Towards a 'Non-Universal' Architecture: Designing with Others through Gestures (1:1 Scale)

NEURAL INFORMATION PROCESSING SYSTEMS

Abstract

This project explores the dynamic relationship between human individuality and cultural heritage through the innovative use of digital tools, centred on the theme of "Ambiguity." By employing virtual reality (VR) and machine learning (ML), it transforms cultural gestures into architectural elements, allowing participants to perform these gestures at a 1:1 scale in VR. The gestures are captured as 3D meshes, which are then interpolated across various body dimensions and gestural typologies using a 3D DCGAN, creating a diverse array of architectural fragments. This process fosters a novel form of co-authorship, blending human input with algorithms.

The resulting structures are organised using SOMs and positioned through Python scripts, aligning the gestural meshes according to their spatial and temporal contexts. These architectural elements form community spaces such as playgrounds, café hubs and performance areas, reflecting the unique rhythms and dimensions of their users. This approach challenges the traditional notion of architecture as static, proposing instead that buildings can be dynamic, evolving expressions of the communities they serve.

The project also delves into the ambiguity of authorship, as the integration of VR and ML creates a blurred line between human and machine contributions. It raises questions about the true 'author' of the design, as personal gestures are algorithmically transformed into architectural elements, blending individual expressions with community representation. Moreover, the research examines the complexities of cultural representation, where digitising and modifying cultural gestures through AI both preserves and transforms the original heritage, challenging conventional ideas of authenticity. It addresses the challenges of using data-driven models to represent diverse populations, emphasising the need to balance statistical generalisations with the unique realities of individual experiences.

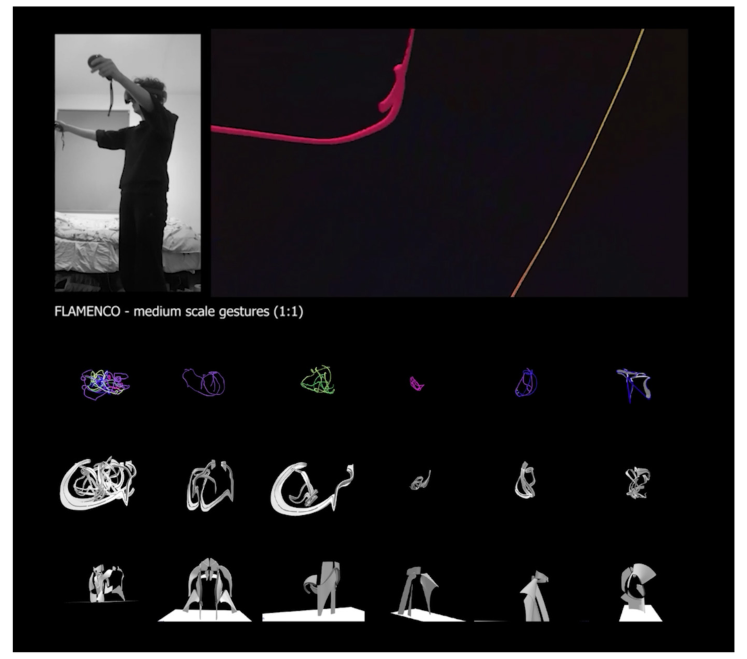

Figure 1 - Transforming the strokes made in VR after tracing the gestures to mesh surfaces

Gesture Capture and Vectorization (VR - scale 1:1)

In the evolving design landscape, VR has become a transformative tool, offering real-time, scale-accurate design and visualization that outpaces traditional methods. Gravity Sketch stands out by enabling immersive 1:1 scale work, revolutionizing concept creation, refinement, and execution across design fields. It captures intricate gestures, directly influencing architectural designs. For example, gestures from Spanish cultural practices—like Flamenco dance, Bullfighting moves, culinary motions, or traditional sports such as Aizkora Proba and Valencian Pilota—can shape architectural forms, embedding cultural narratives into the design. Gravity Sketch's pass-through feature allows designers to trace real-time movements while sketching, using gesture projections on walls or scaled 1:1 videos as guides. These life-sized sketches serve as a foundation for mesh surfaces, as shown in Figures 1 and 2.

This digital evolution also revives interest in indexicality, rooted in Peircean semiotics, which emphasizes meaning derived from physical traces. Although digital tools are often seen as distancing design from personal imprints, VR reintroduces these through gestural inputs that carry the designer's unique expression. Sketches created with the stroke tool in VR are developed into mesh surfaces, which later become datasets for the 3D DCGAN after voxelization. (Figure 5)

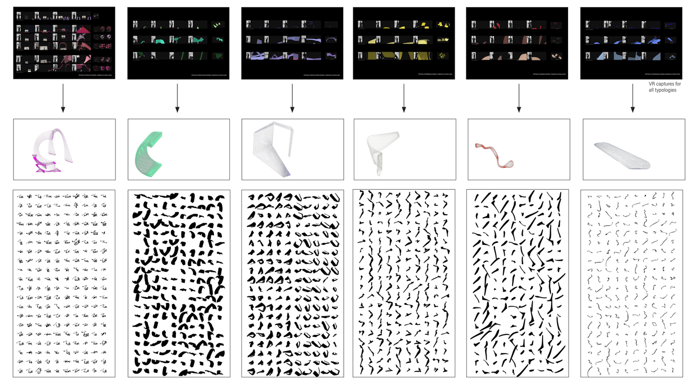

Figure 3 -Gesture- based mesh-surfaces adapted to various body dimensions

Body-Based Variations

Exploring the concept of 'non-standardised architecture,' this methodology advocates for spaces that prioritize the bespoke over the generic, designed to adapt and respond to the unique dimensions and proportions of their users. Central to this approach is a deep respect for individuality, acknowledging that each person interacts with their environment in ways as unique as their fingerprints. To support this vision, variations of the initial forms were generated based on human body data, using input dimensions of 1.x meters in height and x kilograms in weight. The resulting dataset consists of mesh variations ranging from 1 to 2 meters in height and 20 to 150 kilograms in weight. This step is essential for accommodating the diverse functional needs of the spaces being designed. For example, in areas primarily used by children, the gesture-based mesh surfaces would be tailored to a child's scale. (Figures 3 and 4)

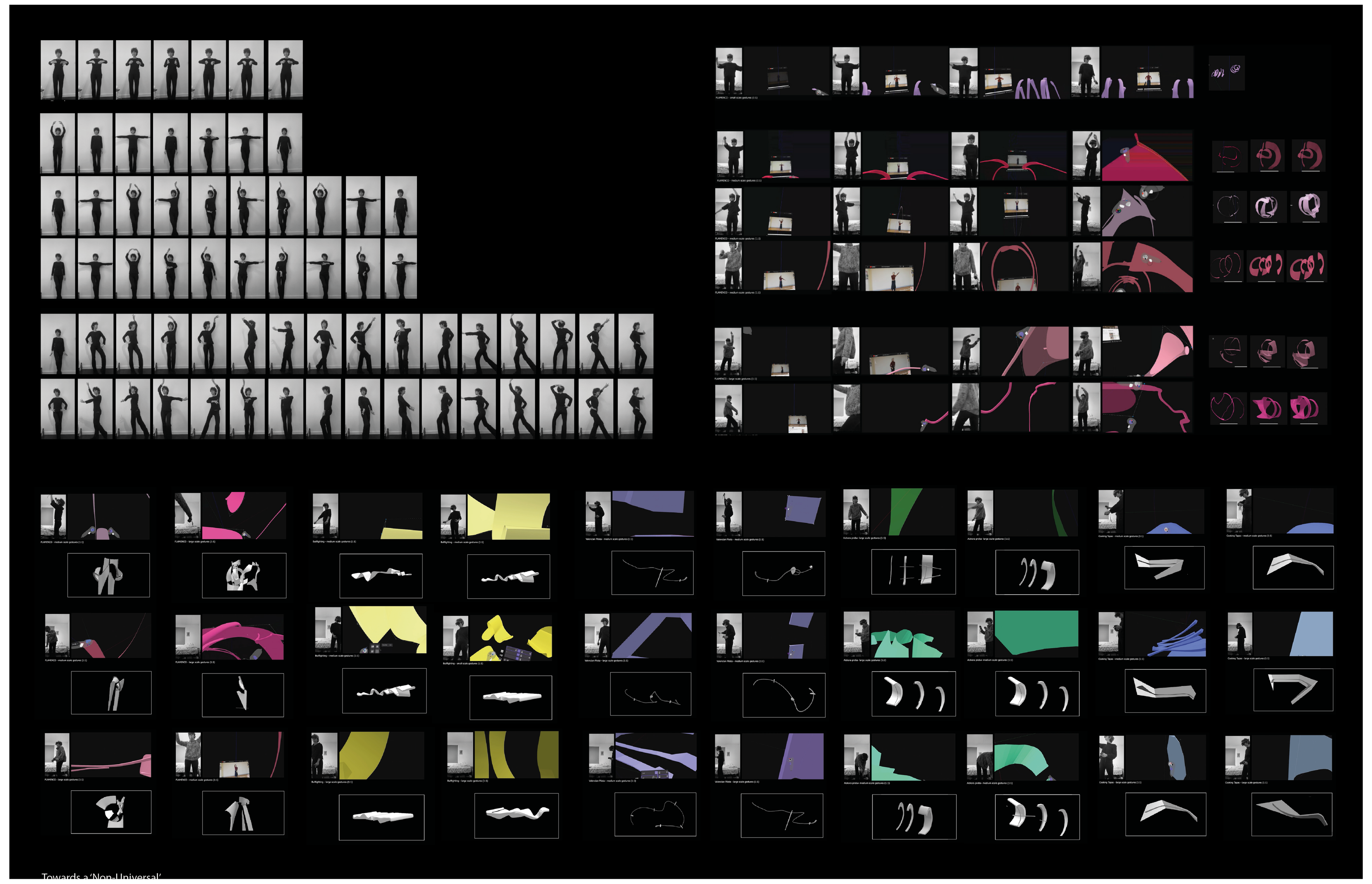

Figure 2 - Tracing Span9sh culture based gestures in VR at scale 1:1 (life-size) - Flamenco, Bullfighting, Aizkora Proba, Valencian Pilota, Cooking Spanish recipes

3D DCGAN and SOMs

The incorporation of a 3D DCGAN enriches the design process by embedding human gestures into architectural forms, creating culturally expressive narratives. The DCGAN is trained on a dataset of voxelized gestures—3D representations of life-scale movements captured in VR. By interpolating these gesture-based meshes, it generates novel and unique forms. This method enables the DCGAN to "co-author" designs that preserve human subtleties, demonstrating that digital tools can amplify personal, physical imprints rather than diminish them. Marching cubes algorithm is used to convert the outputs after training to meshes and SOMs are used to organise the output meshes based on gesture typology and dimensions.

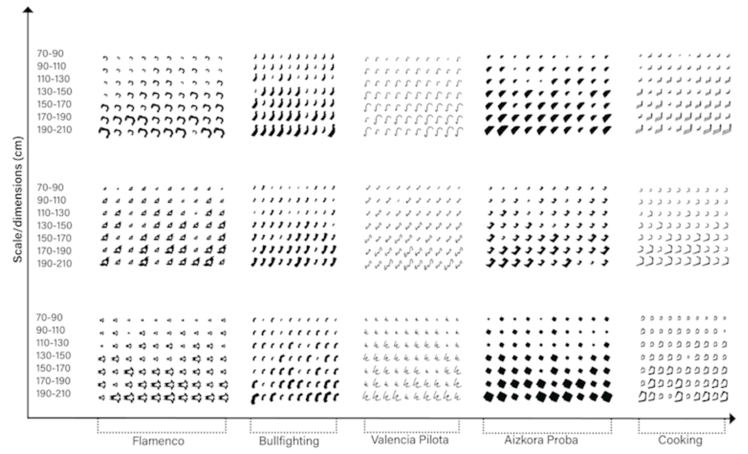

Figure 4 -Gesture- based mesh-surfaces adapted to various body dimensions

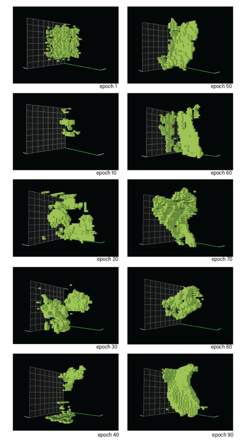

Figure 5 - Vectorizing the gesture based meshes traced in VR

Figure 6 - 3D DCGAN Training over epochs

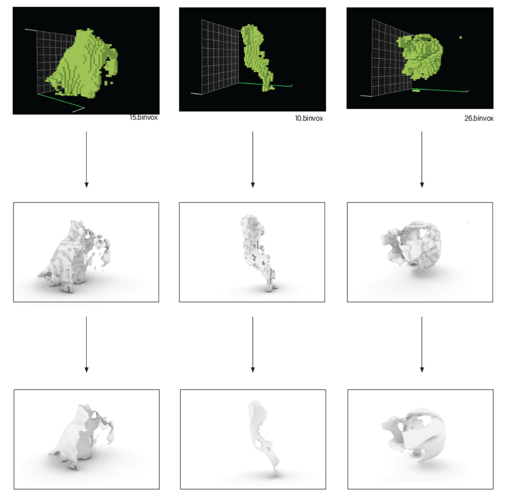

Figure 7 - Marching cubes algorithm for the generated outputs (from voxels back to meshes)

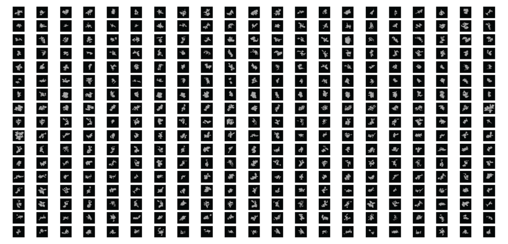

Figure 8 - Using SOMs to organise the output meshes based on gesture typology and dimensions

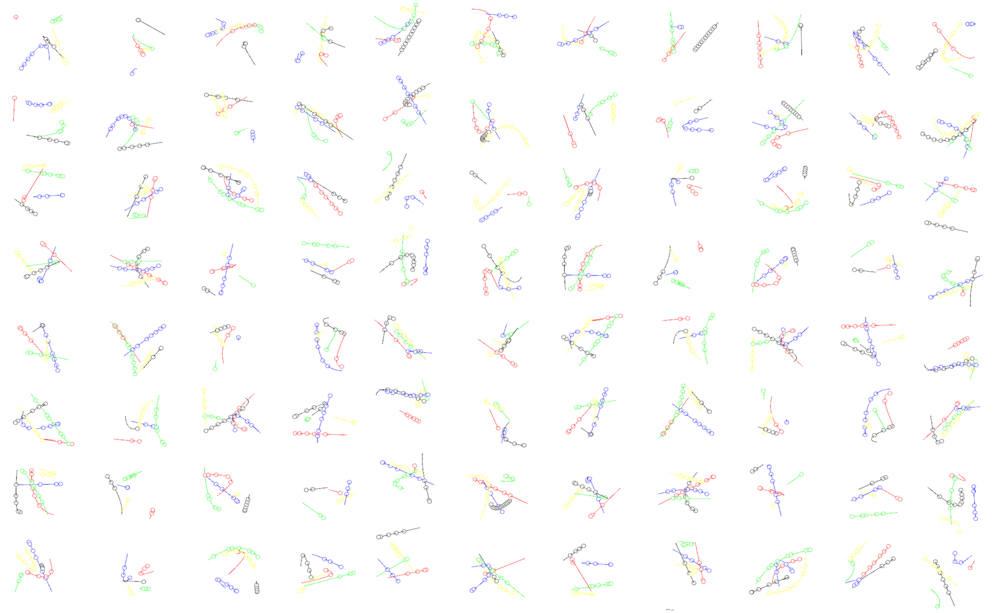

Figure 9 - The output of the script is a series of curves within a bounding box (in this case 10x10x10 m). Each of the curves is divided based on the rhythm and time required in reproducing different gestures`(red - Flamenco, Yellow - Bullfighting, Green- Valencian Pilota, Blue - Aizkora Proba, Black- Cooking)

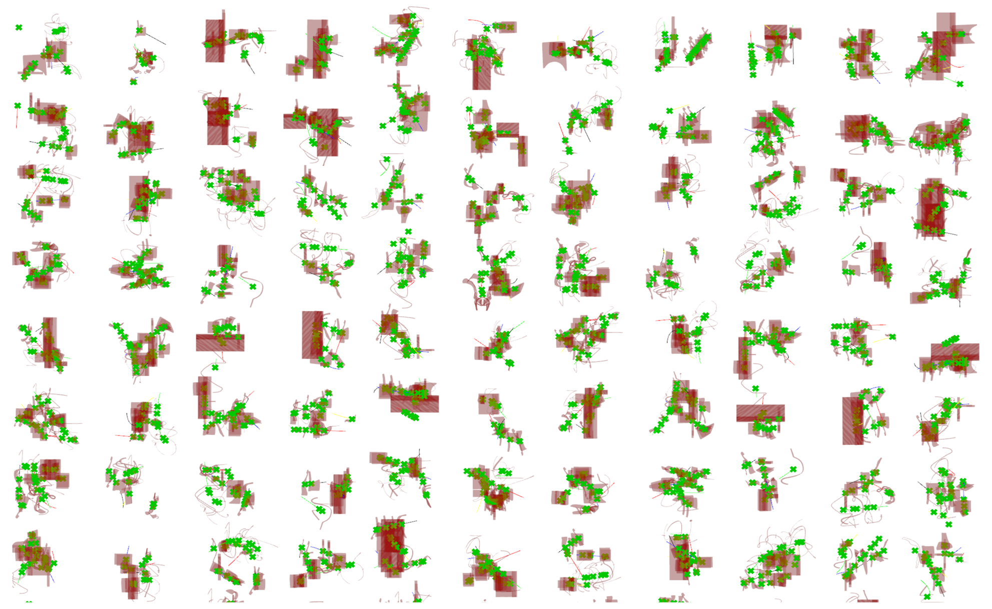

Figure 10 - Meshes corresponding to each of the gestures (color-coded curves) are extracted from the SOMs and attached with their centers to the points of the generated curves resulting in 3D fragments composed of gesture based meshes.

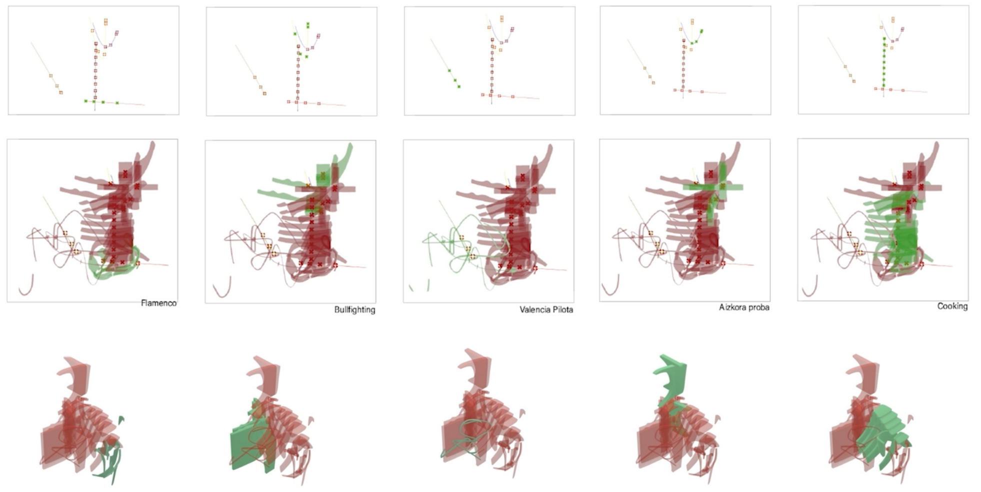

Figure 11 - Example of one of the thousands generated architectural fragments

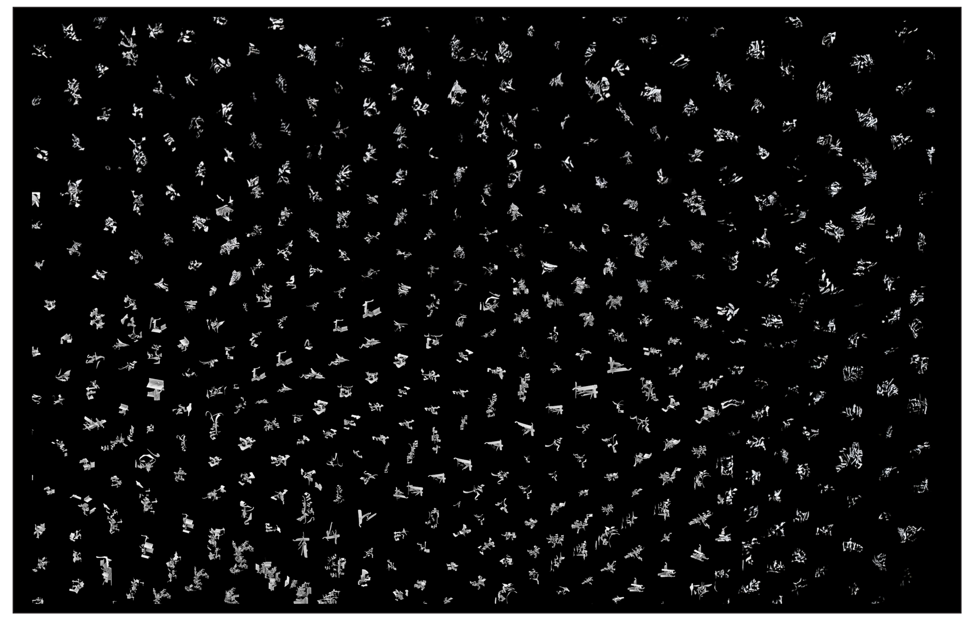

Figure 12 - Example of generated architectural fragments

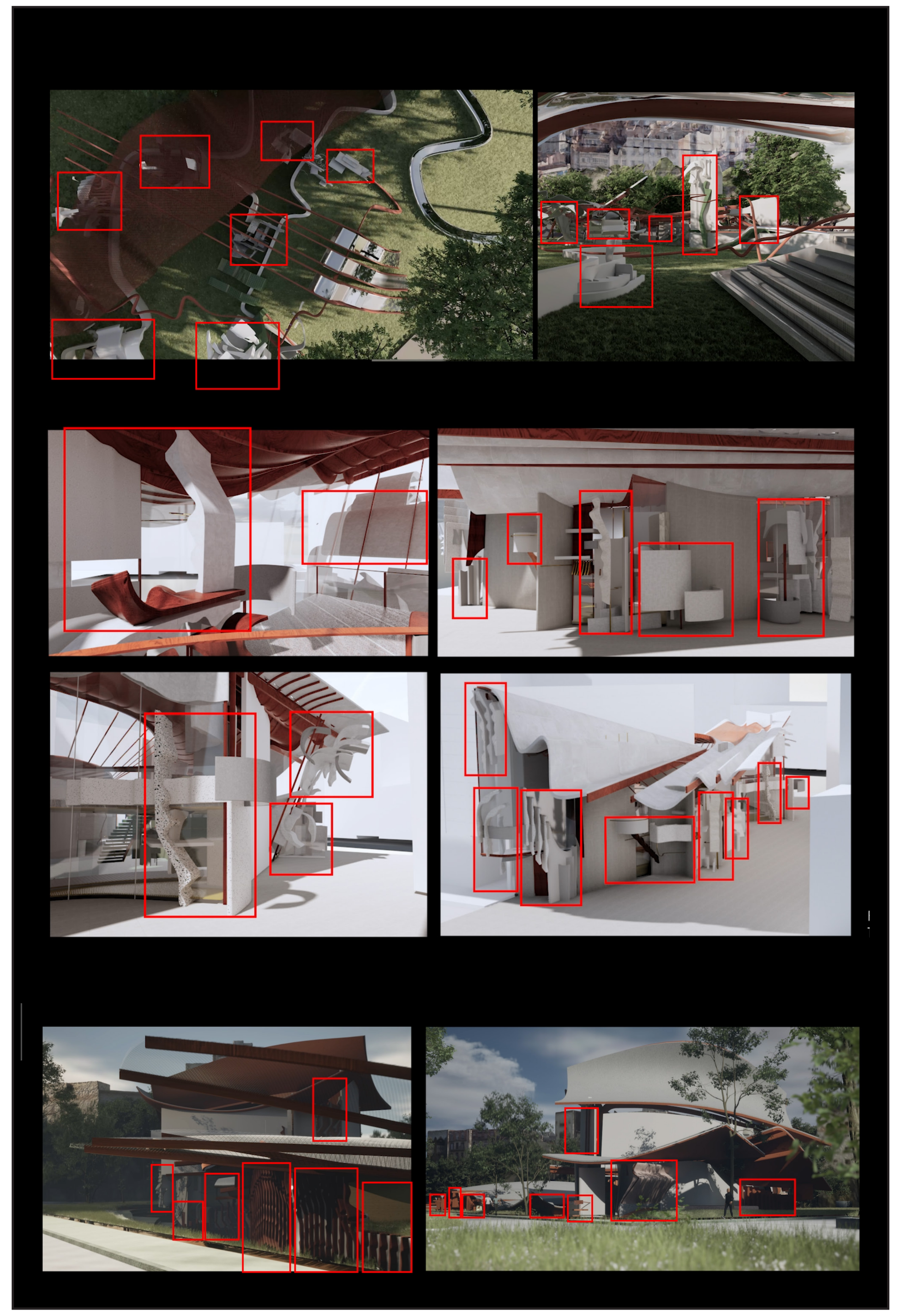

Figure 13- Architectural gesture-based fragments within the buildings (Community Playground, Community Hub-cafe and Community Performance building)

Creating architectural fragments - based on rhythms and time

To integrate the generated gesture-based meshes into architectural designs, they must first form distinct fragments that will later be assembled on-site using VR. A Python script dynamically positions curves within a defined bounding box (e.g., 10x10x10m). Each curve symbolizes a specific cultural action and is segmented according to its rhythm, with points distributed to reflect the temporal flow of the gesture. Corresponding gesture-based meshes are selected from the SOM and attached to these points via their centroids (in Grasshopper), ensuring that the spatial composition respects the rhythm and typology of the cultural gesture. (Figures 9-13)

Figure 14- User in VR within the auditorium space

Community Feedback and Final Adjustments in VR

The process culminated in a VR environment, where architectural fragments were assembled and assessed at life-size, enabling real-time community input and iterative adjustments. This feedback loop plays a vital role in refining designs to better align with user needs and preferences, enhancing both functionality and satisfaction. For instance, auditorium chairs were initially crafted from VR user sketches and later refined using the 3D DCGAN, incorporating user feedback and ergonomic considerations (Figure 10). This process exemplifies the synergy between digital and analogue approaches, blending AI's precision with human insight.

The resulting community spaces, such as playgrounds, café hubs, and performance venues, are both functional and tailored to the needs of their users. The integration of digital tools like VR and AI in architectural design not only redefines how we engage with space but also enriches architecture with cultural and individual identity. Mario Carpo's theories, extended here to include cultural indexicality, highlight the potential of these technologies to create more inclusive and personalized designs. Our workshops explore these concepts in practice, acting as a platform to bridge theoretical frameworks with real-world outcomes.

Figure 15 - Users drawing chairs around them in VR for the auditorium

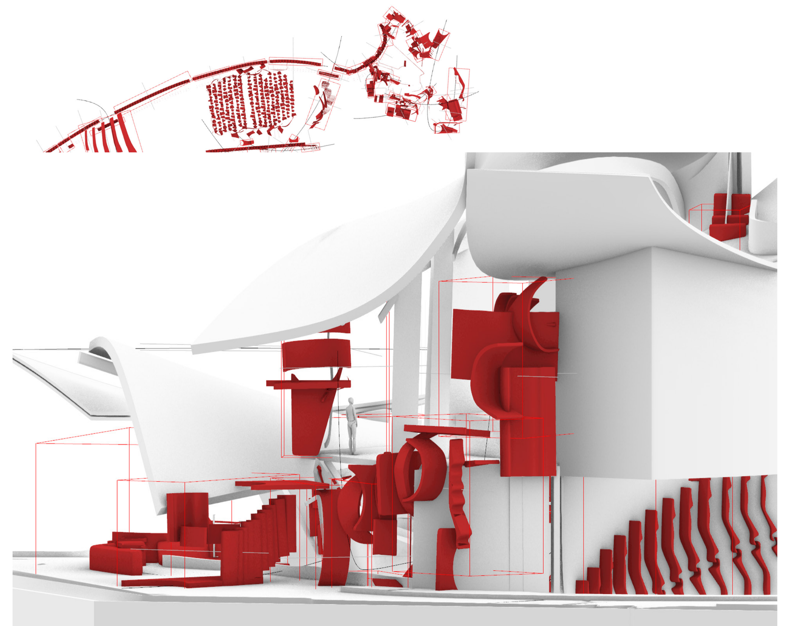

Figure 16 - Fragments (red) and surfaces connecting the drawn in VR (white) - Community Performance spaces building

Figure 16 - Views from the Community Cafe Hub building (small image) and the lobby in the Community Performance Spaces building (large image)