

IL DISEGNO FURIOSO FURIOUS DRAWING

47° CONVEGNO INTERNAZIONALE
DEI DOCENTI DELLE DISCIPLINE DELLA RAPPRESENTAZIONE
CONGRESSO DELLA UNIONE ITALIANA PER IL DISEGNO
ATTI 2026

47° INTERNATIONAL CONFERENCE
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a cura di

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Marcello Balzani, Manuela Incerti, Federica Maietti, Luca Rossato, Fabiana Raco

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IL DISEGNO FURIOSO FURIOUS DRAWING

47° Convegno Internazionale dei Docenti delle Discipline della Rappresentazione
Congresso per la Unione Italiana per il Disegno
47° International Conference of Representation Disciplines Teachers
Congress of Unione Italiana per il Disegno

Ferrara | 10 - 11 - 12 settembre 2026
Ferrara | September 10th - 11th - 12th 2026

a cura di / curated by
Marcello Balzani, Manuela Incerti, Federica Maietti, Luca Rossato, Fabiana Raco

Isbn e-book Open Access: 9791282811040

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PART II

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Focus 1 | Visible and invisible (The castle of Atlante)

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Indice Index

PARTE II PART II

Focus I | Visibile e invisibile (il castello di Atlante) Focus I | Visible and invisible (the castle of Atlante)

7

Gaia Leandri

Lines of enchantment and disenchantment

19

Manuela Piscitelli

La narrazione visiva del Furioso nelle illustrazioni di Gustave Doré

The Visual Narrative of the Furioso in the Illustrations of Gustave Doré

43

Cristina Cándito

Delirio di possesso e di occultamento nell'opera di Dorothea Tanning

Delirium of possession and concealment in the artwork of Dorothea Tanning

63

Alessia Segalerba

La Promenade di Atlante. L'anamorfose come dispositivo di rivelazione spaziale

The Promenade of Atlante. Anamorphosis as a spatial detection device

83

Sara Peña Fernández, Carlos Montes Serrano

The Impatient Drawing: Mies van der Rohe's Project Drawings

93

Francesco Cotana

La Galleria delle Carceri alla Scarzuola di Tomaso Buzzì. La prospettiva accelerata 'doppia' come dispositivo simbolico e percettivo

Representing the sound: toward an Expanded Perceptual Framework for Architectural Drawing

121

Adriana Caldarone, Carlos Campos, Martina Empler, Tommaso Empler, Pasquale

Micelli, Silvia Ridolfi

Rappresentare il suono. Per una estensione percettiva del disegno architettonico

Representing the sound: toward an Expanded Perceptual Framework for Architectural Drawing

145

Valeria Menchetelli

"Fingendo la sua imago". L'allucinazione nella cultura visuale

"Fingendo la sua imago". Hallucination in visual culture

173

Adriana Arena

Strategie di disegno e modelli di rappresentazione nelle xilografie dell'Orlando Furioso di Vincenzo Valgrisi

Drawing strategies and representation models in Vincenzo Valgrisi's woodcuts for the Orlando Furioso

193

Vincenzo Cirillo, Domenico Iovane, Rosina Iaderosa

Furia fra segno e significato. La geometria dei simboli Adinkra come significato di pensiero

Fury Between Sign and Meaning. The Geometry of Adinkra Symbols as a Language of Thought

213

Luiza Paes de Barros C. L. Beltrami, Ana Tagliari

Il dialogo tra schizzi e testi esplicativi nell'architettura di Decio Tozzi

Dialogues between sketches and explanatory texts in Decio Tozzi architecture

231

Edoardo Dotto, Fabio Quici

La distanza necessaria. Derealizzazione come dispositivo critico

The Necessary Distance: Derealization as a Critical Device

255

Alexandra Castro, José Pedro Sousa, João Pedro Xavier

Dentro la scatola: reinterpretare la scatola prospettica con strumenti digitali nella didattica dell'architettura

Inside the box: Reinterpreting the Perspective Box with Digital Tools in Architectural Education

277

Raquel Álvarez Arce, María Lucia Balboa Domínguez, Pablo Llamazares Blanco

El dibujo insistente. Carlo Scarpa y el pabellón de la meditación en la tumba Brion

The insistent drawing. Carlo Scarpa and the meditation pavilion in the Brion Tomb

293

Giorgio Garzino, Maurizio Marco Bocconino, Mariapaola Vazzola, Larisa Semis

Rappresentare l'invisibile: il disegno come strumento di sintesi per l'edilizia ospedaliera

Representing the invisible: drawing as a synthesis tool for hospital building design

313

Anna Golikova, Francesco Bergamo, Luigi Latini, Michele Tobia, Luca Zilio

[Un]seen Sound. A sonic investigation and project for the Sile river landscape

323

Caterina Morganti, Cristiana Bartolomei

Figure del Furioso. La rappresentazione pittorica dell'Orlando Furioso tra visibile e invisibile

Figures of the Furioso. The pictorial representation of the Orlando Furioso between the visible and the invisible

347

Starlight Vattano

Guerriere, incantatrici e amazzoni: visualità protofemministe

Warriors, enchantresses and Amazons: proto-feminist imagery

367

Marialuisa Landolfi

La furia di un dente di leone nella leggiadria del volo di un soffione

The fury of a dandelion in the graceful flight of a puffball

383

Pablo Cendón-Segovia, Noelia Galván Desvaux, Álvaro Moral García

Silver Lake: dal progetto al disegno

Silver Lake: from project to drawing

399

Barbara E. A. Piga, Gabriele Stancato, Nicola Rainisio, Marco Boffi

Spatial and 3D Representations of Urban Experience: Integrating Emotional Responses and Thermal Stress in Urban Space

411

Cecilia Maria Roberta Luschi, Novella Lecci, Alessandra Vezzi, Marta Zerbini

Disegno dell'onirico per la torre di Siedlęcin (PL): il progetto LANCE-LOT

A dreamlike drawing for the tower in Siedlęcin, Poland: the LANCE-LOT project

435

Fabrizio Banfi, Sara Prometti, Alberta Cazzani, Marco Pela, Jacopo Alberto Bonini,

Antonio de Trizio

Hybrid Heritage Spaces: HBIM, Embodiment, Human-Centric WebVR, and Accessibility in Browser-Based 3D Game Engines

445

Giancarlo Sanna, Andrea Pirinu

Il progetto dell'invisibilità: analisi grafica del camouflage nei bunker della WWII in Sardegna

The Project of Invisibility: Graphic Analysis of Camouflage in WWII Bunkers in Sardinia

469

Marco Fasola, Elisa Guarino, Flavia Camagni

Dare forma all'illusione: le finestre prospettiche di Palazzo Barberini

Shaping the illusion: the perspective windows of Palazzo Barberini

492

Ángel Allepuz Pedreño, Carlos L. Marcos

Are Borromini's Drawings Furious?

503

Pierpaolo D'Agostino

La teoria espressa nel tratto grafico. L'esempio di Claude Parent
Theory expressed through graphic form. The example of Claude Parent

519

Gjergj Islami, Denada Veizaj, Blerina Tabaku, Saimira Arapi, Edmond Pergega, Gianluca Gioioso, Andrea Maliqari, Luigi Corniello
Furious Drawing and Architectures of the Invisible: Maki Vello between Political Constraint and Graphic Necessity

529

Alessio Cardaci, Pietro Azzola

Le nuvole di punti come disegno concettuale: analisi differenziale e campi derivativi tra visibile e invisibile
Point clouds as conceptual drawing: differential analysis and derived fields between the visible and the invisible

557

Marco Saccucci, Giuseppe Staffieri, Assunta Pelliccio

La rovina come "archivio rovescio". Rilievo integrato e interpretazione critica del caso di Roccaravindola
The Ruin as an "Inverted Archive". Integrated Surveying and Critical Interpretation of the Roccaravindola Case

573

Francesca Maria Ugliotti

Cartografie del disorientamento: il Disegno Furioso tra mappe instabili e progetto contemporaneo.
Cartographies of disorientation: Furious Drawing between unstable maps and contemporary design

597

Francesco Di Paola, Pietro Pedone

Il castello di Atlante come paradigma d'illusione. Prototipo anamorfico riflettente tra digitale e costruzione
The Castle of Atlante as a Paradigm of Illusion. Reflective Anamorphic Prototype between Digital Processes and Construction

617

Veronica Riavis, Alberto Sdegno

Tra malinconia e inquietudine: analisi prospettica, modellazione e comparazione di due abitazioni iconiche dell'immaginario pittorico e cinematografico
Between Melancholy and Unease: Prospective Analysis, Modeling, and Comparison of Two Iconic Dwellings in the Painterly and Cinematic Imaginary

637

Laura Carlevaris

Il modello furioso: la bambola di Alma Mahler tra Modello e Analog Twin
The Enraged Model: Alma Mahler's Doll between Model and Analog Twin

657

Martina Suppa, Gabriele Giau, Guido Galvani

Morfologie corporee e dinamiche della moltitudine
Bodily morphologies and dynamics of multitude

671

Giulia Lazzaretto

Svelare nuove relazioni formali: il progetto Vitra Fire Station di Zaha Hadid
Unveiling new formal relationships: Zaha Hadid's Vitra Fire Station project

691

Fabiana Carbonari, Emanuela Chiovoni, Eduardo Gentile, Fernando Gandolfi, Ana Ottavianelli
La Fiat, veloce e furiosa. Torre Mirafiori a Buenos Aires, 1961/64
Fiat, Fast and Furious. Torre Mirafiori in Buenos Aires, 1961-64

709

Alessandro Luigini

Come fuggire dal Castello di Atlante. Rappresentazione architettonica e finzione negli albi illustrati
How to Escape from Atlante's Castle. Architectural Representation and Fiction in Picturebooks

737

Marta Magagnini, Nicolò Sardo

Tra visibile e visionario: la fotografia di Ico Parisi, dal Razionalismo all'Utopia
Between the visible and the visionary: the photography of Ico Parisi, from Rationalism to Utopia

765

Caterina Palestini, Laura Farroni, Alessandro Basso, Matteo Flavio Mancini

Il disegno illusorio degli apparati effimeri, dalle immagini d'archivio alla rappresentazione AI
The Illusory Drawing of Ephemeral Systems, from Archival Images to AI Representations

789

Elena Ippoliti, Noemi Tomasella, Martina Tagliaferri

Geografie selettive. Visibile e invisibile nelle carte portolaniche medievali
Selective Geographies. Visibility and Invisibility in Medieval Portolan Charts

817

Francesco Maggio, Alessandra Ferro

Unbuilt. Un progetto per Palermo
Unbuilt. A project for Palermo

841

Carlo Biagini, Andrea Bongini, Valerio D'Andrea

From digital survey to structural analysis via H-BIM: the case study of the "Sagrestia Nuova" in the monumental complex of San Lorenzo in Florence

853

Lucrezia Di Marzio, Valeria Fiordimalva

Attraverso lo spazio immaginato da Hans Vredeman de Vries: una proposta di indagine del trattato Perspective
Inside the imagined space of Hans Vredeman de Vries: a proposed investigation on the Perspective treatise

875

Barbara Messina, Salvatore Barba

Disegnare l'invisibile. Il "furioso" come paradigma nelle ricerche di Vito Cardone sulla rappresentazione dell'immateriale
Visualising the Invisible. The 'Furioso' Paradigm in Vito Cardone's Research on Immaterial Representation

895

Luca Martelli

La rappresentazione dell'equilibrio nella Statica grafica, tra segmenti orientati e reciprocità
Representation of equilibrium in Graphical Statics, between oriented line segments and reciprocity

919

Sandro Parrinello, Giovanni Pancani, Alberto Pettineo

Traiettorie riflesse tra Oriente e Occidente nella Fortezza di Kenitra in Marocco
Crossing Paths between East and West at the Fortress of Kenitra, Morocco

Hybrid Heritage Spaces: HBIM, Embodiment, Human-Centric WebVR, and Accessibility in Browser-Based 3D Game Engines

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Abstract

This contribution is situated within the contemporary debate of UID research, offering a critical reflection on the role of digital representation of built heritage as an integrative and complementary device to the traditional museum, with particular reference to heritage conservation and virtual heritage. In response to the growing need to expand accessibility, narrative quality, and public engagement, the paper investigates the use of browser-based 3D game engines and cloud-oriented platforms to design interactive environments that support on-site experiences and extend them into the virtual domain. The originality of the contribution lies in shifting the focus from traditional immersive VR toward WebVR solutions conceived as cognitive, narrative, and interactive spaces, accessible both on-site and remotely. Within this framework, survey data and heritage building information modeling (HBIM) are not merely technical supports but infrastructures of memory and storytelling, enabling advanced forms of heritage communication such as virtual museums and digital exploratory paths. The case study of Villa Arconati demonstrates how survey and information modelling can act as design tools for developing interactive experiences oriented toward spatial understanding and the reactivation of place memory.

Keywords

Representation, Hybrid Heritage Spaces, Game Engine, Virtual heritage, Embodiment.



Design immersive interactive environments that elevate on-site experiences and seamlessly extend them into the virtual realm, forging meaningful connections between physical and digital worlds.

*"Non è sì vago il giardin di Ciprigna,
né quel d'Adone, ove si finge Amore,
come quel ch'a Ruggier la maga indegna
fece veder con tanto alto splendore.
Quivi tutto ciò ch'occhio umano alligna
par che natura e 'l ciel vi metta onore:
ma sotto finto e simulato aspetto
si cela spesso inganno e gran difetto."*

Ludovico Ariosto, Orlando Furioso, VII, 31.

Introduction

The progressive integration of digital technologies into the processes of studying, documenting, and enhancing built heritage has redefined the role of the Science of Representation, expanding its disciplinary scope beyond the traditional boundaries of drawing. In this context, representation assumes an inseparable role in both the cognitive and design processes, configuring itself not as a mere graphic outcome but as an ontological and critical device capable of mediating among survey, information modelling, and the construction of meaning within a shared cultural framework. Within this framework, the main research challenge addressed by this contribution is to define a clear, replicable methodological workflow that connects survey data, HBIM models, and WebVR environments, overcoming the current fragmentation between data production and user experience design, within a broader perspective that intersects digital representation with heritage conservation practices and virtual heritage approaches.

The development of VR and WebVR interactive environments for cultural heritage is situated within this theoretical framework and requires an approach that balances technological development, experience design, and representational culture. These environments cannot be understood as simple digital products, but rather as cognitive and narrative spaces in which an osmosis among data, models, and hermeneutic interpretation occurs, oriented toward the communication and understanding of heritage. In this sense, the paper does not limit itself to presenting a digital application but aims to demonstrate the process that generates it, explicitly defining the relationships between representation, data structuring, and interactive experience. The design of such digital spaces requires attention to proxemics, which Edward T. Hall defines as the study of spatial relationships among individuals, objects, and the environment [Banfi, de Trizio 2026; Hall 1963].

Its transposition into the virtual domain introduces digital proxemics, which governs interaction, orientation, and use within VR and WebVR environments. In this context, distance, scale, and spatial hierarchy serve as representational elements that influence narrative construction and the interpretation of heritage. Similarly, degrees of freedom [Lim, Lee 2024] constitute a key design parameter, shaping the user's cognitive experience and relationship with digital space. Their integration with proxemics and game engine logic enables the design of guided environments that support progressive knowledge acquisition, avoiding both self-referential spectacle and loss of scientific rigor.

From this perspective, browser-based 3D game engines and cloud platforms are interpreted not as replacements, but as coherent extensions of traditional representational practices [Banfi 2023; Lumini 2025]. The contribution specifically investigates how these technologies can be integrated into a scientifically grounded pipeline, clearly identifying input data, transformation processes, and output experiences (fig. 1).

Survey remains the foundation of the knowledge process, while drawing—across its two- and three-dimensional and digital forms—mediates between data and the representation of both visible and invisible aspects of heritage. The contribution adopts the Science of Representation as the theoretical basis for developing WebVR environments and also addresses their potential to support conservation and long-term accessibility. The research investigates the integration of these technologies into a scientifically grounded pipeline that defines input data, transformation processes, and output experiences.

The objective is not technological innovation per se, but the construction of a coherent system for the digital representation and communication of Villa Arconati [Ferrario 1996], capable of conveying both the complexity of the site and the interpretative depth of the process from survey to narrative. Virtual fruition is conceived as a complementary mode of access, fostering inclusive and conscious engagement with heritage. The expected outcome is a structured and transferable methodology applicable beyond the specific case study.

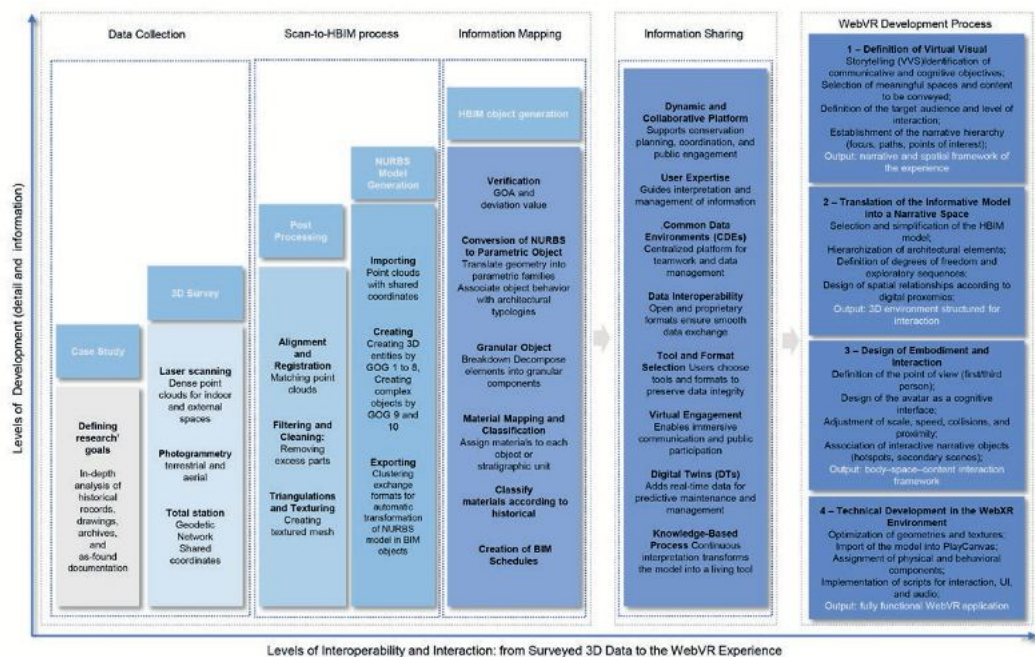


Fig. 1. Methodological approach: from survey data to the development of a WebVR environment
Graphic elaboration by F.B.

From survey to the interactive environment: documentation, model, and experience construction

Within the framework of the Science of Representation, architectural survey is understood as a foundational practice of the knowledge process, through which built space is observed, interpreted, and made communicable.

The integration of digital technologies has expanded this field by complementing traditional methods with advanced data acquisition techniques—such as laser scanning, photogrammetry, and topographic surveying—while preserving its critical and ontological role, in which measurement serves as an instrument for interpreting spatial, temporal, and symbolic stratifications. In this context, the Villa Arconati case study is adopted as an experimental testbed to validate the proposed methodological approach.

The seventeenth-century complex, located near Milan and known as the ‘Little Versailles’, is characterised by richly decorated interiors and extensive historic gardens, relevant not only from a compositional perspective but also for heritage conservation. As a complex architectural palimpsest, the site provides a meaningful context for experimentation in survey and representation. Here, the survey is conceived as an extended cognitive act that integrates material, spatial, historical, and immaterial information.

Point clouds, photogrammetric outputs, and the HBIM model are thus understood not merely as technical datasets, but as digital archives of memory and cultural matrices in which architectural transformations and perceptual relationships are embedded (fig. 2).

In an initial phase, the research led to the construction of the HBIM model and the

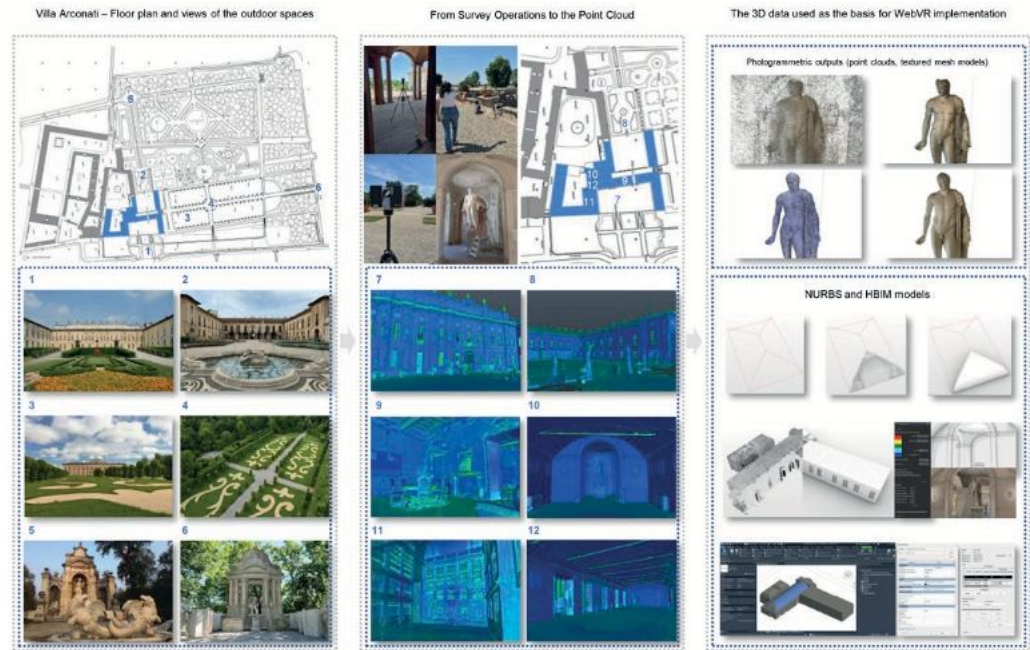


Fig. 2. Villa Arconati and its interior and exterior spaces: from laser scanning, topographic, and photogrammetric survey operations to the registration and post-processing of point clouds, photogrammetric mesh models, NURBS, and HBIM models. Photos and elaboration by F. B.

development of traditional VR environments accessible via head-mounted displays [Banfi, Cazzani, Liu 2025]. The present contribution represents a subsequent stage, based on further data acquisition and methodological refinement, shifting the focus toward interactive environments developed with browser-based 3D game engines and web-oriented technologies, designed for accessibility and scalability (fig. 2). In this context, the HBIM model evolves from a tool for specialist consultation into an experiential space that serves as a narrative and cognitive infrastructure. Drawing—across its two- and three-dimensional and digital forms—functions as a hermeneutic device, translating metric data into semantically structured models that convey both visible and invisible aspects of heritage, including latent geometries and historical stratifications. The transition to WebVR required data optimisation

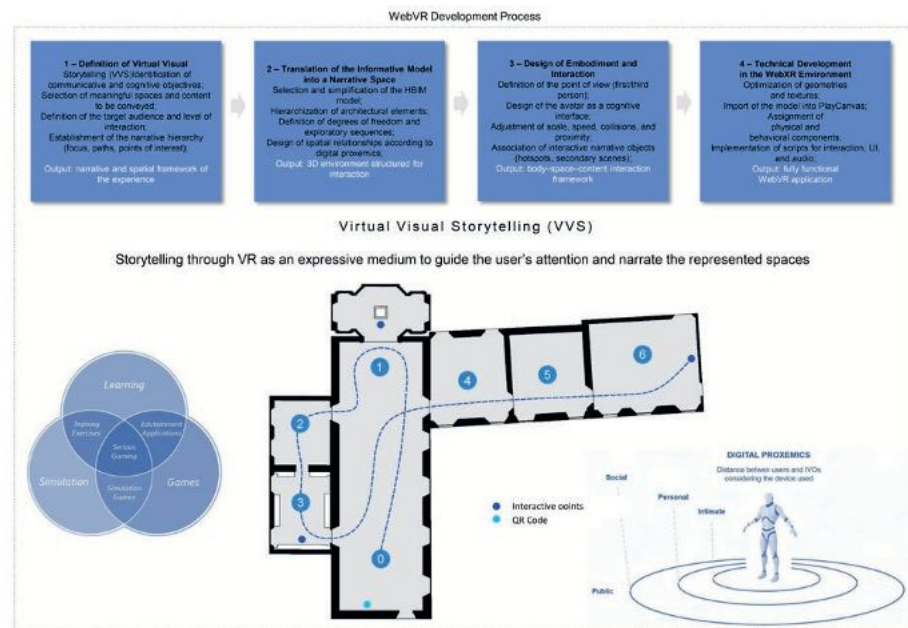


Fig. 2. Villa Arconati and its interior and exterior spaces: from laser scanning, topographic, and photogrammetric survey operations to the registration and post-processing of point clouds, photogrammetric mesh models, NURBS, and HBIM models. Photos and elaboration by F. B.

and reinterpretation to preserve semantic integrity while reducing computational complexity. The Villa Arconati environment is thus designed as an interactive experience, where paths, viewpoints, and informational nodes integrate historical and architectural knowledge, enabling exploration both on-site and remotely. The digital environment becomes a cognitive space in which survey data—mediated by drawing and enhanced through WebVR—extends the knowledge process. As outlined in the methodological framework (fig. 3), development follows a structured sequence integrating narrative, spatial, and interactive dimensions. Virtual Visual Storytelling (VVS) defines objectives, users, and interaction levels, guiding the experience from free exploration to a conscious and structured one.

Experience Design: Degrees of Freedom, Digital Proxemics, and Embodiment

The transition from the informational environment to the interactive one required a theoretical and design advancement in which the user experience becomes an integral part of the representational process. Within this framework, the concepts of degrees of freedom [Chandrasekera, Fernando, Puig 2019] and digital proxemics [Williamson et al. 2022] assume a central role not as merely technical parameters, but as disciplinary categories through which to govern the relationship between space, body, and knowledge within VR and WebVR environments [Mueller et al. 2014]. Degrees of freedom, understood as the set of possibilities for movement, orientation, and interaction granted to the user, constitute a structural component of experience design. Their definition directly affects the construction of meaning and the modes of reading the represented space: expanding, limiting, or guiding degrees of freedom corresponds to an act of drawing, through which spatial hierarchies, perceptual sequences, and levels of cognitive depth are established. In WebVR environments, browser-based access and the absence of dedicated immersive devices make such control particularly important for ensuring orientation, legibility, and experiential continuity. In this research, degrees of freedom were systematically tested and calibrated to balance user autonomy and guided exploration, defining precise interaction scenarios that avoid both disorientation and over-constraint.

In parallel, digital proxemics provides an advanced interpretative key for designing spatial relationships in virtual environments. Its application was operationalized through the design of interaction distances, trigger zones, and view-dependent content activation, making proxemics a measurable and implementable design parameter. Drawing on Edward T. Hall's definition of proxemics, space is understood as a relational system in which distance, proximity, scale, and orientation influence users' perceptions and behaviours.

The transposition of these principles into the digital domain enables the design of environments in which position, field of view, and approach to heritage elements become devices for content activation and narrative construction. Within this framework lies the issue of embodiment in digital experience through the avatar, understood not as a graphic or playful element, but as a design device and cognitive interface.

The avatar was designed not only as a visual element but also as a control interface, with specific parameters (speed, height, camera offset) defined to ensure consistency between human scale and digital space.

In developed WebVR environments—and particularly in the PlayCanvas application—the avatar serves as the symbolic and operational translation of the user's body into digital space. Its design influences perceptions of scale, orientation, and modes of interaction by regulating proximity, movement speed, viewpoints, and access conditions to information. The choice of a third-person configuration allows for a stable visual relationship between user and space, reducing disorientation and fostering a conscious reading of the architecture and its spatial relationships (figg. 4, 5).

In the case of Villa Arconati, the integration of degrees of freedom, digital proxemics, and the avatar enabled the translation of the information model into an experiential environment structured around the logic of progressive discovery. The resulting environment demonstrates how these parameters directly influence user behaviour and information access, providing evidence that experience design variables can serve as representational

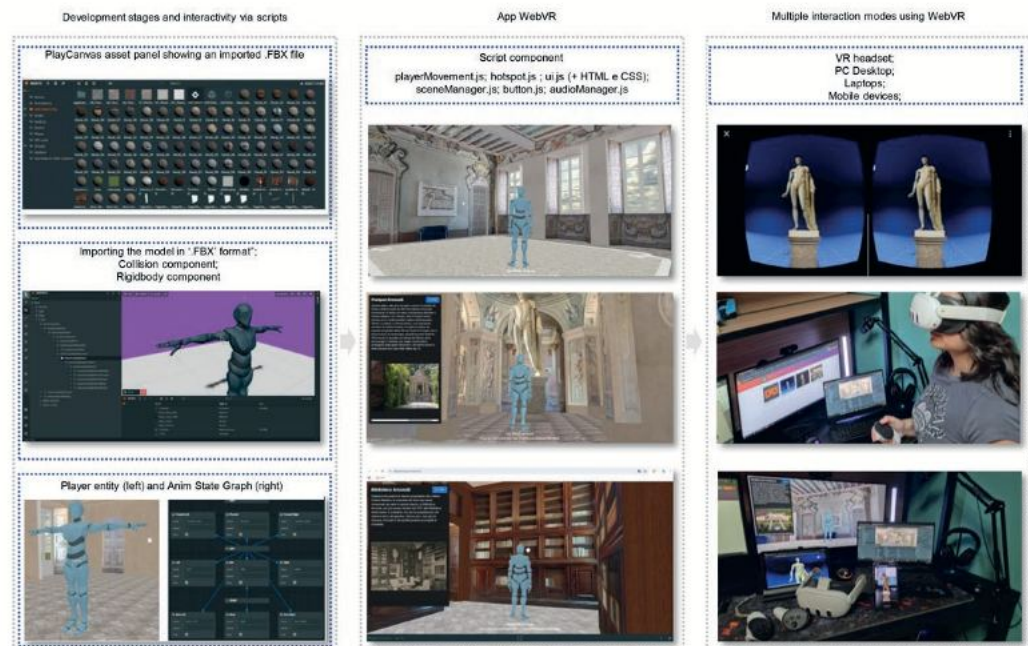


Fig. 4. Development stages and script-based interactivity, the developed WebVR application, and multiple interaction modes in WebVR. Elaboration by F.B. and S.P.

tools rather than mere technical settings. Content is activated based on the user's position and path, conveying the spatial complexity of the heritage without causing informational overload, while maintaining a balance between exploratory freedom and interpretative guidance. From this perspective, the design of the interactive experience is configured as a natural extension of the representational project. Degrees of freedom, digital proxemics, and the avatar do not simplify representation, but rather expand its interpretative potential, strengthening the relationship between knowledge, experience, and memory of built heritage and confirming the potential of WebVR environments as cognitive, inclusive, and narrative spaces (fig. 6).

Critical Evaluation of the Application and Future Perspectives

The development of the WebVR application based on PlayCanvas enabled, in a real-world context, the assessment of the potential and limitations of browser-based 3D game engines for representing and enhancing cultural heritage. Among the platform's main strengths, its high accessibility stands out, enabling direct use in a web browser without dedicated installations or high-performance hardware, aligning with the objectives of inclusivity, the extended museum, and remote access. The evaluation was conducted through qualitative analysis of performance, accessibility, and user experience, with a focus on the relationship between model complexity and browser-based rendering capabilities.

Another positive aspect concerns the rapid development process and the flexibility offered in managing lightweight three-dimensional environments, implementing interaction logic, and designing the avatar as a mediator of the experience. The application demonstrates that it is possible to maintain a coherent representational framework even under web-based constraints, provided that data optimization and interaction design are carefully controlled. The integration of optimized HBIM-derived models, together with control over degrees of freedom and content activation, enabled the construction of an environment consistent with the principles of the Science of Representation while maintaining a guided, readable user experience. The experimentation, however, also highlighted certain structural limitations stemming from dependence on the web ecosystem and browser performance, which

constrain geometric complexity, large-scale scene management, and the implementation of advanced systems. These limitations highlight the need for a more scalable, engine-oriented approach to future development, especially for large-scale heritage environments. Table 1 presents a comparative synthesis between PlayCanvas and the open-source Godot engine, conceived as a further phase of critical verification of the adopted workflow rather than as a performance-based comparison. In light of these considerations, PlayCanvas proves effective for advanced prototypes and virtual museums oriented toward immediate accessibility, while Godot offers a path for more complex and sustainable future developments. The comparative evaluation is not intended as a conclusive judgment, but as part of an open research

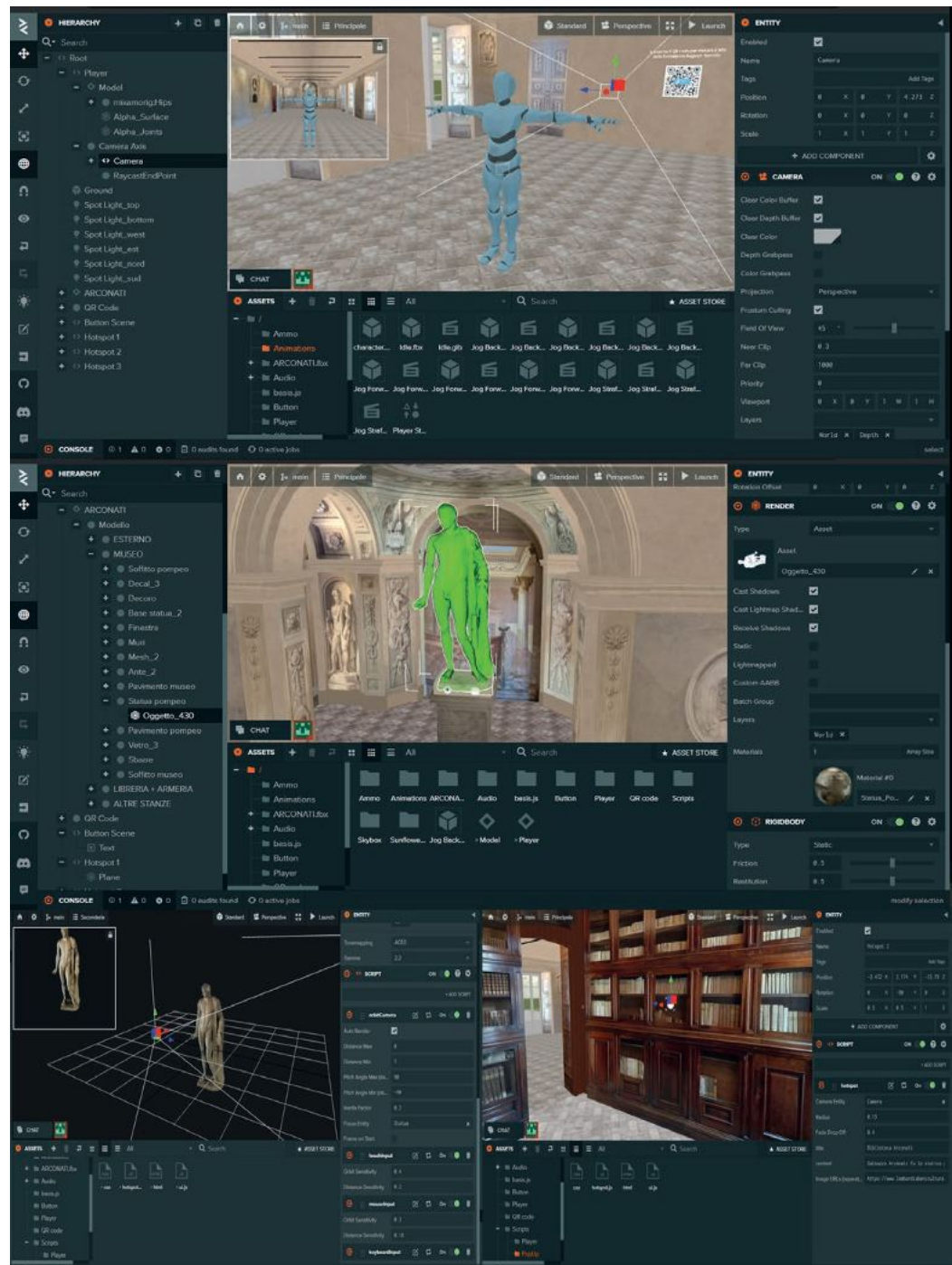


Fig. 5. Development stages and script-based interactivity. Elaboration by F.B. and S.P.

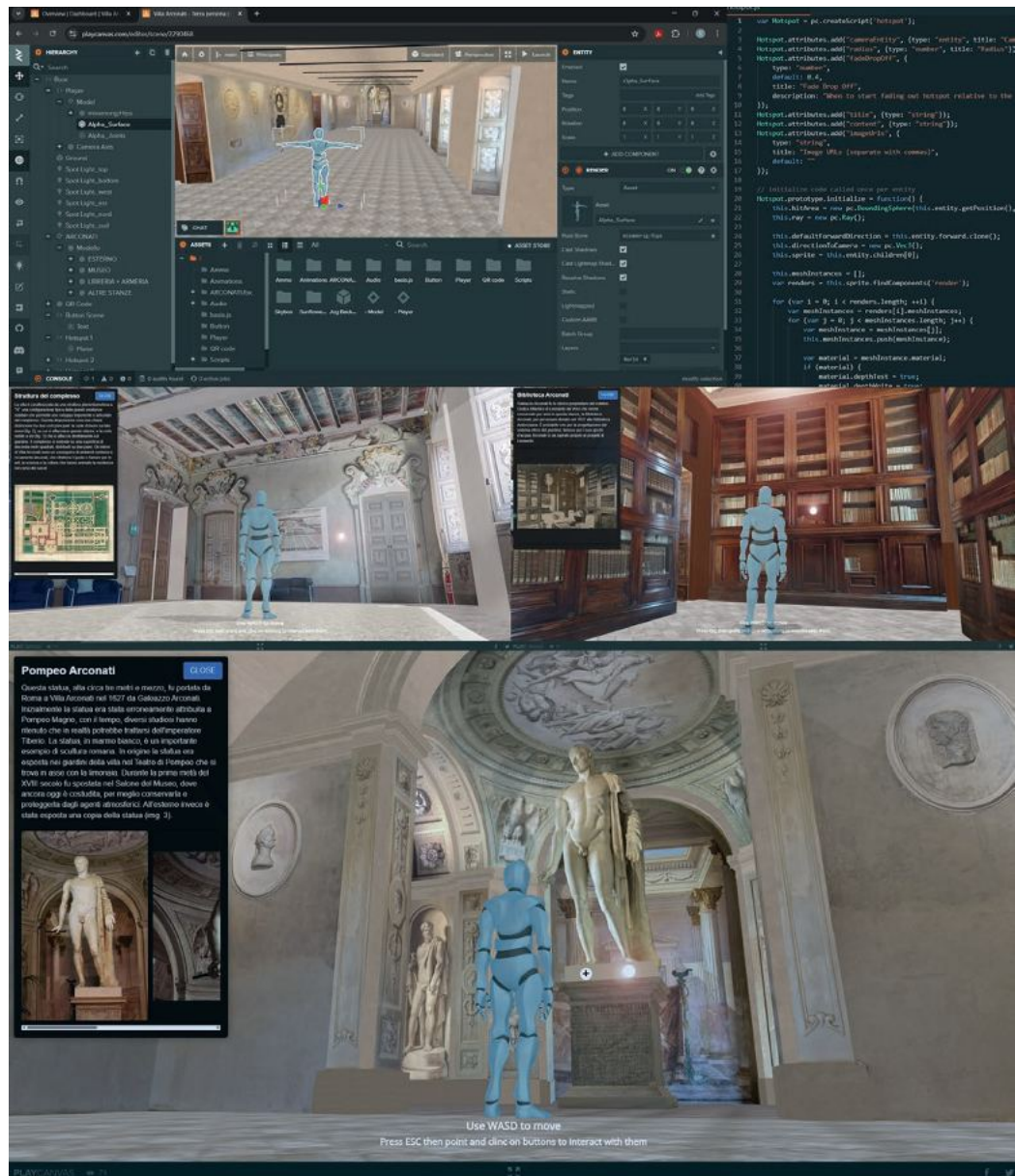


Fig. 6. The WebVR application: from the editor and script to the interactive experience. Interactive point 1 allows visitors to explore the statue of Pompey, accompanied by a brief description of the artwork; interactive point 3 is dedicated to the library; and interactive point 6 is located in the last room, just before entering the inner courtyard of Villa Arconati. Elaboration by by F.B. and S.P.

trajectory aimed at consciously exploring the role of game engines within the theoretical framework of the Science of Representation.

Conclusion

The research confirms that the digitization of built heritage is not a mere technical process but a cultural one, intrinsically linked to the Science of Representation. Survey, drawing, information modelling, and interactive environments form an integrated knowledge process aimed at the critical understanding and reactivation of heritage memory. The main contribution lies in defining a clear, replicable methodological framework that connects survey, HBIM, and WebVR. The Villa Arconati case study validates this workflow, showing how integrated survey data can be translated into HBIM models and accessible WebVR environments. Here, the model acts not as a final output but as a dynamic cognitive and narrative infrastructure, making heritage legible in its spatial and historical complexity. The

shift from immersive VR to browser-based WebVR highlights these tools' potential to balance accessibility and narrative quality, redefining representation as an experience-driven process. Degrees of freedom, digital proxemics, and the avatar emerge as key design components shaping user interaction.

Finally, the evaluation shows that game engines must be selected based on representational goals: PlayCanvas supports accessibility-oriented applications, while Godot offers the potential for more complex development. WebVR environments thus emerge as complementary spaces of knowledge, grounded in a coherent theoretical framework.

Feature / Platform	PlayCanvas	Godot
Runtime Platform	Web browser (WebGL / WebXR)	Desktop, Mobile, Web (HTML5/WebGL), XR devices
Open Source	Yes (MIT core)	Yes (MIT, full engine)
Development Environment	glTF, FBX, OBJ (IFC via conversion)	glTF, FBX, OBJ (IFC via external pipelines)
Model Format Support	Feature / Platform	Feature / Platform
HBIM Compatibility	Yes (indirect, via model con-version)	Yes (indirect, via import pipelines and scripts)
Interactivity & Logic	JavaScript scripting	GDScript / C# scripting
Visual Rendering Quality	Moderate (web-optimized)	Good to high (engine-based rendering)
XR / VR / AR Support	Yes (native WebXR)	Yes (OpenXR support; WebXR via export)
Deployment & Sharing	Yes (instant URL-based access)	Partial (export and hosting required)
Collaboration Tools	Yes (real-time online collaboration)	Partial (external version control needed)
Scripting Language	JavaScript	GDScript, C#
Plugin Ecosystem	Limited but growing	Growing (smaller than Unity, but open-source driven)
Learning Curve	Easy (web-oriented)	Moderate (engine-oriented)
Licensing Model	Free (MIT core) + paid services	Fully free (MIT, no royalties)

Table 1. Comparative analysis of the main editors and development engines for WebVR applications.

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To cite this chapter: Banfi Fabrizio, Prometti Sara, Cazzani Alberta, Pela Marco, Bonini Jacopo Alberto, De Trizio Antonio (2026). Hybrid Heritage Spaces: HBIM, Embodiment, Human-Centric WebVR, and Accessibility in Browser-Based 3D Game Engines. In M. Balzani, M. Incerti, F. Maietti, L. Rossato, F. Raco (Eds.) *Disegno furioso. Atti del 47° Convegno Internazionale dei Docenti delle Discipline della Rappresentazione/Furious Drawing. Proceedings of the 47th International Conference of Representation Disciplines Teachers*. Roma: UID Press, pp. 435-444.