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THREE PARAMETRIC SPACES SHAPED BY AI FOR THE EXTENSION OF THE VIRTUAL MUSEUM OF INTANGIBLE CULTURAL HERITAGE. FROM IDEA TO CODE TO MODEL: RANDOMISATION, HELICOIDAL STRUCTURE, STRANGE ATTRACTOR

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Abstract

In the context of the macro theme of the conservation and exhibition of digital heritage – certified by the 2003 UNESCO Charter –, and specifically of the interdisciplinary studies on the shaping of the Virtual Museum idea – from the historic Virtual Museum commissioned by the Guggenheim Foundation in '99 to Asymptote studio, up to Saul Kim's recent Flappy Box –, we present three new parametric spaces shaped by AI that extend the Virtual Museum of Ephemeral Architecture (VMEA) project that we initiated ten years ago. The research experiments with the integrated use of different representation technocultures, testing an elaborative process that combines AI (from idea to code) with parametric modeling, with the aim of shaping habitable digital spatialities in the Virtual Museum. The essay illustrates the working method tested to shape the geometry of three new exhibition spaces of the VMEA: Randomisation; Helicoidal Structure; Strange Attractor.

Keywords

Virtual Museum Applications, Ephemeral Architecture, Intangible Heritage, Virtual World, IA, Parametric Modelling.

1. *Introduction*

This essay presents the elaborative process experimented to expand the spaces of the Virtual Museum of Ephemeral Architecture (VMEA), founded ten years ago by a group of researchers from the "Digital Representation Laboratory", coordinated by Professors M. Unali and G. Caffio, of the Department of Architecture at the "G. d'Annunzio" University of Chieti and Pescara.

To synthesise the outcomes of the research conducted – the result of a shared elaboration – the contribution has been articulated around three main thematic areas addressed in the study, each treated individually by an author.

The first theme – paragraph *2. The State of the Art of the Virtual Museum of Ephemeral Architecture (VMEA)* – was elaborated by Maurizio Unali, and synthesises the structure of this new phase of research in the context of the project's general programme, analysing the results achieved and highlighting possible developments.

The second topic – par. *3. Generative AI and New Methodologies for 3D Modelling* – was elaborated by Giovanni Caffio, and introduces the potential of AI in the "automatic" conformation of geometries and three-dimensional spaces.

The third topic – par. *4. The Method: From Code to Parametric Model* – was elaborated by Fabio Zollo, and illustrates the elaborative processes adopted (the experimented workflow, the definition of optimised prompts, Python code generation, Grasshopper implementation, etc.) to shape the geometry of the three new spaces that expand the VMEA: randomisation; helicoidal structure; strange attractor.

2. *The State of the Art of the Virtual Museum of Ephemeral Architecture (VMEA)*

As the history of the Virtual Museum (VM) concept demonstrates [1] – from the now-historic Virtual Museum commissioned by the Guggenheim Foundation in '99 to Asymptote

[1] Cfr. www.lineamenta.it/avc22, in M. Unali, G. Caffio (2022). Toward a history of Virtual Living.From Cyberspace to Second Life to the Facebook Metaverse and beyond, in C. Battini, & E. Bistagnino (Ed.), *DIALOGUES visions and visuality. Witnessing Communicating Experimenting*. Milano: Franco Angeli, pp. 205-220.

Architecture, to the Virtual Museum NFTism by Zaha Hadid Architects, to Saul Kim's recent Flappy Box – this theme represents one of the most interesting contemporary design approaches for experimenting with the latest technocultures, testing methods and techniques for shaping digital immersive environments, both online and offline. Since its inception in the 1980s, the interdisciplinary concept of VM, following the technocultural achievements of the times, has explored multiple dimensions of digital space configuration, experimenting with various visualisation systems, semantic models, and different forms of interaction.

When the exhibition theme of the VM is Ephemeral Architecture (Unali, 2010, 2021), the potential energy of the adopted technocultures – used to represent and document immaterial works whilst re-establishing the meaning of their spatiotemporal forms – expands into a kaleidoscope of opportunities. Creative processes emerge that also fit into the solid evolutionary path of representation history, triggering semantic, ideal, utopian and radical projects (among others) that deserve study and historical contextualisation.

Moreover, this is a macro-theme that also concerns the conservation and exhibition of digital heritage, certified by the 2003 UNESCO Charter, and manifested in various subjects, such as that proposed by the exhibition *Archaeology of the Digital*, curated by Greg Lynn in 2013 for the Canadian Centre for Architecture in Montréal.

These topics, only briefly mentioned here, are part of a broader study on the shaping of "Virtual Living" (Unali, 2008, 2014, 2022) which, between research and teaching, has long involved several professors from the Department of Architecture at the "G. d'Annunzio" University of Chieti and Pescara, as previously mentioned in the introduction.

In this general context, we present here the latest outcomes of an ongoing experimentation of three new AI-shaped parametric spaces that extend the Virtual Museum of Ephemeral Architecture (VMEA) project, which we initiated in 2022 (Unali, Caffio & Zollo, 2024). A continuously evolving project, a "post-digital" thematic metaverse (Unali, 2019), in which to experiment, with awareness of today's technocultural potential – especially in the field of AI, VR and AR – network-habitable spaces through avatars.

Specifically, the research presented here experiments with the integrated use of different representation technocultures, testing an elaborative process that combines AI (especially in Python code writing) with parametric modelling, with the aim of shaping habitable digital spatialities in the VM. The intention is thus to reflect on the adopted workflow and the semantic models developed for the expansion of the VMEA, sharing the experimental working method to shape the geometry of its three new exhibition spaces: randomisation; helicoidal; strange attractor.

The map in Fig. 1 shows the state of the art of the VMEA: on the left, in black and white, the VM set up until 2024; on the right, in colour, the 2025 expansion presented here, with its three new exhibition spaces.

In its entirety, the general compositional scheme includes: a main distribution path (called "red carpet"); the informative videowall (an interactive rotating tube) to the left of the path; the thematic islands of exhibition pavilions (to the right of the main path), designed by various authors.

To date, there are 11 exhibition pavilions in the VMEA, built in three time blocks. (Fig. 2)

The first block, called VM5, offers 5 exhibition rooms hosting as many semantic models of ephemeral architecture (Figs. 4-7).

In room I, examples of "Historical Ephemera" have been represented: from Andrea Pozzo's *Sacred Theatre* (1695) to Giovanni Battista Piranesi's *Imaginary Prisons* (Plate VII, 1745).

In room II, historical examples of "1960s Light Shows" have been represented: Thomas Wilfred, *Lumia Suite, Op. 158*, 1963; Mark Boyle and Joan Hills, *Son et Lumière for Earth, Air, Fire & Water*, 1966; The Joshua Light Show, *Liquid Loops*, 1967; Pink Floyd, *14-Hour Technicolor Dream*, Alexandra Palace, London 1967.

In room III, "The EPI Model" has been reconstructed: Andy Warhol, Velvet Underground and Nico, *Exploding Plastic Inevitable*, 1966.

In room IV, an example of "Postmodern Ephemera" has been simulated: Aldo Rossi, *The Theatre of the World*, Venice 1979.

In room V, an example of "Contemporary Urban Ephemera" has been represented, set in Potsdamer Platz in Berlin (from 1990 to 2005): Roger Waters, *The Wall Live in Berlin*, 21 July 1990; Peter Eisenman, *Berlin Memorial to the Murdered Jews of Europe*, 2005.

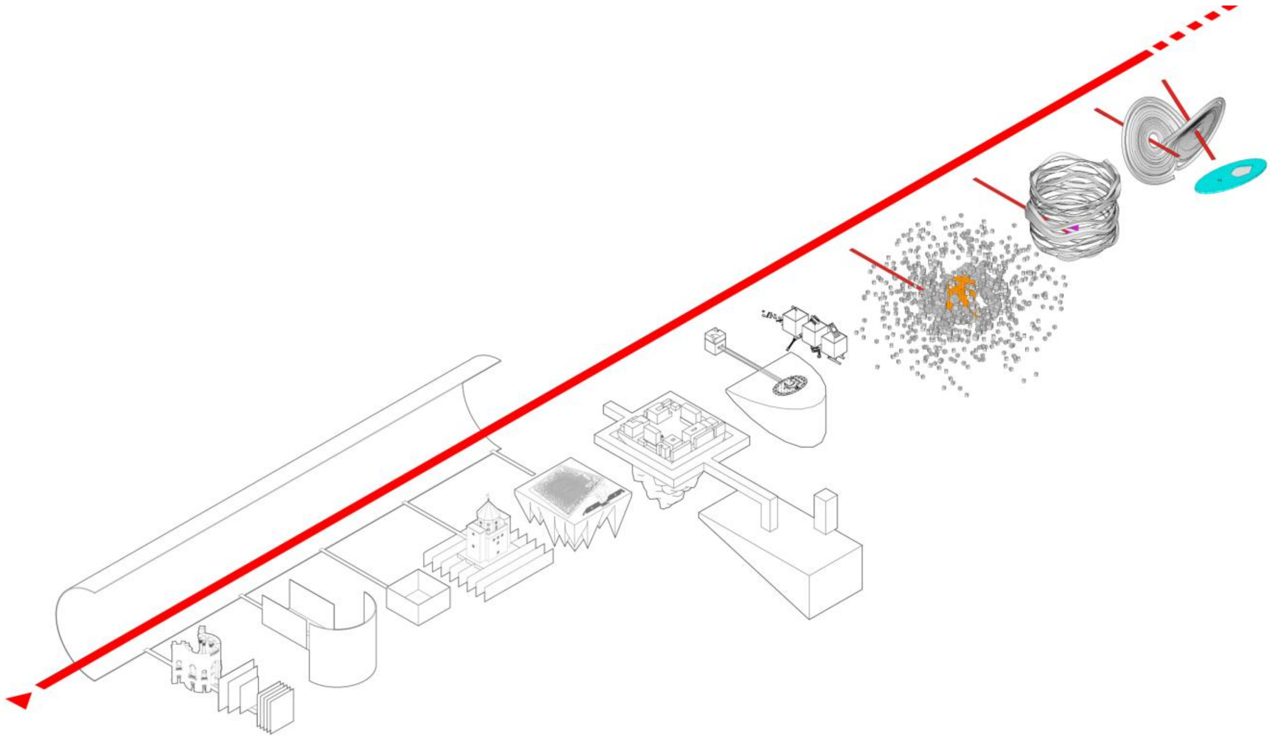


Fig. 1: Map of the state of the art of the Virtual Museum of Ephemeral Architecture (VMEA), developed within the "Digital Representation Laboratory", coordinated by Professors M. Unali and G. Caffio of the Department of Architecture at the "G. d'Annunzio" University of Chieti and Pescara. On the left, in black and white, the VM set up until 2024; on the right, in colour, the 2025 expansion presented here, with its three new exhibition spaces. In its entirety, the general compositional scheme includes: a main distribution path (the red carpet); the informative videowall (a rotating tube to the left of the path); the 11 thematic islands of exhibition pavilions (to the right of the main path).

The second block, VM3, consists of three exhibition rooms.

In room VI, examples of "Urban Ephemera" have been displayed, from Superstudio's idea of *Continuous Monument* (1969-1970) to Toyo Ito's project, *Huge Wine Glass*, installed in Piazza Salotto in Pescara from 2008 to 2013.

In room VII, the theme "Ephemera and Nature" has been explored; specifically, the *Blur Building* project (2002) by Diller-Scofidio has been exhibited.

In room VIII, the theme presented is "Historical vs Contemporary Ephemera", and three spaces have been created using AI (Midjourney), hybridising the works exhibited in pavilions VI and VII with the "style" of some of Giovanni Battista Piranesi's projects.

Finally, as we will explore further – cf. par. *4. The Method: from Code to Parametric Model* – the three new exhibition spaces that expand the VMEA (Figs. 8-11).

In room IX, shaped by random geometry, the temporary project by artist Franco Summa, *La Porta del Mare*, created in Pescara in 1993, has been re-exhibited.

In room X, shaped by a helicoidal geometry that updates Frank Lloyd Wright's historic Guggenheim Museum, various artistic works from Abruzzese culture have been displayed. At the centre, Toyo Ito's Project, *Huge Wine Glass*, installed in Piazza Salotto in Pescara from 2008 to 2013, has been represented.

In room XI, shaped by the variable geometries of the strange attractor, the fountain created in 2004 by artist Ettore Spalletti in Pescara has been exhibited.

In conclusion, the VMEA appears as an autonomous digital architecture, a metaverse that can be explored in the network space through avatars, accessible in FPV (First Person View); a structured set of thematic environments designed for the fruition of digital works representing examples of ephemeral architecture; interactive environments created with different media, which aim to present and document works and objects of Intangible Cultural Heritage.

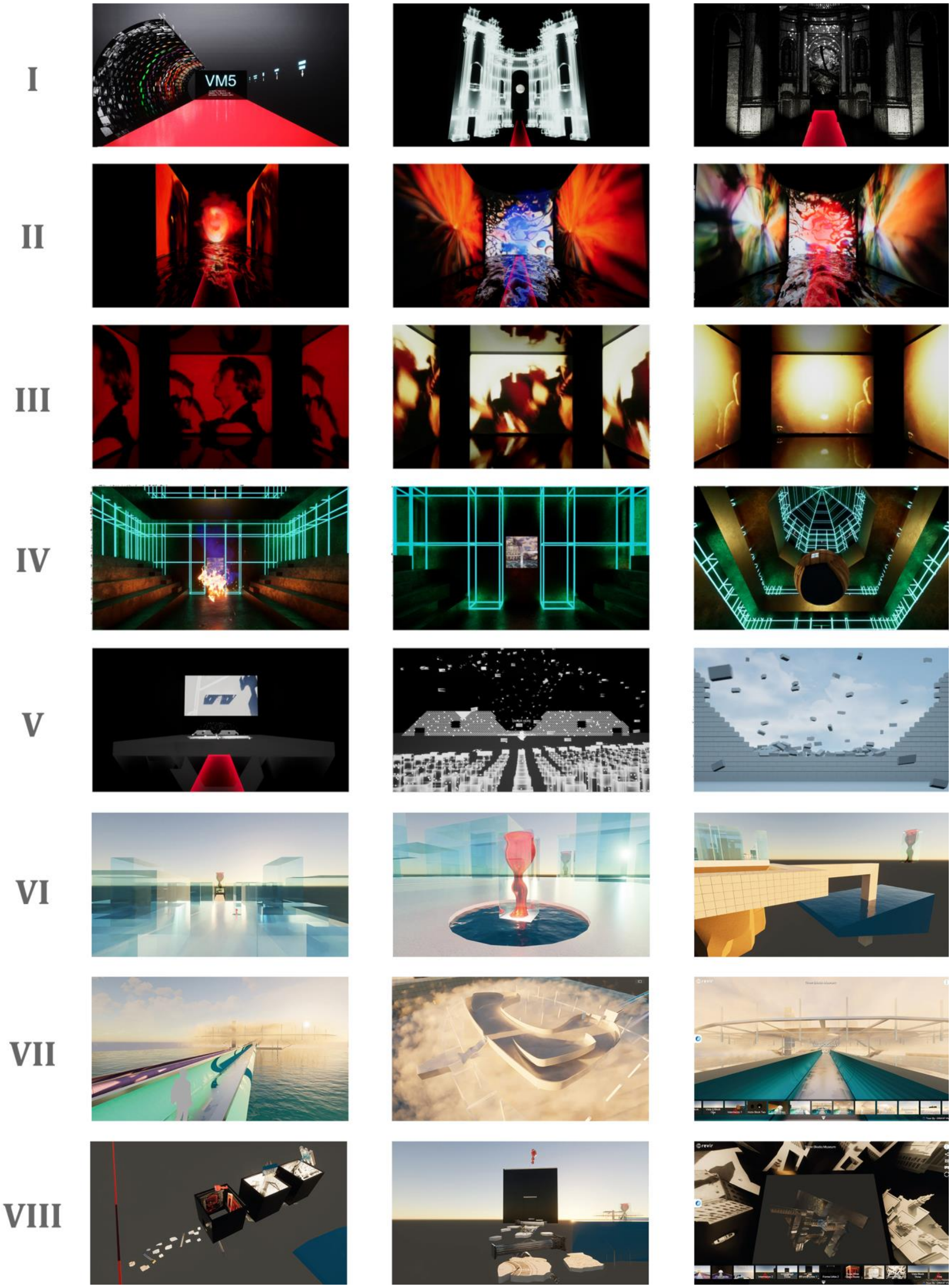


Fig. 2: Views of the first eight exhibition rooms of the Virtual Museum of Ephemeral Architecture (VMEA) completed by 2024.

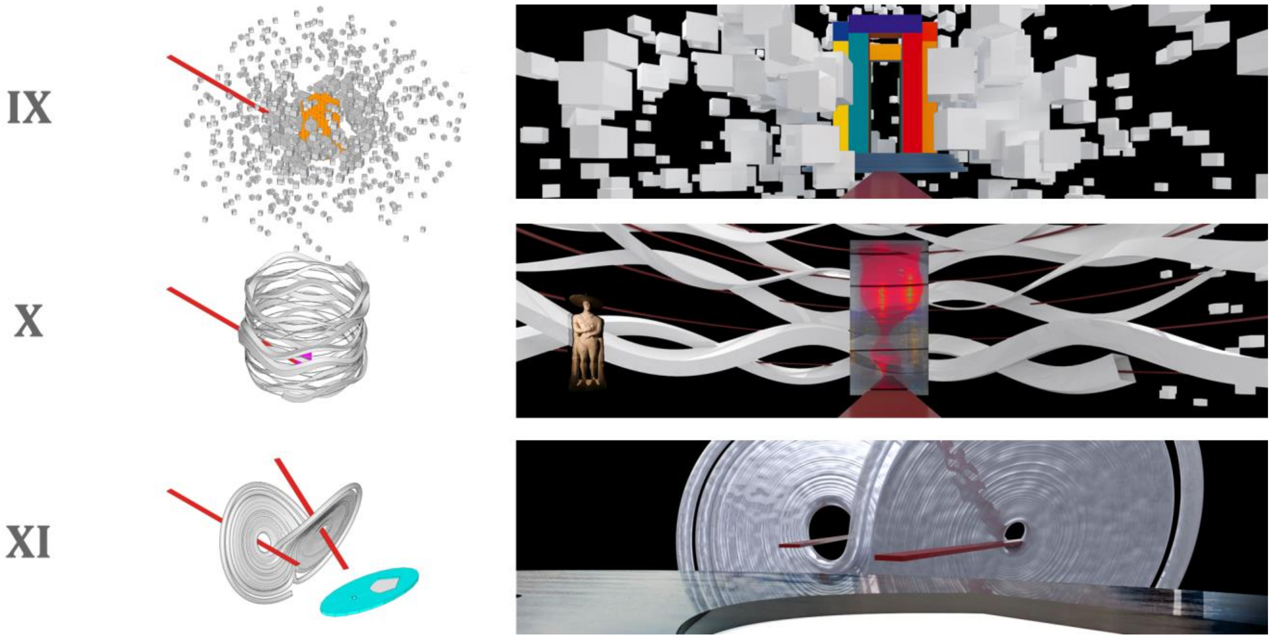


Fig. 3: Views of the last three exhibition rooms of the Virtual Museum of Ephemeral Architecture (VMEA) completed in 2025.

3. Generative AI and new methodologies for 3D modeling

The recent development of generative artificial intelligence has introduced significant and increasingly profound changes across various creative fields, from music to art, from graphics to architectural design, as we previously illustrated in an earlier paper (Unali, Caffio & Zollo 2023). This phenomenon has aroused fears and resistance (Akers, 2024), as well as enthusiastic support. As often happens when new paradigms emerge – initially technological, then cultural – opposing positions take shape, which Umberto Eco had incisively defined as "apocalyptic and integrated" (Eco, 1964).

In this context, avoiding rigid positions appears appropriate, as the evolution of these "intelligences" is so rapid that any prediction becomes uncertain. If we focus on the field of representation, which has always been an expression of human sensitivity and creativity, we can observe how the generation of two-dimensional images has reached extraordinary levels of effectiveness in just a few years, thanks to models like DALL·E, Midjourney, and Stable Diffusion. This progress suggests that the generation of three-dimensional models from textual inputs, currently less developed compared to 2D image creation, may quickly bridge the gap, opening new perspectives and possibilities for innovation.

It is therefore essential to observe the evolution of research and emerging applications with openness and attention, exploring hybrid solutions that integrate text and image generation platforms, parametric systems, and 3D modelling tools.

In the field of three-dimensional modelling, the challenges are unique and more complex compared to 2D image generation: besides ensuring structural coherence and geometric optimization, it is necessary to ensure compatibility with CAD software, so that the models are not mere visual representations, but elements with real spatial and functional consistency.

The main challenge lies, therefore, in moving beyond mere figuration, that is, the creation of plausible images, to develop three-dimensional models endowed with structural and semantic integrity. These models must not only occupy digital space coherently but also respond to specific application needs, interacting with users and other systems. The goal, therefore, is not just to achieve convincing aesthetics, but to create digital objects capable of integrating advanced functionality and dynamic interaction in the three-dimensional space of architecture.

Generative AI for images, born from the first experiments conducted by Google DeepDream (2015) based on pattern recognition in images and their dreamlike reinterpretation, and then developed through technologies such as Generative Adversarial Networks (GANs) and diffusion models, has refined the ability to generate realistic and stylistically coherent images, providing a useful tool for exploring numerous design alternatives in the initial concept phase.

One of the first architectural firms to use generative AI for image creation was Zaha Hadid Architects (ZHA). The studio's director, Patrik Schumacher, stated that the adoption of generative artificial intelligence tools, such as DALL·E 2 and Midjourney, has allowed the studio to stay "one step ahead" (Flatman, 2025) in the industry, improving productivity and creativity in the early stages of projects. Schumacher emphasized that integrating AI into the initial phases of the design process leads to rapid exploration of a wide range of design alternatives, facilitating the ideation and visualization of innovative and different concepts to present to future clients (Barker, 2023). This synergy and encounter between human creativity and computational power may represent a significant step forward in contemporary architectural design, but it is not yet concretely translated into simple and effective tools to directedly generate 3D models.

Despite the challenges, several research projects are trying to bridge this gap through innovative methodologies. Currently, there are various strategies for obtaining AI-generated 3D models, each with specific advantages and limitations.

Some of the recent approaches focus on adapting generative neural networks already used for 2D images to three-dimensional modelling. An example is the integration of Generative Adversarial Networks (GANs) with Neural Radiance Fields (NeRF), as illustrated in the study by Xu et al. (2021) where it is proposed a new framework called VolumeGAN for high-fidelity 3D image synthesis. In this approach researchers aims to overcome the limitations of previous GAN and NeRF-based methods which are not accurate to comprehend the global structure and are costly for high-resolution images. The VolumeGAN framework explicitly learns structural and textural representations allowing, in this way, independent control over shape and appearance with superior results in terms of quality and 3D control. In this direction we can find another interesting example: the GIRAFFE is a framework (Niemeyer & Geiger, 2021) in which 3D scenes are represented as compositional neural feature fields allowing manipulation of individual objects and background during the generation of images from unstructured and unlabeled image datasets. This specific model aims to overcome the limitations of previous 2D approaches and offers more precise control over the creation of three-dimensional visual content.

These two examples demonstrate how the adaptation of generative neural networks for 2D images to 3D modelling is advancing and offers new possibilities towards the synthesis of three-dimensionally aware images and the representation of more complex scenes.

Other systems are based on the generation of voxels, point clouds, or meshes and allow to construct three-dimensional shapes that can be directly interpreted by modelling software. DreamFusion, developed by Google Research (Poole, Jain, Barron & Mildenhall, 2022), optimizes a NeRF representation starting from a text-to-image diffusion model, enabling the creation of coherent three-dimensional representations. Point·E (developed by OpenAI) generates a point cloud from a text prompt, which is then transformed into a three-dimensional mesh that can be directly interpreted by modelling software (Nichol et al., 2022). Also developed by OpenAI, Shap·E represents an evolution of Point·E, offering greater precision in conversion to solid geometry as it can generate high-quality 3D assets quickly (Heewoo & Nichol, 2022). 3DFuse is a framework that integrates three-dimensional awareness into pre-trained 2D diffusion models, overcoming the limitations of traditional 2D diffusion models that often struggle to maintain consistency between different views of a 3D scene (Seo et al., 2024).

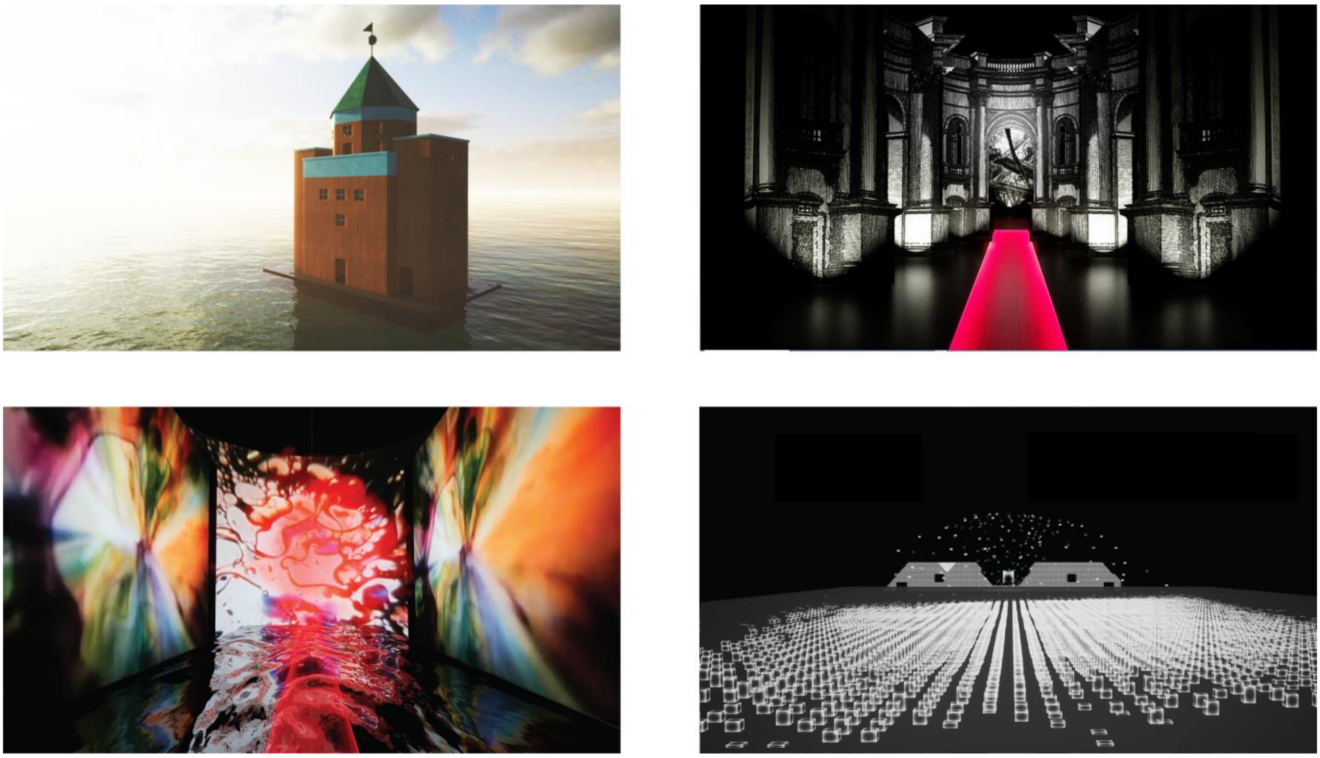
Other approaches, based on Neural Radiance Fields (NeRF), focus on volumetric representation, allowing the synthesis of three-dimensional scenes from two-dimensional inputs. Instant Neural Graphics Primitives (Instant-NGP) (Müller et al., 2022) is a technique developed by NVIDIA that enables training a NeRF in real-time or near real-time, drastically reducing the time needed for three-dimensional scene reconstruction. Mip-

NeRF 360, on the other hand, is an evolution of NeRF models developed by Google (Barron et al., 2021), designed to improve the quality of reconstruction of complex 360° three-dimensional environments.

Other experiments proceed with 3D reconstruction starting from images and videos. Among these, we highlight NeuralRecon (Sun et al., 2021), a deep learning model designed for real-time 3D reconstruction from monocular videos that uses convolutional neural networks to process video sequences and generate coherent three-dimensional representations of scenes. Luma AI (https://lumalabs.ai/), on the other hand, is a NeRF-based platform that transforms photographs and videos into photorealistic 3D models. Thanks to advanced neural rendering techniques, it enables the capture and visualization of three-dimensional scenes with a high level of detail and realism.

At the conclusion of this brief examination of the numerous alternatives that current technology offers, it seems useful to proceed experimenting with a methodology that focuses on the integration between generative artificial intelligence and parametric modelling, where machine learning algorithms are combined with advanced CAD software to create forms that can be adapted and optimized in real-time. In the architectural field, this synergy is particularly promising, as it allows for the exploration of innovative design solutions without losing control over structural and functional constraints.

The conscious adoption of these technologies, in a continuous dialogue between research and practice, therefore represents a fundamental key to transforming AI's potential into tools serving design innovation and creativity.



Figs. 4-7: Some images from the Virtual Museum navigation. Above, from left to right: room IV, Aldo Rossi, *Il Teatro Del Mondo*, Venice 1979; room I, *Teatro Sacro* (1695) by Andrea Pozzo; room II, 1960s *Light Show*; room V, Roger Waters, *The Wall Live in Berlin*, July 21, 1990.

4. *The Method: From Code to Parametric Model*

After summarizing the new methodologies for 3D modeling triggered by Generative AIs (see Chapter 3), the chosen method intentionally focuses primarily on the use of ChatGPT for code generation, rather than on the creation of 3D objects through generative AI systems.

This “hybrid” approach stems from the need to maintain a high level of authorial and curatorial control within the virtual environment, avoiding the opacity and unpredictability often associated with end-to-end 3D generative systems.

By combining code generation with commercially available parametric 3D resources (Grasshopper), the design process allows for both the free exploration of innovative solutions and their testing through the generation of three-dimensional elements, thus aligning with the educational and interpretative objectives of the virtual museum.To illustrate the elaboration processes adopted (the experimented workflow, the definition of optimized prompts, the generation of Python code, the implementation in Grasshopper, etc.) in shaping the geometry of the three new spaces that expand the VMEA (randomized; helical; strange attractor), the method used can be summarized as follows: Section 4.1 provides a theoretical framework on parametric modeling and the use of generative AI for code writing; Section 4.2 describes the methodology adopted to generate Python scripts with ChatGPT and integrate them into Grasshopper; Section 4.3 presents the results obtained.

4.1. Background and State of the Art

Interest in virtual museums has grown significantly in recent years, thanks in part to advances in immersive technologies and artificial intelligence that emphasize dynamic and generative environments (Unali, Caffio & Zollo, 2023b). Numerous examples span a variety of fields: *The Virtual Guggenheim Museum* designed in 1999 by Asymptote Architecture, a New York-based studio led by Lisa Anne Couture and Hani Rashid (Virtual Museum, 1999); the well-known interactive video sculpture *Quantum Memories* (2020) by Refik Anadol, featuring AI-generated imagery; the virtual gallery for the Spanish organization Fundación Arquia designed by the studio Space Popular, based on the urban layout of Barcelona (Fairs, 2020); the virtual exhibition *NFTism* designed by Zaha Hadid Architects, a virtual gallery exploring new forms of cultural

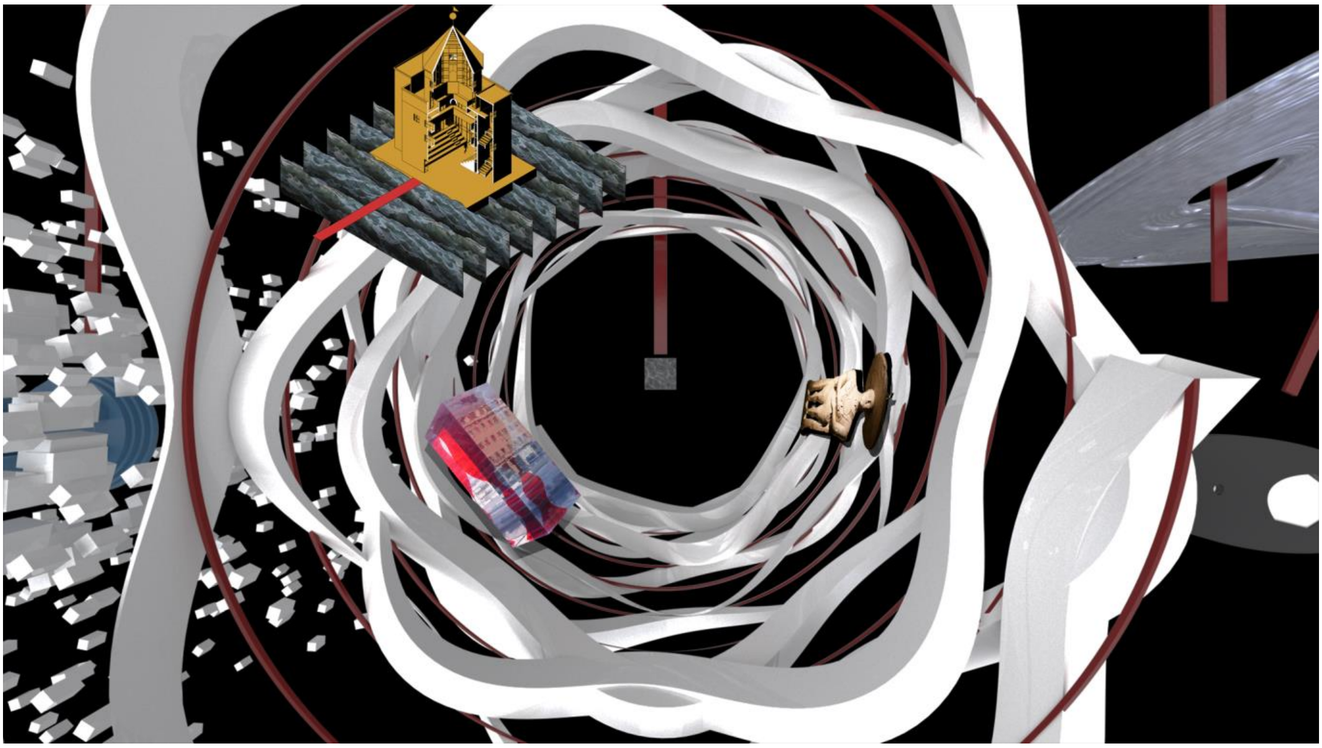


Fig. 8: Frame taken from navigating the three new exhibition spaces of the VMEA created in 2025.

production and experience linked to digital art and virtual art museums (Niland, 2021); various performances staged within *The Sphere* in Las Vegas (Unali & Caffio, 2024); virtual reconstructions of historical sites (Siotto & Cignoni, 2024); and AI-assisted curatorial tools such as the custom ChatGPT interface developed at the Nasher Museum of Art (Duke University), trained on over 14,000 works from its collection (Di, 2023).

However, few implementations have integrated conversational artificial intelligence and procedural spatial generation into a coherent design methodology aligned with both technologies and objectives. The project we present thus positions itself at the intersection of digital design experimentation and AI-mediated content creation, attempting to bridge the gap between ongoing scientific research and implementation through technologies that are both accessible and customizable.

4.1.1 Parametric and Generative Modelling

Parametric modelling is a digital design approach that uses variables and mathematical rules to generate and control complex geometries. Thanks to its flexibility, it is widely adopted in architecture, engineering and industrial design. This method allows exploring design solutions through parameter variation, supporting iterative processes and optimisations based on structural and aesthetic criteria.

Grasshopper, the visual plug-in for Rhinoceros 3D, is one of the most used tools for generative modelling, enabling the creation of complex forms through the manipulation of parameters and geometric relationships (Tedeschi, 2011, 2014). The integration of programming languages like Python (via GHPython) further expands automation and customisation capabilities, allowing the development of advanced algorithms for geometry generation, structural optimisation and computational analysis (Celani & Vaz, 2012).

In the context of virtual environment and metaverse design, parametric modelling plays a fundamental role in generating interactive and adaptable architectures. Recent research has highlighted the potential of parametric techniques in creating immersive digital spaces, where algorithmic definition of forms enables the production of highly configurable environments.

4.1.2. Artificial Intelligence in Code Generation

Artificial Intelligence has revolutionized assisted programming, with tools like ChatGPT delivering powerful code generation capabilities from text-based inputs.

These language models, trained on extensive open-source code datasets, excel at writing, debugging, and optimizing scripts across multiple languages, including Python and C# – essential tools in 3D modeling.

4.2. Methodology Implementation

Our three-dimensional model generation process using ChatGPT and GHPython in Grasshopper consists of four key phases:

- Strategic prompt design for code generation;
- Python script development;
- Grasshopper workflow integration;
- Geometry validation.

This streamlined approach harnesses AI to enhance code generation, maximizing the efficiency of parametric modeling processes.

4.2.1 Prompt Definition for Code Generation

The effectiveness of ChatGPT-generated code directly correlates with prompt precision and clarity.

To achieve optimal Grasshopper scripts, we structure our requests with these essential components:

- Precise geometry specifications;
- Clear input parameters and constraints;
- Structured code framework with specific library references;
- GHPython-compatible formatting.

4.2.2 Python Script Development

After prompt submission, ChatGPT generates code that undergoes thorough analysis to ensure optimal performance and accuracy.

Key development phases include:

- Rigorous syntax verification and GHPython compatibility testing;
- Strategic code optimization through manual refinements;
- Comprehensive geometric validation in Grasshopper.

4.2.3 Grasshopper Integration

The refined code integrates into a GHPython component within Grasshopper, establishing essential connections for parametric model manipulation.

This phase establishes:

- Code input parameters;
- Geometry construction through Python scripting;
- Output channels for further transformation and analysis.

4.2.4 Geometry Validation

Final assessment evaluates model quality through:

- Geometric integrity;
- Input parameter responsiveness;
- Computational efficiency.

This methodology leverages ChatGPT to accelerate GHPython script generation while maintaining strict control over code quality and geometric output.

4.3. Spatial Results: The Three Approaches

We implemented three distinct approaches for 3D model construction:

- Case 1 (4.3.1 Randomized Space): Random generation prompt (Fig. 9);
- Case 2 (4.3.2 Helicoidal Element): Curve-based prompt with sectional 3D generation (Fig. 10);
- Case 3 (4.3.3 Lorenz Attractor): Function-based generation with point processing (Fig. 11).

4.3.1 Randomized Space (Chaos)

This methodology defines the generation of a parametric 3D model featuring cubes distributed in space based on attractor distance, with dynamic control over density and orientation.

The algorithm executes in six phases:

1. Grasshopper Input Processing and Validation:
   - Cube quantity;
   - Size parameters (minimum and maximum);
   - Distribution method (grid, random, or radial);
   - Attractor position;
   - Randomization factor;
   - Attractor influence on distribution.
2. Spatial Distribution Generation Based on Selected Mode:
   - Grid Distribution – Systematic three-dimensional cube arrangement;
   - Random Distribution – Controlled placement within defined volume;

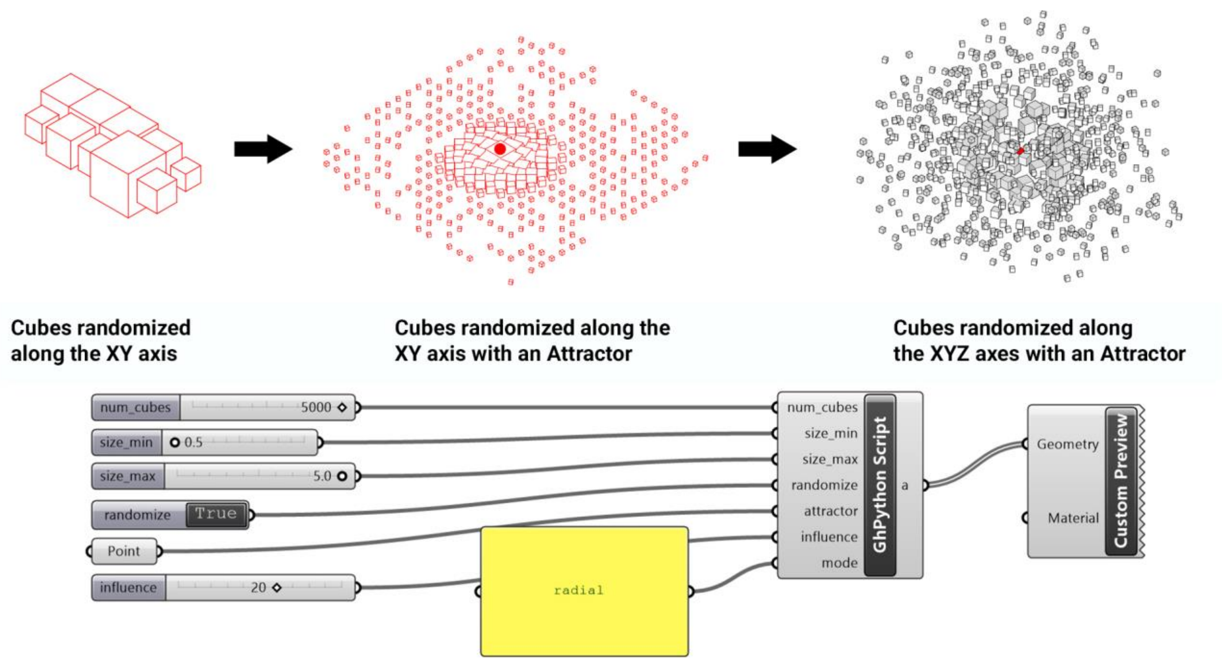


Fig. 9: Representation of the elaborative process of the space that shapes Room IX: Randomized Space (chaos).

   - Radial Distribution – Attractor-based positioning with variable radius.
3. Size and Density Calculation Based on Attractor Distance:
   - Density variation inversely proportional to attractor proximity;
   - Size adjustment based on attractor distance.
4. Position-Based Cube Rotation Implementation:
   - Spatial orientation determined by attractor distance;
   - Enhanced rotation effects at greater distances.
5. 3D distribution with variations along the Z axis, for greater spatial variability:
   - In radial mode, the cubes are arranged three-dimensionally, avoiding a distribution limited to an XY plane:
   - The position along the Z axis is influenced by the attractor, allowing for a more articulated spatial distribution.
6. Final output and visualization with Grasshopper and Rhino.
   - The model is displayed in Grasshopper through "Custom Preview";
   - The export is performed using the Bake command.

4.3.2. Elicoidal Structure

This methodology describes the process of generating a parametric 3D model starting from a helicoidal curve that represents the generator of a three-dimensional surface.

The procedure involves 3 main phases:

1) The base curve is created using a mathematical function in Python that generates a parametric helicoidal curve along the Z axis.

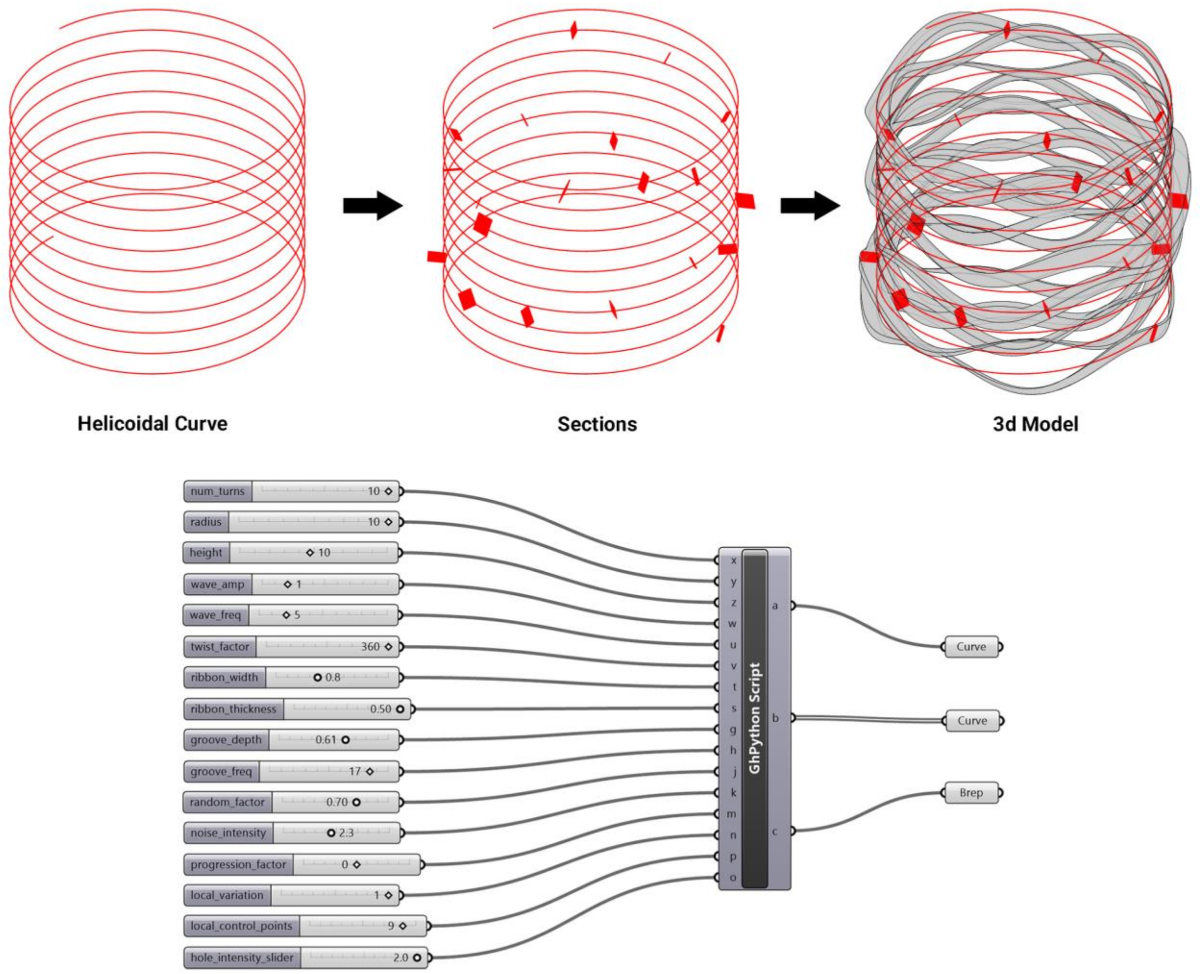


Fig. 10: Representation of the elaborative process of the space that shapes Room X: Helicoidal Structure.

The curve is defined with the following parameters:

- Number of coils;
- Initial radius;
- Total height;
- Frequency and amplitude of sinusoidal oscillations;
- Progressive torsion factor.

The resulting curve is obtained by interpolating a series of points calculated through trigonometric functions.

2) Creation of Cross Sections and surface.

A series of cross sections are generated along the guide curve. Each section is a rectangle that can be modified in height and width, whose shape is dynamically adapted.

The modified sections are used to generate a surface using the Sweep command in Rhino.

3) Geometry Export and Bake.

The model can be exported to Rhino using the Bake command.

4.3.3 Lorenz Attractor (Strange attracttor)

The system considered in this study is a three-dimensional dynamic system described by a set of first-order differential equations, characterized by complex and potentially chaotic behavior.

The differential equations governing the temporal evolution of the state variables x,y, zx, y, zx, y,z are defined as follows:

$dt/dx=a(y-x)+dzx;$

$dt/dy=kx+fy-xy;$

$dt/dz=cz+xy-ex^2.$

The system parameters are set to the following values:

a=40, c=1.833, *d*=0.16, *e*=0.65, *k*=55, *f*=20.

The numerical integration has been implemented within GH-Python, a scripting environment based on RhinoCommon that allows for the generation and manipulation of geometries within Grasshopper for Rhino.

The algorithm follows these steps:

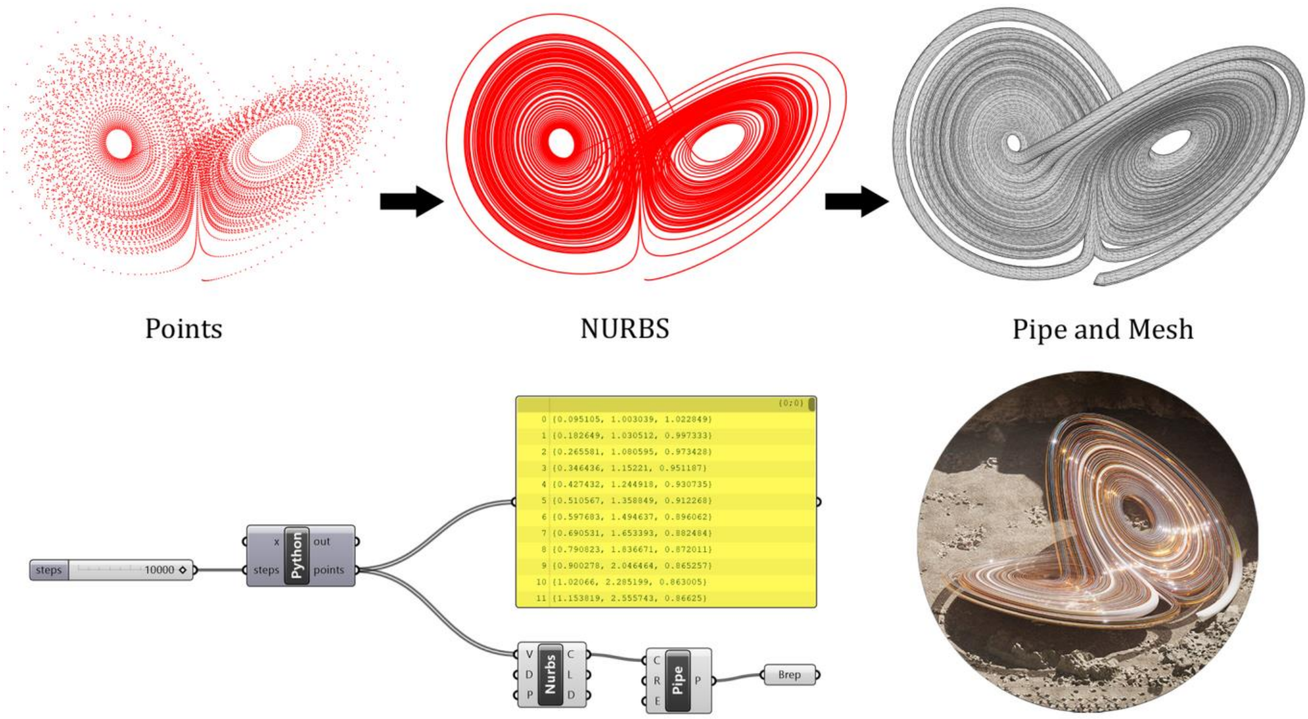


Fig. 11: Representation of the elaborative process of the space that shapes Room XI: Lorenz Attractor (strange attractor).

- Definition of differential equations as a function in GH-Python;
- Numerical iteration using the explicit Euler method;
- Generation of a list of Rhino *Point3d* points, representing the system's trajectory in phase space;
- Transformation of points into a NURBS curve and model thickness *Pipe*;
- Definition of curve steps;
- Export performed using the *Bake* command.

5. Final Notes on Possible Developments of VMEA

The VMEA is currently accessible in prototype form and can be explored via a dedicated server. At the time of writing, access is available upon request for review and academic purposes, with the intention of making it publicly available through a permanent URL and an accompanying repository. This gradual distribution is intended to allow for iterative feedback and refinement in line with the exploratory ethics of the research.

After summarising the structure of this new phase of research on VMEA – describing the general cultural context and the method adopted in expanding its exhibition halls -, in addition to the conclusions already anticipated in the previous paragraphs, analysing the results achieved and highlighting some possible developments of the project, we can observe that the application of generative AI to code writing allows for obtaining a series of evident advantages in terms of both aesthetics and configuration technologies. The latter, for example, through the contribution of AI, help to speed up the configuration process by reducing syntactic errors and expanding programming accessibility to less experienced users. From the experimentation carried out, we can also highlight that the use of generative AI – specifically the use of ChatGPT in parametric modelling through GH-Python – is a research field still in continuous evolution with great growth potential, especially in the direction of improving automated design and creating optimised workflows. Returning to the general theme of the Virtual Museum for intangible heritage – part of a broader study topic on contemporary Virtual Living –, this experimentation has provided us with further critical insights related to two themes (closely related to each other) that need further investigation: the methods and techniques of AI-supported space representation and modelling; the design of immersive thematic environments for the Virtual Museum in continuity with the historical immaterial, virtual, ideal, utopian and radical design of architecture. The integration of these technocultural processes provides multimedia technology and Information & Communication Technology designers with a potential workflow to follow and implement with respect to the subject of the simulation; especially in the post-production phase, always ensuring control over the design outcomes of the proposed elaboration. A topic of great interest to discuss and explore further in the context of the evolution of representation sciences and the aesthetics of visual culture.

Beyond the technocultures deployed in the design and implementation process, the VMEA is conceived as a narrative space in which architectural form, visual elements, and spatial progression converge to evoke new interpretive meanings. Each newly generated room is linked to a semantic theme that emerges from the conversation with the artificial intelligence, creating a spatial metaphor that transforms textual content into an immersive experience.

This approach challenges conventional curatorial logic by proposing an emergent, co-authored aesthetic that reflects both computational creativity and human imagination. In this way, the virtual museum functions not merely as a container of artifacts, but as a reflective and synergistic space that invites visitors to navigate conceptual landscapes shaped by AI and design sensibility.

To conclude, we highlight once again the potential energy inherent in the hybridisation processes between AI tools and representation technocultures; a *creatio mundi* (Maldonado, 1993) that involves multiple disciplines allowing for various thematic applications.

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