Holographic Artifacts for the Enhancement of Academic Heritage: The Curioni Collection at the Polytechnic University of Turin

Electronic Media and
Visual Arts

Elektronische Medien und
Kunst · Kultur · Historie

EVA Berlin 2026

18 - 20 March
2026

Intelligence Space.
Creativity in Dialogue
with Technology

Brandenburgische Technische Universität Cottbus - Senftenberg

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TENTATIVE CONFERENCE PROCEEDINGS

EVA BERLIN 2026

Electronic Media and Visual Arts

Intelligence Space.
Creativity in Dialogue with Technology

29th Issue of the EVA Berlin Conference
Electronic Media and Visual Arts

March 18, 2026 – March 20, 2026
CINIQ @ Fraunhofer Heinrich-Hertz-Institut, Salzufer 6, 10587, Berlin

BTU Brandenburg University of Technology
in cooperation with Fraunhofer Heinrich-Hertz-Institut
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March 18, 2026

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Published by:
Univ.-Prof. Dipl.-Ing. Dominik Lengyel
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Editorial Team: Dominik Lengyel, Begüm Çalık, Jacopo Spinelli, Jessika Krüger
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EVA BERLIN 2026

March 18 – March 20, 2026

Holographic Artifacts for the Enhancement of Academic Heritage: The Curioni Collection at the Polytechnic University of Turin

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ABSTRACT: This paper develops a methodological reflection on strategies for enhancing the wooden models created by professor Giovanni Curioni in the second half of the nineteenth century, aimed at investigating the structural principles underlying architectural and engineering forms. The study examines the academic collection preserved at the Department of Structural, Building, and Geotechnical Engineering of the Politecnico di Torino, which includes over 140 scale models derived from the books L'arte di fabbricare (1867–1885), conceived as didactic instruments for the emerging discipline of construction science, in which Curioni was a pioneer in Italy. Within the framework of the university's Third Mission, the research promotes the creation of a Virtual Museum to disseminate and valorize polytechnic collections through digital platforms and interactive interfaces. The integration of holographic technologies enables the transformation of manuals and models into dynamic, three-dimensional projections, fostering new modes of knowledge transmission. Preliminary applications to selected models from the Curioni Collection highlight the interpretive and narrative potential of holographic representation as a medium for contemporary scientific and cultural communication.

1. INTRODUCTION (MMB)

Research has been carried out on Giovanni Curioni's collection of wooden models, which is preserved at the Politecnico di Torino's Department of Structural, Building and Geotechnical Engineering (DISEG). This research explores the role of Drawing as a cognitive and tactile infrastructure for knowledge. An operational system for the enhancement of academic heritage has been developed through an integrated process of surveying, modelling, digitisation, 3D printing and holographic projection. The project emphasises the importance of striking a balance between digital mediation and physical tangibility, which includes returning the original models to educational settings. Representation is interpreted as a cyclical process in which drawing connects material memory and technological innovation to generate shared, inclusive knowledge.

This contribution offers a methodological reflection on the enhancement of analog models created in the second half of the 19th century. His work aimed to explore the structural essence of architectural and engineering forms. The collection includes over 140 scale models derived from illustrations in Curioni's seminal work L'arte di fabbricare (1867–1885), conceived as a scientific aid for teaching construction science, a field in which Curioni is considered a pioneer in Italy.

The research, aligned with the goals of the university's Third Mission, seeks to promote and disseminate knowledge of polytechnic collections through the creation of a Virtual Museum with the aim of stimulating and encouraging a return to reading physical models and a deeper and more conscious material contact with them. This museum will host information models and digitized documents, accessible through multiple platforms - web repositories, physical and digital interfaces - to reach a broad and diverse audience. The Curioni collection is thus reinterpreted as a contemporary communication tool, where manuals and models are transformed into

"virtual and dynamic projections" through new representational technologies.
Central to this transformation can become the use of holography, a technology based on light diffraction and interference that produces highly realistic three-dimensional images. Holographic devices such as tables, display cases, and projectors enable immersive environments in which images and stories are projected, creating new experiential realities. This new research phase investigates the potential of holographic reproduction, user interaction with holographic artifacts, and how visual representation techniques support this intangible but spatially and materially grounded form of communication. A preliminary application to selected models from the Curioni Collection highlights the narrative and interpretive opportunities enabled by holographic display.

2. ORIGINS, MOTIVATIONS AND KNOWLEDGE PATTERNS FOR THE RESEARCH (MMB)

The research on the Curioni Collection was developed within the domain of Survey and Drawing, which is concerned with the "generation, construction and analysis of drawings, images and models as the results of scalar representations of existing or designed realities" and the "visual translation of concepts, ideas and narratives".
In this epistemic framework, Drawing is conceptualised as a cognitive language and a medium for mediating the relationship between the tangible world and its informational translation.
The collection of wooden models created by Giovanni Curioni in the 19th century as educational aids for construction constitutes a technical and educational heritage that is unique in terms of quality and completeness (Figure 1).
The objective of the research was to restore the models to their original function as tools of knowledge. This was achieved by reinterpreting them in the contemporary digital context and placing them at the centre of a process of representation that combines documentation, communication and, ultimately, teaching.
The activity forms part of a multi-year process of enhancing the technical and scientific heritage of DISEG, which commenced with the Mosca Library [1] and continued with the Porcheddu Archive [2]. These experiences have facilitated the experimental development of methodologies for the surveying and digitisation of historical technical documents, thereby establishing the theoretical and operational foundations for the more complex digitisation of the Curioni Collection.
The most recent phase of the process was represented by the experimentation conducted on the Betta-Bardelli Archive [3], which saw the consolidation of the methodology and its expansion to the field of the representation of constructive memory.

Figure 1: *Classification of models in the Curioni collection.*

In this continuum, the Curioni Collection constitutes the central axis of a research project that has confirmed drawing into a cognitive and disciplinary infrastructure, capable of connecting the history of technical knowledge to its contemporary digital reinterpretation. The objective was twofold: firstly, to document, and secondly, to reactivate the models as formative and perceptive devices. In doing so, drawing, in the broadest sense of the term and in its original form, was placed at the centre of the process of knowledge.

2.1 METHODS AND OPERATIONAL TOOLS (MMB)

The operational process involved three primary methods of surveying and modelling, which were executed concurrently [4].

The acquisition of the subject was undertaken with the employment of a precision laser scanner, with the objective of producing high-density three-dimensional point models for the purpose of conservation documentation.
The utilisation of smartphones equipped with LiDAR cameras facilitates low-cost surveying, a technique that is conducive to the expeditious and replicable acquisition of data for educational and informational objectives.
The reconstruction of the artefacts was simultaneously informed by Curioni's original drawings, which are contained in the volumes entitled L'arte di fabbricare (The Art of Manufacturing). The geometric reconstruction was based on historical sources.
These methods were complemented by traditional direct surveying techniques, utilising instruments such as squares, calipers, and metres, which served as a training aid to instruct students in the requisite knowledge for accurate measurement and representation. The educational approach commenced with a reduced scale model of the artefacts, fostering a foundation for students to develop proficiency in measurement and representation at a smaller representation scales.
The plurality of approaches adopted has enabled the consolidation of the concept of drawing as a comparative process, which integrates tools, scales and languages to facilitate an integrated understanding of the object (Figure 2).
Operationally (see. Cap. 3), the processing was carried out using Polycam Pro, Rhinoceros 3D, Blender and Revit for geometric and informational modelling, while the publication of the models on Sketchfab allowed them to be disseminated on the web with metadata and descriptive sheets.
The 3D printing of the digitised models represented the phase of returning to the material: a cognitive and educational act rather than a reproductive one. This made it possible to verify the geometric consistency and restore the physical perception of the form.
Concurrently, the reintroduction of the original wooden models to the students' desks in the courses taught by professors Ursula Zich and Martino Pavignano (third year of the Architecture degree programme) served to reinforce the connection between tactile experience, observation and representation, thereby restoring drawing to its original function as a sensory cognitive practice.

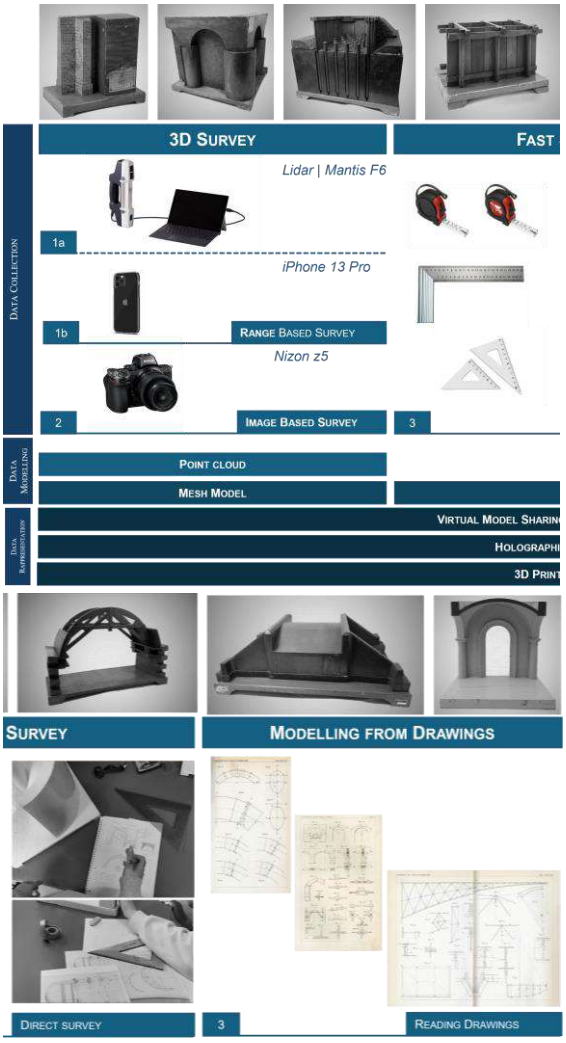

Figure 2: *Survey processes: a matter of integrative techniques in a knowledge system.*

As a preliminary conclusion to the research process, commercial low cost disseminastion of holographic projection technology has paved the way for a novel form of immersive and synaesthetic representation, characterised by the utilisation of digital models. Despite the absence of weight, the hologram restores the three-dimensionality of the form in real space and strengthens the perceptual relationship with the physical object, posing significant problems of scale representation and graphic codes for perception and interaction with projected models, through appropriate interfaces. This phase thus brings the methodological cycle of the research to a conclusion, confirming that digital mediation does not negate matter, but rather serves to amplify its understanding and cognitive value [5].

2.2 EXPERIMENTATION WITH HOLOGRAPHIC IMAGES (MMB)

The most recent updated outcome of the research process was experimentation with holographic images, which served as a phase of reflection on the very nature of representation.
The hologram, understood as a three-dimensional image generated by light and perceived in real space, takes the form of a complex projection, in which the visible form does not exist in itself, but is reconstructed by the observer through an active perceptual process.
It is evident that two primary classifications of holography exist, which differ in terms of their fundamental nature, underlying principles, and methodological value.
The first, more widespread, is that based on retinal memory: the persistence of the image on the retina allows visual perception to reconstruct the continuity of a figure that does not actually exist materially.
This phenomenon is exemplified by rotating LED devices (3D Hologram Fan), which project a sequence of two-dimensional images in rapid succession into space.
The visual system, incapable of perceiving temporal discontinuity, integrates successive projections into a stable figure that appears suspended and three-dimensional.
The holographic image thus arises as a perceptual event, rather than a physical object, and its three-dimensionality is the result of a mental construction based on visual memory.
From a disciplinary perspective, this form of holography is considered to be part of the tradition of drawing, referred to as a "synthetic vision". This is defined as an act of image recomposition through the perception of time and movement.
The perceptual hologram is not a geometric projection; rather, it is a cognitive reconstruction that renders visible the ability of drawing to translate the dynamics of form into visual experience.
The second mode is of a geometric-constructive nature and is distinct in that three dimensionality is not attributed to retinal persistence, but rather to the spatial recomposition of multiple simultaneous projections.
In this instance, holographic reconstruction is based on a principle analogous to that of descriptive projections: a three-dimensional object is represented by four images, placed at the vertices of an optical tetrahedron.
The arrangement of the four views, set at 90° and reflected on semi-transparent surfaces, combines visually at a point of intersection, thereby rendering an actual spatial configuration.
In this case, the hologram is not perceived as an imagined figure, but as a real geometric figure in space, generated by the convergence of orthogonal or perspective projections.
The methodological shift is of pivotal significance: we transition from the act of projection to that of object, from the drawing that serves as a representation of form to the image that meticulously reconstructs it.
From a disciplinary perspective, this signifies that holography transcends its traditional role as a mere advanced form of representation, instead emerging as a three-dimensional synthesis of projections. This assertion positions it as a significant model within the broader history of theories of vision and the construction of space.
The distinction between perceptual and constructive holography provides a methodological framework for interpreting drawing as a medium that transcends conventional boundaries, thereby facilitating the transition from surface to light, from two-dimensional plane to three-dimensional volume, and from the act of drawing to its representation as an image.
In the initial case, representation is considered to be a perceptual act, whereby form manifests itself in the retinal continuity of movement.
In the second, it is a geometric act: form is generated by the convergence of projections, as in descriptive construction or informative modelling.
The two modes articulate the interdisciplinary and cognitive essence of drawing.
The perceptual hologram is the consequence of the synesthetic and temporal dimension of representation, whereby the image is the result of active vision and a bodily experience of space.
Conversely, the constructive hologram serves to reinvigorate the tenets of descriptive geometry, translating the theory of projections into a dynamic three-dimensional system, wherein sections and shadows metamorphose into planes of light interference.
From this standpoint, holographic representation can be regarded as a novel form of projection and section: light substitutes the line, transparency becomes the plane of intersection, and space itself becomes the support of representation.
The section is no longer a static cut, but rather a field of light crossing; the projection is no longer the reduction of form on the plane, but its expansion in real space.

The configuration of the holographic image as an act of three-dimensional drawing is therefore achieved, resulting in a visual construction that facilitates the establishment of a unified perceptual space for both the observer and the object.

3. DEMATERIALISATION OF CURIONI MODELS (MPV&ER)

The process of surveying and digitising wooden models is part of a research project dedicated to the enhancement and digital preservation of the Curioni Collection. The aim of this project is to define a method for managing and archiving three-dimensional models based on the FAIR principles (Findable, Accessible, Interoperable, Reusable), with a view to ensuring the interoperability, traceability and long-term preservation of digital data [6]. The activity was therefore focused on the documentation and conservation of the artefacts, allowing them to be consulted by the public and enjoyed online, with the aim of creating a virtual museum and transforming them into tools for widespread and participatory knowledge. Digital technologies generate new ways of accessing and relating to cultural heritage, fostering a broader dialogue between people and objects and redefining the way the public engages with collections [7].

The first phase involved three-dimensional scanning of the models using the Polycam Pro application, based on a photogrammetric process that combines high geometric accuracy with an efficient and replicable procedure. The acquisition was carried out through automatic video recording, from which the software extracted sequences of images at regular intervals, processed to generate the point cloud and three-dimensional mesh.

The use of mobile devices and photogrammetry and videogrammetry techniques allows three-dimensional models of good accuracy to be obtained with rapid and automated procedures (Figure 3), thanks to the photogrammetric processing of video frames without the need for complex interventions by the operator [8].

Figure 3: *Visualization of the digital model in a mobile environment.*

For each survey, the maximum detail parameters were set, enabling the "use object masking" option to isolate the model from the support surface and surrounding elements. Uniform lighting and a constant shooting distance ensured the photometric homogeneity necessary for the correct texturing of the model. Once the mesh generation was complete, cleaning and finishing were performed directly within Polycam, using the 'Crop Box' command to remove background residue or unwanted portions and obtain a clean, centred geometry (Figure 4).

This preliminary optimisation phase allowed the digital model to be refined and prepared for the modelling and publication phase. Following cleaning, the files were exported in '.obj' and '.fbx' formats and stored in a dedicated folder structure, which also contained the photographs taken during the survey and the cropped versions. Each model was accompanied by a direct link to the relevant Historical Collection of the Polytechnic University of Turin, so as to create a correspondence between the physical object, its digital replica and the archival documentation.

The subsequent operations were carried out in Rhinoceros 3D, where the meshes were imported to create the support base using the surface extrusion command (Figure 5). The base has a dual function: on the one hand, it closes the lower face, which was not photographed and therefore not reconstructed by the mesh, and on the other hand, it provides a unified dimensional reference for all reproductions.

At this stage, a transparent virtual display case was also added, with a protective and museum enhancement function, as well as a graphic scale indicating the main measurements, useful for restoring the actual proportions of the artefact.

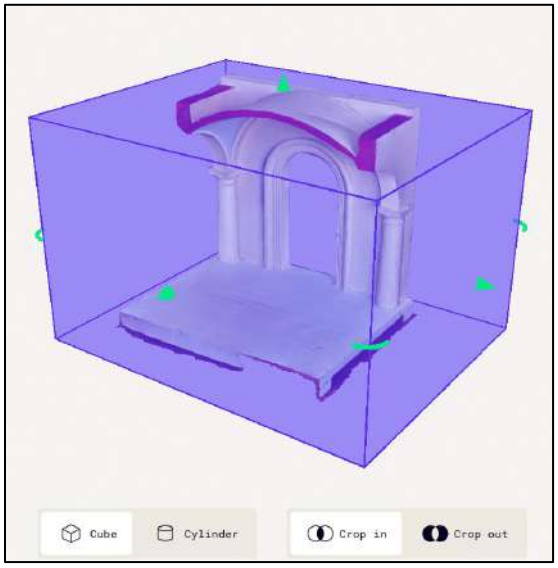

Figure 4: *Visualization of the digital model in Polycam – the "Crop Box".*

Once the complete group, consisting of the wooden model, the base and the display case with measurements, had been defined, it was exported in '.fbx' format, suitable for online publication. The platform chosen for dissemination was Sketchfab, which allows interactive three-dimensional models to be viewed directly from a browser, while maintaining textures and geometric information (Figure 6).

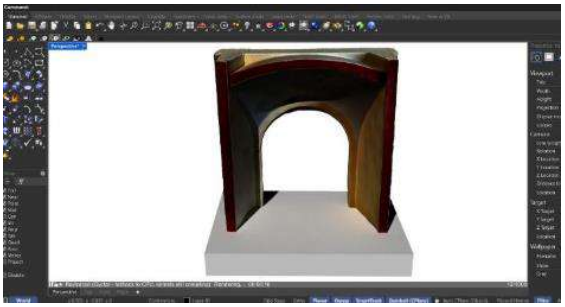

Figure 5: *Visualization of the digital model in Rhinoceros 3D.*

After uploading, the models underwent a visual optimisation process, which included adjusting the lighting, colouring the base and creating descriptive annotations using interactive labels containing technical information, high-resolution photographs and direct links to the Politecnico's Historical Collections website. The integrated annotations make the model not only a three-dimensional object, but also a real information support, through which it is possible to combine spatial representation with the consultation of detailed data and images.

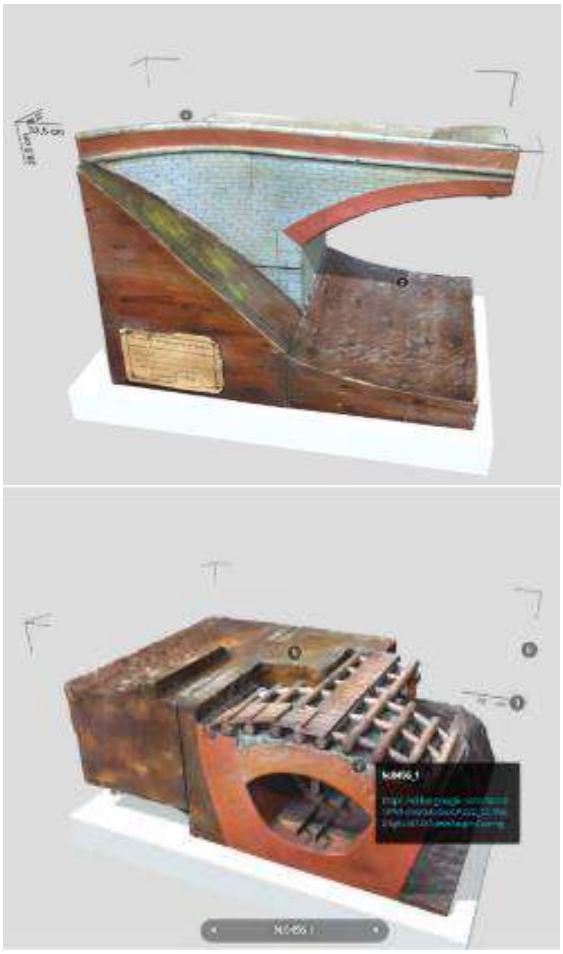

Figure 6: *Visualization of the digital model in Sketchfab.*

The publication of Curioni's models on open platforms such as Sketchfab can be interpreted as a form of distributed digital archive, in which visual documentation, descriptive metadata and provenance information help to ensure the authenticity, traceability and scientific accessibility of the digitised heritage, prolonging its usability and cognitive function over time [9].

Following online publication, the digitisation project was extended to include three-dimensional holographic visualisation using a 3DHologramFan, a device based on high-speed rotating LEDs capable of generating images suspended in space with a depth effect. After modelling and publication, an orbital video was created with the model rotating around its own axis, useful for representing the object in 360 degrees. This video was imported into the SpinDisplay application, software dedicated to managing the contents of the holographic fan, which allows for its synchronisation and projection in real space. In this way, the collection has become not only a digital archive, but also accessible to the public through a visual and interactive installation capable of rendering

the three-dimensional perception of the model and projecting it in holographic form.

4. OUTCOMES, IMPACT AND PROSPECTS (MMB)

The project's methodological elements are characterised by a diversity of skills, ranging from digital representation to diagnostics, documentation to geometric surveying, and information modelling, construction engineering to visual communication [10]. This diversity aligns with the interdisciplinary approach characteristic of the Drawing disciplinar sector, where graphic representation is conceptualised as a scientific, cognitive and communicative language, adept at integrating diverse forms of knowledge into a unified cognitive and representational process. The research has yielded substantial results across multiple domains, establishing a robust and replicable methodological framework for the documentation and enhancement of academic assets [11].

From a scientific perspective, the triangulation between laser scanners, LiDAR and modelling from historical drawings has enabled the comparison of accuracy and survey times, thus establishing a validated protocol that can be transferred to other archives and collections. The incorporation of thermographic investigations has led to the establishment of a novel diagnostic level, thereby demonstrating the potential for drawing to extend to the domain of material and structural knowledge.

From a disciplinary standpoint, the research reinforces the notion of drawing as a dynamic instrument for the acquisition of knowledge and the interpretation of ideas. The dialectic between the digital and the tangible, as evidenced by the transition from modelling to 3D printing, and the reintroduction of wooden models in lessons, demonstrates that representation does not merely substitute for matter; rather, it serves to revitalise its perceptual and cognitive significance. The act of drawing, therefore, becomes a cyclical process: from the real to the digital and back again, in a continuous dialogue between observation and reconstruction.

The experience has resulted in the establishment of an integrated teaching model at educational and cultural levels. This model combines technical knowledge with direct experience of the artefact, thereby facilitating a holistic learning approach. The integration of conventional surveying techniques, digital modelling methodologies and holographic visualisation has been instrumental in cultivating an understanding among students of representation as a critical, measured and interpretative act.

The research on the Curioni Collection, in conjunction with earlier studies of the Mosca Library and the Porcheddu Archive, and ongoing research in the Betta-Bardelli Archive, establishes a cohesive trajectory. In this trajectory, the act of drawing is recognised as a medium for the transmission of knowledge and as an integral component of the disciplinary infrastructure that underpins technical and scientific heritage. Representation, in its complete cycle from the real to the virtual and back again, becomes the locus where science, culture and memory meet, thus restoring drawing to its original function as a tool for understanding and transmitting knowledge. It is evident that, through these experiments, design reaffirms its ability to adapt to contemporary languages of representation, while maintaining its epistemic nature. Drawing, as a discipline, is one that, while transforming its tools, continues to deal with the relationship between space, vision and knowledge.

Holography, in its various forms, thus becomes the contemporary heir to projection and section, not as a substitute for descriptive geometry, but as its luminous and perceptive evolution, capable of translating the theory of drawing into the logic of light and vision.

The digitisation of the Curioni Collection has enabled the development of a methodological model that integrates the precision of surveying, the geometric consistency of modelling, and the communicative power of digital representation. The transition from documentation to interaction — from 3D surveying to holographic projection — marks an evolution of drawing as a cognitive language capable of extending from the represented space to the perceived space (Figure 7).

Representation is no longer regarded as a closed product (as it seems in archives and collections), but rather as a shared process, in which the digital model becomes a node in an information network that can be consulted, commented on and reproduced.

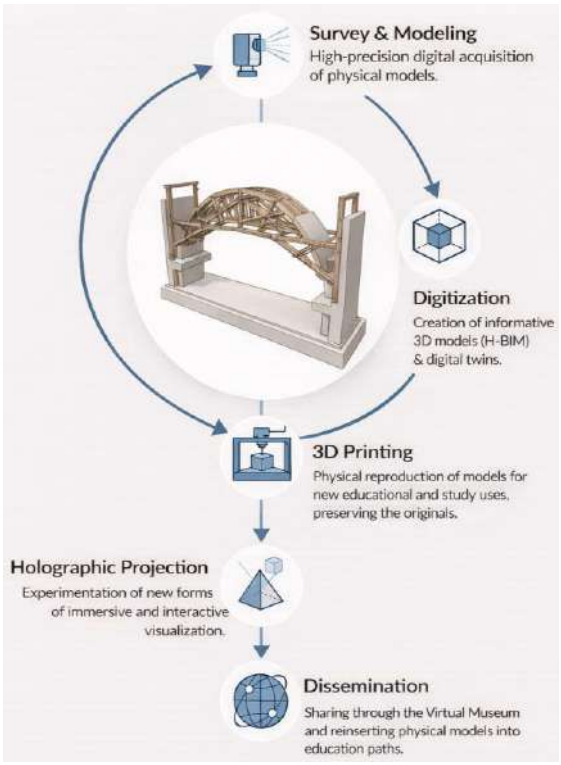

***Figure 7**: An operating system for heritage valorization has been developed to manage analog models into modern communications tools. This cyclical process connects tangible memory with digital innovation.*

***Figure 8:** Example of a model of a complete suit of armour, known as suspended armour, with wooden fittings (Modello di una armatura completa, detta sospesa con ferramenta in legno), 40x76x20 cm, Inv. 47 (1865-1887, DISEG); A –original wooden model; B - 3D printed model; C – holographic model; D – polycam model; E – sketchfab model).*

The utilisation of cost-effective technologies and open platforms, such as Sketchfab, has rendered models accessible and interoperable, thereby translating the FAIR principles into an operational paradigm of openness and traceability (Figure 8).

This finding serves to substantiate the assertion that drawing functions as a conceptual instrument, serving both as a conduit for comprehending form and, concomitantly, as a medium for the edification of knowledge surrounding it. Experimentation with holographic projection has engendered a novel paradigm in the realm of disciplinary reflection in this applied research.

This experimentation serves to restore the original function of drawing as an instrument of integral knowledge, capable of mediating between sensory experience and theoretical construction.

In terms of future prospects, the project offers a replicable model for the construction of dynamic digital archives and interactive virtual museums. In such a scenario, three-dimensional and holographic representation would become a common language of access, study and dissemination.

The Curioni Collection provides a compelling illustration of how the digitisation process, guided by the meticulous delineation of drawings, can not only accurately restore the physical form of models but also their original function as instruments for thought, comprehension and the dissemination of knowledge, in this case pertaining art of construction.

5. ACKNOWLEDGMENT

The working group involved in the project to enhance and digitise the Curioni Collection is composed of a diverse set of skills and disciplinary profiles from different areas of academic research. It brings together figures from the sciences of representation, surveying and construction, creating a cross-sector collaboration that has made it possible to integrate different methods, tools and objectives into a unified research framework:

Scientific responsibility and coordination: Maurizio Marco Bocconcino; coordination (surveying and modelling): Mariapaola Vozzola; coordination (historical research and educational applications): Martino Pavignano; Ursula Zich, for educational aspects; Marco Piras and Paolo Dabove, for geomatics and measurement skills; Professor Mauro Borri Brunetto, for construction sciences; architect Margherita Bongiovanni and Dr Francesca Gervasio, for activities related to the University's cultural and scientific heritage; engineer Nives Grasso and DISEG technician

Pierluigi Guarrera, for support with acquisitions and metric processing; engineers Luca Gioberti, Federica Bonino, Larisa Semis, Tommaso Verdier, Muhammad Daud, José Luis Reyes Mesias, for assistance with surveying and modelling; junior engineers Emanuele Ricchiello, Roberto Cagliero and architect Salvatore Tartaglia, involved in acquisition, information retrieval and experimentation with three-dimensional and holographic models. The group is also collaborating with the thermographic analysis team coordinated by Monica Volinia, in recent cooperation with the CNR in Padua, for non-invasive diagnostic investigations on wooden models.

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