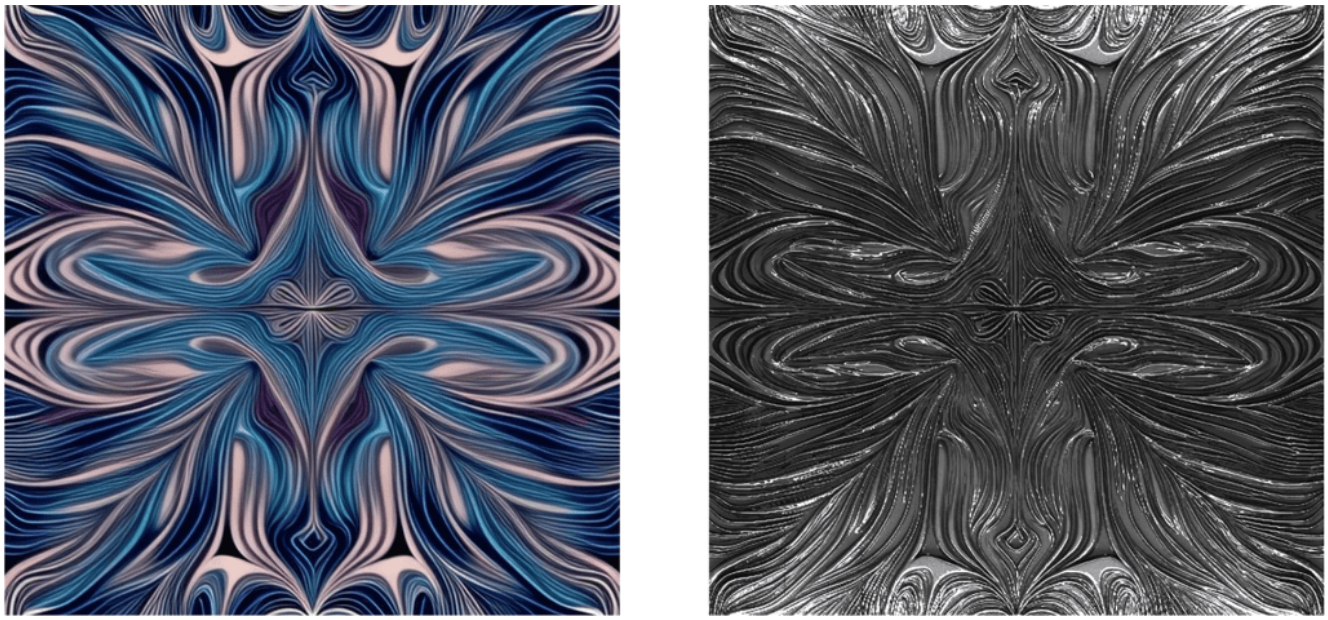
NEXUS: From Machine Learning to Manufacturing

During Cairo Design Week, ENCODE Studio unveiled NEXUS, a pioneering project that blends machine learning, generative design, and additive manufacturing to explore new possibilities for architectural surfaces and full-scale installations.

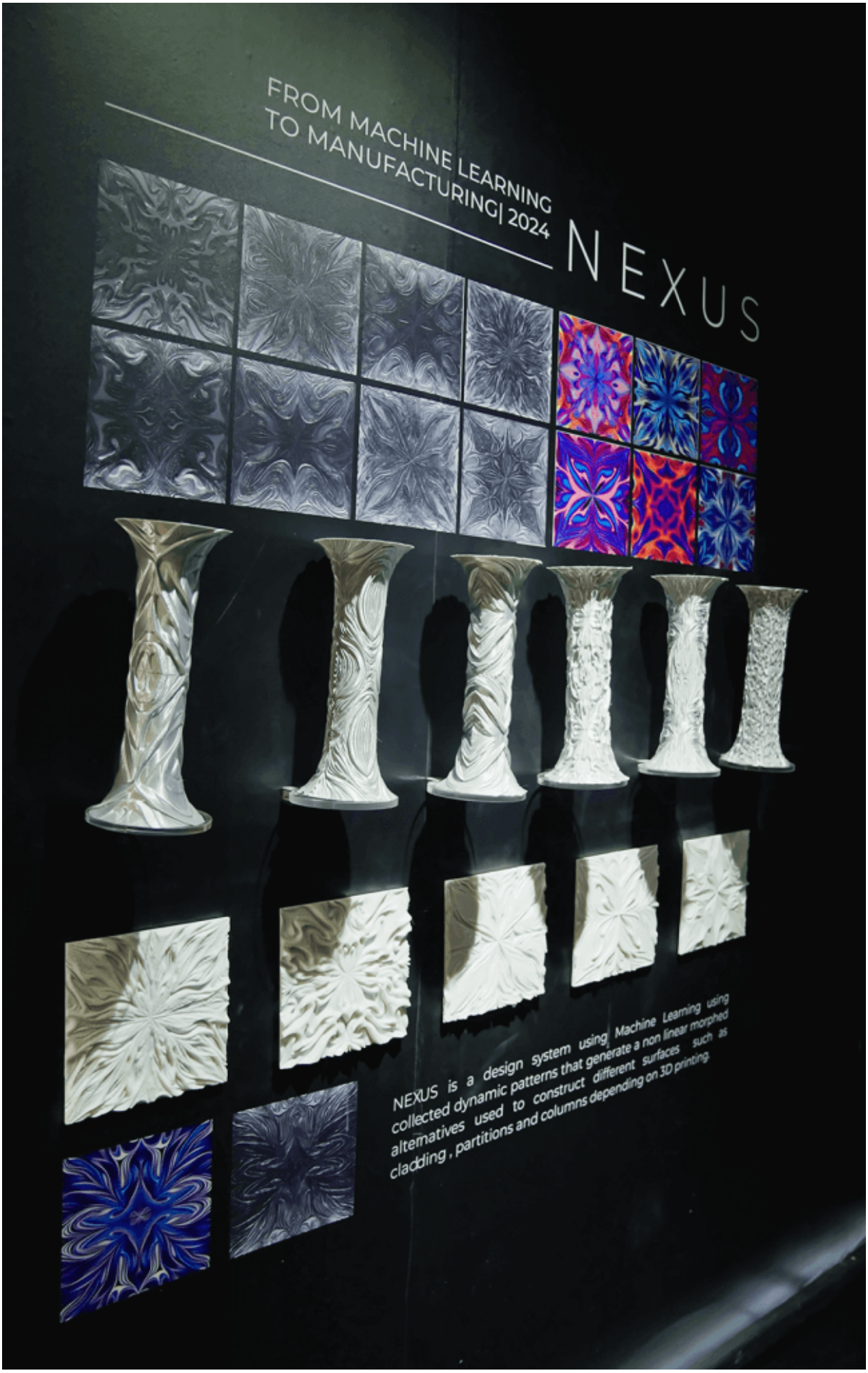
At its core, NEXUS is a machine learning–aided design system that collects dynamic patterns to generate non-linear, morphing geometries. Unlike traditional parametric approaches, which rely on predefined rules, NEXUS leverages AI to produce emergent outcomes, designs that would be nearly impossible to script manually.



The AI model generated 2D image patterns based on textual prompts.

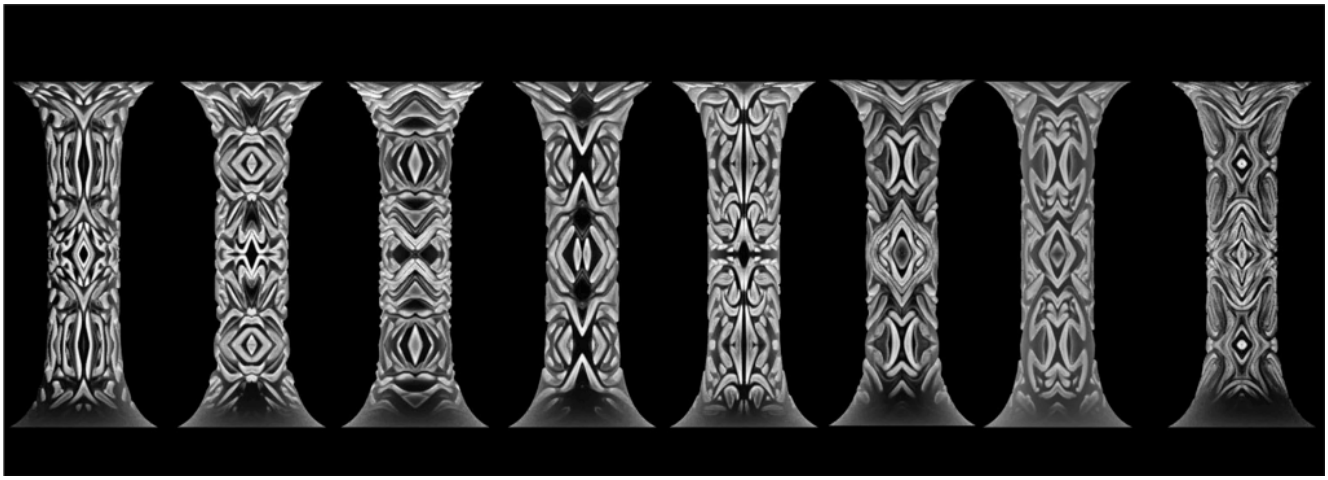
FROM CONCEPT TO MACHINE LEARNING

The conceptual inspiration behind NEXUS was driven by a desire to transcend the limits of traditional design tools. ENCODE Studio sought to explore new dynamic geometric patterns and create aesthetically complex relationships that couldn’t be efficiently achieved using standard parametric modeling.


FROM MACHINE LEARNING
TO MANUFACTURING| 2024
NEXUS
NEXUS is a design system using Machine Learning using collected dynamic patterns that generate a non linear morphed alternatives used to construct different surfaces such as cladding , partitions and columns depending on 3D printing.

Prototypes.

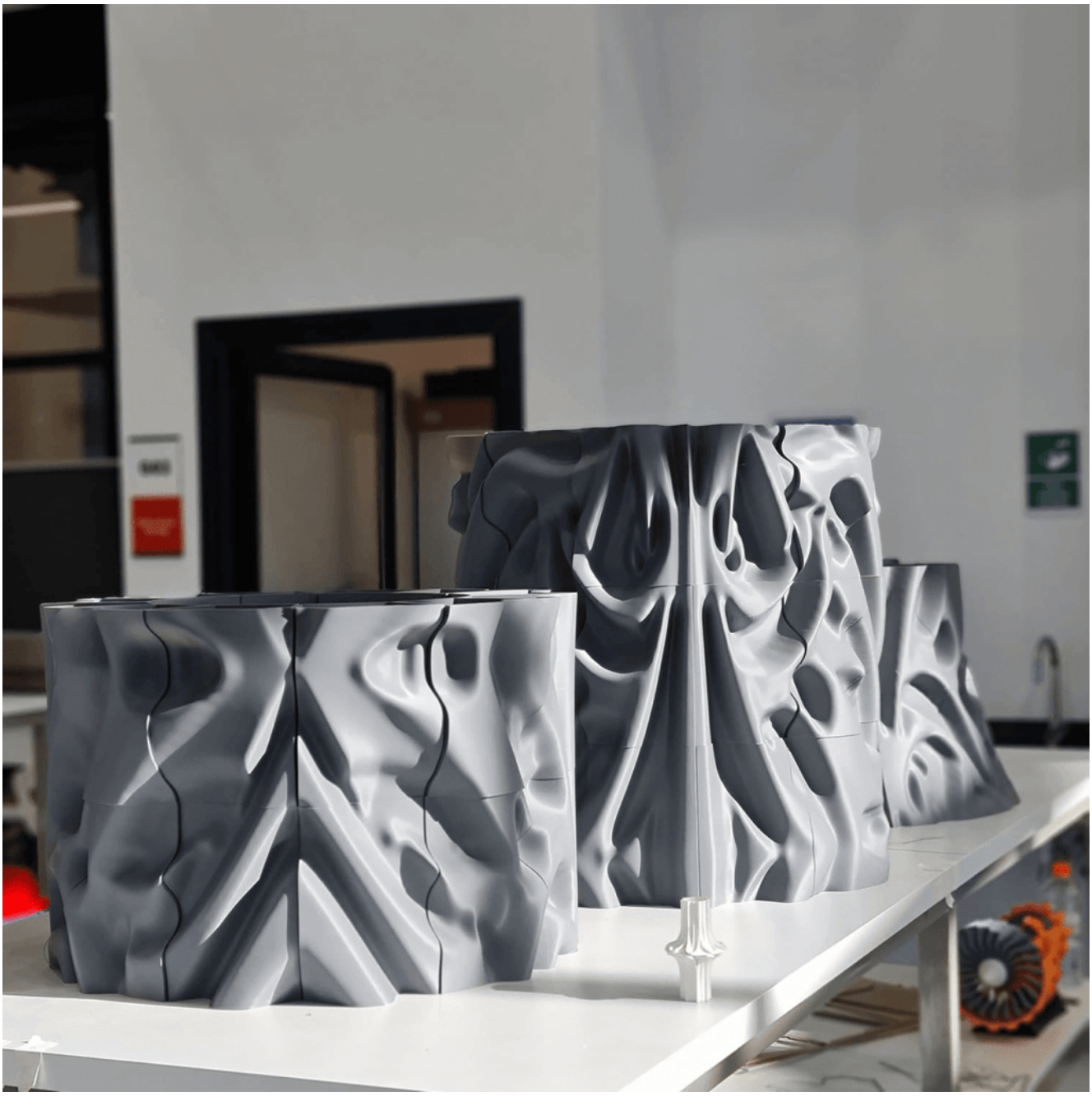
To achieve this, the team developed a workflow combining Grasshopper, Rhino, and Stable Diffusion. The AI model generated 2D image patterns that were based on textual prompts. These images were then processed in Grasshopper, where the luminance values of each image informed the extrusion depth, creating a 3D topography of intricate, flowing patterns. This process was done through a custom plugin developed by ENCODE Studio.



Some of the alternatives generated by the AI model.

Once generated, these forms were rationalized for fabrication directly within Rhino. Grasshopper handled essential processes, including offsetting for material thickness, designing joinery systems, segmenting geometries into printable layers, and preparing data for full-scale 3D printing.

Pre assembly of the 3D printed models.

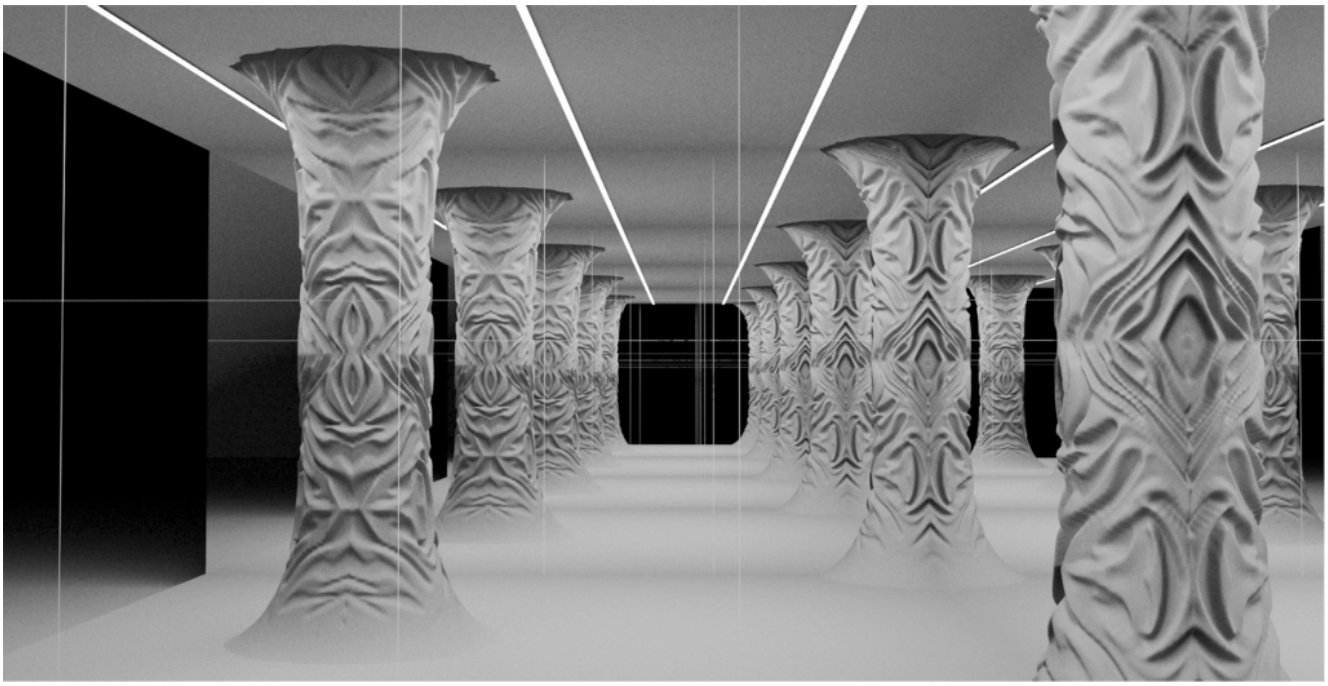


Pre assembly of the 3D printed models.

THE BUILT INSTALLATION

The resulting installation featured one central column and four quarter-columns, each 2.7 meters in height and fabricated using PLA+ 3D printing filament. Reflective dark plastic surfaces were integrated to enhance the immersive experience, creating a dialogue between real and imaginary architectural elements.

Detail of 3D printed models.



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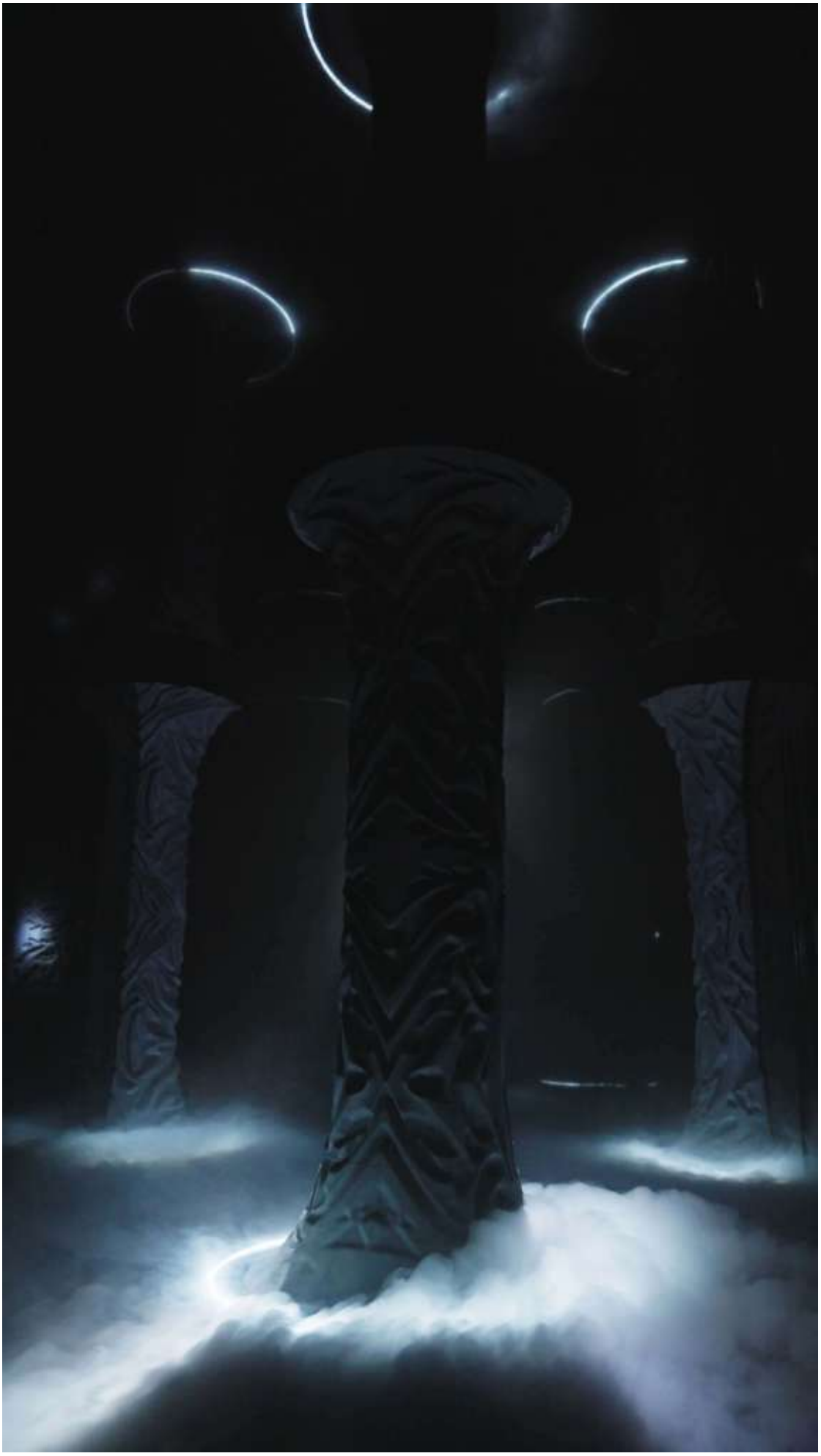
This interplay of physical and virtual design challenged the audience’s perception of space, inviting them to experience an ever-shifting, dreamlike environment.

PUSHING THE LIMITS OF FABRICATION

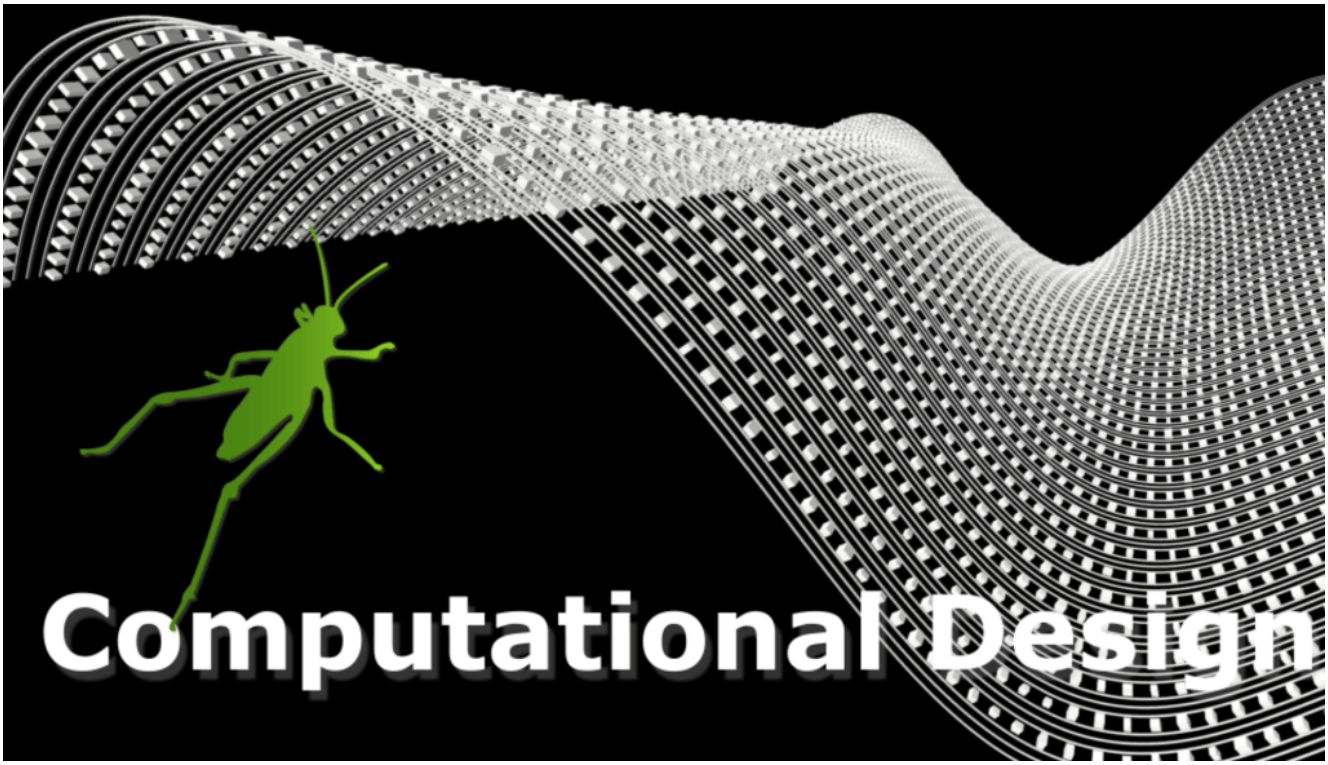
Scaling complex generative designs to full-size architectural elements presented multiple challenges, particularly within Egypt’s still-developing digital fabrication landscape. NEXUS pushed the local limits of additive manufacturing, not only by using PLA+ for its biodegradability and energy efficiency, but also by integrating circular economy strategies.



All printed elements can be shredded and converted back into filament using machines from Precious Plastic, which were developed by San3a-tech. This approach minimizes material waste and reflects ENCODE Studio's commitment to sustainable design practices.

IMPACT & FUTURE POTENTIAL

As one of the first projects in Egypt to introduce machine learning–aided design to architectural workflows, NEXUS has sparked significant interest among universities, manufacturers, and local designers. Its success has inspired conversations around AI's role in design education and the future of digital fabrication in the region.



See Also

COMPUTATIONAL DESIGN WITH GRASSHOPPER

ENCODE Studio is now exploring 3D concrete printing in collaboration with local startups, with potential applications in architectural

façades, urban furniture, and landscape elements. By fusing AI-driven generative design with emerging fabrication techniques, NEXUS represents a paradigm shift, not just for Egypt’s design community, but for architectural innovation globally.

CREDITS

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