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

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eXploRA

virtual journeys to discover *in*accessible heritages

a cura di

Francesco Stilo
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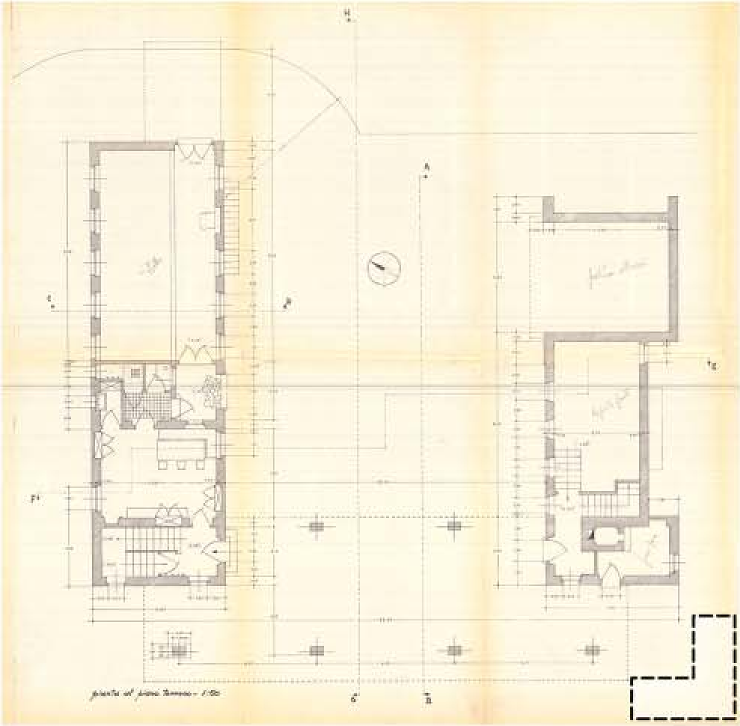

CASCINA
TREVES-SACERDOTE

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

Quantità: 20
Tipologia: fototipo/i

Descrizione: Progetto di fattoria nella proprietà Treves-Sacerdote, sita in strada Valsalice 97 a Torino.
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
Sottoargomento: edifici residenziali

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

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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.

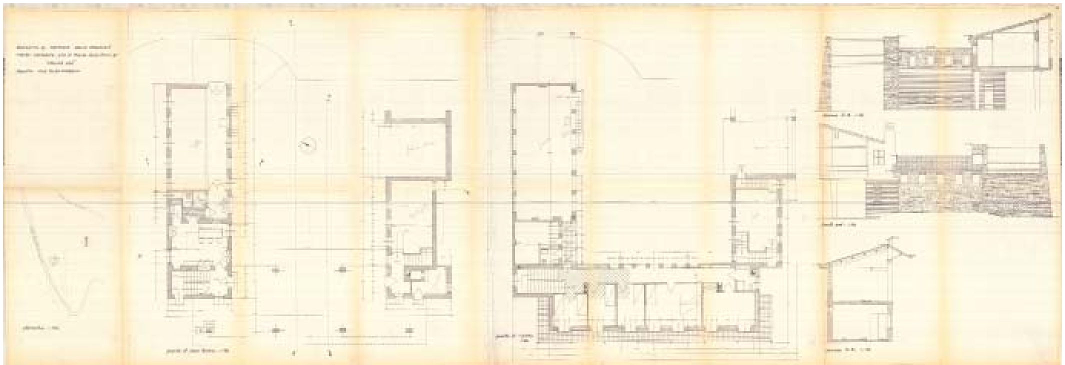

Fig. 2 - A. Morbelli, *Farm project at the Treves-Sacerdote property, located in Turin - Strada Valsalice 97, "Cascina Ada"*. Archivi BCA, Fondo Aldo Morbelli.

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

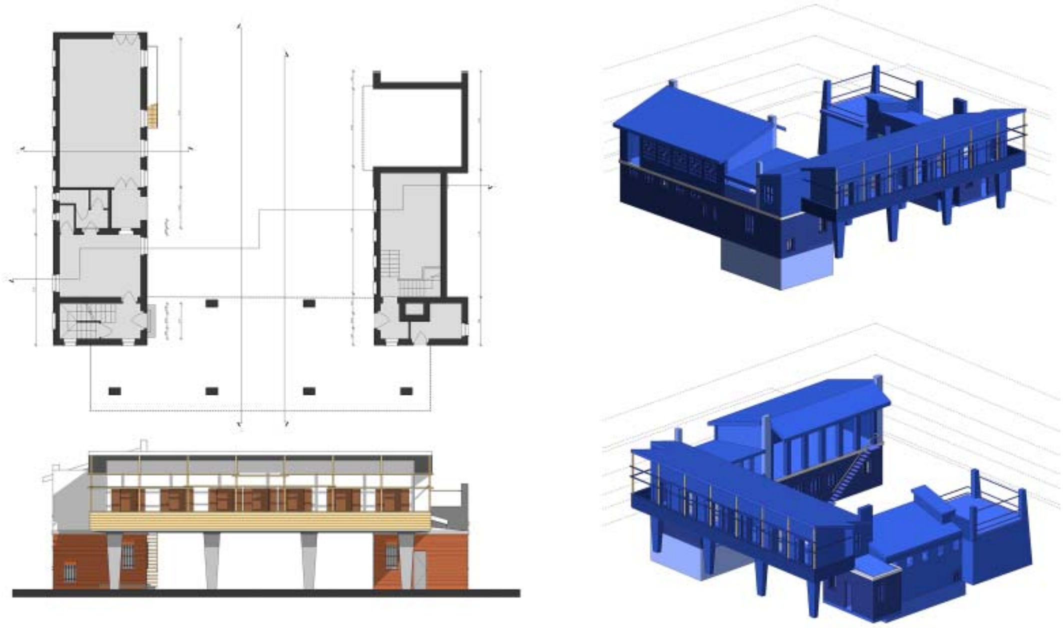

Fig. 3 - Reconstructive H-BIM model and Level of Reliability of Treves-Sacerdote farmhouse (Modeling by F. Natta).

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	
0	
0,5	
1	
1,5	
2	
2,5	
3	
3,5	
4	
4,5	
5	
5,5	
6	
6,5	
7	

LOR - Architectural elements									
CODE	FLOOR PLANS	Plans	Elevation and Sections	Texts	Functions	Dimensions	Details and Sketches	Photos	Class results
	Basement level (*-2,60 m.*)								2,5
b	Wall (Foundation)	0	1	0	1	0,5	0	0	2,5
d	Wall (Interior)	0	0,5	0	1	0,5	0	0	2
f	Floor (Interior)	0	1	0	1	1	0	0	3
g	Stair	0,5	0	0	0,5	0,5	0	0	1,5
h	Window (Exterior)	0	0,5	0	0,5	0,5	0	0	1,5
m	Door (Interior)	0	1	0	1	1	0	0	3
	Semi-basement level (*-1,20 m.*)								4
b	Wall (Foundation)	1	1	0	1	1	0	0	4
d	Wall (Interior)	1	1	0	1	0,5	0	0	3,5
f	Floor (Interior)	1	1	0	1	1	0	0	4
g	Stair	1	1	0	1	1	0	0	4
h	Window (Exterior)	1	1	0	1	1	0	0	4
	Ground level (*+0,00 m.*)								3,5
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.*)								3,5
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.*)								4
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.*)								5
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								4
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								4

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).

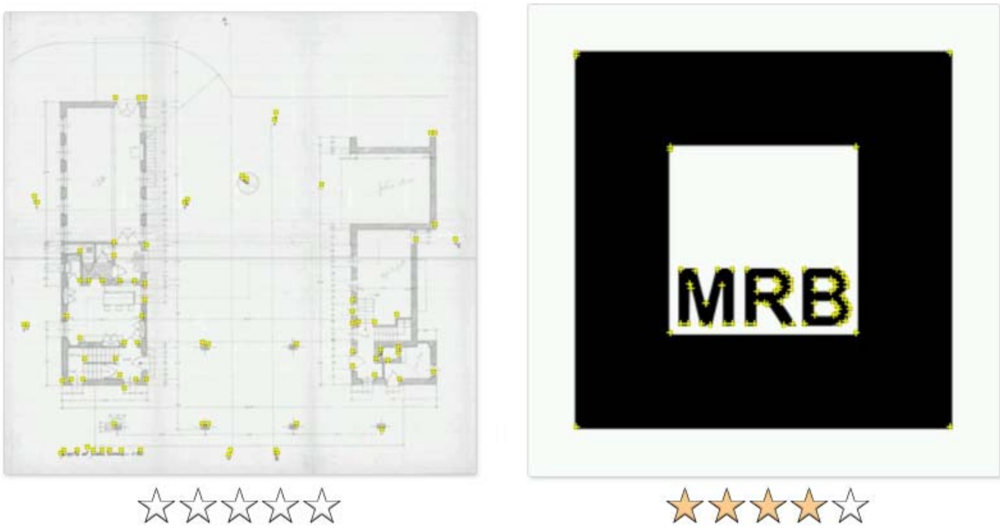

Fig. 5 - "Vuforia Target Manager - Augmentable Rating" for archival drawing and customized target with "Visible Features" (image extract from Vuforia® Engine™ Developer Portal).

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

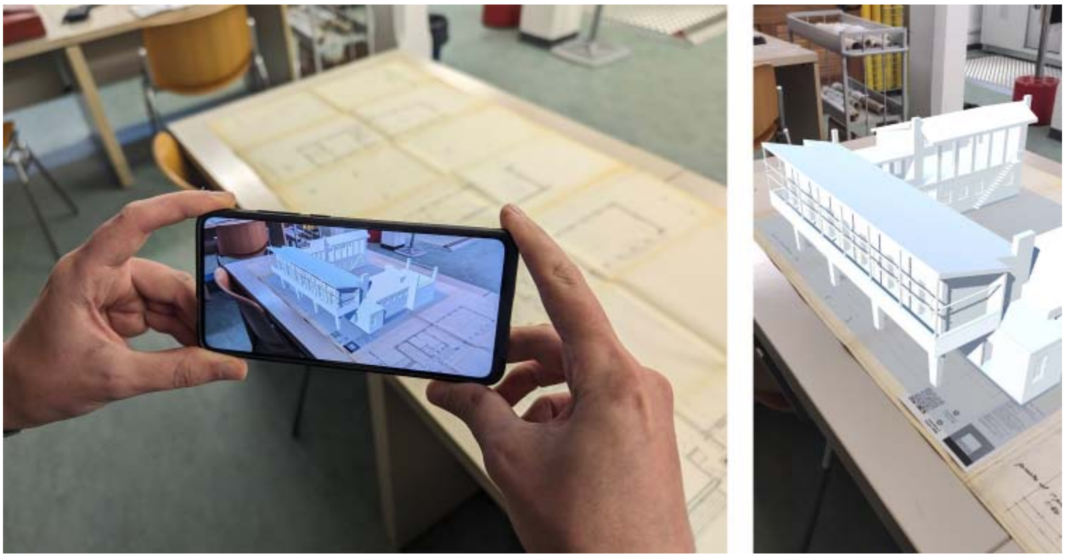

Fig. 6 - Photo during the AR application launch and APP screenshot of the Treves-Sacerdote farmhouse project.

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.

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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.

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