Digital tools and conservation processes: Tomaso Buzzi's staircase at Palazzo D'Azeglio in Turin

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# Digital tools and conservation processes: Tomaso Buzzi's staircase at Palazzo D'Azeglio in Turin

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**Figure 1:** ***Images of the actual condition of Tomaso Buzzi's grand staircase, from the basement to the first floor.***

**Abstract**

*The proposed research refers to the documentation of the grand staircase of Palazzo D'Azeglio in Turin, designed between 1953 and 1957 by the Lombard-born architect Tomaso Buzzi. The awareness of the identity value expressed by Buzzi's work makes its preservation urgent, the first step of which is the knowledge stage for a long-term conservation. The integration of historical sources and direct investigation allows for a more complete description of Buzzi's intervention, highlighting his design choices and relationship with the existing building, so as to guide future restoration work toward more conscious choices. The complexity of the object related to the geometry, the light conditions and materials and surfaces of the decorative apparatus, required an integrated methodology based on 3D metric survey with the use of advanced laser digital technologies. The topographic survey organizes the refence systems and measures a set of point coordinates to co-register and validate the accuracy of the 3D model. The 3D scanning of the space benefits from the combined use of static and mobile scanner, that has been used in the connection between the narrow spaces of the underground environments and the main volume. Through the presented workflow, as a preliminary part of the research and consultancy project, it was thus possible to analyse and describe the geometric, architectural and decorative complexity of the staircase, also in connection with historical phases of the building and archival documents and drawings related to the Buzzi's project, and providing the essential basis for subsequent studies and conservation and enhancement actions.*

***CCS Concepts***
*• Computing methodologies → Computer graphics; • Hardware → Sensor applications and deployments;*

## 1. Introduction: documenting a hidden heritage

The heritage knowledge phase is an inescapable step towards its protection and enhancement, through in-depth study of sources and critical analysis of documents, supported by direct comparison with consistency. In this process, the architectural 3D survey represents a fundamental moment, since it is not a simple act of documentation, but is a complex critical operation to be designed phase by phase aimed at understanding and interpreting the asset in the transformations that have led it to its current configuration, the result of stratifications, changes of use and interventions that have affected it over time [L07]. The transcription of the results through 2D/3D metric elaborations aims to transmit and communicate the results of the research to a heterogeneous public.
Nowadays 3D digital models, on the one hand, supports professionals and technicians in the field, for planned maintenance and restoration interventions; on the other hand, it raises community awareness of the importance of examples of often hidden and little-known heritage in our layered cities, such as the subject of this research: the





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Tomaso Buzzi's staircase at Palazzo d'Azeglio, Turin (Figure 1).
In recent decades, technological progress has profoundly transformed the methods of documenting, modeling, analyzing and managing architectural heritage during time. These innovations have also revolutionized the concept of digital replicas and data management in semantically enriched 3D models implementing consolidated approach toward what we increasingly define “Digital Twins” [TB*23] and “Memory Twin” [IK*24].
These technological advancements have not only increased the quantity and quality of the data collected but also supported the construction of complex models, as a more articulated, layered, and integrated knowledge of the asset, capable of effectively supporting the activities of analysis, conservation, management, and enhancement. At the base of the designing of Digital Twins environments, 3D geometric and semantinc documentation and the use of advanced surveying tools makes it possible to collect a large amount of data, improving the quality of research and documentation and making it accessible to an increasingly wide audience. This surveying methodology enables the continuous monitoring of the conservation status of heritage assets, facilitating the development of targeted and informed intervention strategies. [CVA23] However, it requires a multidisciplinary approach capable of integrating historical, scientific and technological knowledge to ensure conservation interventions that respect the authenticity and integrity of the property. On the other hand, the knowledge of a diffuse and less visible heritage represents a crucial challenge for contemporary historical-architectural research, which is called to develop innovative strategies for its digital and physical accessibility, toward valorization and transmission to future generations. [I17]

## 2. The case study: the Tomaso Buzzi staircase at Palazzo d'Azeglio

The historical and architectural context Tomaso Buzzi's intervention on the staircase of Palazzo d'Azeglio represented a fundamental moment in its long historical stratification [F98]. The initial design of the palace was conceived in 1679 by the renowned architect Michelangelo Garove for Marquis Giuseppe Mesmes di Marolles. Construction began in 1683, following different modifications and ownerships up to 1863, by Cesare Tapparelli d’Azeglio. In 1919, the property was acquired by Giovanni Agnelli, FIAT, but during World War II, the building was damaged by bombing, requiring major restoration work. In 1953, Emanuele Filiberto Nasi began a radical renovation of the interior, entrusting the work to the architect Tomaso Buzzi. This phase of construction is notable for the addition of the monumental double-helix staircase, which features an impressive design and neo-rococo decorations. The intervention was not limited to the staircase, but also included the rearrangement of the interior, giving the whole a new aesthetic appearance, inspired by the refined and scenographic tastes of the time. After the acquisition by FIAT, it became the headquarters of the Luigi Einaudi Foundation in 1970, and this led to spatial reorganization that partially altered its original perception as a noble residence.

Tomaso Buzzi's work at Palazzo d'Azeglio was part of a wider series of interventions he carried out to renovate numerous noble palaces of the Italian aristocracy [C93]. His work was characterized by a refined interpretation of space, combining a historical sensibility with a sense of theatricality. Through a constant search for beauty and a balanced integration of historical memory and design innovation, Tomaso Buzzi left a significant legacy in the field of 20th century Italian architecture and design, of which the Palazzo d'Azeglio in Turin, enriched by his presence, is still an important example. The most radical intervention in the palace was the replacement of the main staircase, which previously had the usual two-flight conformation. The existing staircase was demolished in its entirety, and the entire south wall separating it from the ground and second floor spaces was demolished to allow for a new open structure. The original access to the atrium was walled off and concealed by the insertion of a sculpted marble fountain. The new grand staircase, with a strong scenic impact, was characterized by its intricate double spiral configuration, with sinuous steps and a compartment that accommodated its curvilinear course through an articulated decorative apparatus. The latter included niches, stucco volutes, mirrors, paintings, putti, urns and candleholders in an ensemble of great ornamental richness. The suspended landing, made of thick sheets of transparent glass with a greenish reflection, helped to emphasize the lightness of the composition (although it is now covered by a thick carpet), while the handrail, made of gilded and painted wrought iron, developed into a refined design of elaborate elegance.

## 3. Knowing to preserve for a digital conservation

The documentation of minor and difficult-to-access architectural heritage represents a fundamental challenge for contemporary research in art historical studies, as well as for the preservation and enhancement of cultural heritage. Collecting, analyzing, and effectively communicating information about such artifacts is the indispensable basis for more appropriate interventions. In this context, the introduction of digital technologies has profoundly changed the way architectural heritage conservation process is managed, studied and preserved, providing tools capable of guaranteeing a level of detail, precision and accessibility that was unthinkable just a few years ago. In recent years, digitization has become one of the most effective tools for protecting, studying and enhancing the built heritage. Advanced techniques such as digital photogrammetry [C13], 3D laser scanning [BM04], and the use of drones for aerial photogrammetric surveying make it possible to acquire a vast amount of metric and morphological data at high resolution. These methods are particularly effective in the case of complex assets, indoor and underground spaces, such as the monumental staircase designed by Tomaso Buzzi at Palazzo d'Azeglio, where the decorative richness and spatial complexity require advanced strategies capable of capturing geometry material and ornaments. The wide use of digital tools also makes it possible to overcome some limitations of traditional direct survey methods, producing multi-level, geo-referenced and easily updated information models.

The primary goals of digitization include the creation and multi-temporal population of open-access digital archives, the continuous monitoring of the state of preservation, and the planning of maintenance and restoration activities based on objective, stratified, and verifiable data. [FC*23] In this sense, digital modeling can be integrated with Building Information Modeling (BIM) platforms [MMP09] and Geographic Information Systems (GIS) to create an information ecosystem aimed at sustainable heritage management. The digital approach also encourages more structured transdisciplinary collaboration, involving actors from different fields - historians, architects, engineers, restorers, etc. - in shared knowledge and design processes. Such synergy is particularly important in the case of complex historic architecture, where architectural, structural and material dimensions are inextricably intertwined. In parallel, the possibility of returning and disseminating results through immersive environments, online platforms or interactive models in augmented or virtual reality opens new perspectives in terms of accessibility and public participation, contributing to the construction of a more widespread and conscious collective memory. Finally, in the context of preventive conservation and risk management strategies, the digital documentation in the complex process of creation of Digital Twins of the architectural heritage makes it possible to simulate impact of future scenarios, - such as seismic events, environmental degradation or climate change - and virtually test intervention solutions. In this sense, digitization is not only a documentary tool but is increasingly becoming an operational and strategic tool for proactive, sustainable and forward-looking heritage protection. [DT21]

## 4. Managing the survey planning and data acquisition

### 4.1. Challenging elements for the survey and digitization

The survey of the monumental staircase of Palazzo d'Azeglio represented a particularly complex case study, both for the crucial data acquisition phase, and even more in the vectorial digitization phase and drawings creation. The articulated nature of the work, characterized by fluid geometry, a layered decorative apparatus, an unfavorable lighting environment, necessitated an accurate planning approach, combining advanced survey techniques with critical and selective data interpretation for graphical restitution. From the surveying planning perspective, the primary challenges arose from the staircase spatial configuration, defined by curved connections and a non-orthogonal distribution of architectural elements. These characteristics rendered traditional surveying techniques impractical and incomplete (only metric wheel, sketches and eidotypes, LiDAR distance-meter, photography, etc.), necessitating the employment of high-precision tools such as the 3D laser scanner, capable of capturing the completeness of complex morphology of the environment, ensuring adequate overlapping with a high level of detail. Additionally, the presence of numerous reflective surfaces, such as mirrors and stained-glass windows, throughout the vertical development of the staircase posed a challenge. The light interference produced by these elements compromised the quality and precision of the point cloud in some areas of the stairs. Consequently, a careful subsequent phase of cleaning and optimization of the raw data was necessary to filter the 3D data by the noise error. The filtering approaches, implemented in the CloudCompare Open-source software, can be based on points information, intensity and points distribution, and was based on filtering by % of points and on filtering-by-distance algorithms.

However, the most significant critical issues were faced in the restitution phase, where in this case it was essential the critical interpretation of the expert, to constantly mediate between the geometric fidelity of the relief and the overall legibility of the work. The decorative density of the staircase, including stucco, cornices, friezes and niches, required data selection and interpretation in order to distinguish structural elements from purely ornamental ones. This plausible was particularly challenging, as many decorative components directly interfered with the spatial reading of the architectural organism. The three-dimensional nature of the environment presented challenges in employing conventional two-dimensional modes of representation, such as plans, sections, and elevations. To address this challenge, it was imperative to find graphic solutions capable of effectively representing both the overall volumetric articulation and the richness of decorative details, considering the information contained in the project documentation preserved in the archives.

### 4.2. Point cloud acquisition and 3D data generation

As introduced, the scan planning was a crucial phase of the work, due to the complex environmental condition challenging uniformity of the final data quality, density and overlapping. A set of n°30 scans were positioned and captured by the Trible X7 [ST7] LiDAR static scanner (Figure 2a). Parallelly, a topographic set of points ensuring


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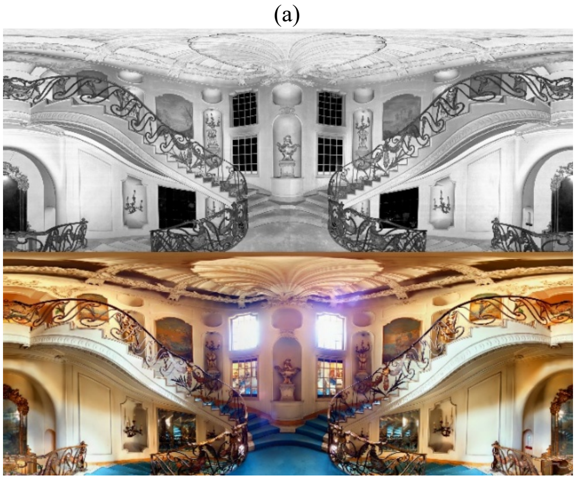
accuracy control and reference system have been measured from topographic vertices. The acquisition process was set up in twofold models:

- n°6 scans in high-res. (55-56 mln points, 7 minutes) with average local density of 130 pt/1cm sphere, a general density of 270.000pts/$m^2$ on the ceiling and 350.000pts/$m^2$ on the pavement.
- n°24 standard scans (10-11 mln points, 4 minutes) with average local density of 34pt/1cm sphere, and a general density of 80.000pts/m2 on the ceiling and 85.000pts/$m^2$ on the pavement.first char of each family name plus year – e.g. [FH93] or [KSS97] or [LFTG97]

(a)



(b)

**Figure 2**: *Detail of the Trimble X7 equipment used to survey the staircase (a) and preview of a scan dataset intensity/colors (b).*

The single scan was acquired by the sensor in the usual form of intensity/RGB colors (Figure 2b). The 3D scans dataset was processed with the Trimble Business Centre software. Scans registration delivered final accuracy values of 0.71 mm for ICP clouds registration, and 20-30mm on target-based rigid registration. A final 3D optimized point cloud data of about 14.5 Gb size was finalized for the sectioning and drawing restitution purposes. (Figure 3).

**Figure 3**: *Sections of the staircase 3D model obtained from the point cloud.*

### 4.3. Restitution of the survey

The preliminary graphic restitution of Buzzi's monumental staircase is configured as a device capable of restoring the spatial, formal, and constructive complexity of the architectural organism. The horizontal volume and vertical sections simplify the comprehension of the ramps and the continuity of the vertical system, not only highlight the distributional logic of the architectural element but also underscoring dynamism of the spaces. (Figure 4). The application of established graphic conventions enables the drawings to effectively convey the material and decorative nature of the surfaces, thereby distinguishing between structural components and purely ornamental elements.

This distinction is crucial to a layered reading of the artifact, in which the articulation between structure and covering emerges as one of the most relevant aspects of Buzian's intervention. The presence of moldings and stucco surfaces is thus accentuated not only from a formal point of view, but also as an element that contributes to defining its architectural image (Figure 5).

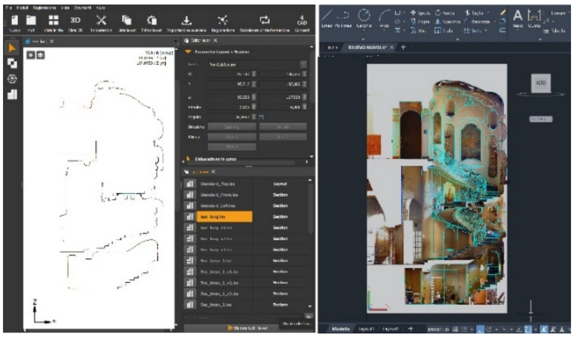


**Figure 4**: *Elaboration of profile sections from the point cloud (PointCab), and processing in Autodesk AutoCAD.*

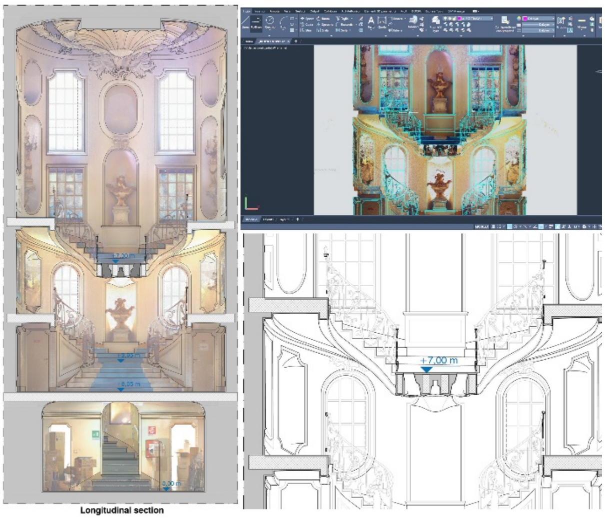



**Figure 5:** *Elaboration and interpretation of the decorative apparatus during the vectorialization process*

The identification of the materials utilized is facilitated by a precise thematic mapping approach. The identification of the various finishes, in conjunction with the differentiation between original, transformed, and assumed elements, allows the reconstruction of a complex material geography in which historical, technological, and perceptual values are intertwined.

Consequently, the set of representations is not confined to documenting the state of affairs; rather, it is configured as a critical instrument capable of activating broader reflections on the nature of the work, its historical evolution, and its potential for intervention. In this regard, the act of drawing assumes an epistemological significance, functioning not only as the result of a surveying process, but as a form of inquiry capable of restoring the complexity of architecture through a codified and scientifically grounded language. Its usefulness extends beyond the cognitive phase, serving as an operational basis for strategies of conservation, enhancement, and management of the built heritage. (Figure 6).

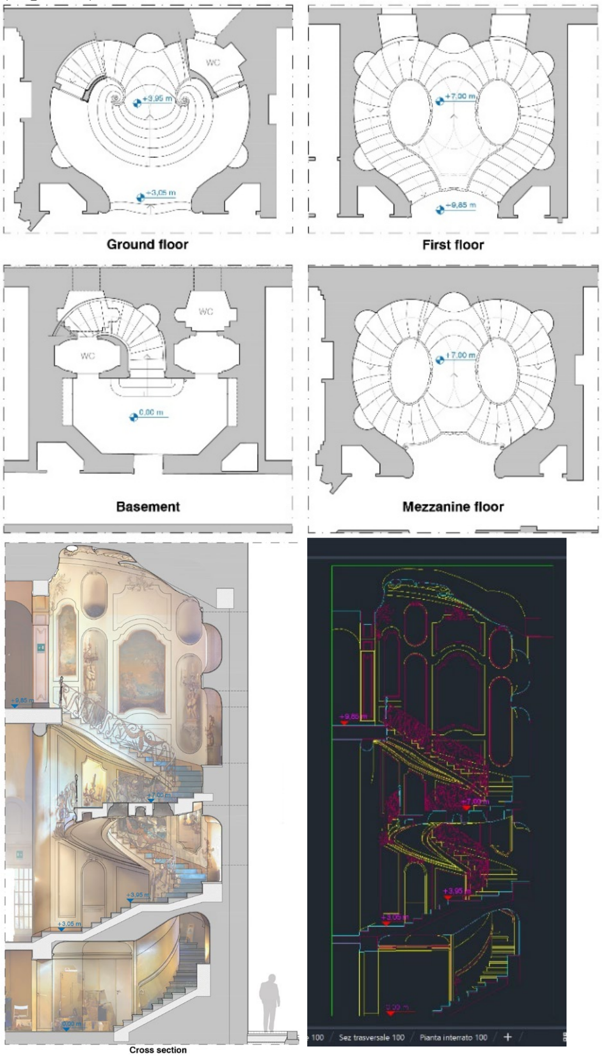



**Figure 6**: *Architectural survey of the staircase obtained by point cloud elaboration.*

## 5. Discussion

The case of the study and documentation of the staircase designed by Tomaso Buzzi for the Palazzo d'Azeglio in Turin is a perfect example of the importance of the integrated documentation process. The project from the 1950s is emblematic of its ability to blend modern elements with historical tradition in a formal synthesis that defies the aesthetic convention of the time.

The documentation of a work of this nature necessitates a careful analysis of its structural, ornamental and spatial components, since each element responds to a precise design intention and represents a moment of innovation and reinterpretation with respect to the canons of the period. The documentation of a work such as Buzzi's staircase now utilizes diffuse advanced technological tools enabling highly precise three-dimensional representations, ensuring high level of detail supporting historical and material interpretation. Techniques such as 3-D laser scanning and digital photogrammetry offered not only a geometric model of the building, but also the possibility of monitoring and analyzing the state of conservation of its components, allowing for timely and targeted intervention if restoration is needed. These tools, combining technical precision and analytical potential, contribute to a multi-layered reading of the work, restoring the complexity of the architectural project in a way that is more complete and less subject to partial interpretations.

However, the process of architectural documentation also presents significant challenges. Specifically, the morphological complexity of works such as Buzzi's staircase imposes a difficult balance between the precise restitution of geometry and the need to adequately represent aesthetic and material qualities. The primary challenge lies in the integration of the decorative and structural components, ensuring that both are readable with equal clarity and importance. This challenge is not merely technical but also conceptual in nature. Documentation is not merely a transposition of the physical characteristics of the building; rather, it serves as a mediation between material reality and the design intentions that determined its form and function.

In addition to technological aspects, architectural documentation plays a key role in the enhancement of cultural heritage. It is not only a tool for conservation, but also a means to develop strategies for public enjoyment and awareness of heritage culture. Digital models, graphic representations, and augmented reality offer new ways of understanding and accessing heritage, overcoming the physical limitations of a visit to the site and allowing a wider and more diverse audience to enjoy it in greater depth. In this sense, the digitization of architectural heritage does not merely preserve the static image of a building but contributes to its reinvention as a dynamic and interactive element capable of responding to contemporary needs for knowledge and participation.

## 6. Conclusion and future perspectives

In conclusion, architectural documentation is a vital process for heritage preservation and enhancement. It allows for the preservation of a material asset and the transmission of its historical, cultural, and symbolic complexity. The use of advanced technologies should not be limited to mere three-dimensional reproduction but should become a tool that enriches the understanding and experience of heritage, thus contributing to its perpetuation and evolution as an element of reflection and cultural identity. In perspective, these elaborations do not only represent a snapshot of the state of the art, but they are configured as a starting point for the development of more complex information models, possibly integrable in BIM or GIS environments for a dynamic management of the architectural asset. The precision of the digital survey facilitates the monitoring of the state of preservation over time and provides objective data to support future design phases, whether conservative, integrative, or interpretative.

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