing data related to visitors and collections, where the contribution of representation disciplines is nowadays mainly connected to the possible outputs of Object recognition operations and the applications of this technology. The link between plastic model, AI, and AR is articulated in several aspects based on the 'human–model' interaction and is articulated in some prevalent research strands, such as studies on computational design methods developed for 3D printing and component evaluation, or the work on Responsive Architecture, in which the physical model is the medium through which to experiment and communicate the design of dynamic and adaptive buildings.

AI (and AR) in Cultural Heritage (FN)

According to the most recent experiences with the valorization and communication of Cultural Heritage (CH), they should be the result of a balanced synergy between interaction, experience, and representation.
The current scenario offers research methodologies investigating Cultural Heritage through Artificial Intelligence (AI) tools to increasingly democratize the access of CH, the development of AI technologies for automatic digitization, or the use of Deep Learning (DL) for monument recognition and the development of mobile apps. As an example, the study by Pisoni et al. (2021) proposes the use of AI to support the accessible design of CH. One of the points of greatest research interest is now on eXplainable AI (XAI) techniques, "a suite of machine learning techniques that produces more explainable models while maintaining a high level of learning performance (e.g., prediction accuracy), and enable humans to understand"[Barredo et al. 2020, p. 2]. The tools offered by these developments in technology can enable museums and CH sites to modify their knowledge transmission. By opening up informal learning opportunities to the general public, based on experience and personal interaction with CH, gaps in Natural Language Processing (NLP) and Computer Vision (CV) can be assessed.
Another research approach is that by Traviglia and Del Bue (whose study focuses on the development of AI technologies for the automatic digitization of CH: the different nature of the CH assets does not facilitate the creation of common standards and protocols going in this direction. The main idea of the approach is to incrementally build a 3D reconstruction that is not metric (i.e. where positions are measurable with a metric reference) but rather in the space of projective geometry. In this way, the digitization is made user–independent making total automation of the scanning process possible [Traviglia, Del Bue 2019].
A line of research to be highlighted is that developed by Valerio Palma. He introduces a project aimed at studying the techniques of convolutional neural networks (CNN) in the field of architectural heritage, which workflow has still to be developed. The first steps and results in the development of mobile applications for monument recognition are discussed:

while AI is just beginning to interact with the built environment through mobile devices, heritage technologies have long produced and explored digital models and spatial archives. The interaction between DL algorithms and state–of–art information modeling is addressed as an opportunity both to exploit heritage collections and to optimize new object recognition techniques [Palma 2019, pp. 551-556].
The developments that these research can bring are almost all aimed at enriching the databases, which are still quantitatively limited and refer much towards two–dimensional objects that are "easier" to read in ML algorithms. Another challenge related to AI relates to the use of personal data. The implementations that augmented CH experiences can provide necessarily involve reading and constantly updating regulations and ethical guides for the responsible use of this powerful tool.

The Digital Transformation in Museums: AI and AR as Tools to Engage Visitors (FR)

Within museum institutions, artificial intelligence is increasingly used to develop different tools such as robots, chatbots, and websites, which allow analyzing data related to visitors and collections [Styx, 2020]. The network "Museums + Artificial Intelligence" (n.d), founded in 2019 by Oonagh Murphy and Elena Villaespesa is proof of this growing interest in AI tools applied in this field.
At the same time, VR and AR have become a popular trend worldwide for the dissemination, communication, and enhancement of cultural heritage [Bekele et al. 2018].
The contribution of representation disciplines in the AR field is quite evident: just think of the use of 3D virtual models, holograms, graphics for specific apps, and gaming, up to True AR technology [Sandor 2015]. The group coordinated by Geronikolakis (2020) proposes an interesting application in the field of cultural heritage conservation to improve the experience of visitors, involved in the construction and restoration of archaeological sites.
In the field of AI, the representation disciplines could mainly be involved in the outputs of Object Recognition operations. The applications of this technology involve the user also outside the museum, as in the project 'Recognition', winner in 2016 of the IK award [Styx, 2020] or the application 'Art Selfie'. Several museums base the exploration of their collections on Object Recognition: on color similarities, [Cooper Hewitt Smithsonian Design Museum, n.d; Dallas Art Museum, n.d.], formal, line direction, or space and light [Barnes Foundation, n.d].

Fig. 1a. Exibition Mont Saint–Michel. Digital Perspectives on the Model (photo by Microsoft, source: https://iciseattle.com/en/mont-saint-michel-in-mohai/); Fig. 1b. The system of ICAR–CNR group experienced in art and tech exhibitions [Caggianese et al., 2020].

In recent years, technologies have made considerable progress in the creation of content tailored to the needs and interests of different types of users, with a democratic and human–centered approach. However, there are still few examples where AI has been used to foster accessibility and inclusion in the field of museums and cultural heritage [Pisoni et al., 2021].
The AI context is certainly characterized by a high level of multidisciplinarity. The mixed–use of AI/AR/VR technologies represents an important field of investigation to meet the needs of an increasingly wide audience, from an inclusive perspective.
The exhibition "Mont Saint–Michel – Digital Perspectives on the Model" (fig. 1a), held in late 2019 at MOHAI (Museum of History and Industry) in Seattle, represents an example of the application of mixed techniques [Ici Seattle, 2019]. Visitors were immersed in the history of Mont–Saint–Michel by framing a real scale historical model of the site with a mixed reality device (Microsoft HoloLens 2).
Another example in this frame is the work conducted by ICAR–CNR [Caggianese et al., 2020] related to the display of Leonardo da Vinci's machines (fig. 1b). This presents the combined use of cutting–edge technologies, such as holograms, with artificial intelligence (AI) to offer the visitor an augmented space involving new forms of interaction (visualization, manipulation, and conversation).

AI in Digital Fabrication Experiences on Architecture (GB)

The link between real model, virtual reality and augmented reality is articulated on two main lines of research. The first one is based on the construction of informative real models, the second one on the interaction 'human–material' through the practices of 'augmented *craftsmanship*' and '*design by making*'. Regarding the first, many studies are now focused on the creation of prototypes aimed at the transmission of knowledge and information of architectural heritage. In the last years, this has happened both through the realization of static models on which to apply immersive technologies, and with more complex dynamic systems in which physical and digital models have come to overlap to the point of almost confusing.
With regard to the application of immersive technologies, reference can be made to the experience carried out for the Basilica of Loreto [Rossi et al. 2017, pp. 239-255]. A project that involved the setting up of a space consisting of a multimedia table with a 3D printed physical model, conceived as a '*wunderkammer*' equipped with a series of technological devices referable to different applications characterized by different levels of interactivity and immersiveness.
In recent years, however, rapid advances in technology have begun to challenge even those aspects that go beyond the mere static and physical representation of architecture. An example is the interactive model of InFORM [Follmer et al. 2013, pp. 417-426] a dynamic shape display proposed by the Massachusetts Institute of Technology (MIT), that suggests different ways of physical interaction in real time between users, physical model and digital data. Regarding the 'human–material' interaction, the main fields of investigation concern the application of biological principles on architectural construction and the study of innovative structural morphologies through digital fabrication methods. In particular, the ICD/ITKE Research Pavilions are a series of full–scale prototypes realized through the integration of computational engineering, advanced analytical techniques and digital fabrication aimed at investigating the architectural potential of fiber composites [Doerstelmann et al. 2015].
Regarding the same themes, in London there are also the Protohouse project and the Flow-

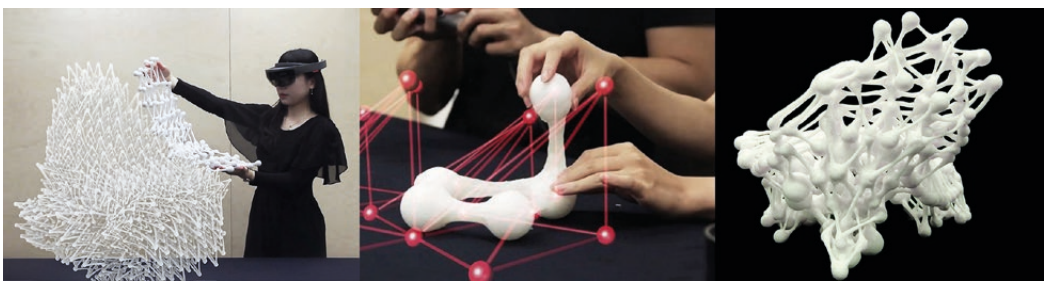


Fig. 2. Project FLOWMORPH [Hahm et al. 2019].

Morph project [Hahm et al. 2019, pp. 553-562] (fig. 2), that proposes an unconventional method of fabrication using *Mixed Reality* to materialize highly complex geometries that could not be realized manually or by robotic fabrication alone.
The practices of *digitally augmented craftsmanship* open to a series of reflections on the theme of interactive digital simulations and their link with traditional craft practices. Mario Carpo, within his book The Second Digital Turn [Carpo, 2017], emphasizes the value of such simulations as they allow today's artisans to learn intuitively, through mistakes, trial and attempts, by making and unmaking as many test samples as possible.

References

Barnes Foundation. Barnes Collection Online. https://collection.barnesfoundation.org/ (1 March 2021).

Barredo Arrieta Alejandro et al. (2020). Explainable Artificial Intelligence (XAI): Concepts, Taxonomies, Opportunities and Challenges toward Responsible AI. In *Information Fusion*, 58, pp. 82-115.

Bekele Mafkereseb Kassahun, Pierdicca Roberto, Frontoni Emanuele, Malinverni Eva, Gain James (2018). A Survey of Augmented, Virtual, and Mixed Reality for Cultural Heritage. In *Journal on Computing and Cultural Heritage*, 11(2), art. 7.

Caggianese Giuseppe, De Pietro Giuseppe, Esposito Massimo, Gallo Luigi, Minutolo Aniello, Neroni Pietro (2020). Discovering Leonardo with artificial intelligence and holograms: A user study. In *Pattern Recognition Letters*, 131, pp. 361-367.

Carpo Mario (2017). *The Second Digital Turn. Design Beyond Intelligence*. Cambridge (MA): MIT Press.

Cooper–Hewitt Smithsonian Design Museum. The Collection. https://collection.cooperhewitt.org/ (1 March 2021).

Doerstelmann Moritz, Knippers Jan, Koslowski Valentin, Menges Achim, Prado Marshall, Schieber Gundula, Vasey Lauren (2015). ICD/ITKE Research Pavilion 2014-15: Fibre Placement on a Pneumatic Body Based on a Water Spider Web. In *Architectural Design*, 85, pp. 60-65.

Follmer Sean Weston, Leithinger Daniel, Olwal Alex, Hogge Akimitsu, Ishii Hiroshi (2013), inFORM: Dynamic Physical Affordances and Constraints through Shape and Object Actuation, In *Proceedings of the 26th annual ACM symposium on User interface software and technology (UIST '13)*. New York: ACM Digital Library, pp. 417-426.

Geronikolakis Efstratios, Zikas Paul, Kateros Steve, Lydatakis Nick, Georgiou Stelios, Kentros Mike, Papagiannakis George. (2020). A True AR Authoring Tool for Interactive Virtual Museums. In Liarokapis Fotis, Voulodimos Athanasios, Doulamis Nikolaos, Doulamis Anastasios (eds.). *Visual Computing for Cultural Heritage*. Cham: Springer, pp. 225-242.

Hahm Soomeen, Maciel Abel, Sumitiomo Eri, Rodriguez Alvaro Lopez (2019). FLOWMORPH. Exploring the human–material interaction in digitally augmented craftsmanship. In *Proceedings of the 24th International Conference of the Association for Computer–Aided Architectural Design Research in Asia (CAADRIA)*, Vol. 1, Hong Kong, CAADRIA, pp. 553-562.

High Level Expert Group on Artificial Intelligence (2019). *Ethics Guidelines for Trustworthy AI; Technical Report.* European Commission.

Ici Seattle (2019). The Mont–Saint–Michel in the MOHAI. https://iciseattle.com/en/mont-saint-michel-in-mohai/ (1 March 2021).

Jun Ji Won, Ilubia Josep Alcover, Silverio Matteo (2015). Remembrane. Responsive Kinetic Structure. http://www.iaacblog.com/programs/remembrane/ (15 March 2021).

Palma Valerio (2019). Towards Deep Learning for Architecture: A Monument Recognition Mobile App. In *The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences*, Volume XLII–2/W9, pp. 551-556.

Pisoni Galena, Dìaz–Rodrìguez Natalia, Gijlers Hannie, Tonolli Linda (2021). Human–Centred Artificial Intelligence for Designing Accessible Cultural Heritage. In *Applied Sciences*, 11 (2), p. 870.

Rossi Daniele, Meschini Alessandra, Feriozzi Ramona, Olivieri Alessandro (2017). Cose dell'altro mondo. La realtà virtuale immersiva per il patrimonio culturale. In Luigini Alessandro., Panciroli Chiara (eds.), *Ambienti digitali per l'educazione all'arte e al patrimonio*. Milano, FrancoAngeli Open Access, pp. 239-255.

Sandor Christian, Fuchs Martin, Cassinelli Alvaro, Li Hao, Newcombe Richard, Yamamoto Goshiro, Feiner Steven (2015). In *Breaking the barriers to true augmented reality*. arXiv preprint arXiv:1512.05471 (1 march 2021).

Styx Lauren (2020). How are museums using artificial intelligence, and is AI the future of museums? Museum Next. https://www.museumnext.com/article/artificial-intelligence-and-the-future-of-museums/ (1 march 2021).

Traviglia Arianna, Del Bue Alessio (2019). Intelligenza Artificiale per la Digitalizzazione 3D del Patrimonio Culturale, In *Ital–IA Italia Intelligenza Artificiale*. https://www.google.com/search?client=firefox-b-d&q=Traviglia+Arianna%2C+Del+Bue+Alessio+%282019%29.+Intelligenza+Artificiale+per+la+Digitalizzazione+3D+del+Patrimonio+Culturale%2C+In+Ital–IA+Italia+Intelligenza+Artificiale (1 march 2021).

Authors
Marco Vitali, Dept. of Architecture and Design, Politecnico di Torino, marco.vitali@polito.it
Giulia Bertola, Dept. of Architecture and Design, Politecnico di Torino, giulia.bertola@polito.it
Fabrizio Natta, Dept. of Architecture and Design, Politecnico di Torino, fabrizio.natta@polito.it
Francesca Ronco, Dept.of Architecture and Design, Politecnico di Torino, francesca.ronco@polito.it

Copyright © 2021 by FrancoAngeli s.r.l. Milano, Italy Isbn 9788835125280