

Reconstructive models and AR applications to archive drawings. Aldo Morbelli's forgotten architectures

Original

Reconstructive models and AR applications to archive drawings. Aldo Morbelli's forgotten architectures / Natta, Fabrizio; Spallone, Roberta; Vitali, Marco - In: eXploA - Virtual journeys to discover inaccessible heritages / Stilo F., Castiglione V., Cazzaro I., Ceracchi M., Natta F., Pileri M., Pizzonia L., Tomalini A., Tomasella N., Trivi M. B.. - ELETTRONICO. - Alghero : Publica Sharing Knowledge, 2024. - ISBN 9788899586492. - pp. 697-709

Availability:

This version is available at: 11583/2998084 since: 2025-03-05T08:55:28Z

Publisher:

Publica Sharing Knowledge

Published

DOI:

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)

explORA

virtual journeys to discover *inaccessible* heritages

a cura di

Francesco Stilo
Vittoria Castiglione
Irene Cazzaro
Michela Ceracchi
Fabrizio Natta
Marta Pileri
Lorella Pizzonia
Andrea Tomalini
Noemi Tomasella
Maria Bélen Trivi

PUBLICA

COMITATO SCIENTIFICO

Marcello Balbo
Dino Borri
Paolo Ceccarelli
Enrico Cicalò
Enrico Corti
Nicola Di Battista
Carolina Di Biase
Michele Di Sivo
Domenico D'Orsogna
Maria Linda Falcidieno
Francesca Fatta
Paolo Giandebiaggi
Elisabetta Gola
Riccardo Gulli
Emiliano Ilardi
Francesco Indovina
Elena Ippoliti
Giuseppe Las Casas
Mario Losasso
Giovanni Maciocco
Vincenzo Melluso
Benedetto Meloni
Domenico Moccia
Giulio Mondini
Renato Morganti
Stefano Moroni
Stefano Musso
Zaida Muxi
Oriol Nel.lo
Joao Nunes
Gian Giacomo Ortu
Giancarlo Paba
Rossella Salerno
Enzo Scandurragher
Silvano Tagliagambe

Tutti i testi di PUBLICA sono sottoposti a *double peer review*

eXploRA UID 2024

Premio Giovani UID Vito Cardone 2023

Giornata di Studi Internazionale. Roma, 15 marzo 2024.

COMITATO SCIENTIFICO

Leonardo Baglioni / Sapienza Università di Roma
Carlo Bianchini / Sapienza Università di Roma
Enrico Cicalò / Università degli Studi di Sassari
Edoardo Dotto / Università degli Studi di Catania
Laura Farroni / Università degli Studi Roma Tre
Francesca Fatta / Università degli Studi di Reggio Calabria
Fabrizio Gay / Università IUAV di Venezia
Elena Ippoliti / Sapienza Università di Roma
Massimiliano Lo Turco / Politecnico di Torino
Valeria Menchetelli / Università degli Studi di Perugia
Alberto Sdegno / Università degli Studi di Udine
Roberta Spallone / Politecnico di Torino
Graziano Mario Valenti / Sapienza Università di Roma

Pedro M. Cabezas-Bernal / Universitat Politècnica de València (Spain)
Fabiana Andrea Carbonari / Universidad Nacional de La Plata (Argentina)
Livio De Luca / CNRS (France)
Fernando Gandolfi / Universidad Nacional de La Plata (Argentina)
Mona Hess / Universität Bamberg (Germany)
Pedro António Janeiro / Universidade de Lisboa (Portugal)
Piotr Kuroczyński / Hochschule Mainz – University of Applied Sciences (Germany)
Dominik Lengyel / Brandenburgische Technische Universität Cottbus-Senftenberg (Germany)
Sander Münster / Friedrich Schiller University Jena (Germany)
Pablo Rodríguez-Navarro / Universitat Politècnica de València (Spain)
Renato Vizioli / Universidade Presbiteriana Mackenzie (Brazil)
Simone Helena Tanoue Vizioli / Universidade de São Paulo (Brazil)

COMITATO ORGANIZZATIVO

Francesco Stilo (Coordinator) / Università degli Studi 'Mediterranea' di Reggio Calabria
Vittoria Castiglione / Sapienza Università di Roma
Irene Cazzaro / Università di Bologna – Alma Mater Studiorum
Michela Ceracchi / Sapienza Università di Roma
Fabrizio Natta / Politecnico di Torino
Marta Pileri / Università degli Studi di Sassari
Lorella Pizzonia / Università degli Studi 'Mediterranea' di Reggio Calabria
Andrea Tomalini / Politecnico di Torino
Noemi Tomasella / Sapienza Università di Roma
María Belén Trivi / Sapienza Università di Roma

COMITATO DEI REVISORI

Alessio Altadonna / Università degli studi di Messina
Marinella Arena / Università degli Studi di 'Mediterranea' Reggio Calabria
Martina Attenni / Sapienza Università di Roma
Leonardo Baglioni / Sapienza Università di Roma
Alessandro Basso / Università degli Studi di Camerino
Laura Carlevaris / Sapienza Università di Roma
Lino Cabras / Università degli Studi di Sassari
Emanuela Chiavoni / Sapienza Università di Roma
Enrico Cicalò / Università degli Studi di Sassari
Luigi Cocchiarella / Politecnico di Milano
Daniele Colistra / Università degli Studi 'Mediterranea' di Reggio Calabria
Francesca Condorelli / Libera Università di Bolzano
Marco Fasolo / Sapienza Università di Roma
Francesca Fatta / Università degli Studi 'Mediterranea' di Reggio Calabria
Amedeo Ganciu / Università degli Studi di Sassari
Alessia Garozzo / Università degli Studi di Palermo
Fabrizio Gay / Università IUAV di Venezia
Elisabetta Caterina Giovannini / Politecnico di Torino
Marika Griffo / Sapienza Università di Roma
Elena Ippoliti / Sapienza Università di Roma
Francesco Maggio / Università degli Studi di Palermo
Matteo Flavio Mancini / Università degli Studi Roma Tre
Silvia Masserano / Università degli Studi di Udine
Domenico Mediatì / Università degli Studi di 'Mediterranea' Reggio Calabria
Valeria Menchetelli / Università degli Studi di Perugia
Davide Mezzino / Politecnico di Torino
Maria Milano / Escola Superior de Artes e Design (Portugal)
Sara Morena / Università degli Studi di Palermo
Caterina Palestini / Università degli Studi di Pescara
Francesca Picchio / Università degli Studi di Pavia
Francesca Porfiri / Sapienza Università di Roma
Paola Raffa / Università degli Studi 'Mediterranea' di Reggio Calabria
Veronica Riavis / Università degli Studi di Udine
Jessica Romor / Sapienza Università di Roma
Daniele Rossi / Università degli Studi di Camerino
Anna Sanseverino / Università degli Studi di Napoli
Giovanna Spadafora / Università degli Studi Roma Tre
Roberta Spallone / Politecnico di Torino
Ilaria Trizio / CNR L'Aquila
Graziano Mario Valenti / Sapienza Università di Roma
Michele Valentino / Università degli Studi di Sassari
Starlight Vattano / Università degli Studi di Trento
Chiara Vernizzi / Università degli studi di Parma
Marco Vitali / Politecnico di Torino

Francesco Stilo, Vittoria Castiglione, Irene Cazzaro, Michela Ceracchi, Fabrizio Natta, Marta Pileri, Lorella Pizzonia, Andrea Tomalini, Noemi Tomasella (a cura di)
eXploRA UID 2024

Virtual Journeys to discover inaccessible heritages

© PUBLICA, Alghero, 2024

ebook ISBN 978 88 99586 49 2

Pubblicazione e stampa Dicembre 2024

PUBLICA
Dipartimento di Architettura, Urbanistica e Design
Università degli Studi di Sassari
WWW.PUBLICAPRESS.IT



PUBLICA

eXplora UID 2024

Virtual Journeys to discover *inaccessible* heritages

a cura di

Francesco Stilo
Vittoria Castiglione
Irene Cazzaro
Michela Ceracchi
Fabrizio Natta
Marta Pileri
Lorella Pizzonia
Andrea Tomalini
Noemi Tomasella
Maria Bélen Trivi

ISBN: 978 88 99586 49 2

INDICE / INDEX

- 15** **Presentazione**
Francesca Fatta
- 19** **Introduzione**
Francesco Stilo
- 23** **Guardarsi dentro**
Edoardo Dotto
- 33** **L'intelligenza grafico-digitale nell'epoca della transizione digitale.**
Implicazioni per la rappresentazione e la comunicazione del patrimonio culturale
Enrico Cicalò
- 43** **Immersive panoramic photography for the dissemination of cultural heritage**
Pedro M. Cabezos-Bernal
- 55** **DISEGNARE / DRAWING**
- Introduzione alla sessione**
 Lorella Pizzonia, Andrea Tomalini, Maria Bélen Trivi

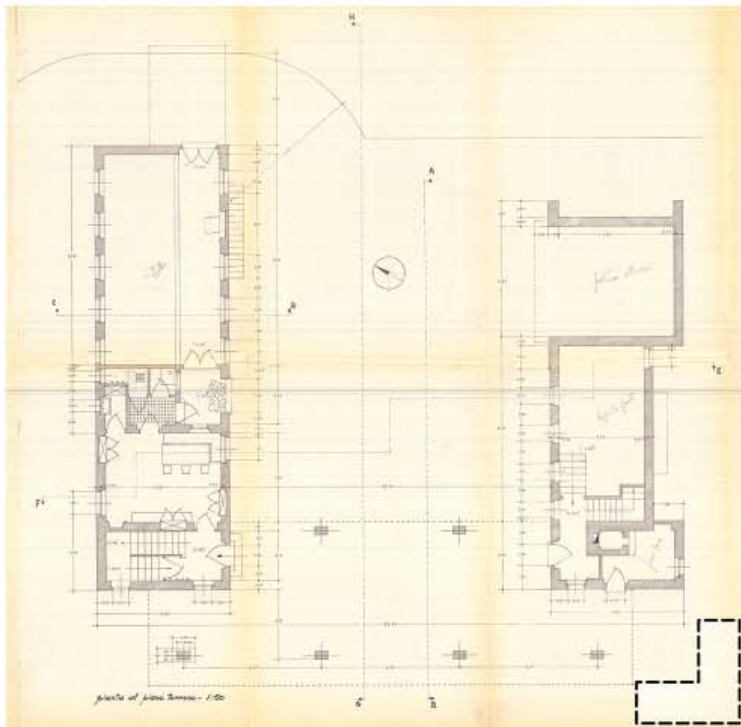
- 62** **Rendere visibile**
Francesco Maggio, Alessia Garozzo
- 80** **Il valore (in)tangibile. Protocolli per la documentazione, la catalogazione e la comunicazione del Patrimonio Culturale Immateriale**
Valeria Menchetelli
- 104** **Il modello ligneo della Chiesa di san Giuseppe a Firenze: alcune considerazioni**
Marcello Scalzo, Francesco Tioli, Andrea Caprara
- 126** **Dal disegno al virtuale. Quando la realtà distorce il progetto: un palazzo romano di Gaetano Rapisardi**
Eleonora Di Mauro, Salvatore Damiano
- 147** **Il rilievo per la fruizione dei beni in digitale: il caso studio di un eremo sull'Isola di Capri**
Rosaria Parente, Riccardo Tavolare
- 164** **La Realtà Estesa come strumento inclusivo per un progetto urbano nel patrimonio archeologico di Canosa di Puglia. Il caso degli Ipogei Lagrasta e della Fullonica**
Roberto Pedone, Rossella Laera, Emanuela Borsci, Ali Yaser Jafari, Gianluigi De Stradis, Giada Vignola
- 176** **La rappresentazione dello spazio sacro nella Cattedrale di Bitonto. Dal rilievo alla ricostruzione grafica**
Gabriele Rossi, Massimo Leserri, Davide Sanzio, Domenico Pastore
- 193** **Architetture tattili di terra per i ciechi: dalla comunicazione alla realizzazione**
Elena De Santis
- 207** **La ricostruzione digitale del Viridarium: complesso del giardino botanico di Federico Cesi e dell'Accademia dei Lincei**
Marco Proietti

- 217 From sketch to immersive reality: Construction Methodology of the 360° Panoramic Drawing from planimetric information. The case of the heritage buildings of the Universidad Nacional de La Plata**
Analía Jara
- 230 Scan2BIM methodology applied to the Faculty of Theatral Art of La Habana**
Carlo Biagini, Andrea Bongini
- 242 Ricostruzione digitale e immagine urbana. La Specola dell'ex Regio Osservatorio Astrofisico presso il Monastero dei Benedettini a Catania**
Nicoletta Campofiorito, Cettina Santagati
- 257 Il cinema Excelsior di Catania: rilievo e documentazione digitale per la fruizione virtuale di un'architettura degli anni Trenta abbandonata**
Graziana D'Agostino, Raissa Garozzo, Mariateresa Galizia
- 272 Il patrimonio del Bioparque La Plata, ex Zoo. Conoscenza e divulgazione attraverso il disegno integrato**
Camila Martin, Fabiana Carbonari
- 291 MODELLARE / MODELLING**
- Introduzione alla sessione**
Vittoria Castiglione, Michela Ceracchi, Noemi Tomasella
- 296 Ri-costruzione filologica, virtuale e tattile della diruta Cappella Palatina di Noto Antica**
Rita Valenti, Concetta Aliano, Emanuela Paternò
- 317 I borghi rurali della riforma agraria: ricostruzioni digitali per la conoscenza e la valorizzazione del patrimonio architettonico contemporaneo**
Raffaele Pontrandolfi, Antonio Bixio
- 339 Modellare e rappresentare Pomezia: anatomia di un concorso**
Antonio Schiavo, Beatrice Teresi

- 359 Le rovine romane a Napoli: il teatro intrappolato**
Angela Cicala, Gianluca Barile
- 371 Modellazione, digital fabrication e AR: un workflow per rendere fruibili le architetture di Mario Botta e le loro matrici geometriche generative**
Francesca Ronco, Giulia Bertola, Enrico Pupi
- 389 Il modello architettonico, dal digitale al fisico: il caso studio del Casale della Cervelletta**
Alessio Buonacucina, Alessia Lamantia
- 396 Rappresentazione per la Valorizzazione: il Patrimonio Universitario dal Gemello Digitale al Gemello Analogico**
Maurizio Marco Bocconcinò, Mariapaola Vozzola, Martino Pavignano
- 416 Tra disegni d'archivio e rilievo digitale dello stato di fatto: il modello del famedio di Leone Savoja al gran camposanto di Messina**
Francesca Fatta, Marinella Arena, Francesco Stilo, Lorella Pizzonia
- 432 ESPLORARE / EXPLORING**
- Introduzione alla sessione**
Irene Cazzaro, Fabrizio Natta, Marta Pileri
- 440 Egle Renata Trincanato. Disegni e modelli digitali di un concorso di progettazione, 1942**
Starlight Vattano
- 455 Viaggi costieri: tra patrimoni inaccessibili e architetture mai realizzate**
Sonia Mollica
- 467 WissKI 3D Repository as a tool for the preservation and exploration of 3D models of cultural heritage**
Igor Bajena, Piotr Kuroczyński

- 490 L'uso del metaverso per la fruizione condivisa e interattiva delle informazioni storiche d'archivio**
Silvia La Placa, Francesca Galasso
- 514 Riscoprire e rifunzionalizzare un patrimonio perduto attraverso tecniche di rappresentazione digitale. L'acquario-rettilario di Enzo Venturelli per un nuovo Museo del fumetto e dell'animazione giapponese a Torino**
Elisabetta C. Giovannini, Valeria Minucciani, Vittorio Bottari
- 533 Other stories. Virtual reconstruction of different design hypotheses for Piazza d'Arogn in Trento**
Anna Maragno, Ambra Barbini, Elena Bernardini, Chiara Chioni
- 547 Realtà estesa all'eredità architettonica perduta. Il sistema di accesso meridionale alla Mostra d'Oltremare**
Pedro G. Vindrola, Erika Elefante, Giuseppe Antuono, Pierpaolo D'Agostino
- 561 Esplorazione immersiva dello spazio disegnato di Andrea Pozzo. La chiesa non realizzata di San Tommaso di Canterbury**
Flavia Camagni, Marco Fasolo, Elisa Guarino
- 581 I cortili rinascimentali all'Aquila: un progetto per l'esplorazione di un patrimonio nascosto**
Luca Vespasiano, Stefano Brusaporci
- 596 Tracce d'Acqua**
Giulia Bocci, Giulia Grottolo, Valentina Marchegiani, Alessandra Marinucci
- 608 Dal rilievo laser scanner al tour virtuale: un flusso di lavoro per favorire l'accessibilità al patrimonio costruito**
Raffaele Argiolas
- 622 Marburger Wissensräume – representing 500 years of university history in form of 4D reconstructions of cultural heritage**
Peter Bell, Katharina Hefe
- 635 Marocco: viaggio virtuale nelle architetture di terra**
Marinella Arena, Paola Raffa

- 654 Il Quirinale come residenza imperiale francese: i progetti di Raffaele Stern**
Annalisa Brancasi
- 667 Online games as a pathway to elevate world cultural heritage conservation in China**
Xiaoxu Liang, Lu Ji
- 682 Preservare l'architettura tradizionale balinese: strategie digitali per la tutela di patrimoni culturali a rischio**
Massimiliano Lo Turco, Filiberto Chiabrande, Andrea Tomalini, Jacopo Bono, Enrico Castorello
- 697 Reconstructive models and AR applications to archive drawings. Aldo Morbelli's forgotten architectures**
Fabrizio Natta, Roberta Spallone, Marco Vitali
- 711 Unbuilt buildings on the Campus of the National College of the city of La Plata, Buenos Aires, Argentina, in the period between 1904 and 1926. Knowledge and graphic dissemination**
Franco O. Morel, Fabiana A. Carbonari
- 731 La ricostruzione virtuale del patrimonio ecclesiastico post-sisma: il caso della chiesa di San Fortunato a Pinaco Arafranca, Amatrice**
Emma Moriconi, Davide Mezzino
- 747 Documentazione digitale per la diffusione del patrimonio. Le torri di difesa del litorale Valenciano**
Pablo Rodríguez-Navarro, Teresa Gil-Piqueras, Andrea Ruggieri



**CASCINA
TREVES-SACERDOTE**

Data: 1948-1949
Motivazione della cronologia:
 presente sui documenti
Tipo data: date della documentazione
Quantità: 18
Tipologia: disegni

Quantità: 20
Tipologia: fototipi

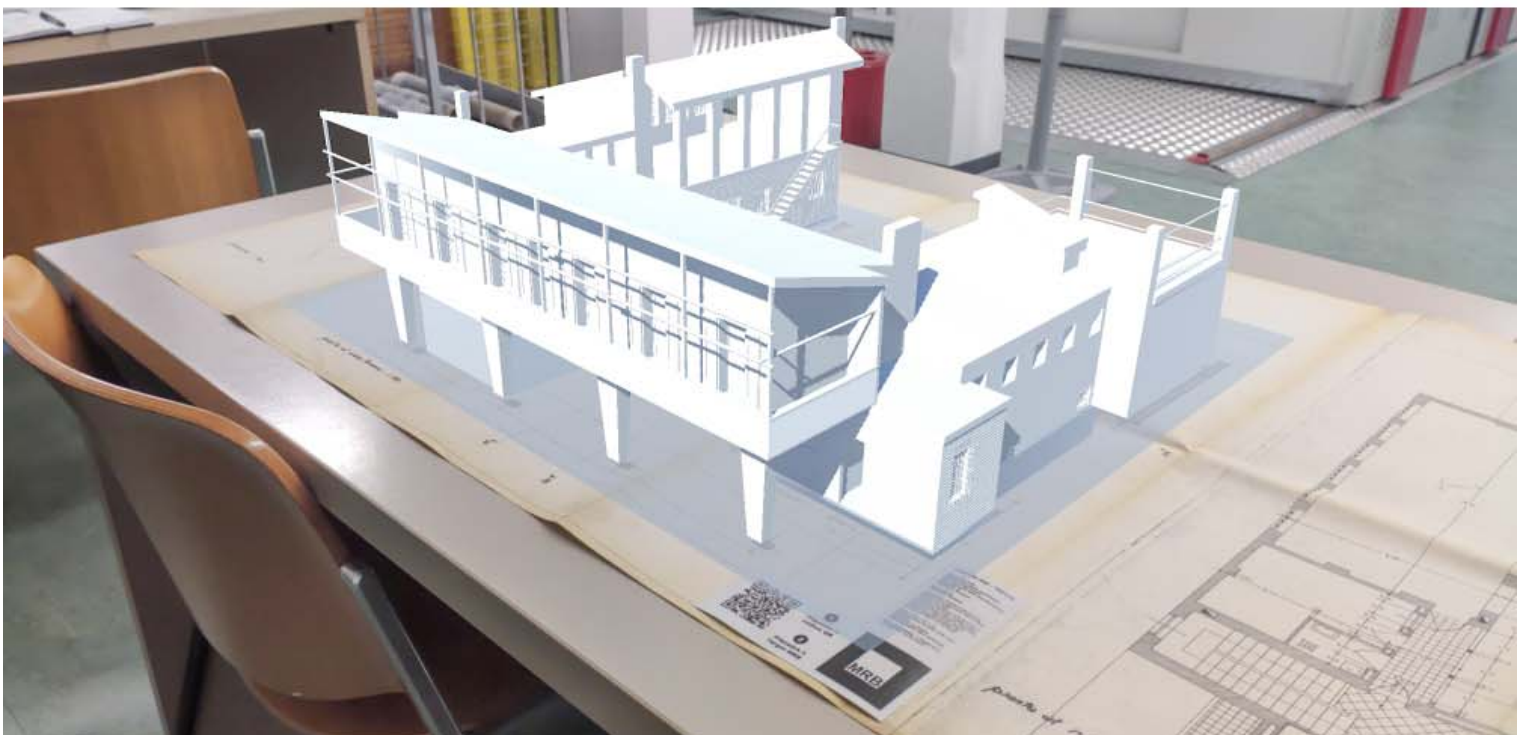
Descrizione: Progetto di fattoria nella
 proprietà Treves-Sacerdote, sitta in strada
 Valsaice 97 a Torno.
 18 disegni, 10 matita su carta da lucido, 2
 china su carta da lucido, 1 matita e china
 su carta da lucido, 5 eliocopie. Planimetria
 lotto in scala 1:1500, piante, sezioni,
 prospetti e particolari in scala 1:50,
 particolari in scala 1:10, 20 fototipi

Scala: 1:500, 1:50, 1:10
Supporto: carta da lucido, carta, carta
 fotografica
Argomento: architettura
Sottogoverno: edifici residenziali
Data compilazione: 11 Maggio 2018
Compilatore: Lionetti Nicola



1
 Inquadra il
 codice QR

2
 Inquadra il
 target MRB



Reconstructive models and AR applications to archive drawings. Aldo Morbelli's forgotten architectures

Fabrizio Natta¹, Roberta Spallone¹, Marco Vitali¹

¹Department of Architecture and Design, Politecnico di Torino, Turin, ITALY

fabrizio.natta@polito.it; roberta.spallone@polito.it; marco.vitali@polito.it

Keywords: Archival drawings; Reconstructive models; BIM; AR; Immersive experiences / *Disegni d'archivio; Modelli ricostruttivi; BIM; AR; Esperienze immersive.*

Abstract

Architecture archives constitute an invaluable source of knowledge and an essential pillar for scientific research dedicated to understanding architecture in all its nuances. This resource interests a wide spectrum of disciplines, including the history of architecture, conservation, design theory, and representation. In recent years, we have witnessed a growing recognition of the importance of preserving archives related to Modernism: these archives often harbor a rich treasure of material that holds invaluable importance for the academic world and an international community of passionate scholars.

A particularly interesting area of research is the digitization and interpretation of architectural projects that, despite being conceived by illustrious masters of architecture, were never realized. These projects represent valuable testimonies of uncompleted creative paths and offer a new perspective on architectural history, worthy of examination and understanding.

The introduction of augmented reality (AR) technologies in the field of historic architecture has opened new possibilities for the documentation and visualization of buildings that no longer exist. AR serves as an innovative tool for preserving historical memory, enriching the experience of studying and enjoying architectural heritage. The process begins with meticulous digitization of historical documents and archive drawings, requiring in-depth analysis to ensure the accuracy of the representation. These are then transformed into digital formats, facilitating integration into 3D modeling environments. Historical photographs, testimonies of past eras, represent another valuable resource, as they capture visual details and provide precious information on the original state of buildings.

This contribution draws on materials preserved at the "Roberto Gabetti" Central Library of Architecture archive at the Polytechnic of Turin: in particular, the archive holds works by Carlo Mollino (1905-1973), subject to previous H-BIM reconstructive modeling studies, and by Aldo Morbelli (1903-1963). On this occasion, the research group resumed the results of a previous BIM modeling experience, aimed at the digital reconstruction of Aldo Morbelli's Treves-Sacerdote farmhouse, built in Turin in 1947 and demolished in 1964, and is developing a communication project using AR technologies. The three-dimensional model can be superimposed on the surrounding environment through the use of mobile devices or AR viewers, employing the tools of the Unity software. The reconstructive model can be considered a prototype for the development of future methodologies in the field of interactive and immersive reality experiences. These will allow scholars, students, and a wider audience to explore the architectural past in a detailed and engaging way. The combined approach of archive documentation,

Fig. 1 - Vintage photographs and ground floor plan of Treves-Sacerdote farmhouse with user and archive project information. Archivi BCA, Fondo Aldo Morbelli; APP screenshot of the Treves-Sacerdote farmhouse project.

3D modeling, and AR opens new perspectives for the conservation of architectural heritage and the understanding of architectures that no longer exist physically.

Gli archivi di architettura costituiscono una fonte inestimabile di conoscenza e un pilastro essenziale per la ricerca scientifica dedicata alla comprensione dell'architettura in tutte le sue sfumature. Questa risorsa interessa un vasto spettro di discipline, tra cui la storia dell'architettura, la conservazione, la teoria del progetto e la rappresentazione. Negli ultimi anni, abbiamo assistito a un crescente riconoscimento dell'importanza della conservazione degli archivi legati al Modernismo: questi archivi spesso custodiscono un ricco tesoro di materiale che riveste un'inestimabile importanza per il mondo accademico e per una comunità internazionale di studiosi appassionati.

Un'area di ricerca di particolare interesse è la digitalizzazione e l'interpretazione di progetti architettonici che, nonostante siano stati concepiti da illustri maestri dell'architettura, non sono mai stati realizzati. Questi progetti rappresentano preziose testimonianze di percorsi creativi non compiuti e offrono una nuova prospettiva sulla storia architettonica, meritevoli di essere esaminati e compresi.

L'introduzione delle tecnologie di realtà aumentata (AR) nel campo dell'architettura storica ha aperto nuove possibilità per la documentazione e la visualizzazione di edifici che non esistono più. La AR si pone come strumento innovativo per la preservazione della memoria storica, arricchendo l'esperienza di studio e fruizione del patrimonio architettonico. Il processo inizia con una meticolosa digitalizzazione di documenti storici e disegni d'archivio, che richiede un'analisi approfondita per garantire l'accuratezza della rappresentazione. Questi vengono poi trasformati in formati digitali, facilitando l'integrazione in ambienti di modellazione 3D. Le fotografie storiche, testimonianze di epoche passate, rappresentano un'altra risorsa preziosa, poiché catturano dettagli visivi e offrono informazioni preziose sullo stato originale degli edifici.

Il presente contributo attinge ai materiali conservati presso l'archivio della Biblioteca Centrale di Architettura "Roberto Gabetti" del Politecnico di Torino: in particolare, l'archivio conserva opere di Carlo Mollino (1905-1973), oggetto di precedenti studi di modellazione ricostruttiva H-BIM, e di Aldo Morbelli (1903-1963). In questa occasione il gruppo di ricerca ha ripreso i risultati di una precedente esperienza di modellazione BIM, orientata alla ricostruzione digitale della cascina Treves-Sacerdote di Aldo Morbelli, costruita a Torino nel 1947 e demolita nel 1964, e sta sviluppando, mediante le tecnologie AR, un progetto di comunicazione. Il modello tridimensionale può essere sovrapposto all'ambiente circostante tramite l'uso di dispositivi mobili o visori AR, impiegando gli strumenti del software Unity. Il modello ricostruttivo può essere considerato un prototipo per lo sviluppo di metodologie future nell'ambito di esperienze di realtà interattive e immersive. Queste consentiranno a studiosi, studenti e ad un pubblico più vasto, di esplorare dettagliatamente e in modo coinvolgente il passato architettonico. L'approccio combinato di documentazione d'archivio, modellazione 3D e AR apre nuove prospettive per la conservazione del patrimonio architettonico e la comprensione delle architetture che non esistono più fisicamente.

Introduction

In an era where the digitization of cultural heritage has become pivotal, the intersection of archival research and cutting-edge technology like extended reality (XR) presents a unique opportunity to re-imagine the study and dissemination of architectural legacies. The eXploRA conference, dedicated to fostering transversal interactions among disciplines such as Representation and Drawing, and emphasizing the exploration of XR technologies, provides an ideal forum for presenting innovative approaches to architectural historiography and conservation. This paper aligns with eXploRA's mission by presenting a case study that not only sheds light on forgotten architectural endeavors but also exemplifies the potential of augmented reality (AR) to bridge the gap between inaccessible or lost architectural works and a broader audience. By leveraging

AR, we aim to offer immersive experiences that enable a deeper engagement with architectural projects that, for various reasons, remained unbuilt, were destroyed, or have been otherwise inaccessible. This initiative underscores the importance of digital reconstructions, surveys, and models in enhancing the accessibility and understanding of architectural heritage, thus contributing significantly to the knowledge and appreciation of architectural projects within the realm of extended reality. Through this lens, the paper will discuss methodologies and outcomes of digitizing and interpreting architectural archives, transforming them into dynamic, interactive 3D models that can be explored and appreciated in novel and meaningful ways.

Archival heritage and digital challenges

In archival heritage preservation, dissemination, and communication, the methodologies, technologies, and tools offered by the so-called digital revolution have been fruitfully employed for several years.

The recognition of contemporary architectural archives as documentary heritage (Domenichini & Tonicello, 2004), the establishment, since the 1970s, of bodies in charge of their enhancement, like the ICAM (International Confederation of Architectural Museums) and the ICA (International Council on Archives), and the creation of standards for cataloging and meta-data structuring, have flanked the massive digitization of these archives.

Digitization involved the heterogeneous materials that characterize these archives (Spallone & Paluan, 2019): graphic ones (sketches, preparatory and demonstrative drawings, and survey and design plates, cartographic material, and preliminary documentation); textual ones (loose papers or collected in envelopes and files, manuscripts and typescripts bound or not, administrative documents, correspondence, advertising or documentary material, extracts from magazines, clippings, books); photographic ones (positive and negative on paper, film, glass); digital ones (audio and video recordings, computer files on various media); objects (scale models and sculptures, tools used in professional activity, paintings, samples of materials).

At the end of the 20th century, several scholars embarked on the path of virtual reconstruction of unbuilt or disappeared architecture from the varied archival documentation described above. Among them, we can mention B. J. Novitski, in particular for his modeling of the unbuilt projects by Antonio Sant'Elia, Iakov Chernikov, and Le Corbusier (Novitski, 1998), Kent Larson, who digitally rebuilt several unbuilt projects by Louis Kahn (Larson, 2000), Edoardo Dotto for his graphic analysis of Louis Kahn's Hurva Synagogue project and its digital reconstruction, Francesco Maggio for his extensive graphical analyses and reconstructions of Eileen Gray's work (Maggio, 2011).

The authors of this paper have also, in the past ten years, created virtual reconstructions and animations of contemporary architecture that remained on paper or no longer

exist, starting from the archives documents kept by the Politecnico di Torino: the Rosani fund at the Archives of the Laboratorio Beni Culturali (Spallone & Paluan, 2017), the Mollino fund (Spallone & Carota, 2018; Spallone & Capaldi, 2019) and the Morbelli fund (Spallone & Natta, 2022) at the Archives of the Central Library of Architecture “Roberto Gabetti”. Some of these reconstructions are currently on display at the Archivio di Stato di Torino – Sezione Corte, in the exhibition “Mollino // Politecnico: The Cultures of Architecture and Engineering in Turin, on the Fiftieth Anniversary of the Master’s Death”, of which the authors of this paper are among the curators in charge for the “Drawing” section.

The most recent application of augmented reality (AR) technologies to heritage, and more specifically to archival documents, makes it possible to significantly increase the potential for communicating archival materials and their interpretation through reconstructive models. The latter, in the past, have been usable remotely, or in the archives’ own locations, through devices that did not allow for overlapping real (the document) and virtual (the reconstructive 3D model).

The present AR experimentation takes place on a project already reconstructed in H-BIM mode by the authors (Spallone & Natta, 2022).

The Morbelli fund arrived, incomplete, at the Central Library of Architecture, donated by his heirs in 2017, and consists of more than a hundred projects currently being cataloged.

Aldo Morbelli (1903-1963) worked mainly in Piedmont for private clients-families of the intelligentsia and emerging industry, and for public commissions, obtained through competitions.

The prevailing typologies in his projects consisted of residences in mountain resorts and the countryside, luxury condominiums, economic-popular housing, office buildings, and entertainment buildings.

Morbelli’s drawings, sometimes complemented by short texts, correspondence, and photographs, document the architect’s graphic ability as he moves from conventional technical drawing to expressive drawing through overall and interior perspectives, the latter enriched by furnishings, decorations, and figures.

The theme of the country house, which has characterized Morbelli’s activity since his first professional assignments in the 1930s, is the subject of the present case study: the so-called Treves-Sacerdote farmhouse.

The farmhouse stood a short distance from the elegant Turin area of Borgo Crimea. Morbelli designed it between 1947 and 1949, equipping it with a barn, fruit storage room, and stable. The complex is arranged according to a U-shaped plan highly articulated on its three fronts. A note of modernity is introduced by the large dark wooden balcony and the central portico supported by plastered pillars with a square section tapering downward and plastically connected to the ceiling of the portico itself. The abrupt demolition in 1964 was due to an allotment for newly built apartment buildings.

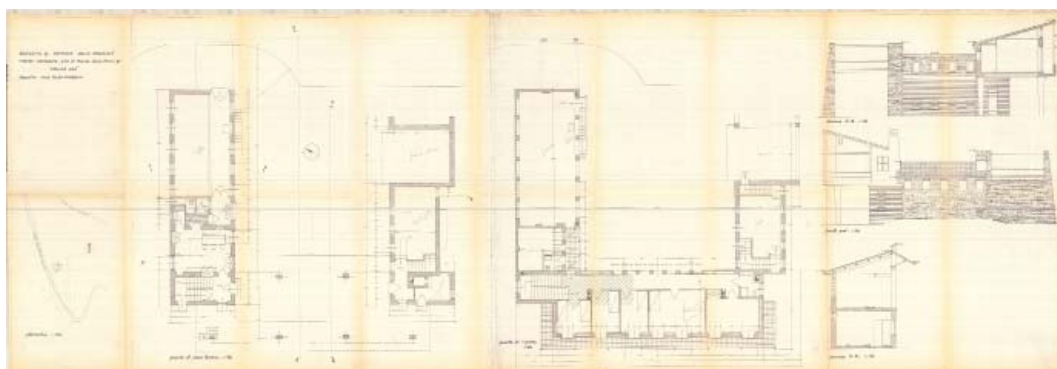


Fig. 2 - A. Morbelli, *Farm project at the Treves-Sacerdote property, located in Turin - Strada Valsalice 97, "Cascina Ada"*. Archivi BCA, Fondo Aldo Morbelli.

The archival documentation includes eighteen plates drawn in pencil and ink on tracing paper and heliocopies, photographs of a physical study model, which has been lost, and pictures of the construction site (figs. 1-2). The plates depict the building through a roof plan at a scale of 1:500, plans, elevations, and sections at a scale of 1:50, and construction and finishing details at a scale of 1:10. A series of perspective views flank the technical drawings.

Reconstructive digital modeling

In the field of reconstructive H-BIM modeling of buildings that no longer exist, the most complex aspects of the work involve visualization of the uncertainties. The subject of several recent research papers: a nodal step in addressing this concerns the construction of a workflow that, respecting the statements of the London Charter (2009) manages to communicate transparently, based on different documentary sources, classifying them through different levels of probability.

Obviously, the digital reconstruction of the case under study is a matter that requires a high level of interpretation: it was conducted by tracing the results obtained back to the life stage of the building chosen for reconstruction and the Level of Reliability (LOR) (Niccolucci & Hermon, 2014). In this regard it was decided to work on the reconstruction of designer's autograph drawings of the so-called executive project (1948), well documented at a scale of 1:50, with some details at a scale of 1:10. However, site photographs of the phase immediately following were used, that clarify elements and details not completely outlined in the drawings. Previous and subsequent phases can be easily implemented in the H-BIM model.

Reconstructive digital modeling based on archive sources starts from a deep graphic analysis of the data, that allows researchers to verify the sequence of drawings and variants and compare the data at different scales. The digital reconstruction was structured to communicate the analysis phase through the quality of the data, distinguishing between those documented and those resulting from interpretation, also evaluating the different

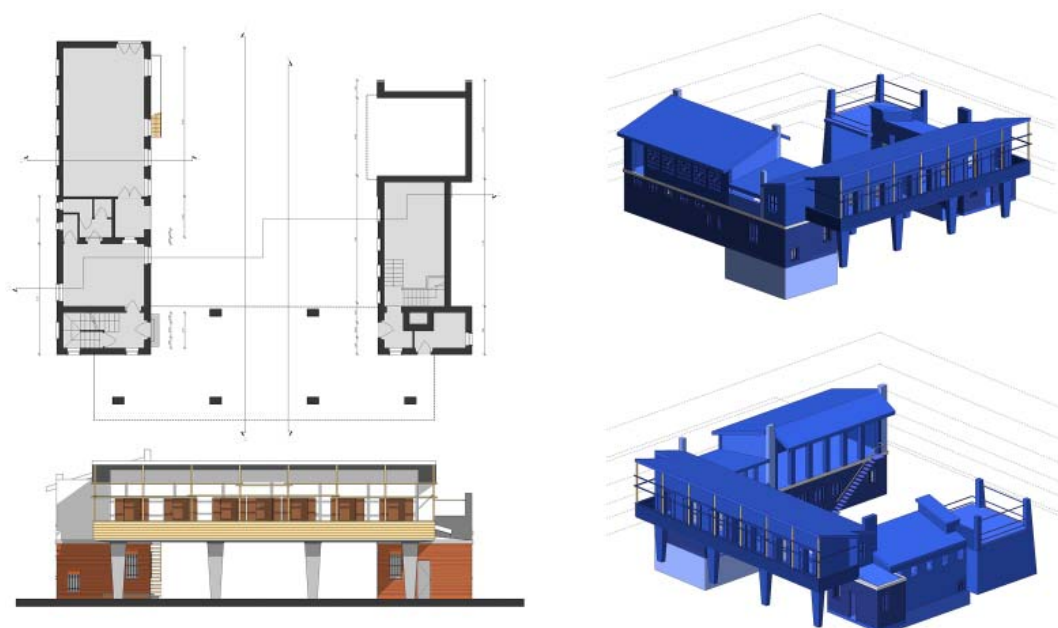


Fig. 3 - Reconstructive H-BIM model and Level of Reliability of Treves-Sacerdote farmhouse (Modeling by F. Natta).

levels of reliability.

Within the selected documents, therefore, the elements necessary for the re-drawing in BIM environment were divided into seven levels of analysis:

1. Plans (starting from the basement floors to the roof);
2. Elevations and sections;
3. Details (construction and architectural details);
4. Dimensions (written measurements);
5. Texts (notes about geometrical features of the building);
6. Functions (possibility of unique identification of the element);
7. Photos (in the construction phase and as-built).

As can be seen, the data are sequenced according to the design workflow.

Each level provides a quantity of information which, together with the others, increases the level of reliability (LOR) of the modeled element.

The first two levels contribute to defining the model in its three-dimensional representation. Each element represented in the plans is compared with its elevations and sections if existing, or it is subject to philological integration of data.

The third level allows for an increase in the degree of knowledge of the selected element (stairs, railings, interior doors, and windows) through technical details.

The next three levels (dimensions, text, functions) serve to validate, correct, or integrate what is represented. It should be noted that the dimensions, which have a prescriptive value in the construction phase, are sometimes inconsistent in the drawings analyzed.

LOR - Colour gradient scale		LOR - Architectural elements									
0		FLOOR PLANS		Plans	Elevation and Sections	Texts	Functions	Dimensions	Details and Sketches	Photos	Class results
0,5		Basement level (-2,60 m.)									
1		b	Wall (Foundation)	0	1	0	1	0,5	0	0	2,5
1,5		d	Wall (Interior)	0	0,5	0	1	0,5	0	0	2
2		f	Floor (Interior)	0	1	0	1	1	0	0	3
2,5		g	Stair	0,5	0	0	0,5	0,5	0	0	1,5
3		h	Window (Exterior)	0	0,5	0	0,5	0,5	0	0	1,5
3,5		m	Door (Interior)	0	1	0	1	1	0	0	3
4		Semi-basement level (-1,20 m.)									
4,5		b	Wall (Foundation)	1	1	0	1	1	0	0	4
5		d	Wall (Interior)	1	1	0	1	0,5	0	0	3,5
5,5		f	Floor (Interior)	1	1	0	1	1	0	0	4
6		g	Stair	1	1	0	1	1	0	0	4
6,5		h	Window (Exterior)	1	1	0	1	1	0	0	4
7		Ground level (+0,00 m.)									
		a	Column	1	1	0	1	1	0	1	5
		c	Wall (Exterior)	1	1	0	1	0,5	0	1	4,5
		d	Wall (Interior)	1	1	0	1	0,5	0	0	3,5
		e	Floor (Exterior)	0,5	0,5	0	0,5	0	0	0	1,5
		f	Floor (Interior)	1	1	0	1	1	0	0	4
		g	Stair	1	0	0	1	1	0	0,5	3,5
		h	Window (Exterior)	1	1	0	1	0,5	0	1	4,5
		i	Window (Interior)	1	0	0	0,5	1	0	0	2,5
		l	Door (Exterior)	1	1	0	1	0,5	0	0	3,5
		m	Door (Interior)	1	0,5	0	1	0,5	0,5	0	3,5
		Mezzanine level (+1,60 m.)									
		c	Wall (Exterior)	1	1	0	1	1	0	1	5
		d	Wall (Interior)	1	0	0	0,5	0,5	0	0	2
		f	Floor (Interior)	1	1	0	1	1	0	0	4
		g	Stair	1	0	0	0,5	0,5	0	0	2
		h	Window (Exterior)	1	1	0	1	1	0	1	5
		First floor level (+3,62 m.)									
		c	Wall (Exterior)	1	1	0	1	1	0,5	1	5,5
		d	Wall (Interior)	1	1	0	1	1	0	0	4
		e	Floor (Exterior)	1	1	0	1	1	0	0	4
		f	Floor (Interior)	1	1	0	1	1	0	0	4
		g	Stair	1	0,5	0	1	1	0	0	3,5
		h	Window (Exterior)	1	1	0	1	1	0,5	1	5,5
		i	Window (Interior)	1	1	0	1	1	0	0	4
		l	Door (Exterior)	1	0,5	0	1	0,5	0	0	3
		m	Door (Interior)	1	0,5	0	1	0,5	0	0	3
		n	Railing	0	0,5	0,5	1	0,5	0,5	0,5	3,5
		Raised first floor level (+3,95 m.)									
		c	Wall (Exterior)	1	1	0	1	1	0	1	5
		d	Wall (Interior)	1	1	0	1	1	0	0	4
		e	Floor (Exterior)	1	1	0	1	1	0	1	5
		f	Floor (Interior)	1	1	0	1	1	0	0	4
		h	Window (Exterior)	1	1	0	1	1	0	1	5
		m	Door (Interior)	1	1	0	1	1	1	0	5
		n	Railing	1	1	0	1	1	1	1	6
		Roof level									
		o	Roof	0	1	0,5	1	0,5	0,5	1	4,5
		p	Gutter	0	1	0	1	1	0	1	4
		q	Chimney	0	1	0	0,5	0,5	0	1	3
LOR - Architectural elements - Final Result											

Fig. 4 - Table with gradient colors and LOR values.

The last level (photos) offers, due to the singularity of the case study, a term of continuous critical comparison with the archive drawings, as mentioned above.

The data related to each architectural element provided by the archive documents have been defined in a class of three values from 0 to 1:

- Certain data (1): the element is defined through the considered level of analysis;
- Incomplete data (0.5): the element is partially documented, but however deductible in its shape and size;
- Missing/incorrect data (0): the element is not documented, or errors and inconsistencies are detected and needs for philological integration.

By entering this data into the reconstructive model, it is possible to get the Level of Reliability (LOR) value of each element and the average reliability value for each identified or overall level of the whole project (figs. 3-4).

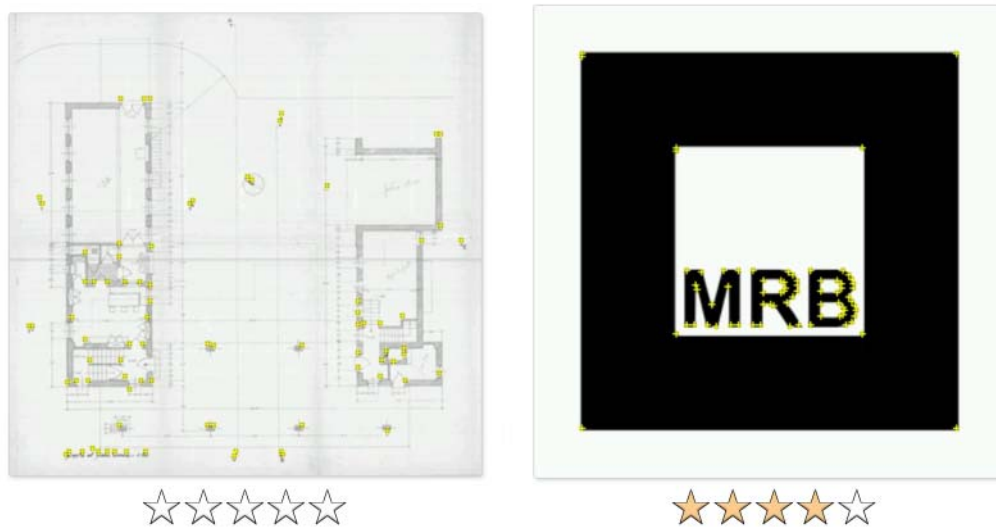


Fig. 5 - “Vuforia Target Manager - Augmentable Rating” for archival drawing and customized target with “Visible Features” (image extract from Vuforia® Engine™ Developer Portal).

Archival documents AR application

The application of augmented reality (AR) to archival documents in the field of architecture represents a technological breakthrough that transforms how people interact with historical architectural heritage. AR, which superimposes virtual elements over physical reality, offers a new layer of information and interpretation, making archival documents more accessible and engaging for specialists and the public (Russo, 2021).

A crucial aspect of integrating AR in this context is improving the accessibility and interpretation of documents. Historical architectural designs, which are often complex and difficult to understand for non-experts, can be explored more intuitively through three-dimensional visualization. For example, the plans and sections of a historic building can be transformed into interactive 3D models, allowing users to virtually ‘walk’ within the spaces, and better understand proportions, materials, and construction techniques.

The integration of BIM modeling with AR, as was done for this experiment, begins with the conversion of the BIM model into a format compatible with AR applications (.fbx). This process requires special attention to the preservation of detailed information, model quality and materials/textures applied to the model [1]. Once converted, the model can be used in an AR environment to visualize the architectural design in a real-world context (Barazzetti & Banfi, 2017; Fiorillo & Bolognesi, 2023; Palma et al., 2022).

In an increasingly wide panorama of applications that allow data, images, models to be visualized in augmented reality, for this example, we have used Unity® software

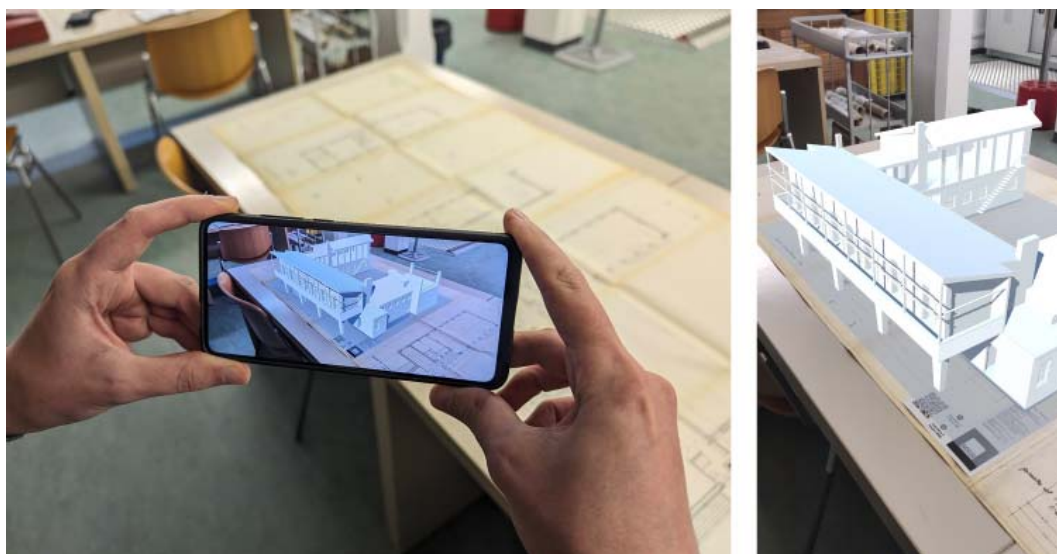


Fig. 6 - Photo during the AR application launch and APP screenshot of the Treves-Sacerdote farmhouse project.

and the Vuforia® software development kit. Unity is a powerful and versatile game development engine that enables the creation of interactive and visually appealing AR applications. Vuforia, on the other hand, is AR software that integrates with Unity to provide advanced object recognition and physical target tracking tools [2].

A key aspect of this integration is the implementation of a physical target to support AR functionality in a non-invasive manner (Bekele et al., 2018). This target, usually a marker and/or QR code placed on or near the archive document, allows a device's camera to recognize and position the AR model in the physical environment. The use of these targets may be essential to ensure proper alignment and scaling of the AR model with the real world, as the original document may not have the characteristics (especially high contrast) to be easily recognized by the AR application. Within Vuforia's Developer Portal it was possible to compare these two potential targets (the archive drawing and a customized marker) and assess the actual 'augmentability' of the data (fig. 5).

To facilitate the following operations, an intuitive Cardboard was created with all the necessary information: the user instructions, the QR to refer to the application [3], the MRB marker with which to anchor the model, a description of the project and archive information (fig. 1).

The most challenging part of the operations to be performed within the software is related to the relationship of the dimensions of the marker and the model, so that the model is perfectly scaled to its representation of the archive drawing.

At this stage of experimenting with the application, with only one model available at this stage of the research relating to Aldo Morbelli's archival collection, it was preferred to work on the single drawing (the ground floor plan, but it is also easy to work with

the first-floor plan) and on displaying the model in its entirety, as can be seen during the activity's running phase (fig. 6).

The use of augmented reality, in synergy with BIM modeling and the use of physical targets, opens up new frontiers in the exploration and understanding of archival architectural documents. This technology not only improves the accessibility and interactivity of historical documents but also offers valuable tools for education and research in the field of architecture while maintaining a respectful and non-invasive approach to the original documents.

Conclusions

The exploration of architectural archives through augmented reality (AR) technologies, as discussed in this study, highlights a significant advancement in how we engage with and understand our architectural heritage. This endeavor not only reconnects us with lost architectural masterpieces but also paves the way for a more inclusive and interactive approach to cultural preservation. The success of integrating AR with archival research within the framework of eXploRA opens a myriad of possibilities for future developments.

Looking ahead, the vastness of architectural archives holds the promise of unlocking an even richer repository of lost heritage. With each document, drawing, and photograph awaiting digitization and reinterpretation, the potential to expand our digital repository is immense. Future efforts will focus on harnessing this extensive archive to model and reconstruct a broader array of architectural projects. This process will not only contribute to the academic and educational realms by providing deeper insights into architectural history and theory but will also democratize access to cultural heritage, making it more accessible to a global audience.

Moreover, the continuous advancement in AR and XR technologies suggests an exciting future for architectural visualization and interaction. As we refine our methodologies and embrace more sophisticated tools, we can anticipate creating more immersive and engaging experiences that bring the architectural past vividly to life. This evolution will further enrich our understanding of cultural heritage, offering new lenses through which to explore the narratives of spaces and structures that have shaped human history.

Notes

[1] For this experimentation, it was decided not to bring back the textures, applied in the Revit models, for a better handling of the model in the AR application on smartphones. As will be seen in the final image, only transparency was applied to the ground surface to visualize the various elements.

[2] The software versions used were: Unity 2022.3.16f1 and Vuforia Engine 10.19.3.

[3] For this experimentation, we used an Android-only locally developed application.

Acknowledgments

We thank for the availability the Archive of the Central Library of Architecture “Roberto Gabetti” of the Politecnico di Torino, managed by Dr. Enrica Bodrato.

Attributions

About the present contribution, whose methodological framework the authors shared, Roberta Spallone wrote “Archival heritage and digital challenges”, Marco Vitali wrote “Reconstructive digital modeling”, Fabrizio Natta wrote “Archival documents AR application”; “Introduction” and “Conclusion” are written together by the authors.

References

- Barazzetti, L., & Banfi, F. (2017). Historic BIM for Mobile VR/AR Applications. In M. Ioannides, N. Magnenat-Thalmann, & G. Papagiannakis (Eds.), *Mixed Reality and Gamification for Cultural Heritage* (pp. 271-290). Springer. https://doi.org/10.1007/978-3-319-49607-8_10
- Bekele, M. K., Pierdicca, R., Frontoni, E., Malinverni, E. S., & Gain, J. (2018). A Survey of Augmented, Virtual, and MixedReality for Cultural Heritage. *Journal on Computing and Cultural Heritage*, 11(2), 7:1-7:36. <https://doi.org/10.1145/3145534>
- Brusaporci, S. (2017). The importance of being honest: issues of transparency in digital visualization of architectural heritage. In A. Ippolito (Ed.), *Handbook of research on emerging technologies for architectural and archaeological heritage*, IGI Global (pp. 66-93). HERSHEY. <https://doi.org/10.4018/978-1-5225-0675-1.ch003>
- Domenichini, R., & Tonicello, A. (2004). *Il disegno di architettura. Guida alla descrizione*. Il Poligrafo.
- Dotto, E. (2012). *Il progetto della sinagoga di Hurva di Louis I. Kahn: analisi grafica*. Aracne.
- Fiorillo, F., & Bolognesi, C. M. (2023). Cultural Heritage Dissemination: Bim Modelling and AR Application for a Diachronic Tale. *Int. Arch. Photogramm. Remote Sens. Spatial Inf. Sci.*, XLVIII-M-2-2023, 563-570. <https://doi.org/10.5194/isprs-archives-XLVIII-M-2-2023-563-2023>
- Larson, K. (2000). *Louis I. Kahn: unbuilt masterworks*. The Monacelli Press.
- Maggio, F. (2011). *Eileen Gray: interpretazioni grafiche*. FrancoAngeli.
- Nicolucci, F., & Hermon, S. (2014). A fuzzy logic approach to reliability in archaeological virtual reconstruction. In F. Nicolucci, & S. Hermon (Eds.), *Beyond the artifact. Digital interpretation of the past* (pp. 28-35). Archaeolingua.
- Novitski, B. J. (1998). *Rendering real and imagined buildings: the art of computer modeling from the palace of Kublai Khan to Le Corbusier's villas*. Rockport Publisher.
- Palma, V., Spallone, R., Cicone, G., Lops, G., & Rinauro, R. (2022). Scalable AR for BIM on Telecommunication Network Sites. *Int. Arch. Photogramm. Remote Sens. Spatial Inf. Sci.*, XLVI-2/W1-2022, 409-414. <https://doi.org/10.5194/isprs-archives-XLVI-2-W1-2022-409-2022>
- Russo, M. (2021). AR in the Architecture Domain: State of the Art. *Applied Science*, 11(15), art. 6800, 1-35. <https://doi.org/10.3390/app11156800>

Spallone, R., & Carota, F. (2018). Digital Interactive Mollino. A Collection of 3D Models from Carlo Mollino's Design Drawings. In G. Amoroso (Ed.), *Putting Tradition into Practice: Heritage, Place and Design* (pp. 607-617). Springer. https://doi.org/10.1007/978-3-319-57937-5_63

Spallone, R., & Capaldi, F. (2019). 3D Modelling for Valorizing 20th Century Architectural Archives: The Case of the Unbuilt Project for a Theatre in Cagliari by Carlo Mollino. *Int. Arch. Photogramm. Remote Sens. Spatial Inf. Sci.*, XLII-2/W15, 1111-1118. <https://doi.org/10.5194/isprs-archives-XLII-2-W15-1111-2019>

Spallone, R., & Natta, F. (2022). H-BIM Modelling for Enhancing Modernism Architectural Archives. Reliability of Reconstructive Modelling for “on Paper” Architecture. In C. Bartolomei, A. Ippolito, & S. H. T. Vizioli (Eds.), *Digital Modernism Heritage Lexicon, Springer Tracts in Civil Engineering* (pp. 809-829). Springer. https://doi.org/10.1007/978-3-030-76239-1_34

Spallone, R., & Paluan, F. (2017). Digital Representation: Techniques to Interpret, Communicate, and Share 20th c. Architectural Archives: The Case Study – Rosani's Archive. In A. Ippolito, & M. Cigola (Eds.), *Handbook of Research on Emerging Technologies for Digital Preservation and Information Modeling* (pp. 116-146). IGI Global. <https://doi.org/10.4018/978-1-5225-6921-3.ch006>

Spallone, R., & Paluan, F. (2019). Digital Archives for Preserving and Communicating Architectural Drawings. In M. Khosrow-Pour, D.B.A. (Ed.), *Advanced Methodologies and Technologies in Library Science, Information Management, and Scholarly Inquiry* (pp. 461-475). IGI Global. <https://doi.org/10.4018/978-1-5225-7659-4.ch037>

The London Charter for the Computer-Based Visualisation of Cultural Heritage, Draft 2.1, 7 February 2009, <http://www.londoncharter.org/>. Last accessed 15 Oct 2020.