

REPRESENTATION CHALLENGES

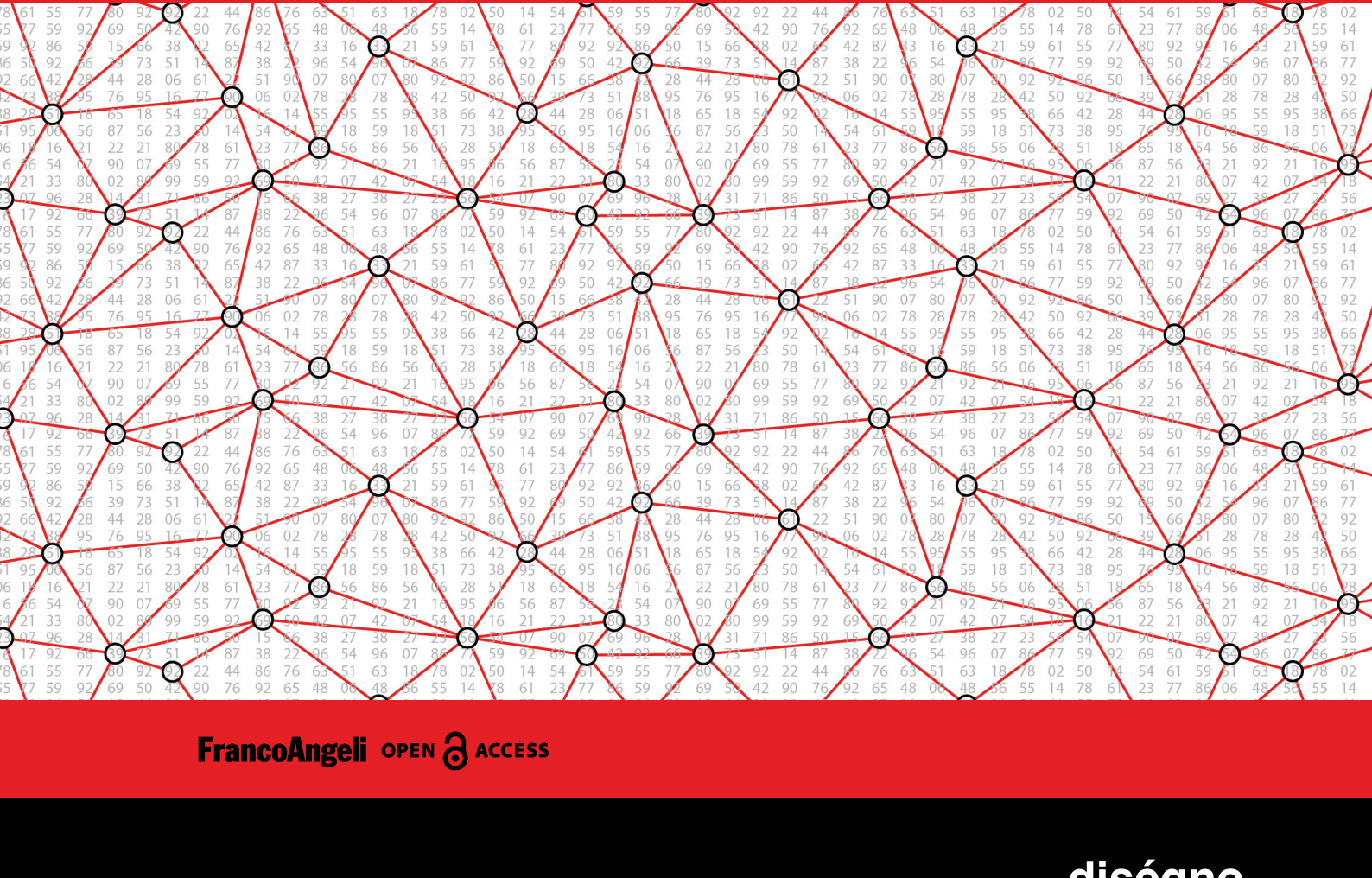
Augmented Reality and Artificial Intelligence in Cultural Heritage and Innovative Design Domain

edited by

Andrea Giordano

Michele Russo

Roberta Spallone



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 Chfás *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*
Glauca 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*



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

1222-2022
80 ANNI



UNIVERSITÀ
DEGLI STUDI
DI PADOVA

ICEA

DIPARTIMENTO DI STORIA
DISEGNO E RESTAURO
DELL'ARCHITETTURA



SAPIENZA
UNIVERSITÀ DI ROMA



Politecnico
di Torino

Dipartimento
di Architettura e Design

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

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.

ISBN printed edition: 9788835116875
ISBN digital edition: 9788835125280

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 Mediatì
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

Patronage



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>

7

Francesca 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 Cãndita, 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 Peticarini, 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 Attadema, Anna Lisa Pecora
Phyigitalarcheology 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 Caprioli, 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 Cini, 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 Anghi: Murals in AR for Urban Regeneration and Historical Memory

253
Caterina Palestini, Alessandra 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 Galeazza, Cosimo Monteleone, Elena Svaldruz
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 Micidario 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 Scotta 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
David 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 Customer-caring

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 Ahmadian, Cecilia Bolognesi
Limitations and Review of Geometric Deep Learning Algorithms for Monocular 3D Reconstruction in Architecture

AR&AI
virtual reconstruction

Physical and Digital Pop-Ups. An AR Application in the Treatises on Stereotomy

Alessio Bortot

Abstract

This paper focuses on the relationship between stereotomic traces and building construction techniques. Starting from the first essential drawings representing stone cutting methods in full scale – which are still visible in some Gothic cathedrals in France and Spain – it will be analyzed the evolution of stone cutting drawings to the most recent examples in 19th-century treatises. In particular, it will be examined the progress in terms of representation according to different centuries concentrating on the development of theory and practice. It will be therefore given a short overview of the most important Renaissance essayists dealing with changes in representation methods according to the codification of assumptions related to descriptive geometry. In the last part it will be proposed the involvement of augmented reality techniques in order to visualize and study Louis Monduit's treatise on stereotomy through the use of digital pop-ups.

Keywords

stereotomy, Louis Monduit, 3D modeling, descriptive geometry, augmented reality.



Evolution of The *Trait* in the History of Stereotomy

The research carried out in this paper has led me to study several stereotomic drawings in order to understand the reasons why these 'blueprints' are connected to the concrete practice of construction. The first stereotomic traces are engravings on the floor (less often on the wall) in some European and Middle Eastern Gothic cathedrals. In this regard Calvo-Lopez states "tracings were prepared exactly below the element under construction in order to control the placement of *voussoirs*. Generally speaking, in the Gothic period they were executed on scaffoldings placed under vaults, at springer level, while in the Early Modern period, they were laid directly on the floor" [Calvo-López 2020, p. 127]. The large-scale drawings – which seem to transform the buildings where they are located in a sort of 'stone treatise' – were used to solve specific problems and allow the formal compliance of the piece under construction. In other words, these first stereotomic developments were not intended as a representation of an abstract problem and didn't want to spread construction skills as well. In fact we should remember that in the Middle Ages stonemasons used to belong to guilds that usually concealed every building skill. As a matter of fact, stereotomy was a type of practical knowledge which used to be conveyed orally by the foreman to his stonemasons only in the construction site. In addition, it should be taken into consideration that writing and drawing materials were very expensive at the time. For instance, parchments were much more used in case of public presentations to clients than in standard communication [Erlande-Brandenburg 1993, p. 79]. In this period the most important graphic document is the well-known notebook *Livre de portraiture* by Villard de Honnencourt (... – XIII century). Even if this latter can't be really considered a treatise on stereotomy, anyway gives us a meaningful example of representation in the field of construction site machines, building techniques and use of proportions in the Gothic period. According to Sakarovitch, it is quite interesting to notice that in the carnet by de Honnencourt one can find some elements which are represented in double projection despite a lack of awareness in terms of a projective correspondence in the two views [Sakarovitch 1998, p. 41].

We know that stereotomy literature thrived in the Renaissance period basically due to *Le premier tome de l'architecture* (1567) by Philibert de l'Orme (1514-1570) [1]. In this treatise the illustrations show how the medieval secrets – traditionally kept by the guilds – were finally unveiled. The stone cutting techniques spread at the same time as the role of the 'architect' flourished – intended in the modern meaning. From being a 'mechanical art' architecture was gradually turning into a 'liberal art'. What's more, these historical dynamics pointed out the separation between the architect and the foreman (the *maître-maçon*), between the designer and the builder. The authentic expressive medium of the building work is the *trait*: the technique allowing to trace the layout of the stone structures in order each ashlar to be properly cut. For what concerns this topic, Robin Evans (1944-1993) asserts that the *trait* is something that is in between two different roles: artisans on one side and architects on the other. Although it isn't part of any of them, it exists as an independent reference such as geometry [Evans 1995, p. 205]. In this period treatises are didactic tools, but also ways to show the skills of the authors, often very critical of the stereotomic solutions developed by their own predecessors or peers. In the treatise by de l'Orme virtuous artifacts arise along with complex illustrations. One of the best examples is the renowned *Trompe d'Anet* – a case mentioned a few centuries later by Viollet-le-Duc (1814-1879) as an "artifice that has nothing to do with the rigorous art of the builder, made to amuse curious spirits with unnecessary problems" [Viollet-le-Duc 1854-1868, book IX, p. 314]. The drawings of this structure (one in pseudo axonometric projection to show the object in a three-dimensional space and some others in pseudo orthogonal projection) aren't able to solve the problem except for a reader who is also an expert in construction site practices. Something similar occurs to other *planches* where geometric operations (similar to 'surface unwrapping') are applied to each ashlar row in order to obtain the corresponding *épures*. In Renaissance treatises it is likely to find a certain need for three-dimensional representations. Thanks to the codification of the perspective laws, in this period these models – which in the Middle Ages were kept secret in the constructor's mind only – acquire education purposes as well.

Several treatises on stereotomy were published in the Enlightenment. This way, cutting solution were codified as well as graphic strategies developed to explain the techniques of division into ashlar. In the huge production of scientific books on this topic it is essential to mention at least the ones by Amedée-François Frézier (1682-1773) [2] and Jean Baptiste de la Rue (1697-1743) [3]. Both are illustrated with high-quality figures using orthogonal projections, axonometric and perspective views of arches, vaults, trompes and staircases. For the first time in the history of treatises on stereotomy some parts dealing with the explanation of general geometrical problems (e.g. conic sections, intersection among shapes, etc.) are included too. This addition is quite important because it reveals a different approach to the relationship between form and structure which can define the superiority of geometry in the field of this construction technique. Other descriptive strategies used by de La Rue suggest the need for a 'stereoscopic' approach which gives the opportunity to go beyond the two-dimensional limits characterizing paper surface such as the use of pop-ups. In fact, his Planche XXXIII describes – both graphically and through pieces of paper which are glued to the page – the mistake made by de La Rue's colleagues in the solution related to the corner segment of a spherical vault. In this sort of stereotomic 'origami' the reader can concretely realize the error by de la Rue's predecessors which is explained developing the faces of the block of stone. More in general, we can affirm that the use of this technique comes from the necessity to control very complex formal configurations such as spherical vaults or trompes.

In scientific literature the tradition connected to the use of pop-ups or movable books dates back to the medieval period [4]. Another example in this field concerns the use of removable paper elements (flaps) or the aforementioned pop-ups in treatises of gnomonics and perspective. Finally, movable books on optics, gnomonics and stereotomy became significant tools when simulating the projective and geometric processes applied to these disciplines, in order to support the representation of elements in space. What's more, three-dimensional paper models used to be designed in order to visualize the cutting flat surfaces of stone blocks in space in order to find the shape of the single faces and define the skin containing the volume.

Louis Monduit's Treatise: a Case Study

I chose the treatise by Louis Monduit as a case study to carry out an experiment on augmented reality. His book was published in a historical period in which stone cutting construction technique was about to be substituted by new methods and materials which were soon the turning point in terms of development in the field of architecture in the 20th century. Stereotomic techniques were therefore strengthened and optimized due to experimentations and publications on the same subject over the centuries. The treatise by Monduit doesn't show any innovation related to cutting solutions, since the case studies included belong to a tradition which dates back to the Renaissance period. Beyond, some features are particularly useful in this research such as the clear projective coherence of the drawings and the general structure that serve specific didactic purposes. This volume opens with a glossary of technical terms in the field of stereotomy and projective geometry. Monduit supplies some definitions referring to the measurement systems and concepts related to planar geometry. Then he draws his attention to the examination of the main proportional ratio, the study of solids, polyhedra (with their development) and a short (but precise) explanation of concepts related to descriptive and projective geometry. A special consideration is dedicated to the method of orthogonal projections which is explained first in three-dimensional space and then on plane. This first section is followed by the study of intersection among solids (cylinders, cones and spheres) – represented in cavalier drawing. This specific part is clearly influenced by the well-established method which was codified by Gaspar Monge (1746-1818) – professor at the École normale supérieure of Paris since 1794. At the end Monduit explains the tracing of the épures and the technical design of the project. Both are useful to develop every ashlar properly.

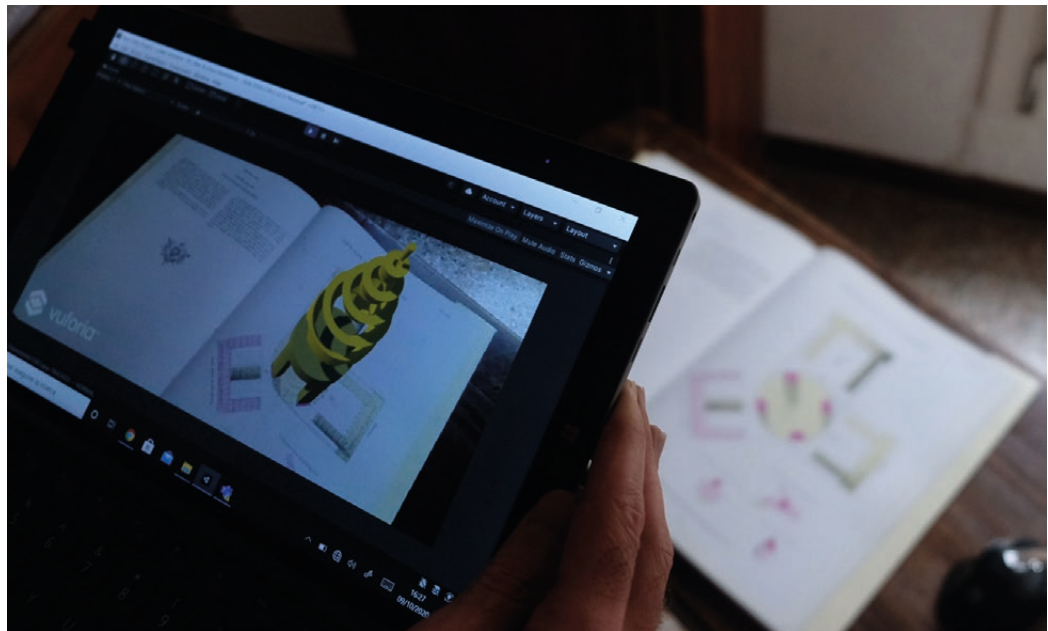


Fig. 1. Exploded view of the 3d model obtained from the digital reconstruction of Planche 46 of Monduit's treatise.

I decided to use digital tools for AR in order to reinterpret the need for three-dimensionality expressed by the historical treatises on stereotomy. The first phase of the work has involved the construction and research on the digital model of the case studies proposed by Louis Monduit. The 3D models were furthermore imported to a Unity software equipped with Vuforia Engine plug-in. As soon as every table in the treatise was set as a target recognizable by the mobile device to display the corresponding model, I defined ambient lights and materials to ensure a successful visualization. The following step involved the organization of contents in the form of an app for tablets and smartphones designed to study the treatise through its digitalization and the definition of models with different semantic values. The different information can be found on the screen overlapped to the real book framed by the device. A first menu entitled 'geometry and shape' allows us to see the digital model divided into blocks, the essential geometric entities representing the cutting planes of the ashlar and the opportunity to observe the model through an exploded view drawing (fig. 1).

For what concerns this device it will be possible to read the Monduit's text through the use of a parallel window in the interface which explains every geometrical phase in the defi-

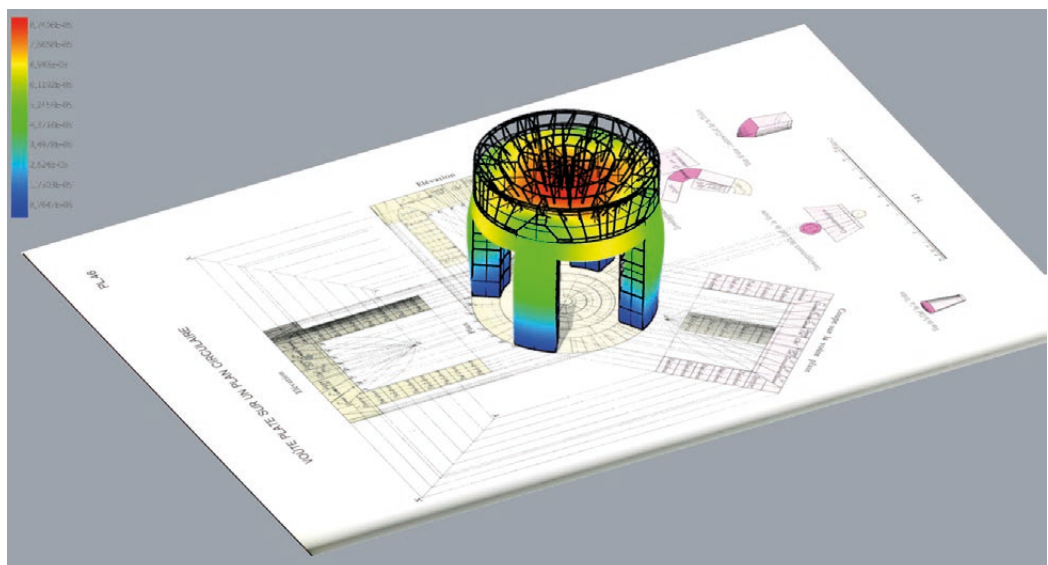


Fig. 2. False color Fem analysis of the 3D model obtained Planche 46 of Monduit's treatise.

nition of various traits. Placing the mobile device in front of the book it will be possible to refer to a database of georeferencing associated with every single case study. This database will gather the existing architectures which were carried out and theoretically described by Monduit in order to obtain an extensible catalogue of stereotomic structures with a description of their own historical and artistic features. Anyway, starting from the important relationship between form and structure in the analysis of stereotomic buildings, I decided to add the opportunity to see a structural model in this app showing the strain of the elements through the use of a false color Fem analysis (fig. 2).

Conclusion

This experiment has shown that the augmented reality can be considered an important tool in the enhancement, analysis and dissemination of cultural heritage through the creation of digital pop-ups. Stereotomy can be considered an excellent field to experiment these kinds of technologies and highlight the closer relationship between geometry and structure while interpreting ancient and complex treatises. In addition, we can state that the use of these technologies must be combined with an in-depth critical development of contents as well. Otherwise the risk is to appear as simple tools of entertainment, instead of sources of knowledge.

Notes

[1] De l'Orme Philibert (1567). *Le premier tome de l'architecture*. Paris: Federic Morel.

[2] Frézier Amedée-François (1737-1739). *La théorie et la pratique de la coupe des pierres et des bois pour la construction des voûtes et autres parties des bâtiments civils & militaires, ou Traité de stéréotomie, à l'usage de l'architecture*. Paris: Guerin.

[3] De la Rue Jean Baptiste (1728). *Traité de la coupe des pierres, où par une méthode facile et abrégée, l'on peut aisément se perfectionner en cette science*. Paris: Charles-Antoines Jombert.

[4] To analyze this topic, please, see for e.g.: Candito Cristina (2018). Drawings and Models in English Perspective Treatises of the XVII and XVIII Centuries. In Cocchiarella Luigi (ed.). *ICGG 2018—Proceedings of the 18th International Conference on Geometry and Graphics*. Milan: Springer; pp. 1882-1894.

References

Calvo-López José (2020). *Stereotomy, Stone Construction and Geometry in Western Europe 1200-1900*. Cham, Switzerland: Birkhäuser Springer Nature.

Erlande-Brandenburg Alain (1993). *Quand les cathédrales étaient peintes*. Paris: Gallimard.

Evans Robin (1995). *The projective Cast. Architecture and Its Three Geometries*. London: The MIT Press.

Kee Kevin, Compeau Timothy (2019). *Seeing the Past with Computers: Experiments with Augmented Reality and Computer Vision for History*. Ann Arbor: University of Michigan Press.

Monduit Louis, Denis Alexandre (1889). *Traité Théorique et Pratique de la Stéréotomie au point de vue de la Coupe des Pierres*. Paris: C. Julliot.

Sakarovitch Joël (1998). *Épures d'architecture. De la coupe des pierres à la géométrie descriptive XVIe-XIXe siècles*. Basel, Boston, Berlin: Birkhauser Verlag.

Viollet-le-Duc Eugène-Emmanuel (1814-1879). *Dictionnaire raisonné de l'architecture française du XIe au XVIe siècle*. Paris: Édition Bance-Morel.

Author

Alessio Bortot, Dept. of Architecture and Arts, Iuav University of Venice, alessio.bortot@iuav.it