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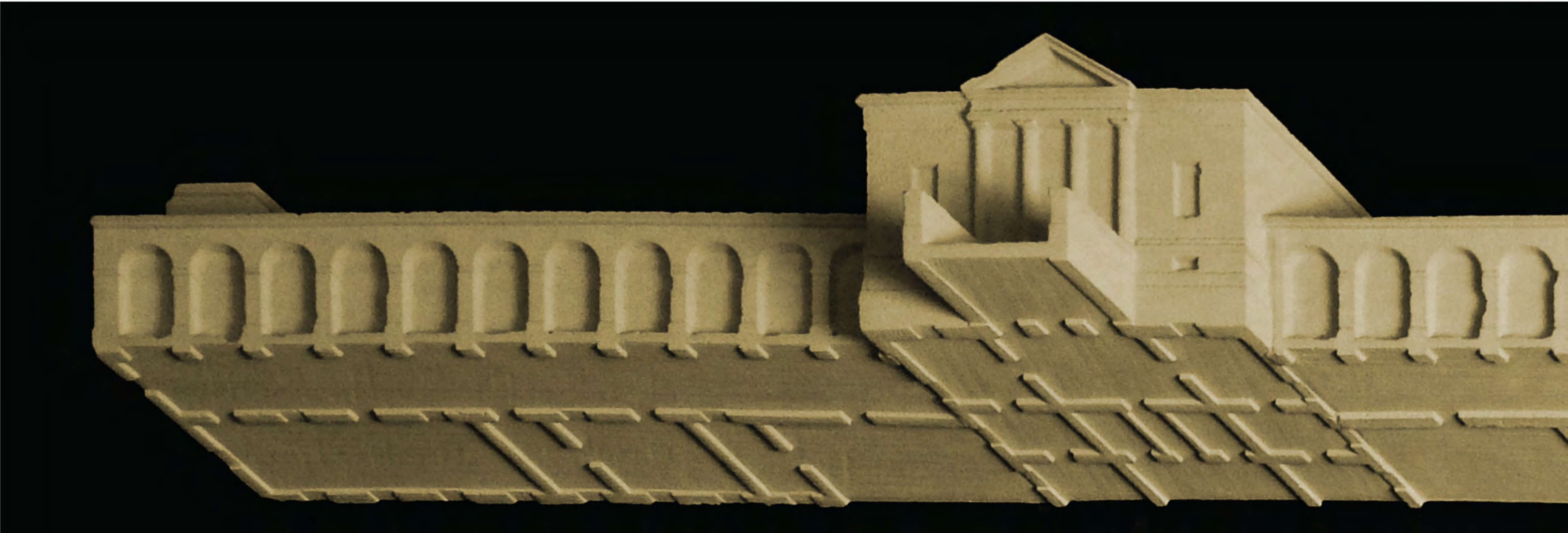

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Cover
Oblique analog model of Andrea Palladio's Villa Emo, plaster, detail (A. Sdegno with B. Gernand, Protoservice realization, 2007).

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Analogue Artefacts for Structural Mechanics and Engineering. A Critical Survey

Maurizio Marco Bocconcino, Mariapaola Vozzola, Martino Pavignano

Abstract

Since time immemorial, Drawing has been the visual language of all activities related to the world of building. It allows for the prefiguration, configuration, realisation and critical analysis of construction. Among its applications is the analogue scale model, which represents a tangible expression of design thinking However, what happens when the object in question is not a work of architecture, but rather a single structural component of a building or an engineering artefact?
This paper offers an analysis of models representing the structural essence of architectural and engineering artefacts. It examines artefacts from an academic collection (second half of the 19th century), the scientific work of G. Curioni. The collection consists of more than 140 models designed as scientific supports for the didactics of Structural Mechanics and Engineering, a field in which Curioni was a prominent figure in Italy. The research represents a potential avenue for the university's Third Mission, namely the dissemination and dissemination of knowledge about the Curioni Collection. This is achieved by creating a virtual museum that hosts the virtual models of the collection in different sharing environments, with the aim of reaching as many users as possible. The model becomes a communication tool brought up to date through the reinterpretation and reinterpretation of manuals and models, transforming the material artefact into a virtual model and introducing new forms of representation.

Keywords: academic heritage, communicative culture, tangible model, virtual museum, woodworking art.

Introduction

Several national studies address the preservation of cultural assets by universities and show a significant 'patrimonial status'. However, there is often a lack of organization to ensure their proper use and valorisation. The issue is also debated internationally and has several main stages [1]. In the first decade of the 21st century, the perspective on university cultural heritage has shifted from being considered 'active resources for teaching and research' (Halle Declaration 2000) to being viewed as a means of transmitting and disseminating knowledge for the development of the territory and its inhabitants. This includes producing social inclusion through direct public involvement in university museums (Carrion Garcia 2012).

In addition to conservation, the Politecnico di Torino has been promoting and disseminating its historical and archival heritage as a unitary system of knowledge and technical information. This system is hosted and preserved in the various components of the University, including the library and museum system and departments. Between 2015 and 2016, the Politecnico adopted a single, open-source, web-based software platform for the description, management, communication, and enhancement of its Historical Collections in the fields of Architecture and Engineering. The Library and Museum Area, as well as the Departments, preserve various types of assets that form a rich heritage of archive collections. These collections are ascribable to a system characterised by cultural matrices common to the

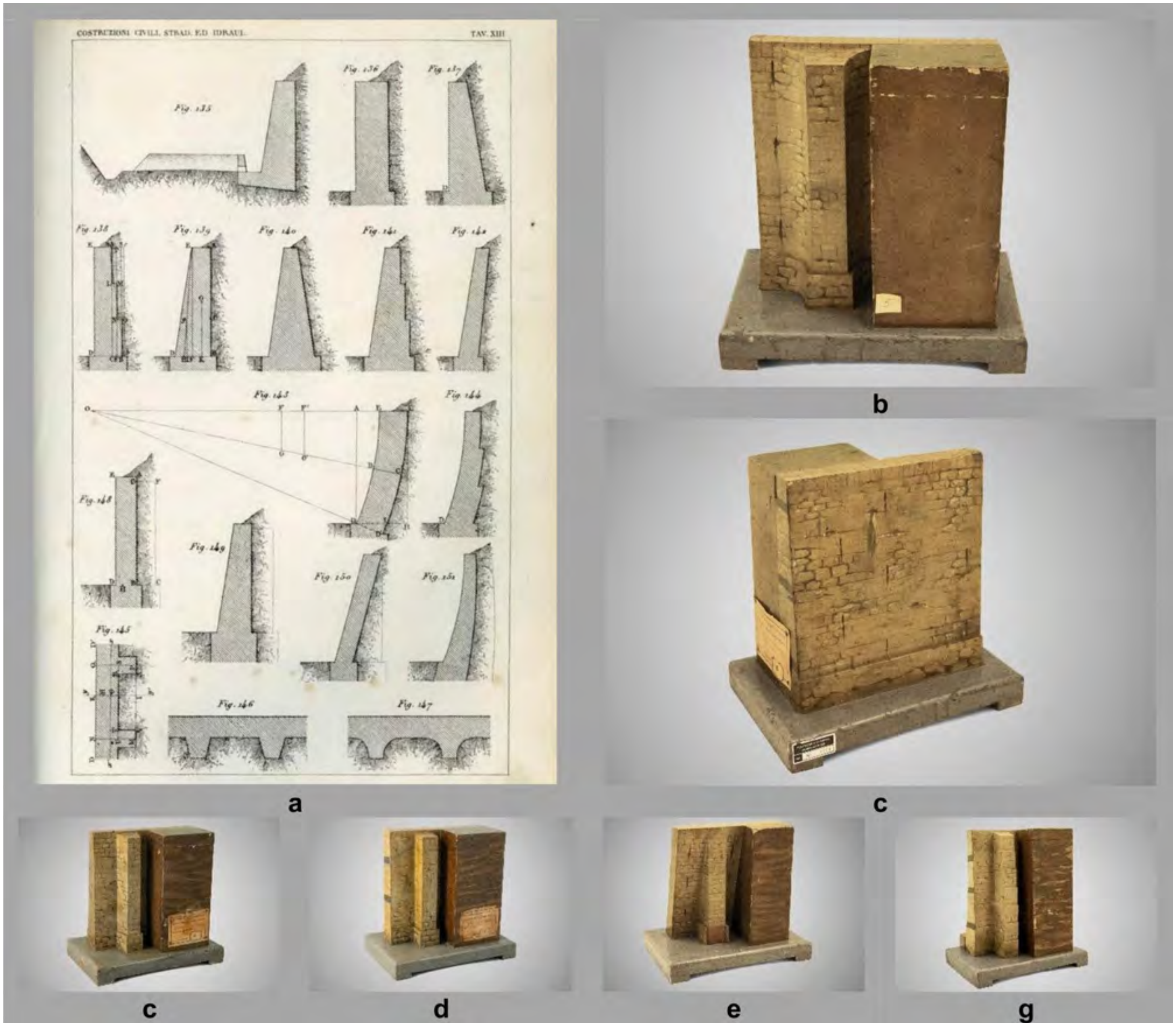

Fig. 1. Retaining walls with internal buttress. a) Curioni 1870. Tav XIII; b-c) model (m. from now on) 5, dim. 240 x 240 x 155 mm; d) m.1, dim. 245 x 250 x 160 mm; e) m.2, dim. 235 x 250 x 160 ; f) m.3, dim. 255 x 260 x 170; g) m.4, dim. 290 x 250 x 180 (graphic elaboration by M. Pavignano).

fields of polytechnic education and research. In addition to traditional documentation, they also contain collections of graphic plates, photographic images, and a significant number of material and plastic models.
The collection of wooden models known as the "Giovanni Curioni" collection, located at the Department of Structural, Building and Geotechnical Engineering of the Politecnico di Torino (DISEG), demonstrates Professor Curioni's dedication to the educational field of construction science and technology and to structural design. This collection supports the content published in his volumes *L'arte di fabbricare. Costruzioni civili, stradali e idrauliche*, which were published in 1870. The models' didactic function is being rediscovered as part of a project to enhance and enliven them, conducted by a composite research group [2]. The research group's articulation demonstrates the collection's intra- and multi-disciplinary interest. The collection has an intangible dimension linked to the didactic information heritage that can be updated, consolidated, and passed on to future generations.
The research on the DISEG archives has been the subject of various reflections expressed in publications and conferences, exploring different aspects [3]. In this contribution, we aim to present the foundational aspects of the work being conducted, the methodological approach to the critical survey of models, and the approach to the subject from the perspective of the survey and expeditious measurement system and processing procedures. Also, concerning both material and digital products, and the relevant elements for managing and representing data, as well as organizing it within knowledge information containers, this text aims to describe the operational elements that characterize the study experience.

Curioni collection: a critical exploration

The collection of models produced on Curioni's commission and for his use has been housed in various institutions over time. Faraggiana's study [1989] identified 137 models and classified them into eight families based on the subdivision of the text of *L'arte di Fabbricare* [Faraggiana 1989, p. 63]. However, the eight families did not consider the 15 models of vaults or the models of the *Mosca*, *Isabella* and *Regina Margherita* bridges, as well as the *Galleria dei Giovi* tunnel. The current study shares Faraggiana's scientific approach but also recognises the visual value of models as (visual) artefacts [Gay 2016b]. It highlights their epistemological value in the context of "didactic theatres" that characterised science education from the second half of the 19^{th} century to the first half of the 20^{th} [Gay 2000; Müller 2009; Cumino 2022; Zich 2022]. The study suggests unifying the models of the three bridges into the bridge family, including the *Galleria dei Giovi* model among the galleries, and officially recognizing a ninth family dedicated to vaults, since Curioni [Curioni 1873, pp. 325-369] extensively treated vaults, like the other families. The cataloguing excludes four models that were present in the 1989 cataloguing but are no longer found in the polytechnic premises. The families are presented in Table 1, which summarises the names, number of models for each class, and reference to Faraggiana's catalogue number. This catalogue number is still used as the basis for the last inventory [Borri Brunetto 2017].

Family	Numbers of models	Current archive numbering
Retaining walls	13	1-13
Foundations/Ground works	21	14-21, 23-34, 116
Centering/frameworks for bridge construction	13	35, 38-47, 65
Bridges	19	48-60, 63, 64, 115, 117, 118, 119
Railways	16	61, 62, 66-79
Tunnels	16	81-95, 123
Building site structures/ machines	9	96, 97, 99-105
Hydraulic constructions	7	109-114, 121
Vaults	25	v1-v25
total	**139**	

Tab. 1. Families of Curioni's models with model listing.

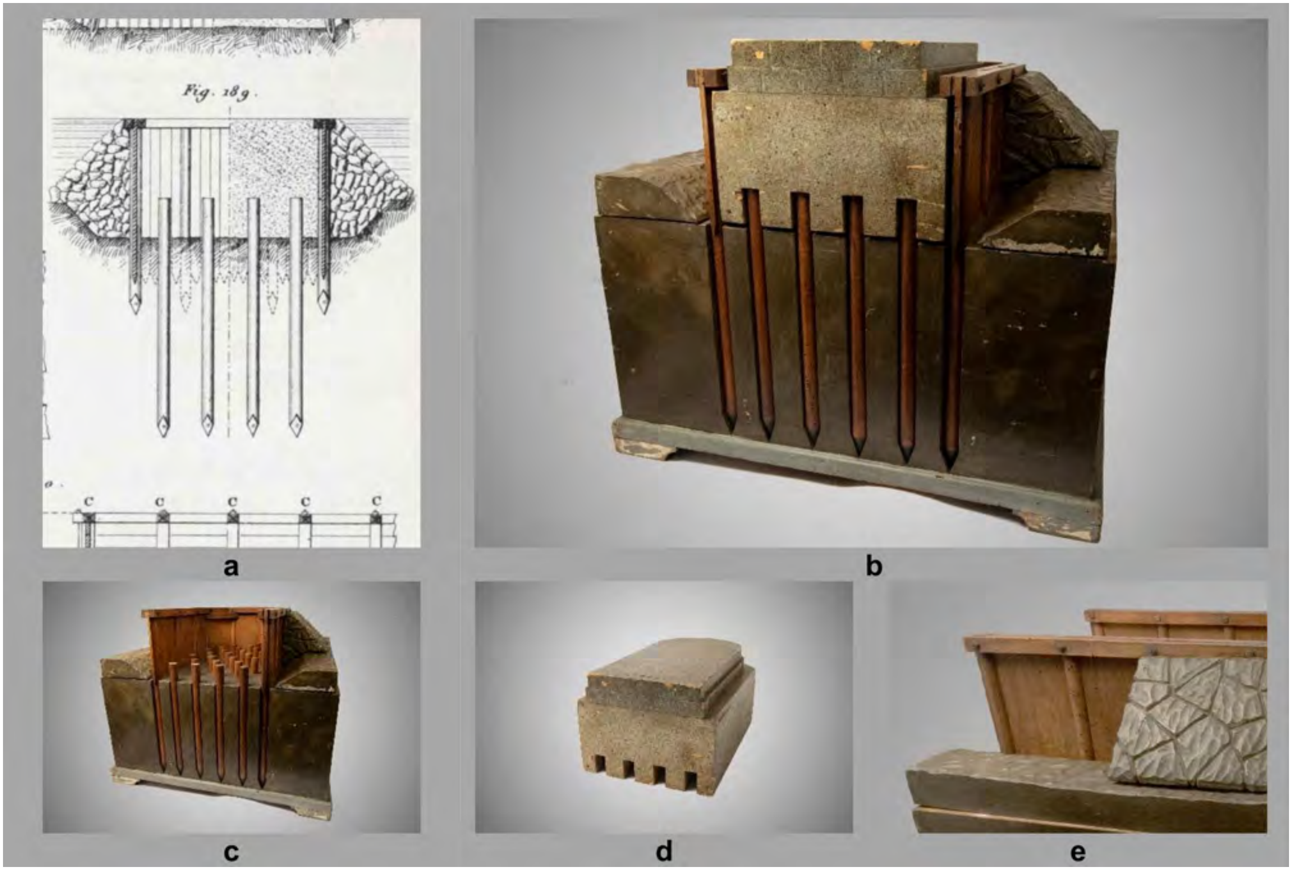

Fig. 2. Retaining walls with arches. a) Curioni 1870. Tab. XIV; b) m.12, dim. 245 x 375 x 190 mm; c) m.13, dim. 240 x 375 x 190 (graphic elaboration by M. Pavignano).

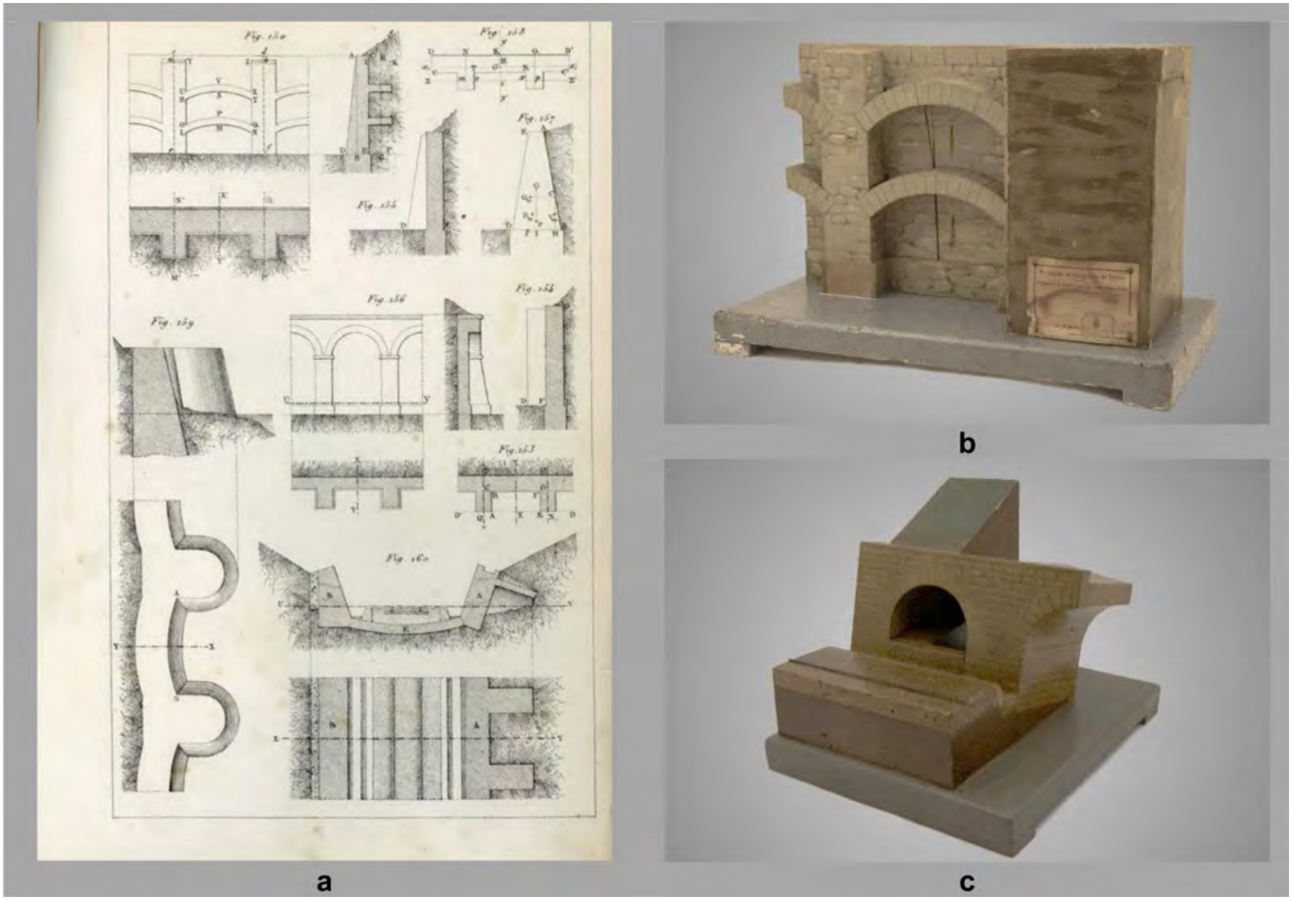

Fig. 3. Foundation with formwork and piling. a) Curioni 1873, Tav. XVII, detail 189; b) m.23, dim. 495 x 580 x 585 mm; c, d) m.23 dismantled; e) use of metal parts (graphic elaboration by M. Pavignano).

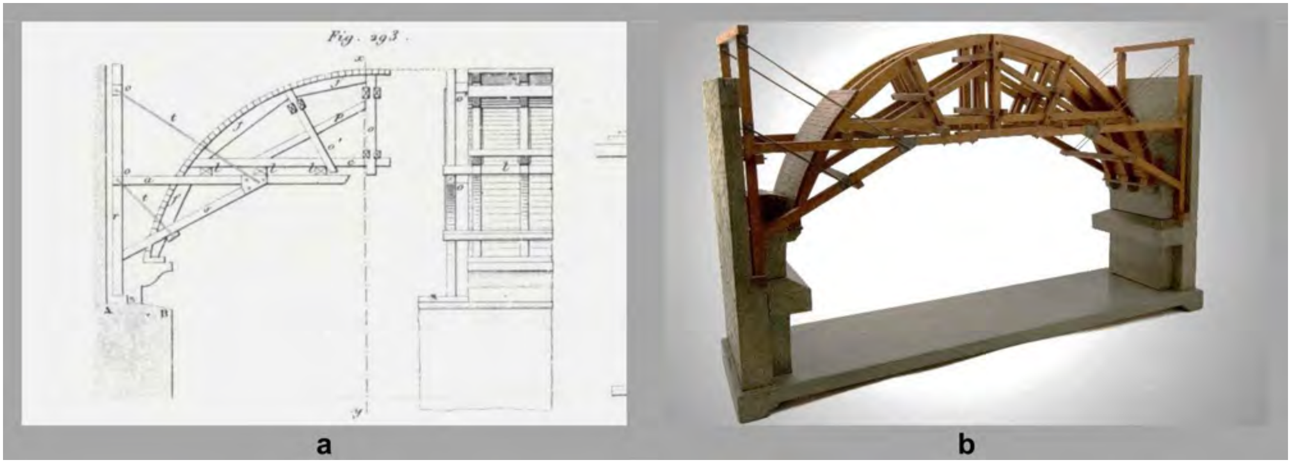

Fig. 4. Complete suspended framework with its hardware. a) Curioni 1873, Tab. XXIV, detail of figure 293; b) m.43, dim. 460 x 760 x 205 mm (graphic elaboration by M. Pavignano).

The new cataloguing, which is based on the recognition of the visual value of the tangible representation as well as on the typological and/or structural characteristics of the modelled artefacts, is not a rigid tool and is open to modification and addition, as some artefacts may belong to more than one family. For instance, models 58, 59, and 60 were described in 1989 as single-arch wall structure bridges for single-track railway. They were included in the family of Bridges rather than railways because they do not represent the tracks, but only the structures (arches, walls) of the bridges. However, such models may be included in the Railways family, depending on their preferred communicative value.

From *L'Arte di Fabbricare* to the model

The visual value of these models, that are heritage of our Politecnico, as tangible declinations of the statutes of representation (Ugo 2008) can now be discussed. It is important to note the reciprocal relationship between the drawings proposed in the figures of *L'arte di Fabbricare* and the models realized by the craftsman Giuseppe Blotto. Most of the artefacts reveal their conceptual derivation from the illustrations of Curioni's manual.

Starting with the family of Retaining walls, Curioni extensively covers this topic in Part Two, Chapter II, which is dedicated to Road Constructions, in the volume on General Works of Civil, Road and Hydraulic Architecture (*Lavori generali di architettura civile, stradale ed idraulica*), which we are here referring to the 1870 edition of Curioni's work [Curioni 1870, pp. 265-303]. Plates XIII, XIV and XV, as well as figures 136 to 144, referred to by Curioni [Curioni 1870, p. 266], illustrate possible wall sections for different configurations of internal and external elevations. Figures 145 to 151 illustrate the sections of four walls between a pair of buttresses. The internal buttresses in figures 145, 146, and 147 do not correlate with the orthographic projection planes, requiring an effort of imagination or integration of another visual support. Models 1 to 5 depict walls with internal buttresses (fig. 1) [5] and illustrate the connection between the vertical and horizontal sections (that are orthographic projections) of the manual. The artefacts are made of wood covered with a smoothing material and feature uniform pictorial finishes, reminiscent of walls made of stone blocks and supporting earth volumes. Sometimes the textures evoke technological elements, such as water drains, which are defined on both the inner and outer elevations (figs. 1a, 1b, and 1e) and in the cross section (figs. 1d and 1g).

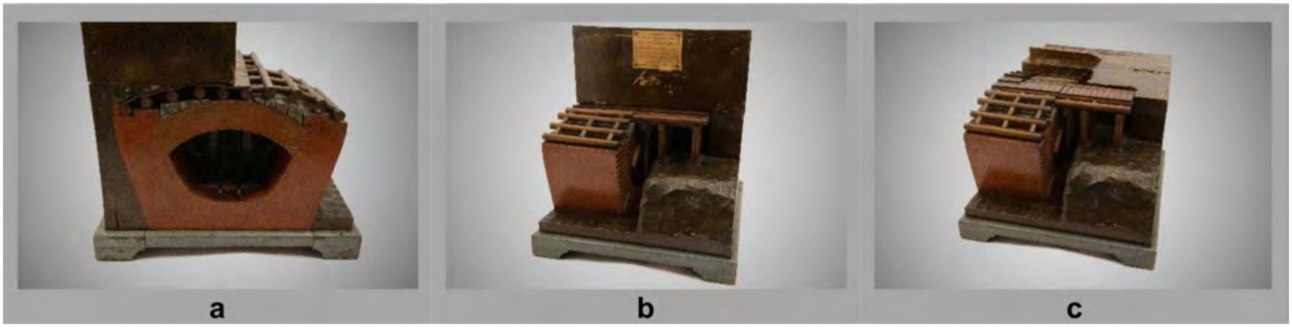

Fig. 5. Framework for tunneling (1st phase), m. 87, dim. 350 x 320 x 325 mm a-b) closed model; c) open model (graphic elaboration by M. Pavignano).

Like the previous models, Curioni highlights the solutions depicted with models 11, 12 and 13 as significant evolutions of the period [Curioni 1870, p. 267]. Model 13 (fig. 2c) is a retaining wall with inclined piers and superimposed arches, which Curioni suggests is a suitable structure for the support of an open trench in compressible and mobile terrain [Curioni 1870, p. 303]. The model section does not display an important aspect of the structure, which is the inverted arch located under the embankment connectingtwo opposing walls. The section only shows the ground, embankment, and wall texture of the retaining structure, including the ashlars of the arches.
A similar method to Model 13 is found in the artefacts devoted to foundation structures. These are discussed in detail in the 1873 update of the volume devoted to civil, road and hydraulic architecture. Tables XIV, XV, XVI and XVII include explanatory illustrations of the content described in Article III. Chapter V discusses the Hydraulic Foundations (*Fondazioni idrauliche*). Model 23, which can be found in figure 189 of table XVII, is of particular interest. The foundation includes formwork and piling, as described by Curioni [1873, p. 271] (see figs. 3a, 3b). The artefact is made of multiple materials and can be disassembled into two pieces (figs. 3c, 3d). It mainly consists of pieces of wood that are painted differently to represent various components, such as piles, planks of the formwork, earth, concrete, and the base of the pillar. Additionally, small bolts with metal nuts are used to indicate the mechanical joints between the formwork beams and planks (see fig. 3e). The foundation soil profile, piles, and formwork structure adhere to the drawing presented in figure 189. However, the model includes two additional aspects. Firstly, it contextualizes the planimetric shape of the formwork with a semicircular course at the head. Secondly, it represents the base of a bridge pier, as specified in the textual description [Curioni 1873, p. 271].
Chapter VIII deals with reinforcement for bridge construction. Article III discusses frameworks and centring [Curioni 1873, pp. 419-424]. Model 47 is of great interest; it is a suspended composite centring with hardware. Two projection planes of the model can be found in figure 293 of Table XXIV. The artefact completes the representations that depict just a half of the structure, and materializes its three-dimensionality, allowing a better understanding of the spatial complexity of the structure (fig. 4).
Some models can be disassembled or have kinematics that allow them to be opened up, thus revealing certain internal details, as already mentioned in relation to model 23 (fig. 5). For instance, in model 87, which pertains to reinforcement for tunnel construction during the first phase of attack with a reinforcement arch, it is feasible to relocate the section of the ground supported by the centring, thereby exposing the planking for viewing. The textures of the wall sections are distinguished from the floor and wooden structures in this model by surface painting.
Finally, the wooden models of the vaults (fig. 6) are of great interest. They are discussed in Chapter VII [Curioni 1873, pp. 325-369] and illustrated in Tables XXII to XXVI. In this case, all vaults are described by two projection planes, and the textual descriptions provide the spatial genesis in terms of descriptive geometry applied to the structure to be designed, as in the case of the barrel vault with pavilion head and lunettes. The description of the geometry consistently

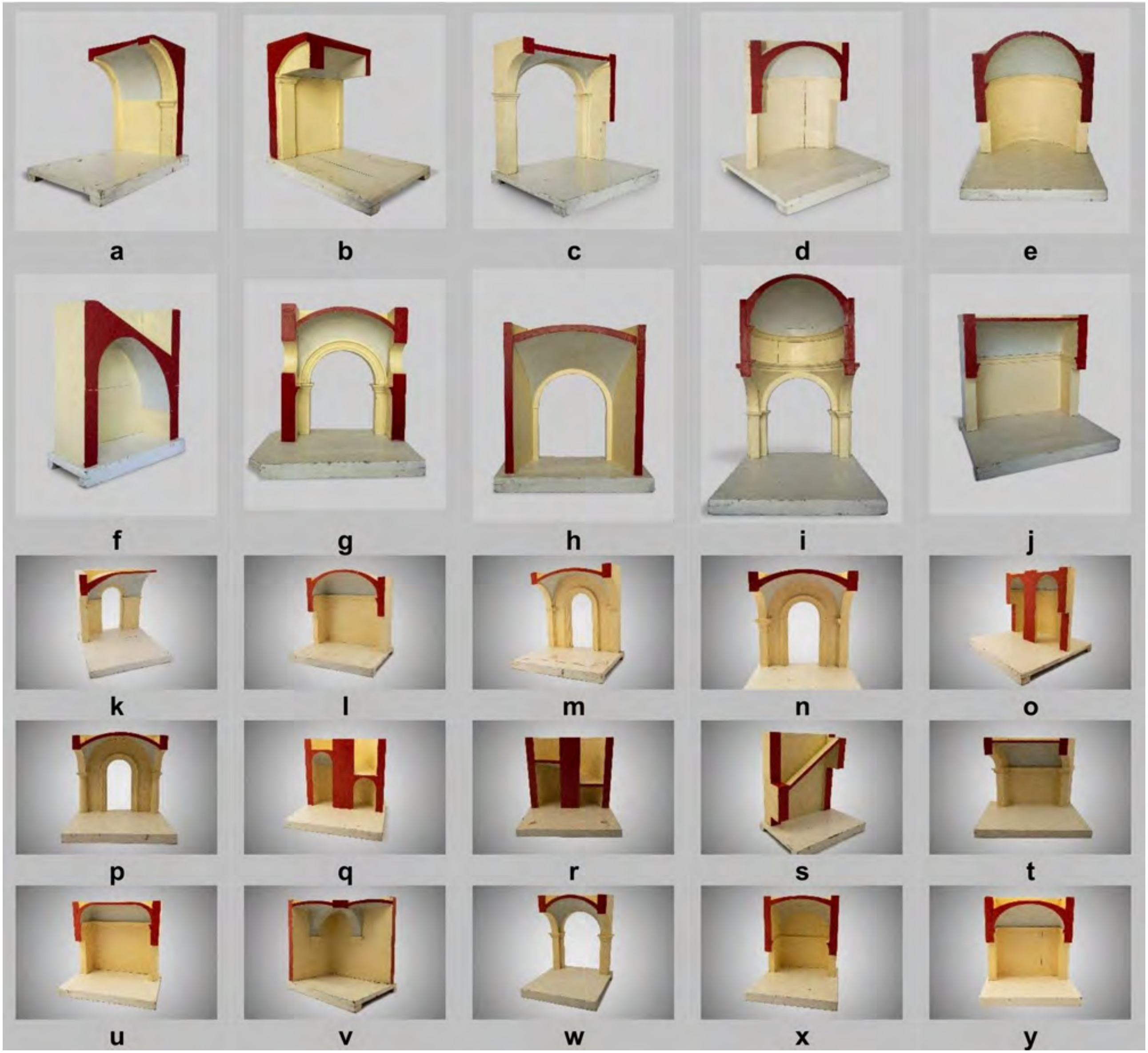

Fig. 6. Vault models, whole family (graphic elaboration by M. Pavignano).

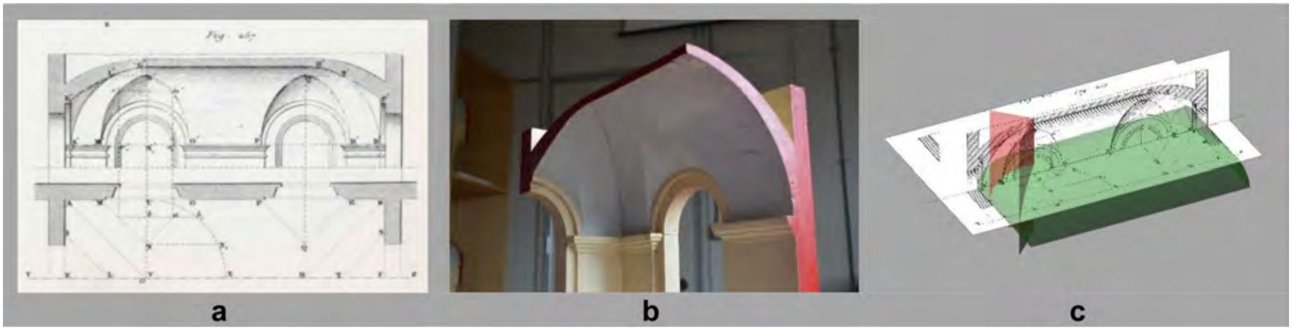

Fig. 7. Barrel vault with pavilion head and lunettes. a) Curioni 1873, Tab. XXV; b) m.123, dim. 345 x 360 x 300 detail (picture by M. Pavignano); c) Geometric interpretation (drawing and graphic elaboration by M. Pavignano).

refers to the data annotated on the drawings, following the method used by Guarini [Spallone 2018, pp. 816, 817] (fig. 7). Such models all have a finish with uniform colours, which are used to differentiate the supporting structures (masonry) from the vaulted surfaces and to highlight the vertical sections.
Based on the preceding discussion, it can be concluded that Curioni aimed to achieve a closer visual and geometric correlation between different types of representations, preceding Paul Deschamps, who later became the director of the *Musée des Monuments Français*, by half a century. Between textual descriptions and, in particular, the words depicted in the illustrations of *L'arte di fabbricare* and didactic models [Gay 2016a, p. 126], there is an advocacy for the 'imaginative dramatisation' that is of fundamental importance for the didactics of architectural and engineering facts [Gay 2020, p. 73].

The digitisation process: from drawings and material models

The field of research that involves the application of 3D digital survey and modelling to museum collections or archaeological artefacts is continuously developing. Its principles are based on the communication, sharing, and dissemination of knowledge of objects that may not always be accessible to users.
The digitisation of the Curioni collection models has been motivated by several needs. The primary need is to create a digital catalogue of 3D models that includes all data and metadata related to the artefacts. Additionally, the digitisation allows for analysis and study of the models without the need for direct physical contact, thus eliminating the risks associated with damaging the original artefacts. Simultaneously, the ability to create a database of 3D models that can be navigated, measured, and examined satisfies various modes of use and interaction, reaching all target users interested in the artefacts. The type of experience can be customized according to the user.
The digitisation project was carried out in several stages, following the guidelines for the use of information and communication technologies (ICT) in the context of Cultural Heritage. The processes of digital reproduction aimed to maintain a high level of morphometric and visual fidelity to the real object, while preserving the scientific integrity of the data [Picchio, Pettineo 2023]. The creation of digital twins was initiated through four different strands of representation and digitisation techniques (fig. 8). The first strand was based on range-based techniques for acquisitions. Due to the peculiarities of the models, two different instruments were used initially. Numerous scientific publications [Allegra et al. 2017] have shown that the final geometry resolution acquired through various survey tools and representation techniques depends on several factors [4]. The Mantis F6 structured light laser scanner was used for more complex objects, while the low-cost lidar scanner supplied with the iPhone 13 Pro was used for less complex models.

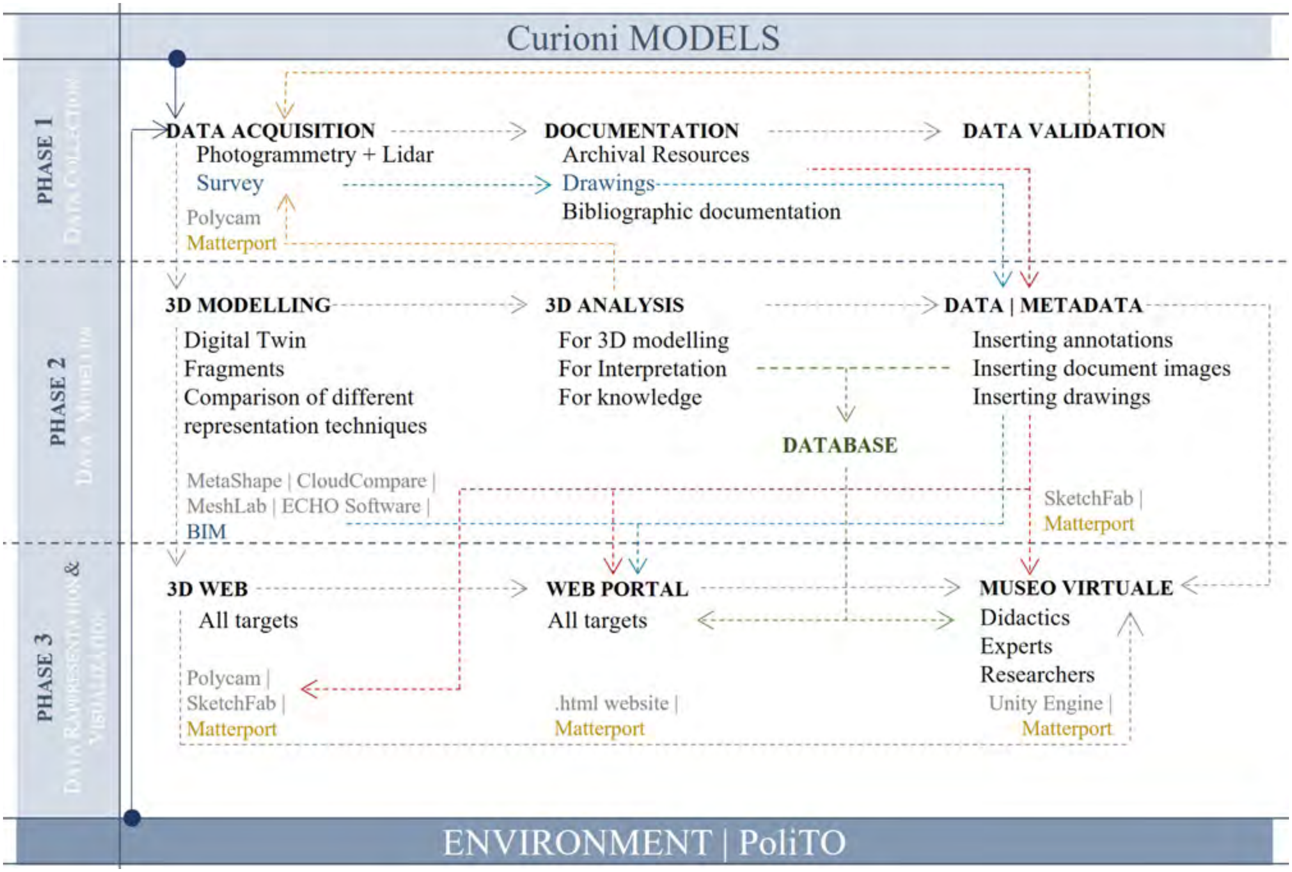

Fig. 8. Methodological workflow for the digitisation of the virtual museum - digital models and museum environments of the Politecnico di Torino (graphic elaboration by M. Vozzola).

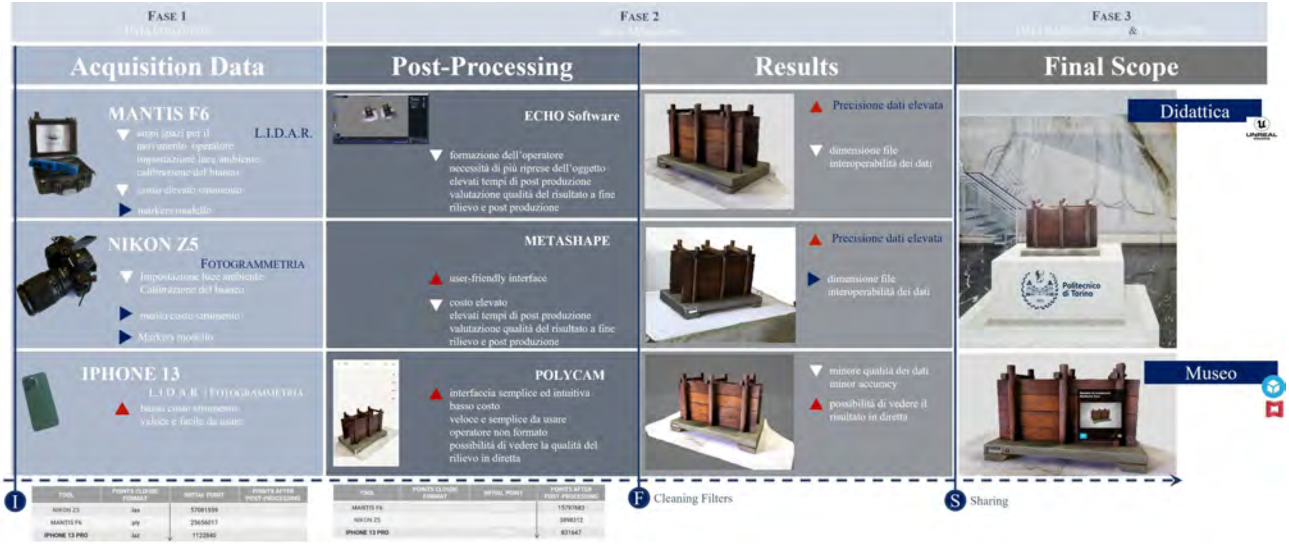

Fig. 9. Comparison of acquisition techniques and results obtained (graphic elaboration by M. Vozzola).

Both procedures enabled the creation of a virtual model from a point cloud. The first method involves exporting to appropriate processing and modeling environments, while the second method involves using dedicated apps like *Polycam*. These apps allow for sharing the model in web environments like *Sketchfab* or exporting point clouds to suitable computing environments (6). The second method of acquisition utilised image-based techniques, employing a Nikon Z5 digital camera with calibrated 18-55 mm lenses to produce a detailed three-dimensional model with high-resolution textures. The third method involved a direct survey of the physical model using analogue tools, from which all geometric data of the elements were deduced to create the parametric virtual model in a BIM environment. The previous modelling method involved directly reading the manual drawings of engineer Curioni. This allowed for the deduction of information and geometric data to create a parametric virtual model in a BIM environment [Bocconcino et al. 2023]. The processes and final models obtained from the first two acquisition methodologies were analysed (fig. 9). To evaluate the optimal solution in terms of tools, the cost ratio will be analysed. This is understood as the ratio between execution and operator knowledge. Additionally, the quality of the collected data will be assessed in terms of quantity and quality, linked to the acquisition times and interoperability in the input phase. The optimal solution will depend on the final quality of the model, metadata, and processing times. Above all, it will depend on the level of interoperability and sharing of the final virtual model in order to speed up the entire acquisition and/or modelling flow.

The above shows that to comprehend the best workflow for acquiring models, it is crucial to understand the desired representative quality of the virtual model. Different digital models, obtained through various acquisition and modelling techniques, serve different narrative and informative objectives, catering to users from diverse fields of knowledge and belonging to different processing/sharing environments. The main objective of this research is to create a path for digitizing models, enabling communication between drawings and models [Parrinello et al. 2022]. The aim is to define a language that can explain information and alphanumeric data to end-users. The work carried out aimed to digitise and create three-dimensional models of the wooden models for various purposes, with the primary goal of making them accessible to a wider audience.

Fig. 10. Visualization of a wooden vault in a processing environment, including possible paths for knowledge and in-depth analysis through the insertion of data and metadata (models and graphic elaboration by M. Vozzola).

On one hand, the purpose is to document the geometric system of volumes as a teaching and experimentation tool for multiple disciplines within the University. On the other hand, the aim is to experiment with new techniques and technologies of interactive navigation and dynamic exploration by creating a virtual University Museum that serves as a container of Polytechnic Culture. Finally, rapid prototyping can be used to create entire physical models or parts of them for direct dissemination. This allows different types of interested users, particularly the academic public, to perceive the models in line with the directives provided by design for all. The previous imperative prohibition on tactile enjoyment of models in museums has been replaced with the more inclusive "forbidden not to touch" [Sdegno, Riavis 2022].
In this context, the methods of preserving and disseminating memory, and sharing and communicating knowledge, are undergoing significant changes. Interdisciplinary training is becoming a fundamental tool for preparing future professionals. The Curioni Collection contains drawings, texts, and models that demonstrate a multifaceted culture from several disciplines. To systematize the knowledge gained from analysing this collection, a digital container has been created to collect, systematize, organize, integrate, and share all documentation. This ensures that the documentary heritage is not exclusive to certain fields or circumscribed within isolated subject areas.

A new narrative for knowledge: from models to collections

The presented research places cultural storytelling at the heart of communication. This is understood as the relationship between the cultural asset and the user, which serves to transmit, reinterpret, and translate the communicative vocation inherent in an artefact. Additionally, it highlights the multiple stories contained within the artefact [Dell'Amico et al. 2023]. The museum, whether populated with virtual or real objects, is transformed from a storage and exhibition of artefacts from the past into an open and interactive space. Visitors are involved in a dialogue and interaction that updates the use of virtual museum resources in the educational process. This allows users to have their own cognitive experience. The research aims to address the absence of a fixed museum structure that is always accessible for the direct exploration of the Curioni collection. To achieve this, a virtual museum was created based on the design of user-centred environments and contents. The approach involved a balanced combination of different types of representation, including 360° views, 3D virtual models, video art, and descriptions. The language used is clear, objective, and value-neutral, with a formal register and precise word choice. The text adheres to conventional structure and formatting features, with consistent citation and footnote style. The sentences and paragraphs create a logical flow of information with causal connections between statements. The text is free from grammatical errors, spelling mistakes, and punctuation errors. No changes in content were made. The purpose of this initiative is to promote and raise awareness about the importance of conserving, protecting, and promoting cultural heritage, particularly through the digital transformation and reuse of 3D digitized cultural heritage. This is in line with the work of Debuch et al. [2024] as shown in fig 10.
Different versions of the same digital object have been developed for various platforms and sharing environments. These versions cater to different levels of communication and in-depth analysis. One such version has been developed in *Unity Engine*, which configures an educational museum. Here, the user can query the model, measure it, read the associated metadata, and enter gaming mode to answer educational questions. To ensure maximum accessibility for users, a second *Sketchfab*

Fig. 11. The image shows the laboratory for testing materials in the Sala delle Colonne of the Valentino Castle. The Sala delle Colonne (Castello del Valentino, historical headquarter of the Politecnico di Torino) is currently being surveyed using an INSTA360 ONE RS camera (graphic elaboration by Mariapaola Vozzola).

virtual environment has been created. Here, users can view and query the model, accessing all associated data and metadata. Finally, we are using indoor mapping techniques to recreate the rooms where the Curioni models were preserved and to place them back into the context in which they were experienced by the students of the former *Regia Scuola di Applicazionie per Ingegneri* (now being our Politecnico) (see fig. 11). *Matterport* technology was utilised to create the museum 'container'. This offers a web platform that enables users to create and share immersive 3D models of physical spaces. It is particularly useful for visualising physical spaces in a virtual environment. Users can insert tags, not links, to external models and/or data and metadata describing the artefacts exhibited in the museum. The creation of one or more environments on the university campus dedicated to the models preserved at DISEG offers new possibilities for the use of virtual environments. These environments can replicate the original settings in which the models were preserved for years, providing an unprecedented mode of use that is no longer passive, but active, interactive, and participatory [Giovannini 2023].

Conclusions and future developments

The study demonstrates that the potential of physical models also lies in the close connection between the theoretical object to be represented through the relevant artefact. Still, the study reveals that "in three dimensions, we can model a solid shape by making an object whose surface is this surface. We can model a two-dimensional surface by making an object whose surface is this surface" [Müller 2009, p. 654].
Placed in their original context, Curioni's models seem to evoke a need for "deferred construction" [Ragazzo 1994, p. 408], which not only supported technical thinking but also instilled in the minds of the students at the *Regia Scuola di Applicazione per Ingegneri* the possible *libido aedificandi* of Albertian memory. In this sense, it is immediately noticeable that there is a clear break in the aesthetics of the models. The vaults reproduce purely theoretical elements and are not characterized by a camouflage appearance. They are limited to the definition of neutral artifacts, where the only chromatic dissonance is between the white of the wall volumes and the red of the sections. This completes the reading with meaning.
The aspects highlighted mainly concern the taxonomic analysis of the wooden models, the cognitive and operational tools used and compared, and the methods for creating parametric digital models that operate within internal information systems and integrated consultation and navigation environments.
The disciplines of visual and graphic analysis and representation are closely linked to the integration of current practices for the preservation, re-use, and dissemination of collections. It is possible to implement

cataloguing sheets that conform to technical regulatory frameworks and include design-specific aspects such as scale of representation, thematic content, functions of individual parts and the whole, material aspects, and methods of assembly and disassembly for restoration and conservation. This will allow for multidisciplinary interrogation filters.
Finally, it is important to highlight that the Collections of our Politecnico are essential testimonies of the 'polytechnic thought' and its constitution. They serve as true "memory repositories" of the Institution [Pagella 2009]. The Curioni models were designed for dynamic and tactile consultation by the student engineers of that time. By 'framing' them in a material and digital display, their original function is transformed. However, digital consultation expands the scope of exploration for the model, with cross-references to complementary textual and graphic information that enable specific in-depth analysis of both general themes and detailed parts and elements. This aspect may encourage the re-use of certain physical examples, as the models or their replicas, or specific parts of the model relevant to the fields of design, structural analysis and visual representation and communication, may be included in the classroom.

Credits

Although the contribution was conceived jointly, M. M. Bocconcino is author of paragraphs *Introduction;* M. Pavignano is author of paragraphs *Curioni collection: a critical exploration* and *From* L'Arte di Fabbricare *to the Model*; MP. Vozzola is author of paragraphs *The digitisation process: from drawings and material models* and *A new narrative for knowledge: from models to collections*. The authors wrote together the paragraphs *Conclusions and future developments*.
Pictures in figure 1, 2, 3, 4, 5, 6 are courtesy of Politecnico di Torino, Ufficio Gestione del Patrimonio Storico dell'Ateneo (arch. M. Bongiovanni).

Notes

[1] In 2000 twelve European universities signed the Halle Declaration, which gave birth to the network Academic Heritage and Universities, i.e. the Universeum project; one year later the International Council of Museums (ICOM) founded the *Committee for University Museums and Collections* (UMAC); in 2005, again at the European level, the Committee of Ministers of the Council of Europe published the *Recommendation on the Governance and Management of University Heritage*; finally in 2009 a project financed by the European Commission was launched, which led in 2012 to the drafting of the Green Paper on the Third Mission of Universities. In this same period in Italy the Commission of Rector Delegates for University Museums at the Conference of Italian University Rectors (CRUI) is active.

[2] It brings together specific skills and disciplines, under the scientific responsibility of Maurizio Marco Bocconcino and the coordination of Mariapaola Vozzola and Martino Pavignano. In the field of Structural Mechanics Professor Mauro Borri Brunetto; for the responsibility of the cultural and scientific heritage of the Politecnico the architect Margherita Bongiovanni; for Structural Engineering Professors Paolo Castaldo and Fabio Di Trapani, on the sciences of representation and information modelling the Authors of the contribution; on Geomatic and Survey skills Professors Marco Piras and Paolo Dabove; as support for acquisitions and elaborations the DISEG technician Pierluigi Guarrera and the junior civil engineer Luca Gioberti.

[3] The following memoirs contain the main moments of the study work: Bocconcino [2006]; Santagati et al. [2017]; Novello, Bocconcino [2018]; Novello, Bocconcino [2018b]; Novello, Bocconcino [2020]; Bocconcino, Vozzola [2022]; Bocconcino et al. [2023]; Bocconcino et al. [2023b]; Bocconcino, Vozzola, Pavignano [2023c].

[4] Regarding the figure captions, the models are identified by the progressive number of the Faraggiana-Borri Brunetto cataloguing and their dimensions are provided.

[5] The quality of acquired data varies depending on the complexity of the geometry, material properties (e.g. colours of different elements), and ambient light intensity during survey phases.

[6] Due to the unique features of certain models, even those that are small in size, it was necessary to increase the number of scans. For instance, in the case of the 87 model, which is characterized by a kinematic mechanism that enables it to be opened for the purpose of dismantling parts of the model and viewing its interior, both external and internal scans were conducted. Similarly, for artefacts that present specific details, such as model 43, scans were carried out to acquire the entire artefact and its construction details, including the tie rods.

Authors

Maurizio Marco Bocconcino, Department of Structural, Geotechnical and Building Engineering, Politecnico di Torino, maurizio.bocconcino@polito.it
Mariapaola Vozzola, Department of Structural, Geotechnical and Building Engineering, Politecnico di Torino, mariapaola.vozzola@polito.it
Martino Pavignano, Department of Structural, Geotechnical and Building Engineering, Politecnico di Torino, martino.pavignano@polito.it

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