

Architectural Maquette. From Digital Fabrication to AR Experiences

Original

Architectural Maquette. From Digital Fabrication to AR Experiences / Bertola, Giulia; Capalbo, Alessandro; Bruno, Edoardo; Bonino, Michele - In: REPRESENTATION CHALLENGES New Frontiers of AR and AI Research for Cultural Heritage and Innovative Design / Giordano A., Russo M., Spallone R.. - STAMPA. - Milano : FrancoAngeli, 2022. - ISBN 9788835127307. - pp. 425-432 [10.3280/oa-845-c240]

Availability:

This version is available at: 11583/2972386 since: 2022-10-18T08:34:52Z

Publisher:

FrancoAngeli

Published

DOI:10.3280/oa-845-c240

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)

REPRESENTATION CHALLENGES

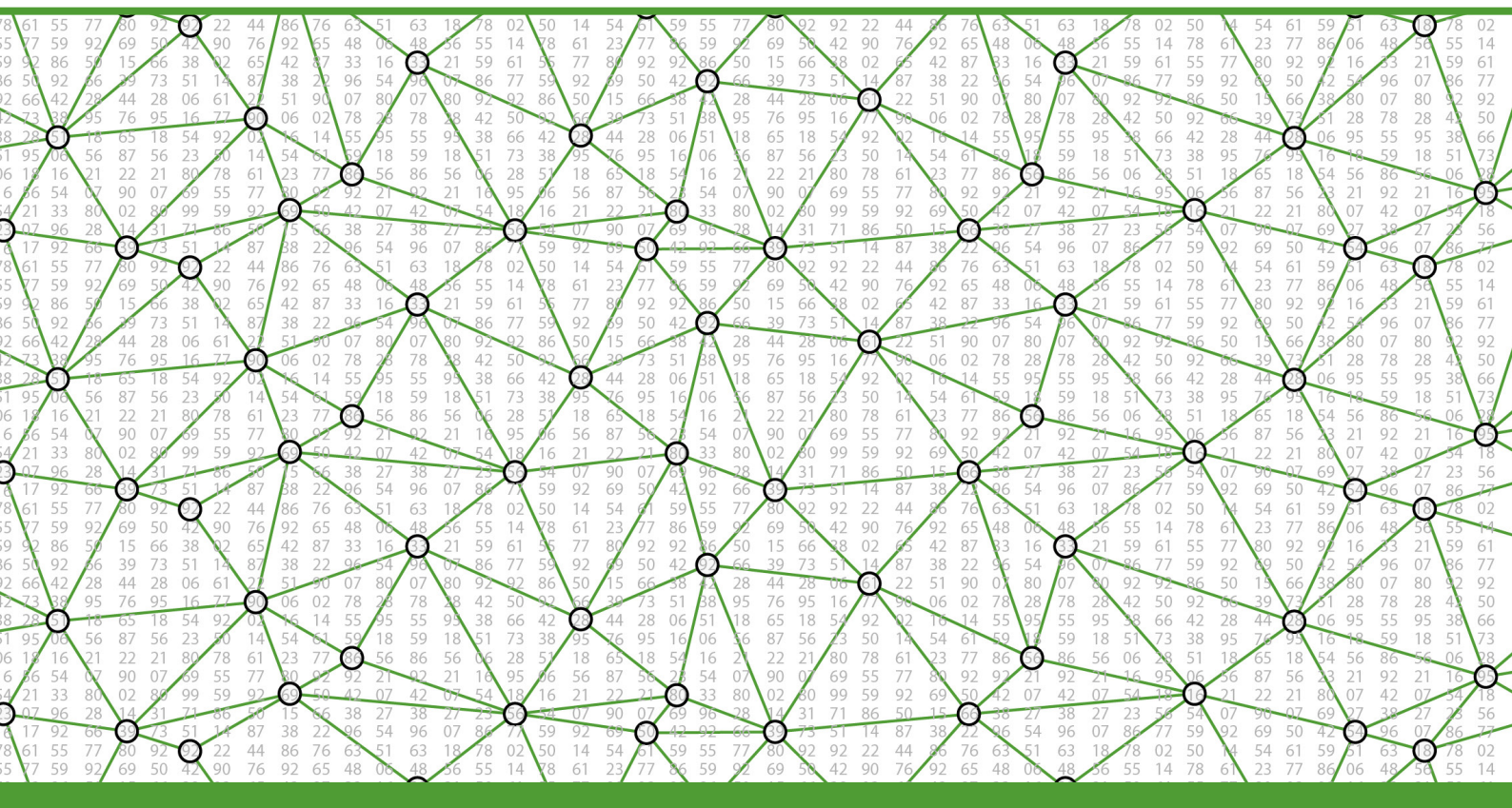
New Frontiers of AR and AI Research for Cultural Heritage and Innovative Design

edited by

Andrea Giordano

Michele Russo

Roberta Spallone



FrancoAngeli OPEN ACCESS

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 *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 - Spagna*
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*



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_publicare/publicare_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

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

Violette Abergel
MAP UMR 3495 CNRS/IMC, 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 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

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>

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 Caprioli, 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'Acunzio, 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 Anagni (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 Nicastrò
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 Techniques

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 Granada-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

Architectural Maquette. From Digital Fabrication to AR Experiences

Giulia Bertola
Alessandro Capalbo
Edoardo Bruno
Michele Bonino

Abstract

With this paper, the authors want to reflect on how, in the age of the immaterial, a plastic model is a tool still current in the representation and able to connect with the new digital tools of augmented reality (AR). In this context, we would like to present a practical case concerning the realization of two static scale models, realized through Digital Fabrication technologies, aiming to increase the accessibility to knowledge about the architectural project in an exhibition context.

The final goal of this work is to develop a methodology that 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. In particular, the following tools were used for tracking: Unity®, a multiplatform graphics engine, and Vuforia®, an augmented reality software development kit.

Keywords

3D modelling, maquette, augmented reality, digital fabrication, multimedia.



AR Technology for the Enhancement of Architectural Maquettes

This paper reflects on how the narrative of architectural design today requires an increasingly interdisciplinary approach supported using of virtual tools for the simulation of architectural and urban space and by digital fabrication technologies for the construction of physical models. Architectural model is a tool that is still current in the field of representation [Sardo 2004, p. 195] and can be integrated with the new digital tools of AR (Augmented Reality) and AI (Artificial Intelligence).

In particular, the link between maquette, AR and AI is currently articulated along two main lines of research. The first is based on the construction of real information models, the second on 'human-material' interaction through the practices of 'augmented craftsmanship' and 'design by making' [Vitali 2021, p. 62].

The maquette can be considered as a narrative artifact to anchor information and create different levels of interactivity and immersion. The authors propose an approach between amusement and edutainment that aims to convey and understand contemporary architectural design [Meschini 2016, p. 4].

The authors intend to present a practical case focused on the construction of multimedia content and its visualization using AR technologies by anchoring it directly to the maquette. The reference project is a circular logistics center characterized by vertical operation, developed after Politecnico di Torino won the third prize in the international urban design competition "Future *Shanshui* City Dwellings in *Lishui* Mountains" in October 2020. Following the competition, the ModLabArch laboratory, where one of the authors is a research fellow, proposed to create a 1:200 scale model to be exhibited in the *Lishui* Exhibition Centre.

The aim of the research is to reflect on how the new scenarios of craft 2.0 extend and intertwine with the more established universes of design and architecture, and how the practices, processes and methods of project communication are currently changing [Micelli 2016, p. 5]. This process is also happening thanks to the continuing trend of placing new digital technologies alongside more traditional techniques. [Pone 2017, p. 9]

In this case, the maquette is a narrating artefact on which information can be anchored, thus generating different levels of interactivity and immersiveness and proposing an approach between amusement and edutainment aimed at communicating and understanding the contemporary architectural project. [Meschini 2016, p. 4]

In the following paragraphs, a methodology will be exposed that allows the user to learn information regarding the architectural project not only through the real model but also through static and dynamic virtual models superimposed on it through current AR technologies.

AR and Architectural and Urban Maquette: the State of the Art

The features and benefits of using physical models in architecture are numerous and well known, while the potential of augmented reality applied to real models is still being explored and developed. Although AR can no longer be considered a novelty, its applications in architecture and the possibilities it opens for representing the architectural and urban environment need to be further explored.

The fusion of physical and digital models creates a powerful tool that can represent the static built environment in a physical, tactile, and three-dimensional way, while allowing the visualisation of dynamic elements such as shadow projections, people and objects in motion, text objects, etc. [Piga 2017, p. 104].

When talking about the interaction between real model and digital model, TUIs – Tangible User Interfaces – are often referred to. A first example is the Luminous Table of the Fausto Curti Urban Simulation Laboratory (LabSimUrb) of the Department of Architecture and Urbanism of the Politecnico di Milano made in 2010. It allows simulating dynamic environmental conditions based on a physical model [LabSimUrb 2010]. Altri esempi sono the In-Form and CityScope projects, each one interactive simulation tools for urban planning aimed at increasing public involvement [Follmer 2013].

In terms of augmented reality applications, reference can be made to the plastic model at Apple Park in Cupertino, in the heart of Silicon Valley (2017), where visitors to the center can see a virtual version of the campus overlaid on the metal model in front of them by using an iPad. They can change the time of day to see how the massive glass structures look when hit by the morning sun. They can also tap on any building to get a small view of the interiors and see how solar energy is collected by cells on the roofs of the buildings and how air moves through the buildings [Cupertino ApplePark 2017].

In the Italian context, we can refer to the monographic exhibition Tex Willer and the project AR, developed by Josef Grunig. A project in which the tracking of the physical model is done through an image and with Apple's ARKit technology, requiring an initial scanning with an iPad, keeping the lighting conditions at the exhibition site constant and not changing during the exhibition day [Tex-70 Years of a Myth 2018] (Fig. 1).

The Case Study: the Logistic Hub of Lishui

The activity presented here started after Politecnico di Torino was awarded the third prize of the "Future *Shanshui* City Dwellings in Lishui Mountains International Urban Design Competition" in October 2020.

It is a project developed by 44 teachers, researchers, Ph.D. students, and undergraduates belonging to the research groups of the China Room (DAD and DIST) and the Institute of Mountain Architecture of DAD.

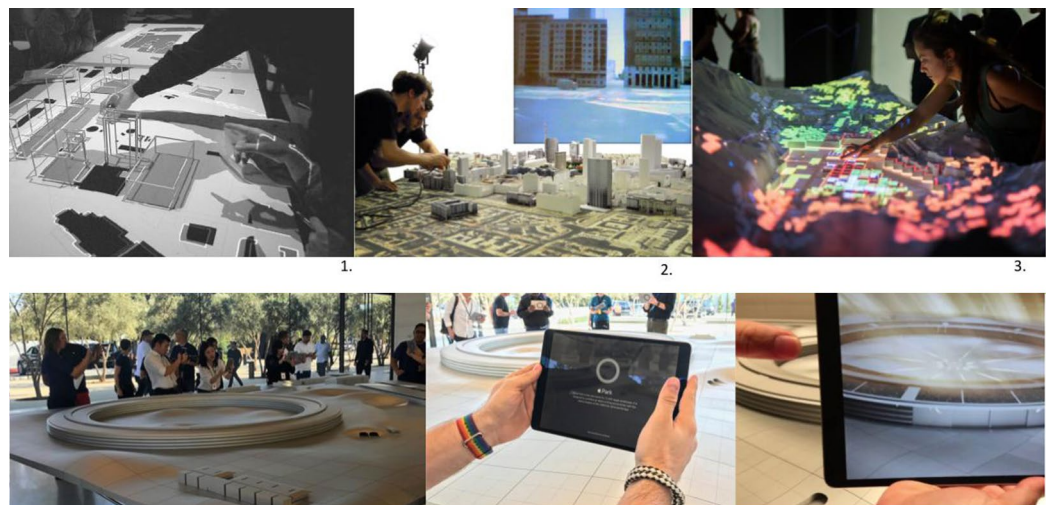


Fig. 1. Luminous Planning Table (LPT), Massachusetts Institute of Technology (MIT), 2000; Luminous Table, Laboratorio di Simulazione Urbana Fausto Curti, Politecnico di Milano, 2010 CityScope, City Science Group del Media Laboratory – Massachusetts Institute of Technology (MIT), 2015; Apple Park, Cupertino, California, 2017.

The work focuses on the *Lishui* Plain, the only plain in southern *Zhejiang*. This area is an important resource for both ecology and agricultural production.

The goal of the master plan was to protect this area and its production by focusing on three project areas: the valley, the housing developments, and the ecological system. Areas that must adapt to the existing city and its main mobility infrastructure without compromising the ecological integrity of the mountains.

The result is a new urban area that shifts its core from the old city to a large central agricultural park designed as a highly specialized and technological platform for production, research, and leisure.

Following the competition, the ModLabArch laboratory proposed to make two 1:200 scale models of two buildings representative of the project to be exhibited in the *Lishui* Exhibition Centre.

The building that is the subject of this case study is a circular logistics center with an area of 192,000 sq.m., located at the crossroads between the air freight system and the road transport system that crosses the valley.

The shape and height of the building are modeled on an air freight system: plants are delivered via cable cars on the upper floor and gradually descend to the lower floors during the various stages of processing until they arrive at the first floor, where they are loaded onto trucks and shipped.

The building has four floors above ground and is organized vertically: the goods coming from the cable cars are deposited in the entrance area, a space dedicated to receiving the goods, unpacking them, and placing them on the conveyors for access to the lower floor; the picking area, where the sorting, storage, and loading of the goods onto containers takes place with the help of overhead cranes; the business district; the commercial area and the public spaces that connect the building with the surrounding villages (Fig. 2).

Methodology Development: from Digital Modelling to Digital Fabrication

For the present work, a workflow has been applied that foresees the coexistence and overlapping of different representation methods, both traditional (drawings and physical models) and modern (3D modelling, integrated CAD /CAM systems, tracking and AR systems). They are all useful for the different communication phases of architectural and urban design (Fig. 3). These different imaging techniques and the relationships that develop between them are becoming increasingly important in defining the new frontiers of architectural practice [Mitchell et al. 1995]. In particular, the work focused on: the three-dimensional digital modeling of the building, the identification of Digital Fabrication techniques (3D printing and laser cut), the executive design of the individual parts, the printing and cutting of all the elements, the assembly and photo-shooting, the design of the AR experience through the identification of specific types of content.

After defining the aesthetic and scale characteristics of the real model, it was decided to use a scale of 1:200 to represent only a quarter of the building, given its large dimensions. The

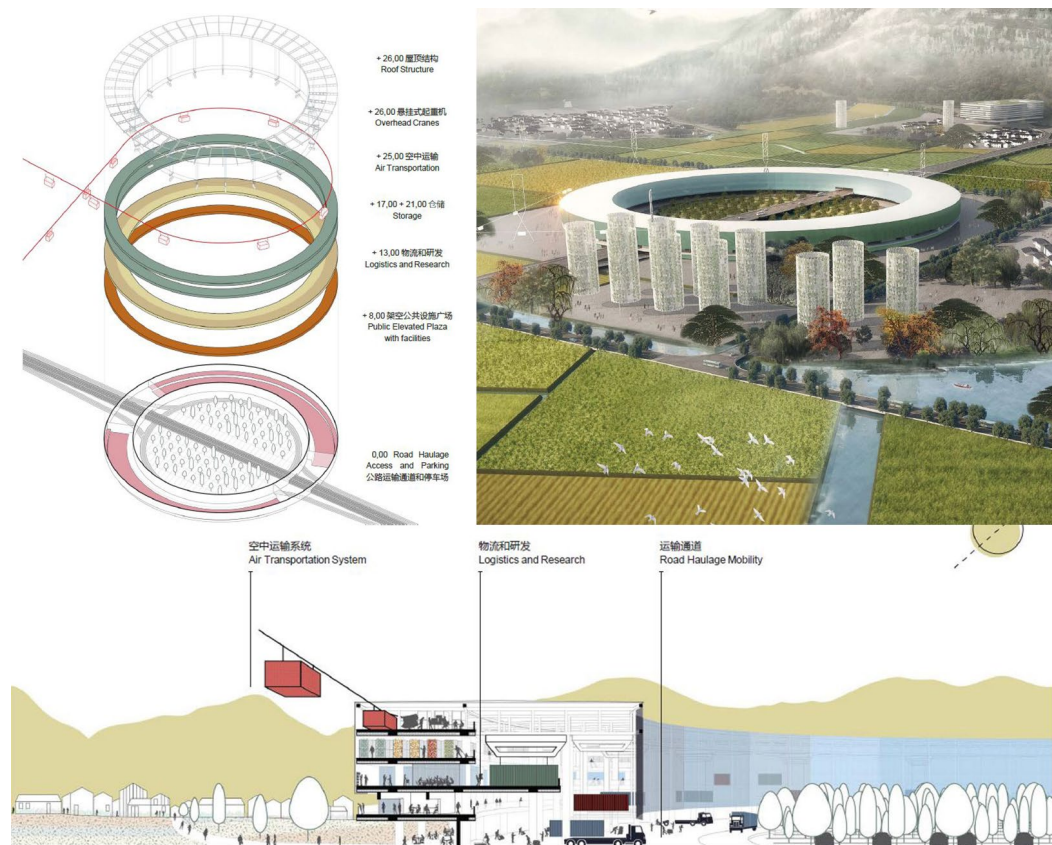


Fig. 2. Prosperous Lishui. South China University of Technology: School of Architecture and Politecnico di Torino, China Room and Institute of Mountain Architecture, Future Shanshui City – Dwelling in Lishui Mountains International Urban Design Competition, 2021.

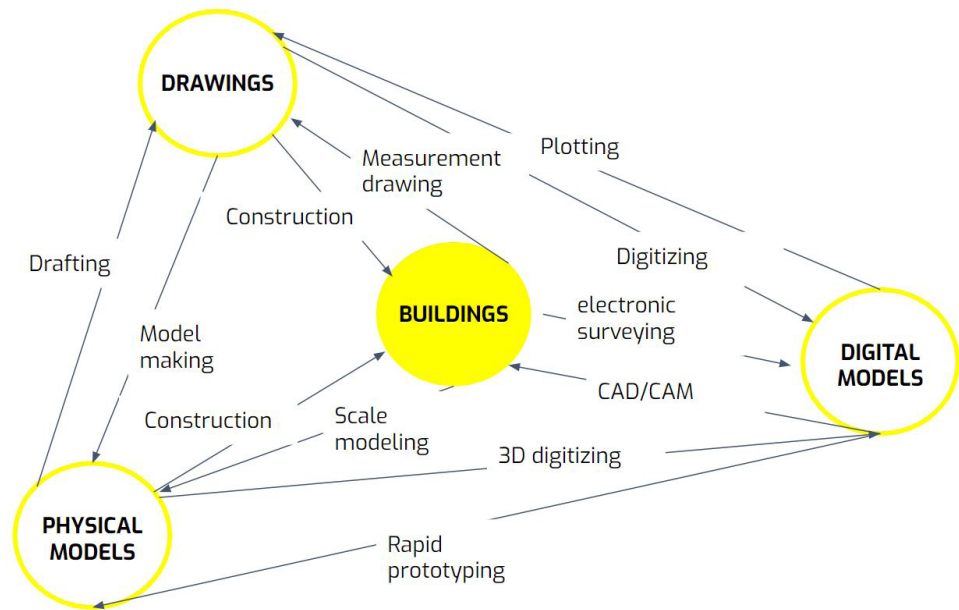


Fig. 3. Mitchell and McCullough, diagram showing the translation paths between physical drawings, digital models, physical models, and the building itself.

model was designed to reveal both the internal and external organization of the distribution, as well as the most representative architectural and structural elements (Fig. 4). The selection of the dimensions of the different elements was based on the Digital Fabrication techniques available in the ModLabArch laboratory: the Ultimaker S5® 3D printer and the Trotec Speedy 400® laser cutter. Consequently, we proceeded with the choice of materials: colored PLA (polylactic acid) for the structural and distribution components and for the transportation means, grey vegetable cardboard, and opaque and transparent plexiglas for the base and floors. Although for AR experiments it is better to have a solid color and opaque materials, in this case, given the need to have a model that can be understood without digital devices, it was decided to use color anyway (Fig. 5).

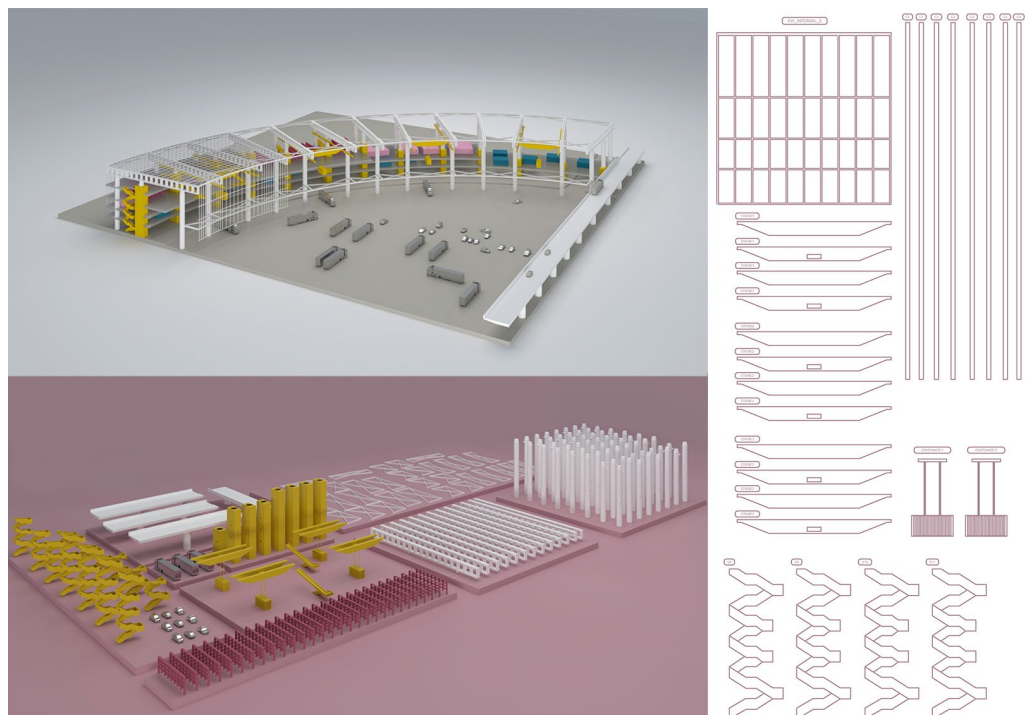


Fig. 4. The 3D model: example of organisation and numbering of some pieces of the model and rendering images. (Project of the Logistic Hub developed by Giulia Bertola, Edoardo Bruno, Alessandro Capalbo, Camilla Farina. 3D model and executive design by Giulia Bertola, Alessandro Capalbo, Enrico Pupi. Rendering and graphics by Giulia Bertola).

Augmented Reality Project

Augmented reality (AR) in the field of architecture and urban planning can be very effective when used to anticipate design projects and their impacts, and to support informed dialogue among the various stakeholders involved in the processes of architectural and urban transformation. This can be done on-site, by acting directly on the area being transformed, or off-site, by using physical scale models [Piga 2017, p. 106].

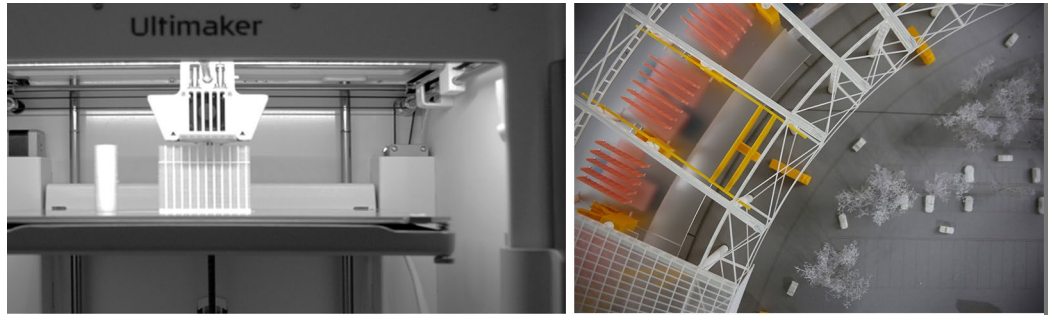


Fig. 5. The final Hub maquette (3D Printing by Giulia Bertola, Enrico Pupi, assembly operation and photoshooting by Giulia Bertola, Enrico Pupi, Areej Awada).

As for the former, static view content can be created where text documents, meaningful images, videos, project drawings, and conceptual schematics can be linked to the maquette through a system based on the recognition of target images placed directly on the model. Users can access the content through downloadable applications or connect directly to a dedicated website for the project, accessible through devices such as phones or tablets. For this project, however, it was decided to focus on the construction of static three-dimensional content that is dynamically displayed directly on the real model. Starting from the 3D model and using special rendering tools, it is possible to create three-dimensional objects that can provide additional information on structure, distribution, energy, and environmental aspects. When the user frames the model through a device, objects appear on the screen that complement the real model (texts or additional architectural and structural elements that are not present in the plastic model). This process was also made possible by the fact that the real model and the multimedia content are derived from the same virtual model. Finally, it is possible to make the same content dynamic by simply animating the three-dimensional objects.

As for the choice of tracking tools, the following applications were used: Unity®, a multiplatform graphics engine and Vuforia Engine®, an augmented reality software development kit. Before we could proceed with creating the augmented reality experience on Unity®, we needed to be clear about which model recognition method we wanted to use. One of the best and most popular SDKs (software development kits) for augmented reality is VuforiaTM®, a tool that works very well with Unity® and allows tracking of layers and 3D objects in real-time. A target is a predefined object that the VuforiaTM® engine recognizes in the real scene and tracks in space. The two most common types of targets are the single image and the 3D object.

In this case, since the object to be tracked is directly the hub model, a 3D object target was created. Using the Model Target Generator (MTG), a software from VuforiaTM®, it was possible to upload the digital model exported directly from Rhinoceros® in .fbx format. In general, for the creation of the Model Target, it is necessary that in the transitions between Rhinoceros®, VuforiaTM®, and Unity® there is a match of the coordinate system, the scale of the object is set 1:1 and there is a general reduction of the complexity of the model. These checks can be performed directly in the Model Target Generator. In the MTG you will then get the auxiliary view, an image file that stylizes the image of the 3D model, in the same position in which it should be framed now of use. Given the complexity of the Hub model, when creating the Model Target, it was necessary to eliminate some components to avoid detection of invisible parts or non-existent features. In the Model Target Generator (MTG),

random colors can also be applied to parts of the 3D model to improve tracking performance. At this stage, colors and textures do not have to be true to reality. On the contrary, the use of photorealistic textures or materials that try to emulate certain physical effects can lead to the opposite effect.

Once the procedure is complete, the Advanced View is created and the Model Target is exported to a .unitypackage file, ready to be imported into the project on Unity®. The first step is to set the device on which the experience will be tested. When you open the Build Setting window, you will find several settings, including the ability to switch between different operating systems.

A preliminary operation to be performed is the setting of the device on which the experience is tested.

Being a preliminary study phase and having a stationary object during the AR experience, it was decided to use the camera of a laptop placed directly in front of the model.

Usually, the use of static movement significantly improves the quality of tracking.

After adding the Vuforia™ package to the project, we proceed with the insertion of the AR Camera, the new Unity® basic camera, the Model Target, and the Child object to be displayed during the AR experience.

The experience takes place when the Game View is activated; in this phase, it is possible to visualize the Guide view (the Model Target), superimpose it on the model, and automatically visualize the Child object (Fig. 6).

Conclusion

This experience intends that the user can acquire additional information about the architectural project. Once the method has been identified, it is planned, in a subsequent phase, to create different types of 3D contents, both static and dynamic, always inserted as Child objects within Unity® and anchored to the Model Target.

The success of modern digital representation technologies is already demonstrated by the rapid spread they are having in various fields of communication. The aim of this study was to show how these applications can have a positive influence on architectural design and the creation of maquettes.

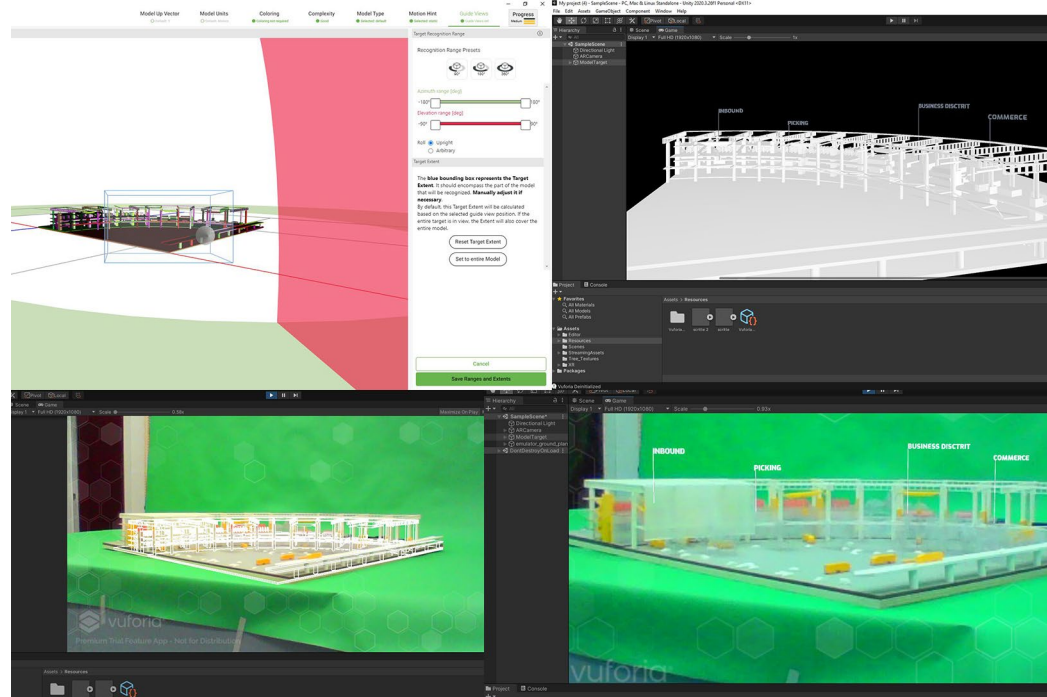


Fig. 6. The Augmented Reality Project. Model Target creations on Vuforia® and the project on the Unity® platform (the recognition of the model target following the overlapping of the real model and the appearance of the Child object in AR). (Design by Giulia Bertola)

Models, even if integrated with such technologies, can still maintain their role as a tangible miniature witness of architectural and urban space and be able to describe the idea of physical space, without simulating its reality but stimulating the critical imagination of the observer [Gulinello 2019, p. 98].

Real models and virtual models can therefore act synergistically even though they come from different approaches: the former maintaining their power to fascinate thanks to the fact that buildings will continue to be designed and built, the latter thanks to their forward-looking approach that helps to achieve other goals such as efficiency in the design process based on the principle of an intelligent process [Schilling 2018, p. 197].

References

- Cupertino Apple Park (2017). Visiting Apple Park in Augmented Reality. <https://www.youtube.com/watch?v=fCU0eeYBujc> (10 January 2022).
- Follmer Sean, Leithinger Daniel, Alex Olwal, 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*. New York: ACM Digital Library, pp. 417-426.
- Gulinello Francesco, Mucelli Elena (2019). *Modelli. Costruire lo spazio / Models. Building the Space*. Siracusa: LetteraVentidue.
- LabSimUrb. Laboratorio di Simulazione Urbana Fausto Curti (2010). <http://www.labsimurb.polimi.it/LPT/index.html> (02 February 2022).
- Meschini Alessandra, Rossi Daniele, Feriozzi Ramona (2016). La Basilica in una scatola. Proposta per una wunderkammer contemporanea. In *DisegnareCon*, 9(17), 2016, pp. 1-10.
- Micelli Stefano (2016). *Fare è innovare*. Bologna: il Mulino.
- MIT Media Lab (2014). CityScope: Augmented Reality City Simulation. <http://cp.media.mit.edu/city-simulation> (20 February 2022).
- Mitchell William John, McCullough Malcolm (1995). *Digital Design Media*. Hoboken: John Wiley & Sons.
- Piga Barbara Ester Adele, Petri Valentina (2017). Augmented Maquette for Urban Design. In Maver Tom, Chapman Paul, Platt Christopher, Portela Victor, Eaton David (eds.). *Envisioning Architecture: Space, Time, Meaning*. Glasgow: Freight Publishing, pp. 104-113.
- Pone Sergio, Colabella Sofia (2017). *Maker. La fabbricazione digitale per l'architettura e il design*. Bari: Progedit.
- Sardo Nicolò (2004). *La figurazione plastica dell'architettura*. Roma: Edizioni Kappa.
- Schilling Alexander (2018). *Architecture and Model Building. Concepts – Methods – Materials*. Basel: Birkhäuser.
- Tex-70 anni di un mito. Museo della Permanente, Milano 2th October 2018 - 27th Genuary (2019). <https://www.youtube.com/watch?v=XapKc9RgOIk> (28 February 2022).
- Vitali Marco, Bertola Giulia, Natta Fabrizio, Ronco Francesca (2021). AI+AR: Cultural Heritage, Museum Institutions, Plastic Models and Prototyping. A State of Art. In Giordano Andrea, Russo Michele, Spallone Roberta (eds.). *Representation Challenges. Augmented Reality and Artificial Intelligence in Cultural Heritage and Innovative Design Domain*. Milano: FrancoAngeli, pp. 57-61.

Authors

Giulia Bertola, Dept. of Architecture and Design, Politecnico di Torino, giulia.bertola@polito.it
Alessandro Capalbo, capalbo.alessandro2@gmail.com
Edoardo Bruno, Dept. of Architecture and Design, Politecnico di Torino, edoardo.bruno@polito.it
Michele Bonino, Dept. of Architecture and Design, Politecnico di Torino, michele.bonino@polito.it