ELEFTHERIOS KOURKOPOULOS

computational designer

PORTFOLIO

selected works

2019 - 2022

INDEX

publication

2022

PAX.WORLD`S METASERAI

professional work

Grimshaw's Metaserai is an integrated project in Pax. World's metaverse that constitues one of the four main gateways and communal places in the world.

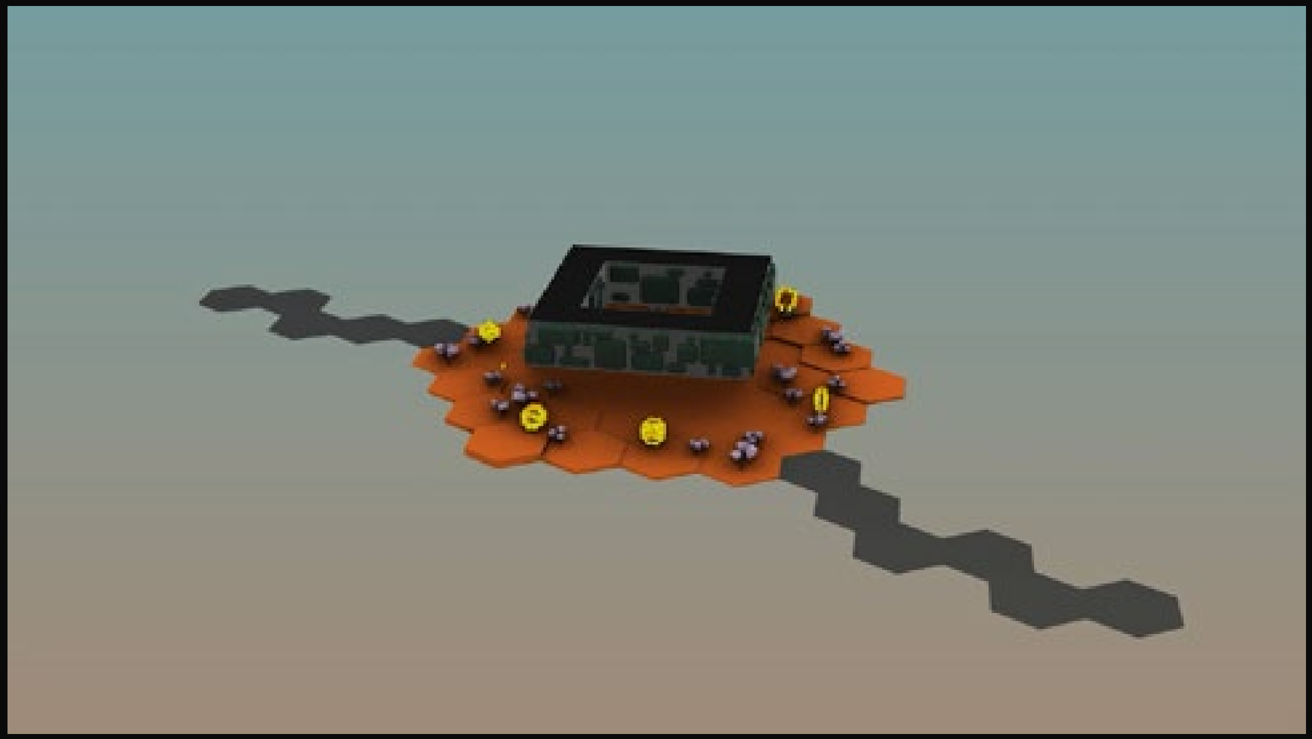
The metaverse was a rectangular shape and the separate meeting spaces are placed on the periphery, a feature reminiscent of the typology of caravan serais.The projects features a monolithic volume, which changed constantly as users generate, inhabit and terminate meeting spaces.

Users can request a meeting space via spherical follies placed on the landscape. The meeting rooms are subsequently generated from a predefined kit of parts. Interactions between users or between users and the environment are captured and reflected on the structure, through digital materiality changes, environment deformations or data-informed events.

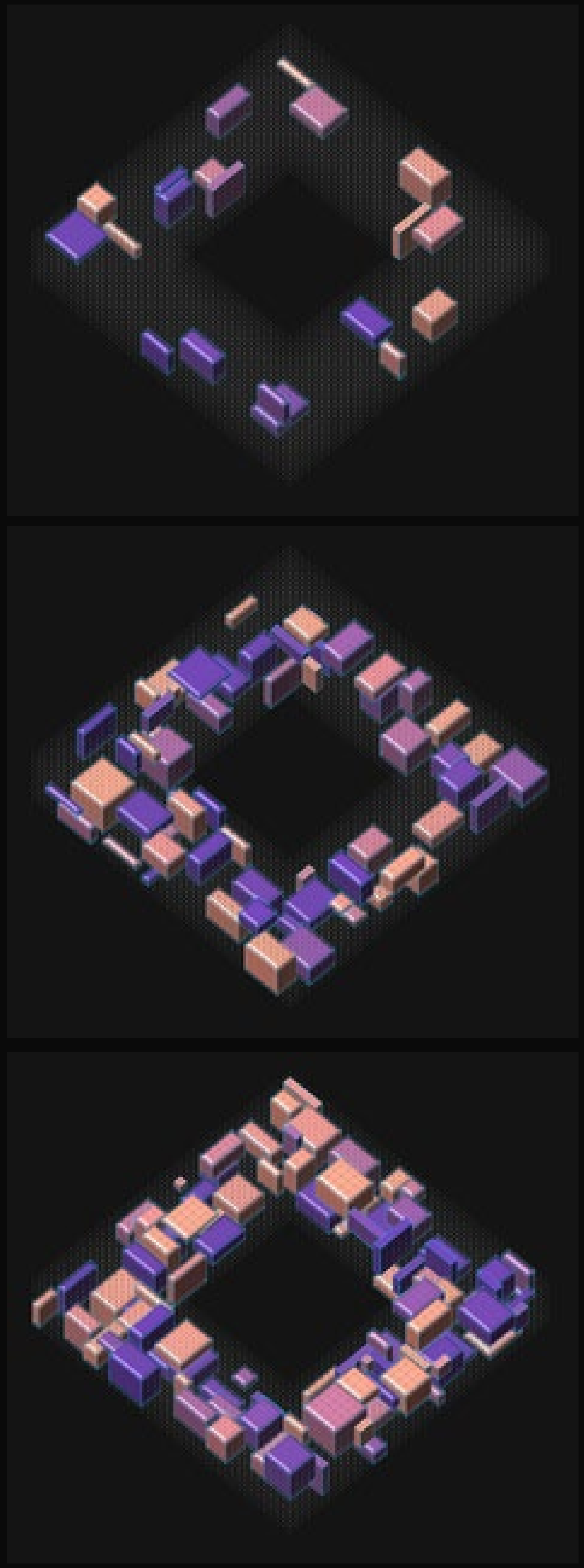
The project was developed and delivered in Unity and C#, incorporating behavioural aspects in the design product.

The main functionality of MetaSerai is enabled by a voxel-based packing algorithm. By providing the users with the capability of generating and occupying meeting spaces, it is evident that a space volume managing system is imperative. To address the feature, a packing algorithm was developed by dividing the monolithic volume into a voxel grid. By collecting specifications from the user, the size, the prefered zone and orientation of the meeting room is defined. Subsequently, the algorithm seeks to place the required volume to the requested area, while at the same time catering to an even distribution of volumes accross the volume. The packing algorithm was further connected to the scripts that handled the asset generation.

To define the geometry of the room, a kit of parts was built. Th e parts of the kit were selected and connected according the meeting room's location, orientation and visibility from the ground. Additionally, further procedural geometry generation techniques are employed to a ensure proper texturing of the volumes, asset addition to scene and functional elements placement (such as colliders).



volume overview

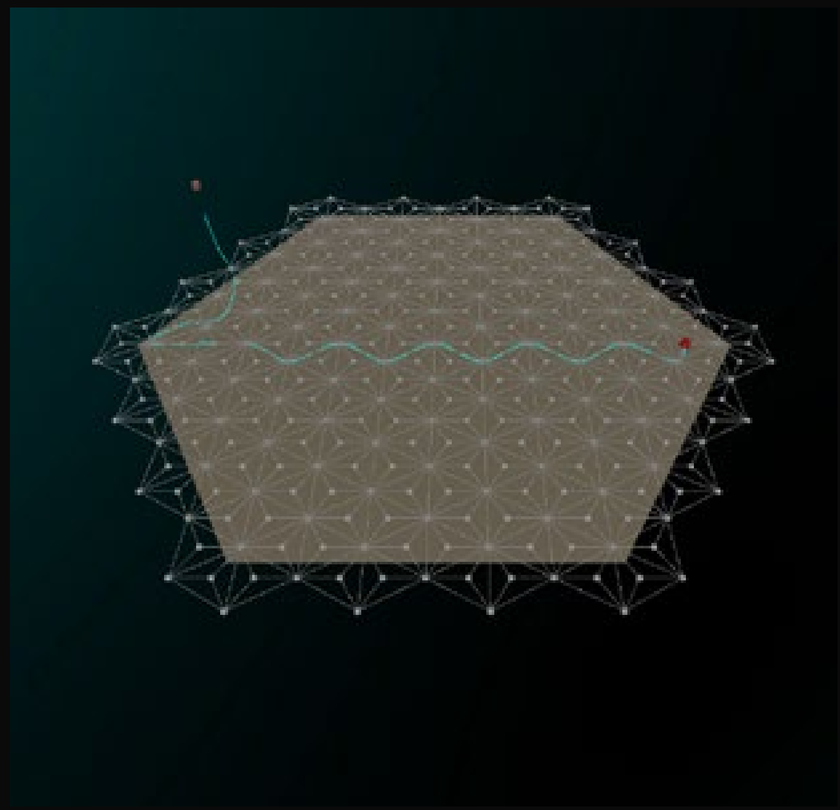


meeting room population

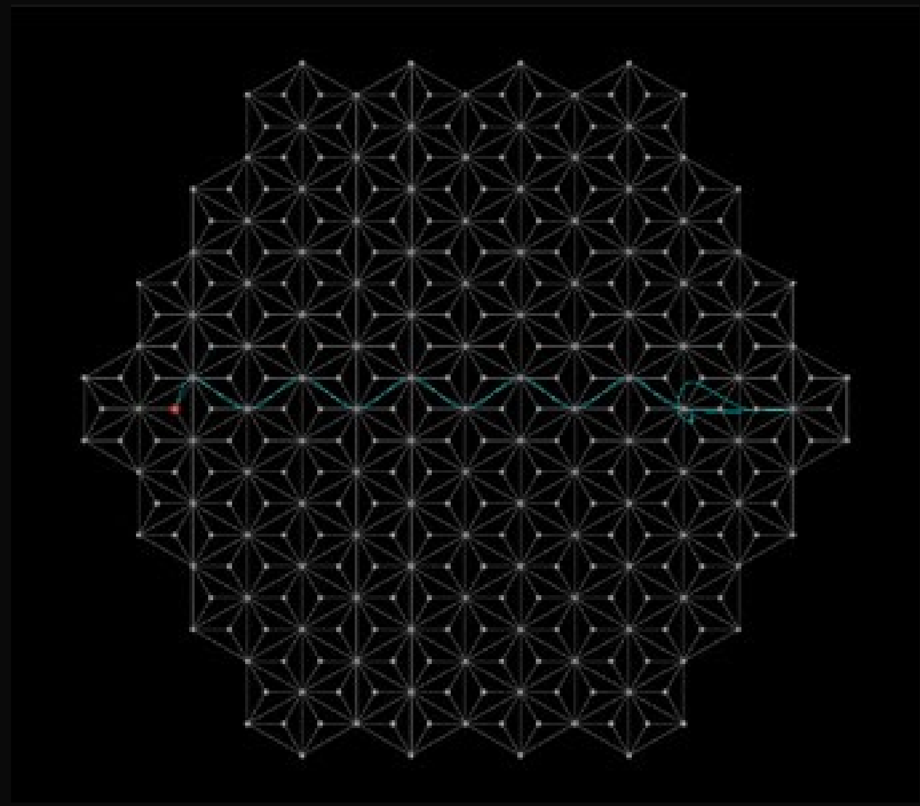
meeting room population

Following the narrative of generation of meeting rooms as seeds, the meeting rooms where spawned as compact volumes near the follies that beared the functionality for meeting room definition. Further to that, the meeting room created a trail on the ground for wayfinding purposes.

The wayfinding was facilitated via the implementation of the a* pathfinding algorithm on a predetermined graph. The generated trail was visualized by a catmul-rom spline in Unity and was further used by the terrain shader, so as to reflect the path as a trench on the terrain.



a pathfinding algorithm implementation*



a pathfinding algorithm implementation*


SPACE

publication

2022

UK VERTIPORTS

professional work

In 2021, Grimshaw Architects, in collaboration with Ferrovial, Mott McDonald and Lillium, begun developing a series of vertiports to be constructed accross the United Kingdom. In particular, the project involves the development of 25 vertiports accross the United Kingdom.

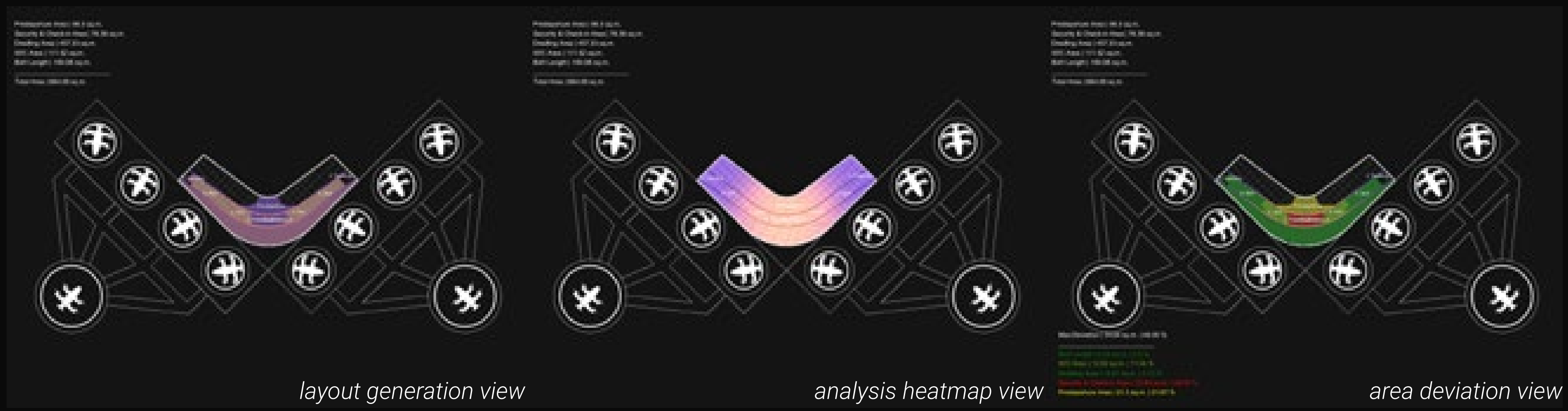
Vertiports constitute intermodal centres of commute that are designed to be integrated within the city fabric and provide high speed, affordable and emmission-free travel. More specifically, at the vertiports, electric vehicles, called eVTOLs are being operated. The airfield of the vertiports are designed to facilitate the departure and landing of a single eVTOL at a time, while multiple eVTOL can be docked at the same time.

The project is still under development and set to be completed by the end 2026. Anticipating the time-based repercussions of planning 25 vertiports, research and development was conducted regarding the development of a layout conifurator, incorporating optimisation capabilities.

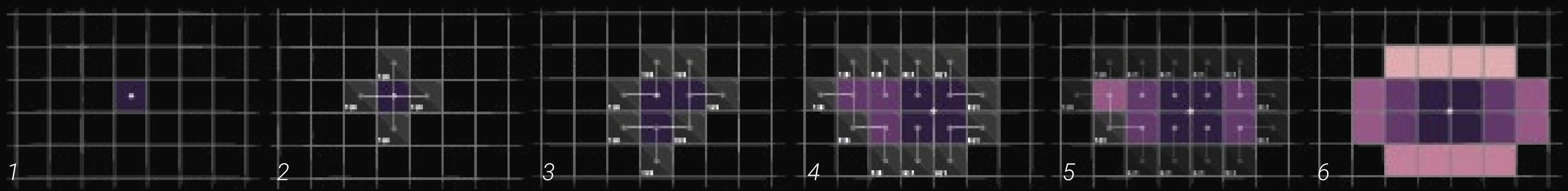
The layout configurator includes the airfield, which was modeled in a parametric manner according to the airfield specialist's guidelines. Simultaneously, the terminal was generated via a graph-based procedural generation system.

With regards to the terminal layout configurator, the boundary of the terminal is divided into grid cells and then converted into graph nodes, with each node containing data associated with the grid cell (i.e. area, distance to entry points etc.). Two distinct graphs are implemented in the system, one reflecting the terminal's program of spaces and an internal graph for each area generated, which reflects the association among the aforementioned nodes. The algorithm is following a growth pattern, by evaluating the graph nodes and assigning a function to them based on predefined criteria.

In order to inspect the results, multiple analysis views were developed, visualizing area deviations, distance heatmaps, average walking distance to the stands and so on. The Grasshopper plugin was also developed in a way that facilitates layout optimisation workflows, utilising evolutionary solvers.



layout configurator based on graphs



graph-based generation sequencing

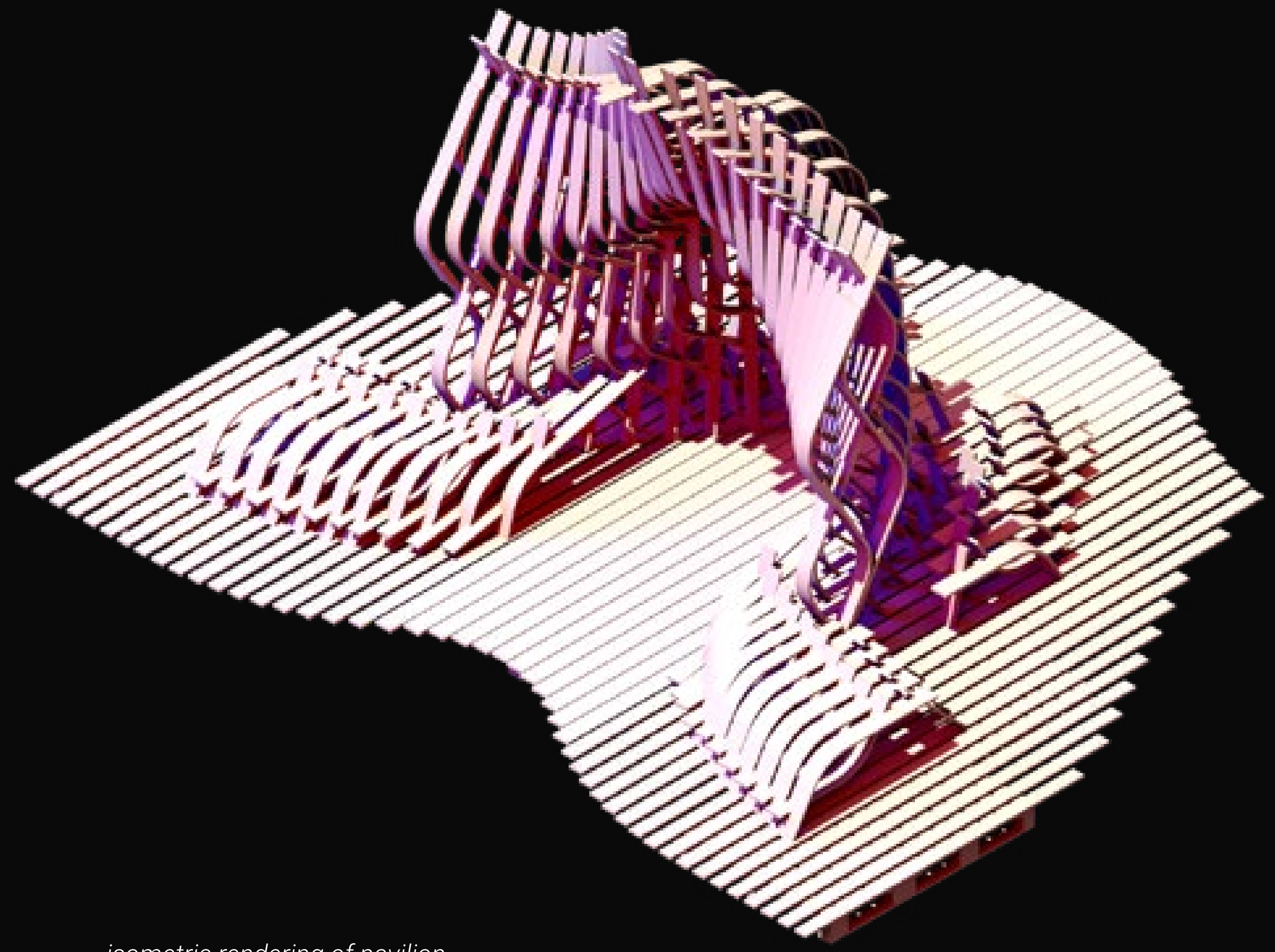
2021

RE-EMERGE PAVILION

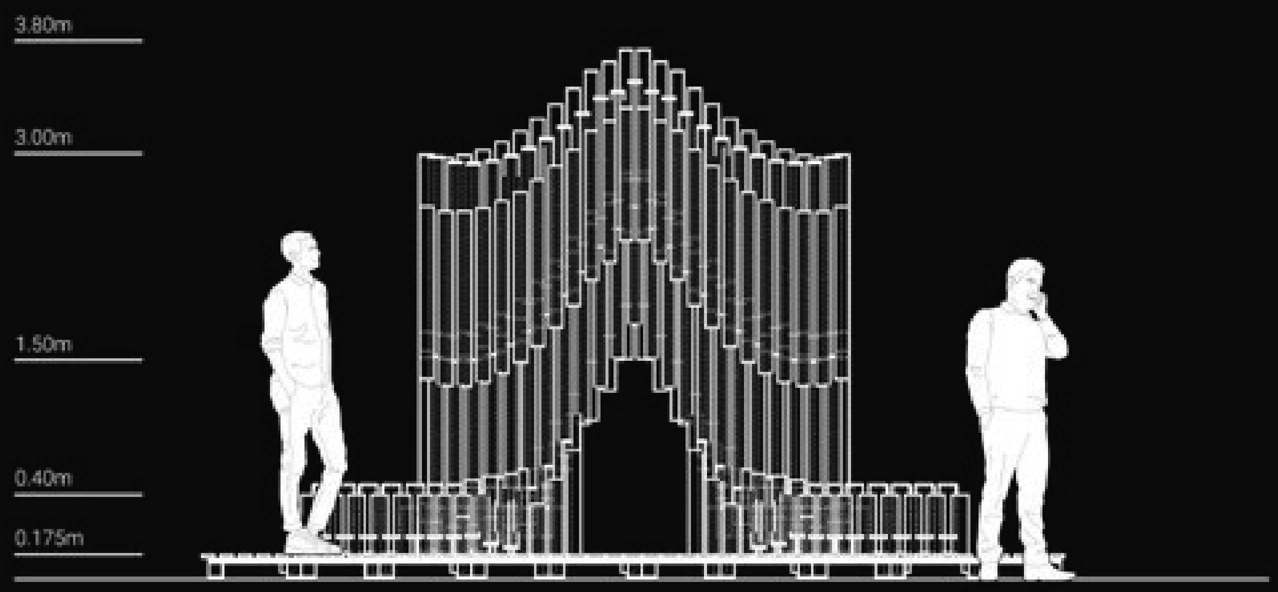
misc. work

As part of the Hassell Studio X EmTech collaboration, this pavilion seeks to explore the re-usability of pallet wood, while extending its life cycle. The fabrication workflow was built around the methods of wood kerfing and steam-bending, while slot joins were preferred, to add structural integrity. The pavilion was designed computationally, taking into account the achievable degree of curvature, the plank length and the amount of planks required. This rendered the workflow iterative, as it was constantly informed by the results of physical testing,

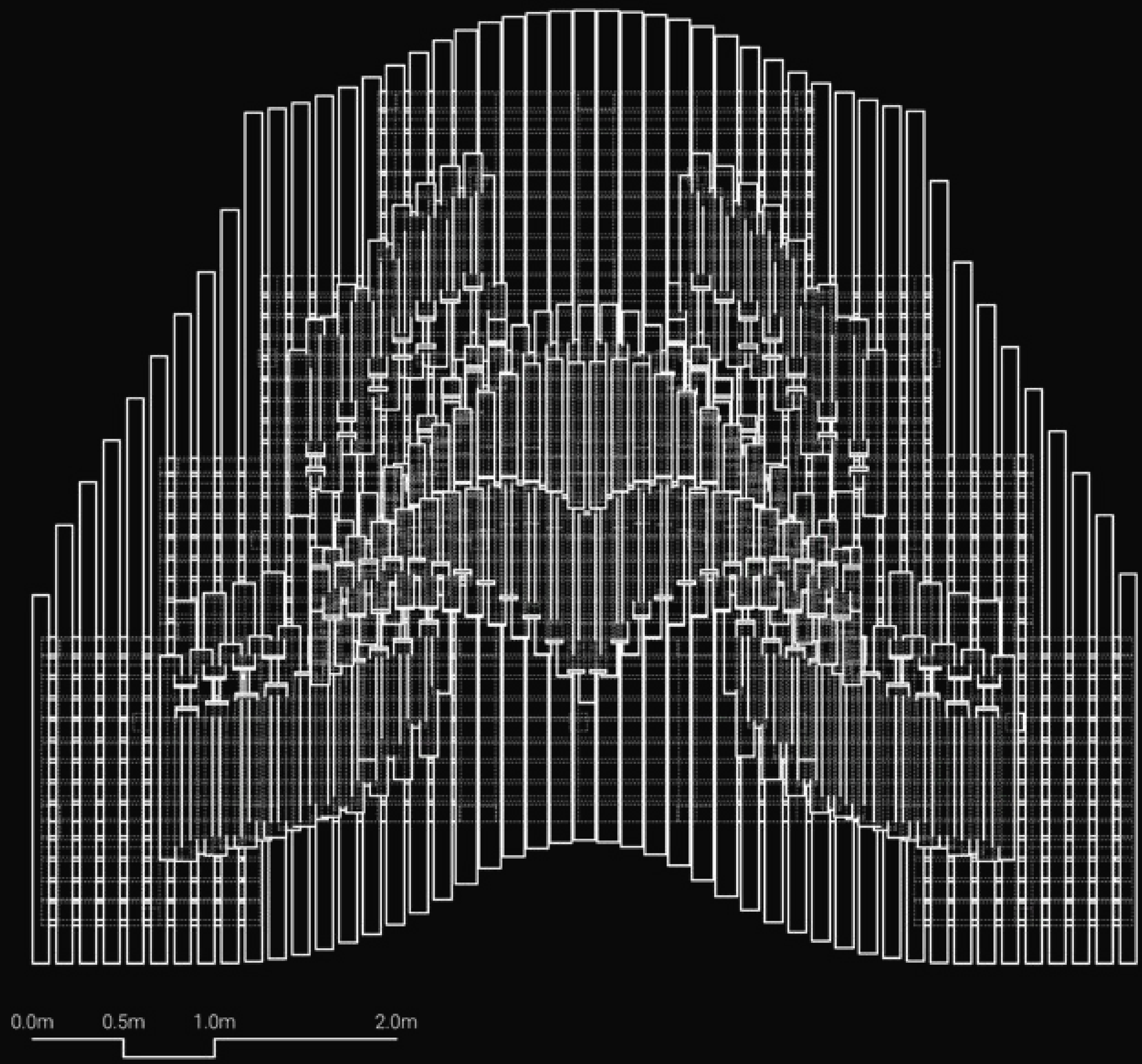
The pavilion was further supported by an Augmented Reality application. In the application, the user can visualize the pavilion off-site or explore the immersive on-site experience and visualize relative data and information.



isometric rendering of pavilion

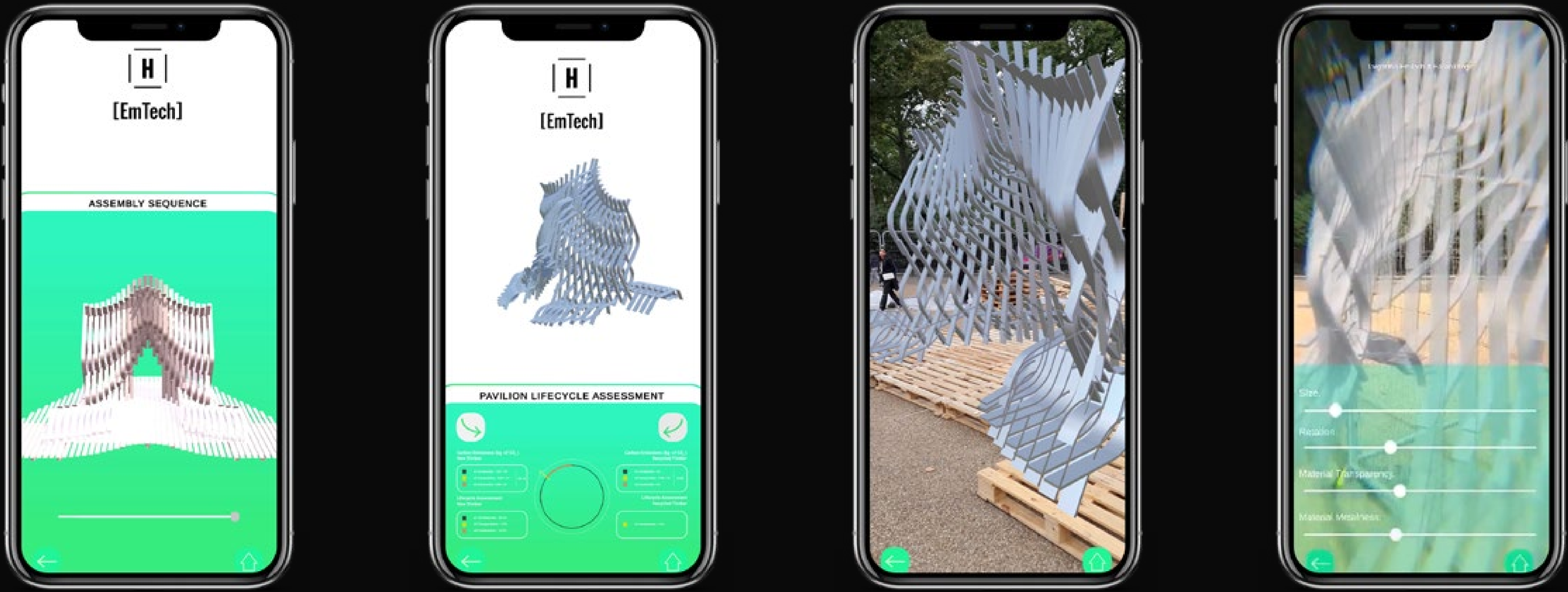


elevation of pavilion



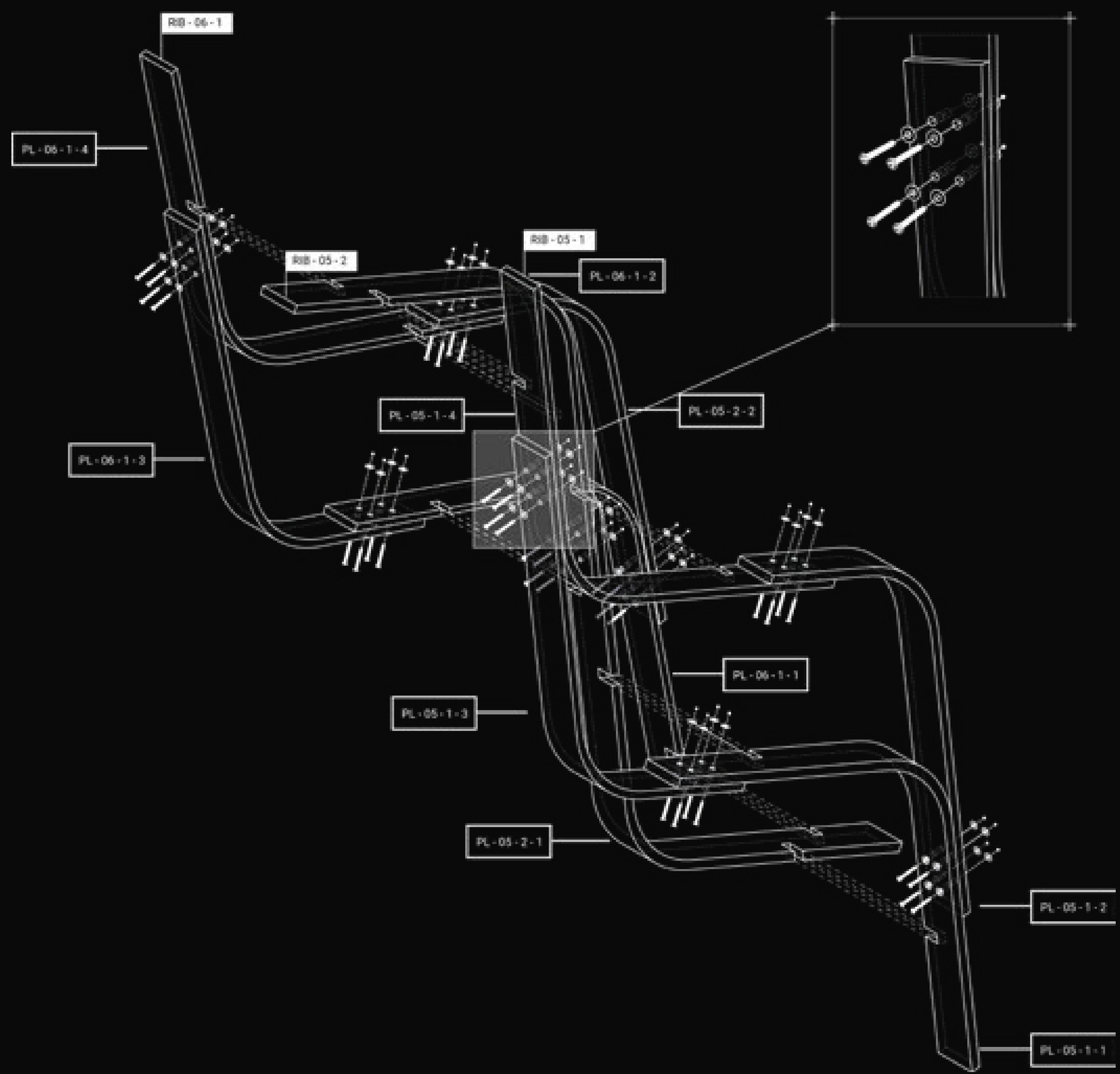
floorplan of pavilion

AR Application



screenshots of augmented reality (AR) application

user interface (UI) design for the AR application



construction detail of pavilion ribs

The computational model was rationalized and translated into construction details and documents using Rhino-Grasshopper and scripts in C#. One-to-one scaled prototypes were constructed to test the efficacy of the workflow. Lastly, fabrication and assembly details were extracted computationally to ensure their precise and proper execution.

video presentation

2021

CY-PHY PROLEPSIS

academic work

Cy-phy prolepsis aims to cater to more inclusive public spaces by unifying the digital and physical realm in the urban environment.

Kinetic pneumatically actuated structures public spaces that can be utilized by a diverse group of people and cater to a number of different activities. Thus, promoting a more diverse urban landscape.

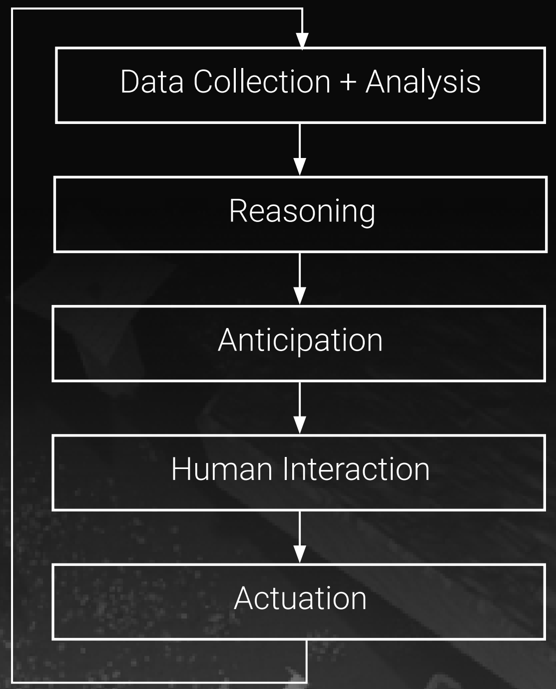
The system is supported by an anticipatory data-driven activity distribution system, which suggests activity distribution based on inclusive strategies. The system collects, processes and utilizes real-time data, to accurately reflect the current state of the public space.

Moreover, cy-phy prolepsis aims to actively integrate the user's intentions and needs, by allowing the users to interact and modify their environment through an Augmented Reality application. Hence, giving proper agency of the users over the public space they inhabit.

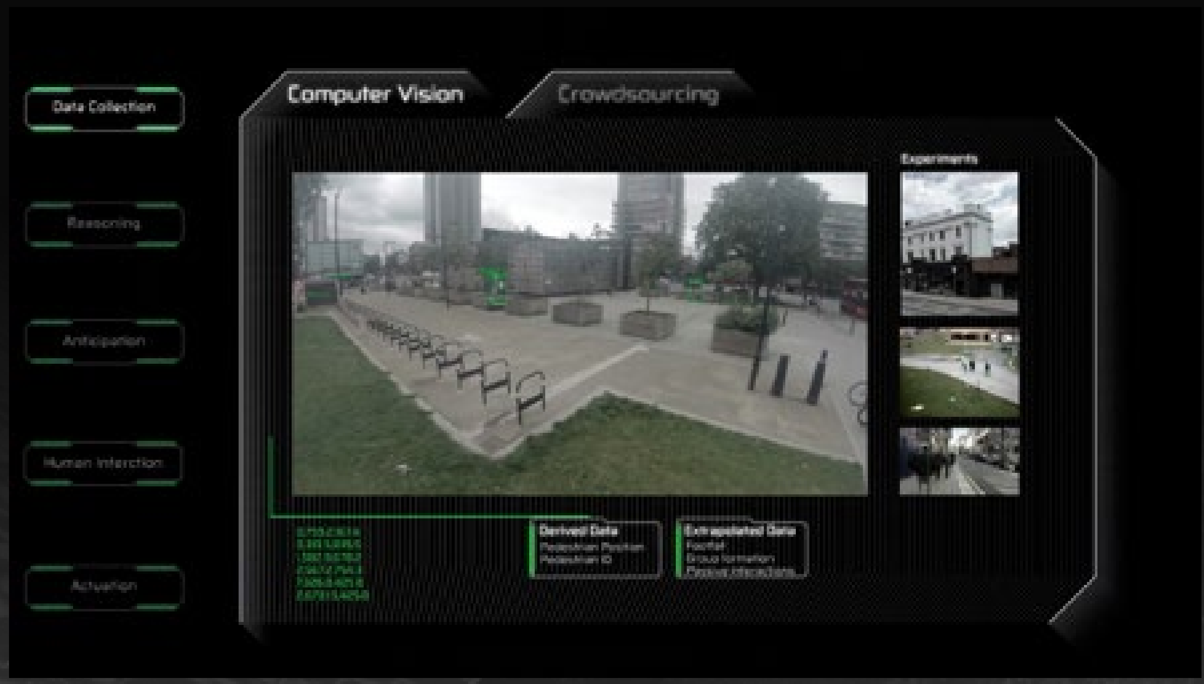
The physical aspect of the developed cyber-physical system consisted of lightweight and deployable kinetic structures, that are able to adapt to a multitude of activities. In particular, five distinct states of the structure were developed.

The compact state allows for transportability. The seating state caters to social and short-span activities. Additionally, the canopy state of the module is able to host extroverted activities that require more precise definition of space and protection from the environmental conditions. Lastly, the states of partition and enclosure allow for the development of activities that require additional layers of privacy.

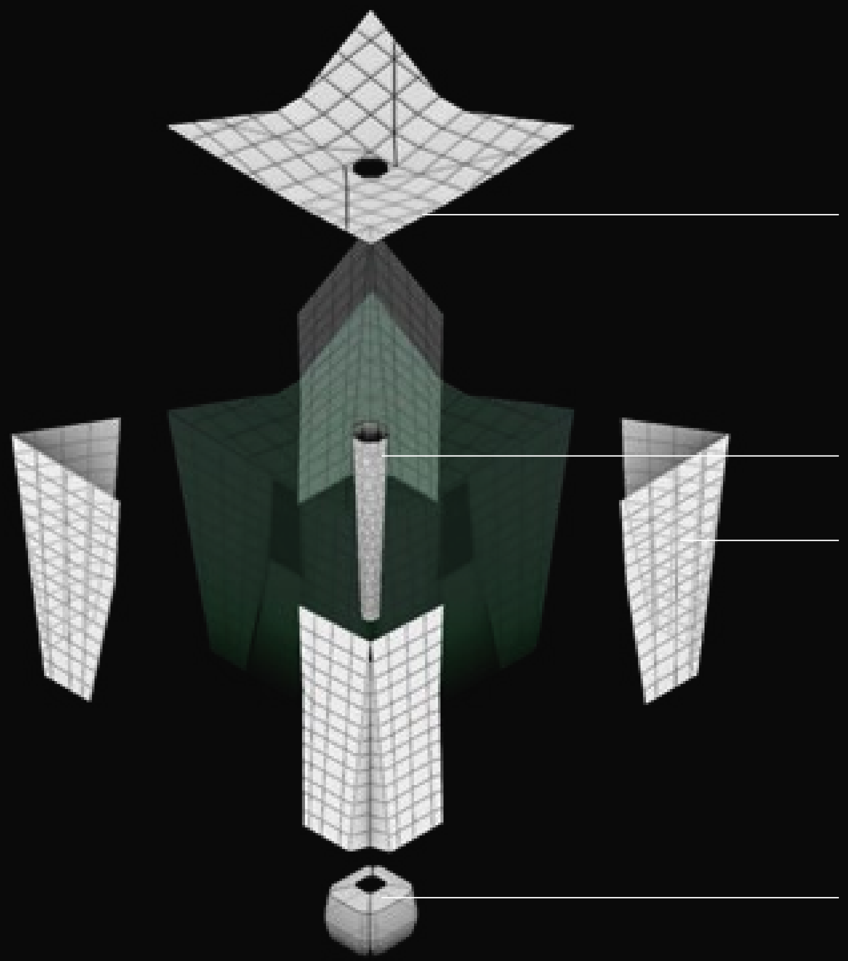
The kinetic structures were designed as ephemeral structures that are easily deployed and can be re-distributed and re-organized according the conditions of the given public space.



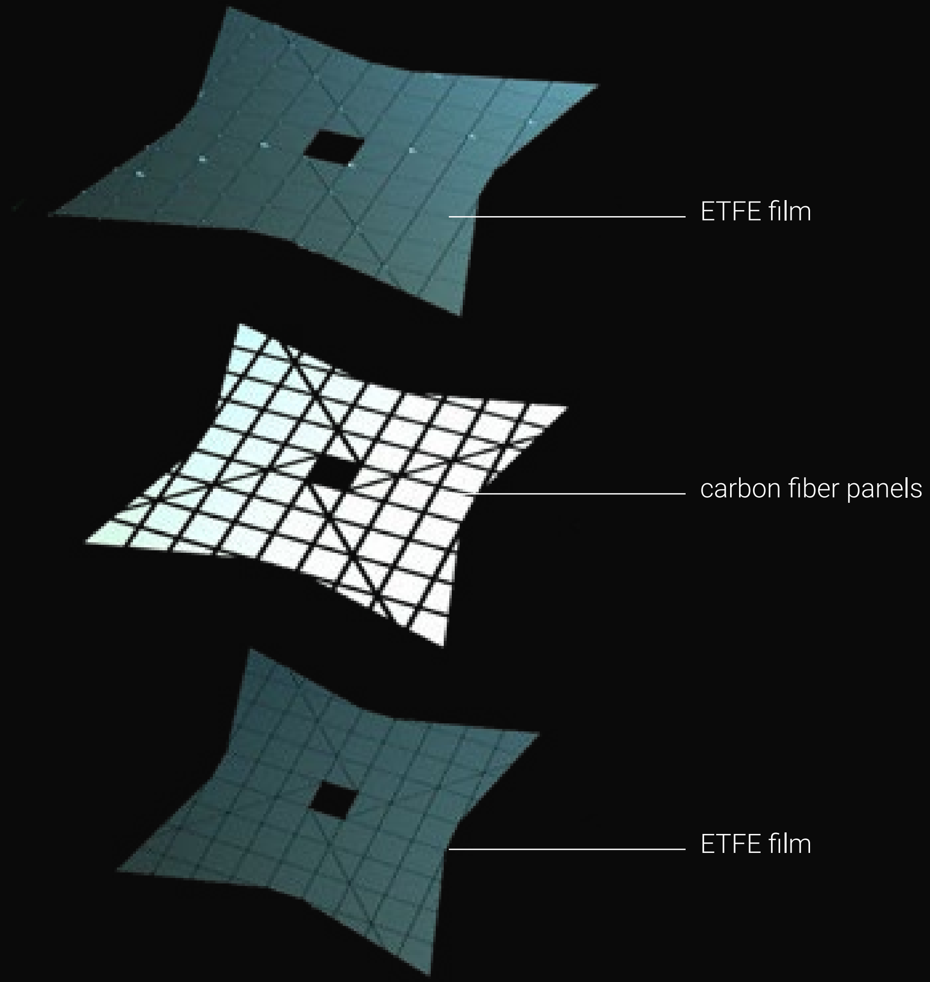
data-driven site activation worfklow



understanding the public space via real-time data



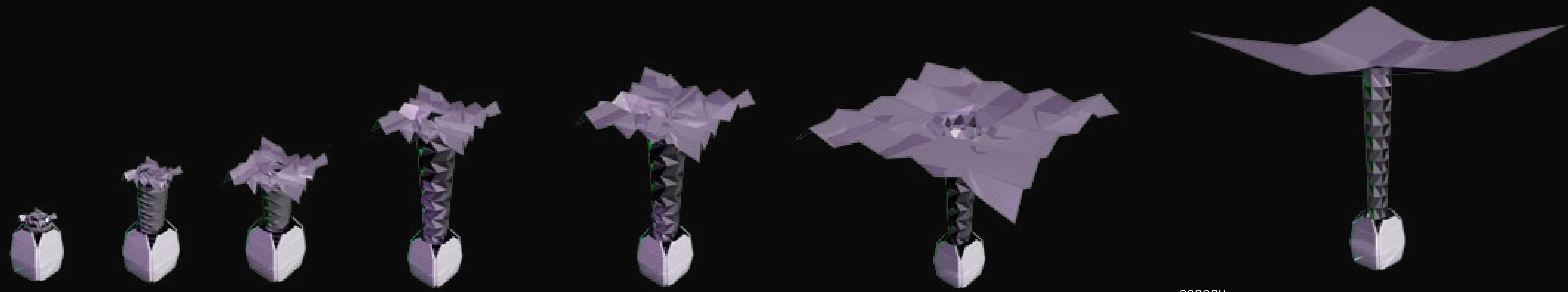
parts of structure



material detail of canopy

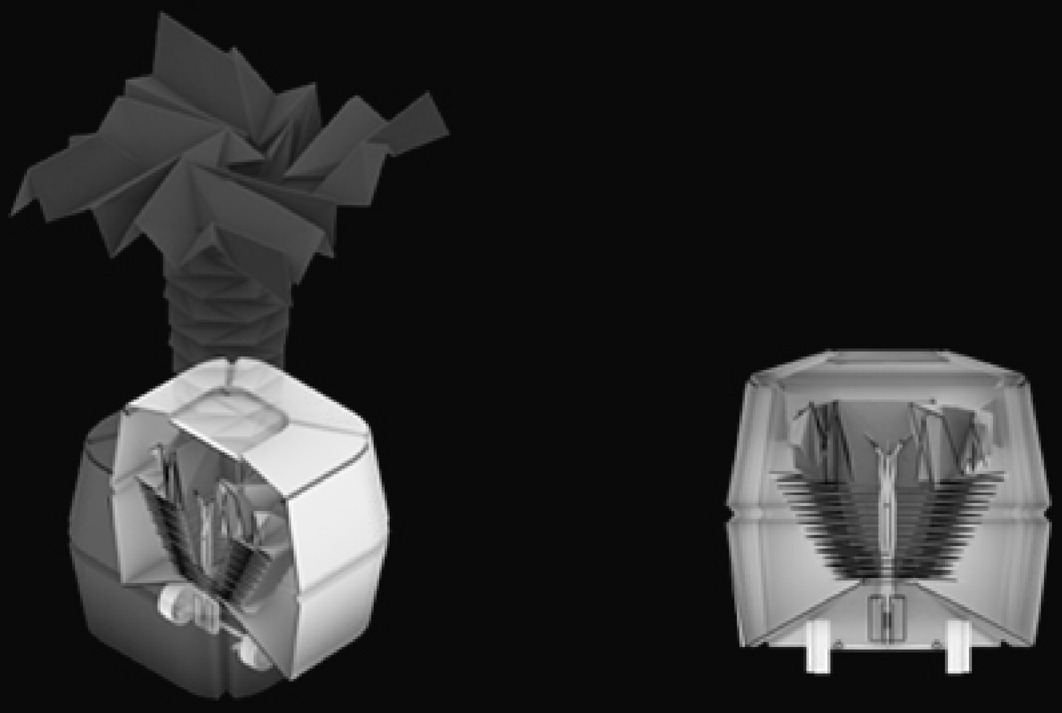
The lightweight kinetic structures were designed utilizing principles of origami folding patterns. The two main materials utilized were carbon fiber panels for rigidity and its light weight and ETFE film as connective tissue. Furthermore, the air compartments and elastic bands were introduced as a pneumatic actuation mechanism. In particular, an air-pump increases the pressure in the air-compartments, located between two adjacent panels, while the elastic bands apply constant tension to the deployment structure, rendering it form-active. The pneumatic actuation mechanism is controlled through micro-controllers.

The development and simulation of the folding patterns were developed in Grasshopper along with the Kangaroo 2 physics engine, while the animation of the deployment process was modeled and animated in Maya.



canopy

deployment sequence



compact version diagram

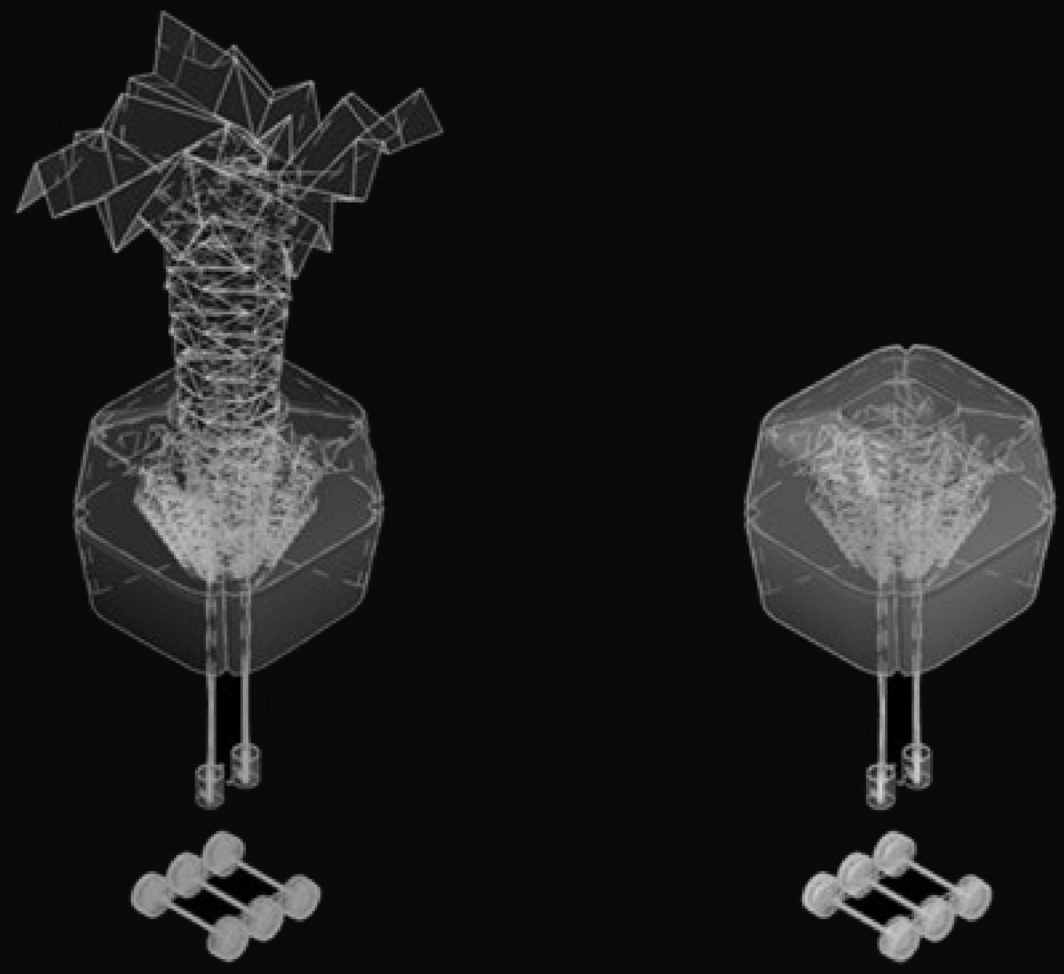
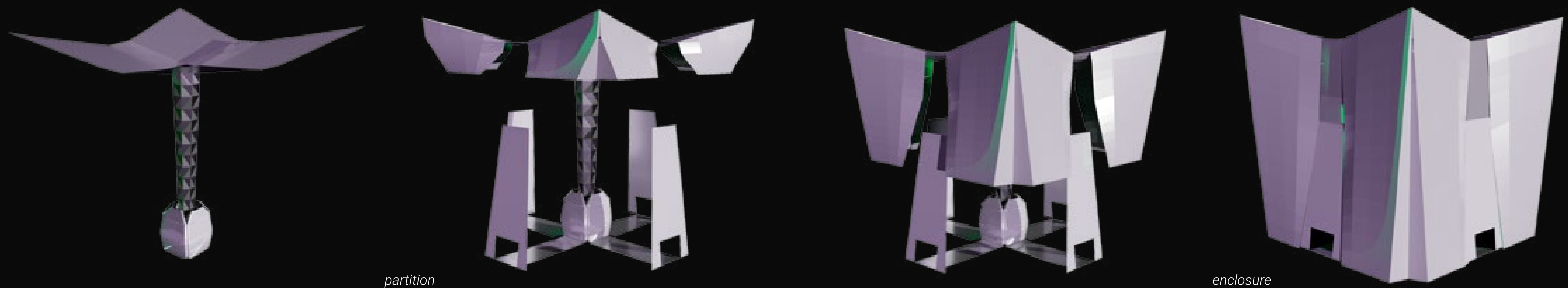
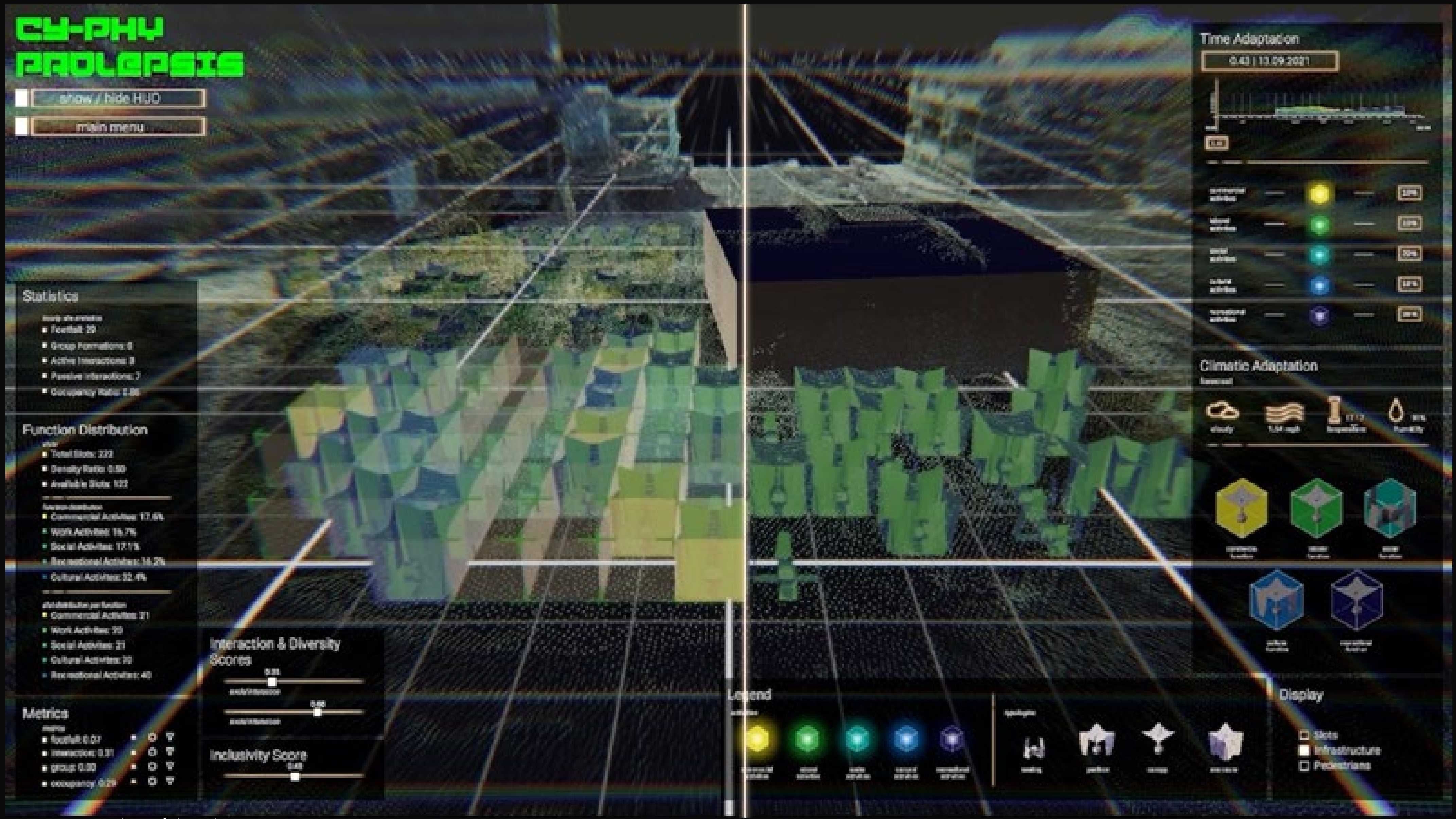


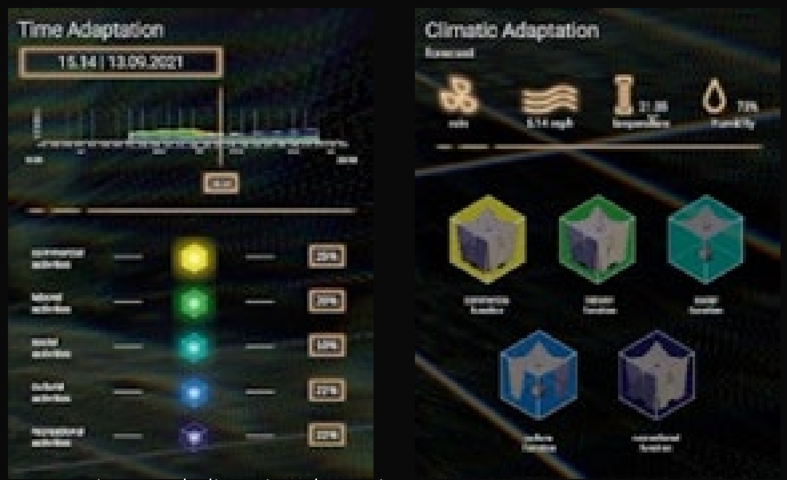
diagram of elements



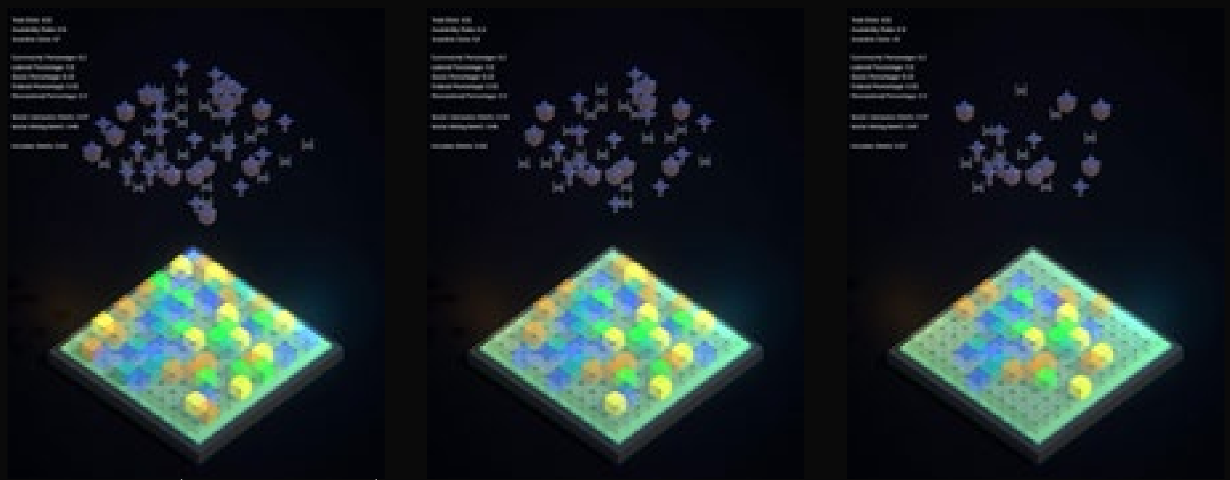
deployment sequence



screenshot of digital twin



time and climatic adaptation



suggestion system experiments

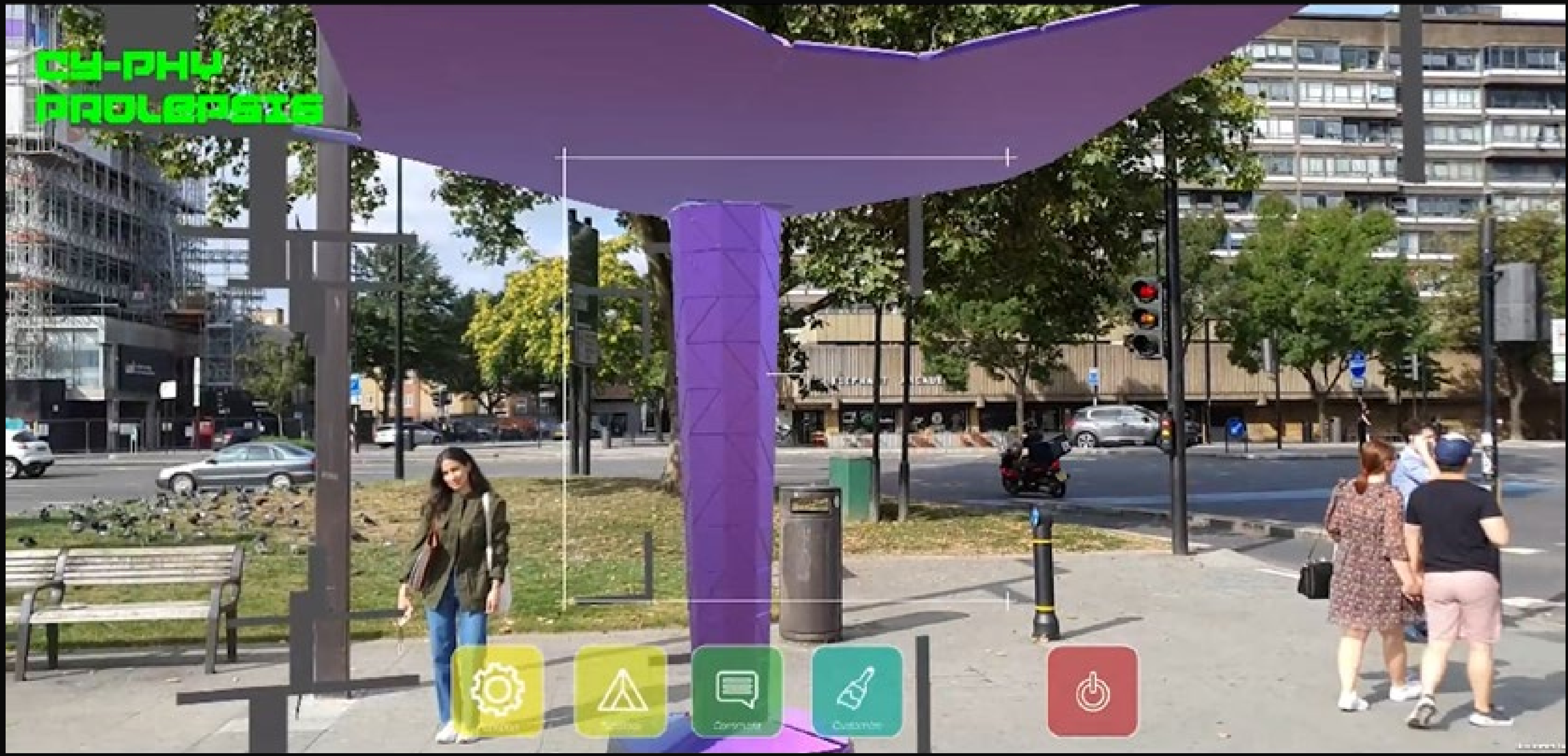
The digital (cyber) aspect of the project was developed in the form of a digital twin. In particular, an application was developed in Unity, intending to gather, rationalize and depict the current state of the public space in a digital form. In particular, the current deployed state of the modules were depicted, along with social and climatic data gathered. In particular, climatic data were gathered and depicted by connecting to the API of OpenWeather in real-time. Moreover, the current conditions of footfall and human activity in the public space were gather and depicted, by utilizing computer vision as a real-time data collection and processing technique.

To support the inclusive aspect of the project, an anticipatory system was developed in addition to the digital twin. The anticipatory system filters and processes the collected data to calculate metrics of social interaction, mixing and inclusion. By comparing them to acceptable benchmarks, the system employs different inclusive strategies in the form of activity distribution. For example, a reduced group formation metric urges for the introduction of more social activities. Hence, the anticipatory system proposes distributions of activities, along with the appropriate combination of the physical structures, to facilitate their development. Furthermore, climatic data are considered when assigning the physical structures to the proposed activities. The system collects data in real-time, but processes and proposes a different distribution of activities on intervals of 1 hour. In order to actively involve the user in the decision process, the anticipatory system suggests but does not actuate the proposed distributions. Hence, proper agency is given to the actual users of the public space.

The anticipatory system was developed using C#, while Unity was used as the platform of visualization. Furthermore, the majority of the data collection techniques were also developed using C#. Moreover, Python was used for experiments regarding computer vision, along with the OpenCV, Yolov4 and DeepSORT libraries and frameworks.

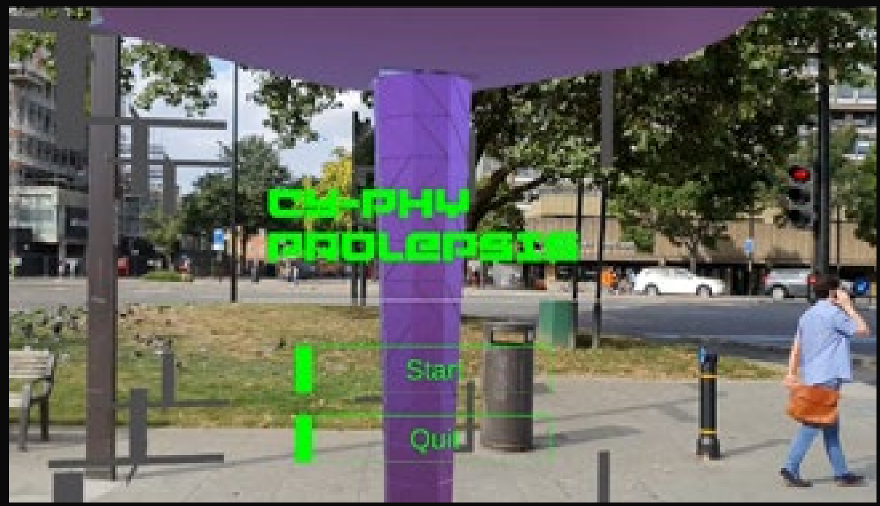
Aiming to provide proper agency over the space to users, the anticipatory system's suggestion can be visualized, interacted with, modified and actuated through an augmented reality (AR) application. In particular, through the AR application, the user can change the assigned activity of the current space, choose which typology (seating, canopy etc.) is most convenient for his activity, interact with the choices of other users and communicate with them through the platform. Thus, the AR application does not only constitute a manner of actuation, but also further promotes and incites social interaction in the digital realm.

The application was developed in Unity and C#, while it was also tested on site, on an Android device.



screenshot of AR application

UI design of AR application



AR application - home screen

2019

ANTI-DESERTIFICATION UNITS

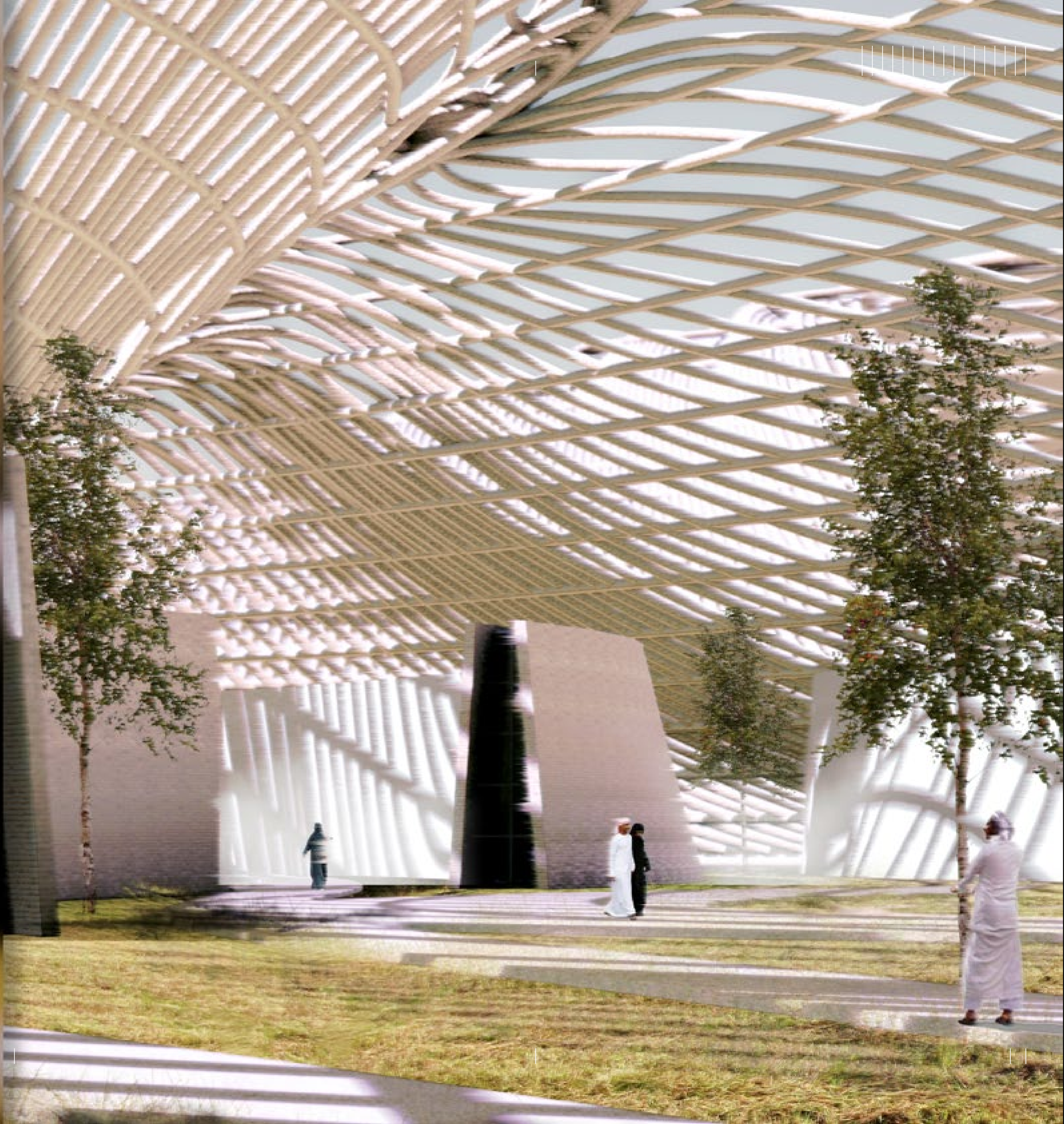
academic work

To address the global sand crisis and desertification menace, this project proposes a mechanism in order to rejuvenate barren lands by using bio-domes.

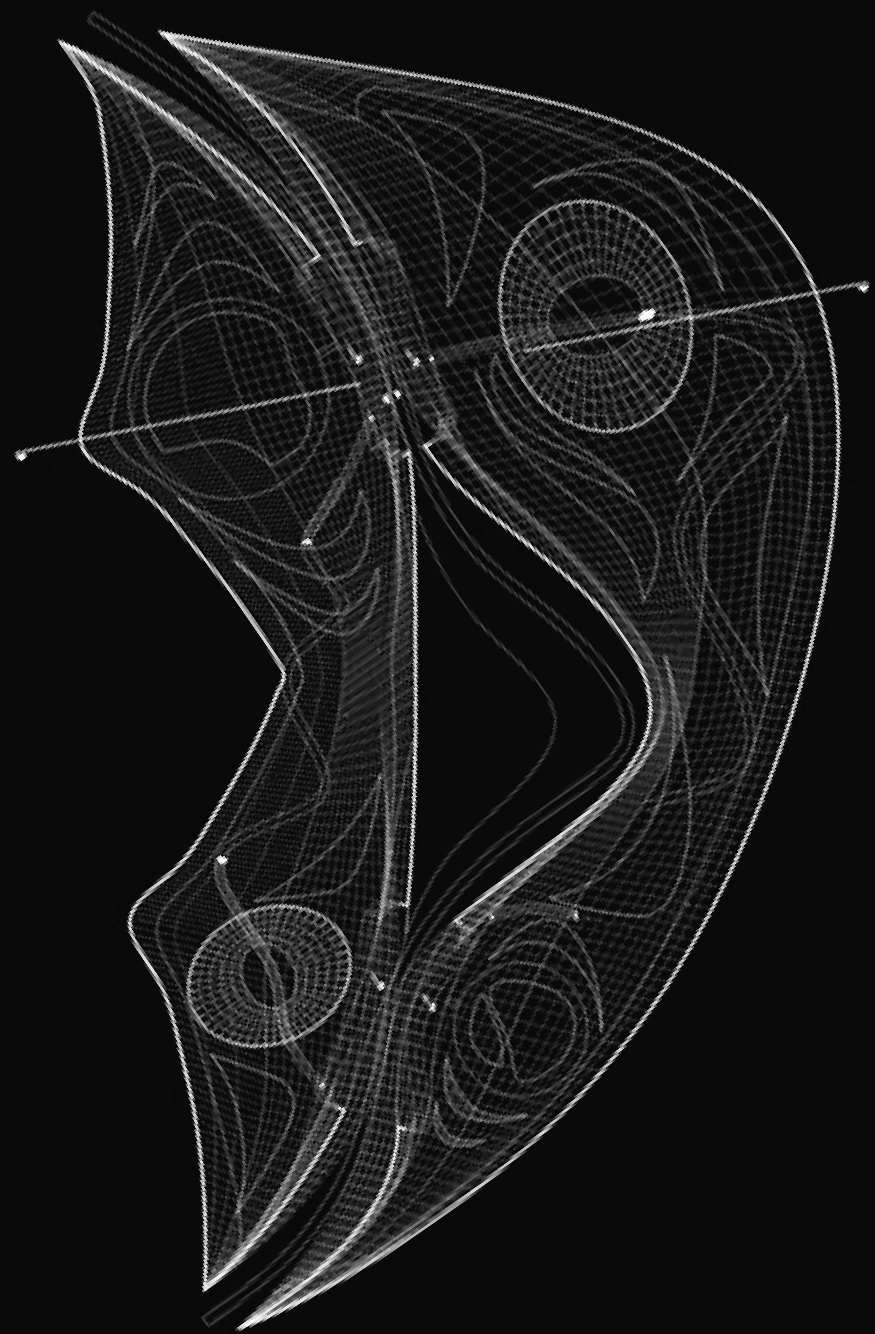
To elaborate, the project follows a speculative path and proposes structures in the desert of Saudi-Arabia, capable of hosting human and plant life under extreme conditions. In chosen locations, permeable bio-domes provide shading and water supply, through an artificial water cycle, rendering the area viable for plantations. Consequently, via the use of contemporary technologies, micro-climates are established, which allow a gradual growth of an ecosystem, both inside and outside of the structure.

Throughout the project, a seamless process is proposed, which can be altered according to the conditions of each location. Moreover, the highly adaptable nature of the process stimulates and incites trans disciplinary collaboration.

Hence, this project constitutes simultaneously a prototype and a case-study of the process mentioned above.



masterplan of the complex of three units



floorplan of enclosure unit

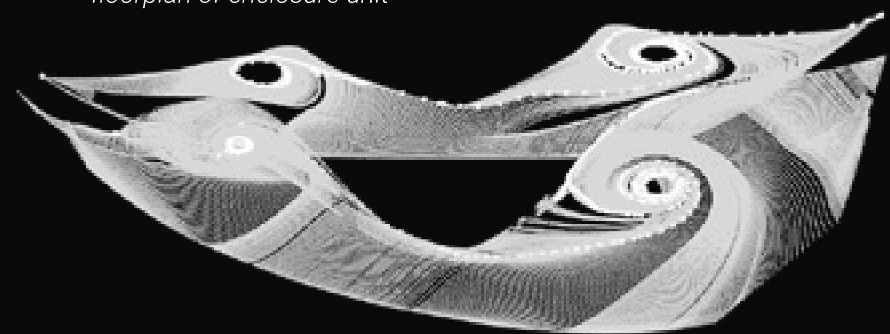
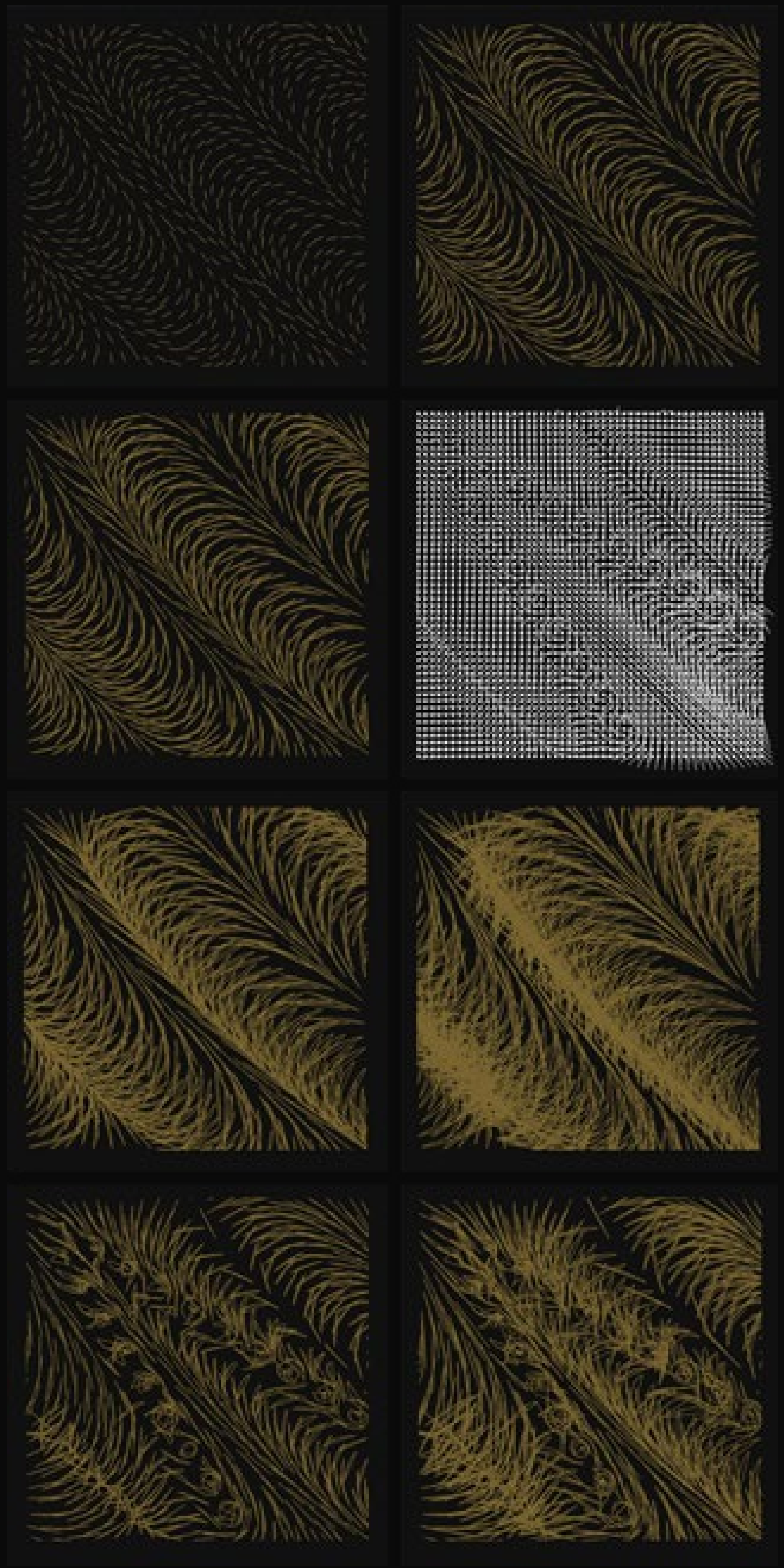
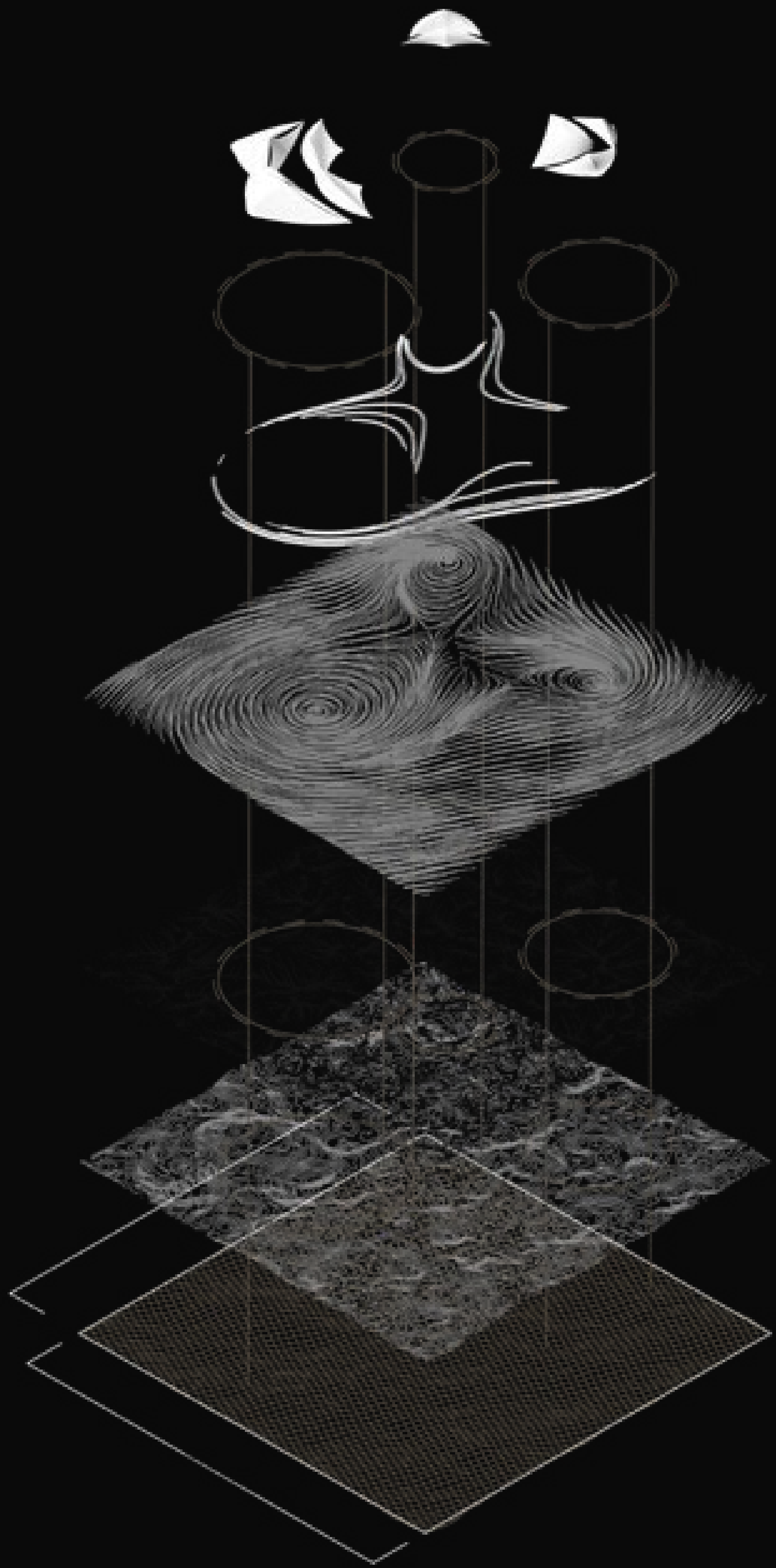


diagram of shell design

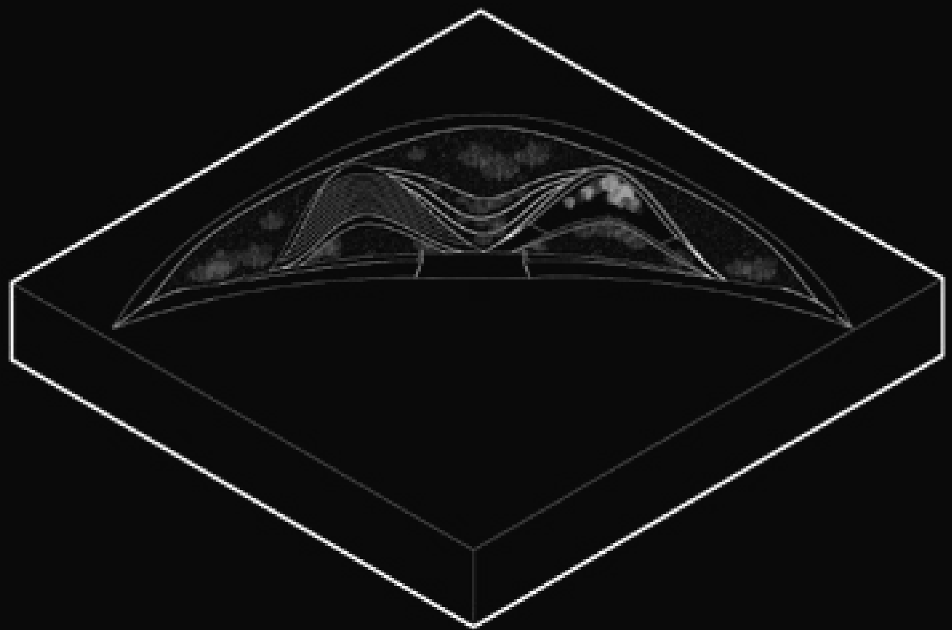


particle simulations using wind flow fields in grasshopper

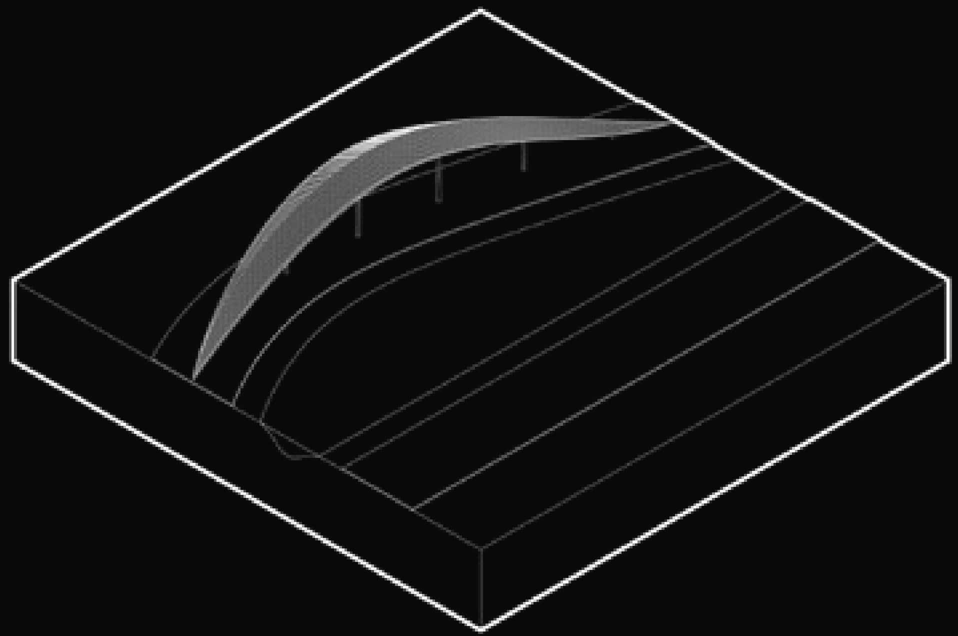


rationalization of flow fields and water runoff to design

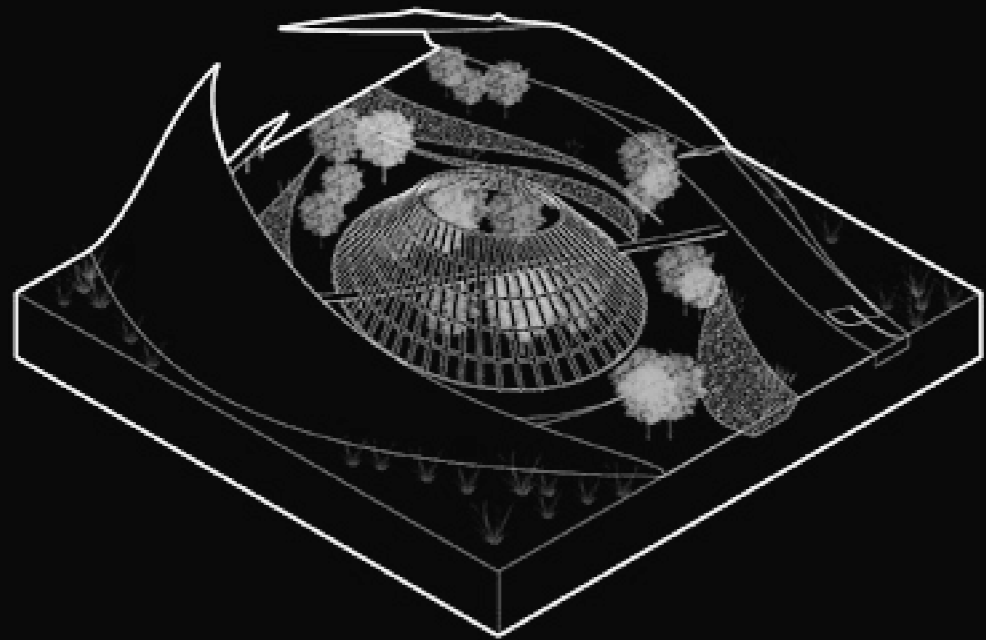
rendering of enclosure bio-dome



axonometric diagram of aquatic plantation dome



axonometric diagram of exterior shading installation



axonometric diagram of double-shell dome

3D-printed model of enclosure dome

2021

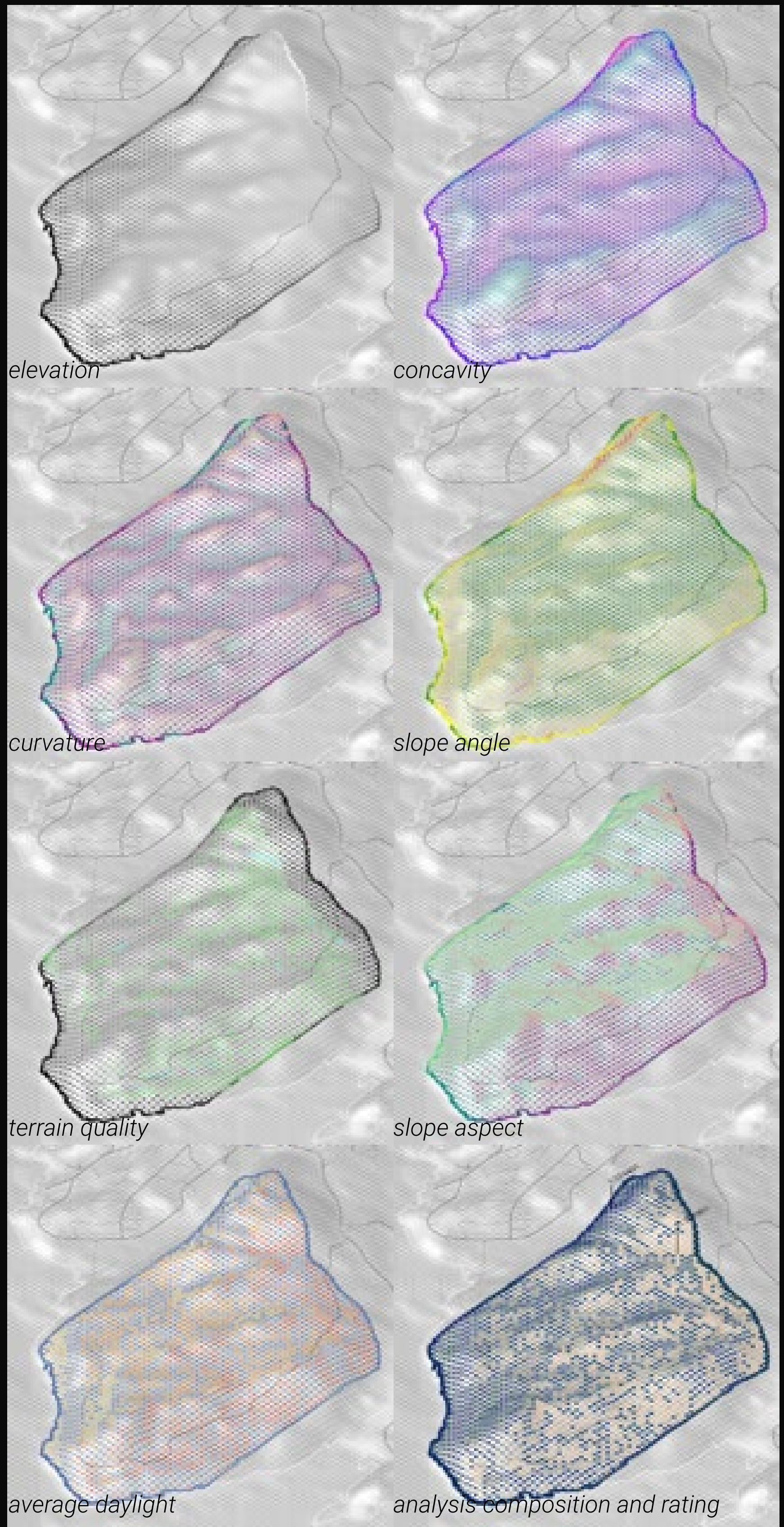
ARCTIC SETTLEMENT

academic work

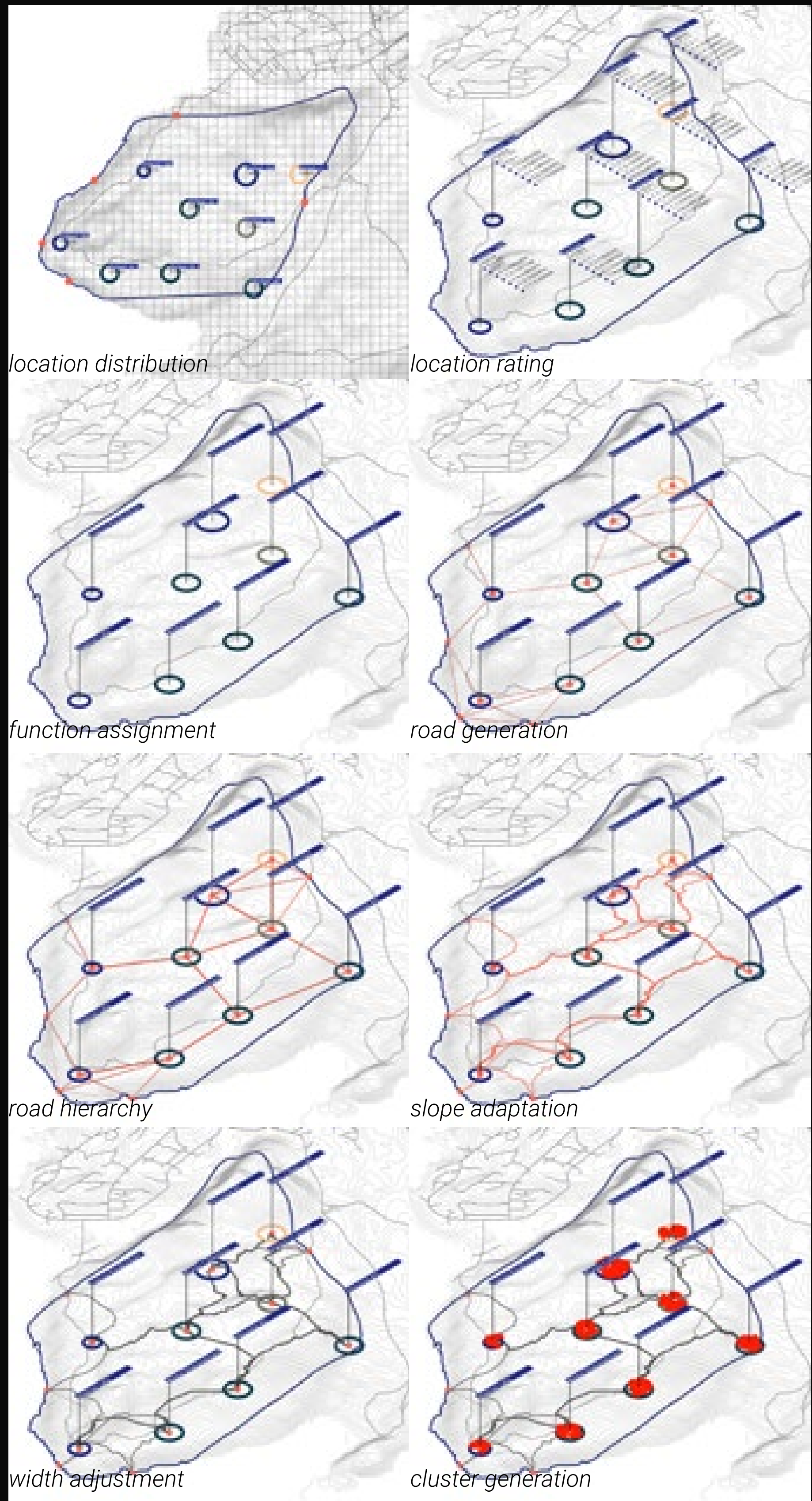
This project aims to develop a self-sufficient settlement in Ilulissat, Greenland. The project involves the development of an autonomous settlement capable to accommodate a population of a thousand individuals and the relocated UK arctic research center.

In this project, a settlement comprising of nine clusters is proposed. Each cluster is constructed following a modular logic. That is, a kit of discrete parts was proposed to accommodate for different timescales of habitation or response to climate change cues.

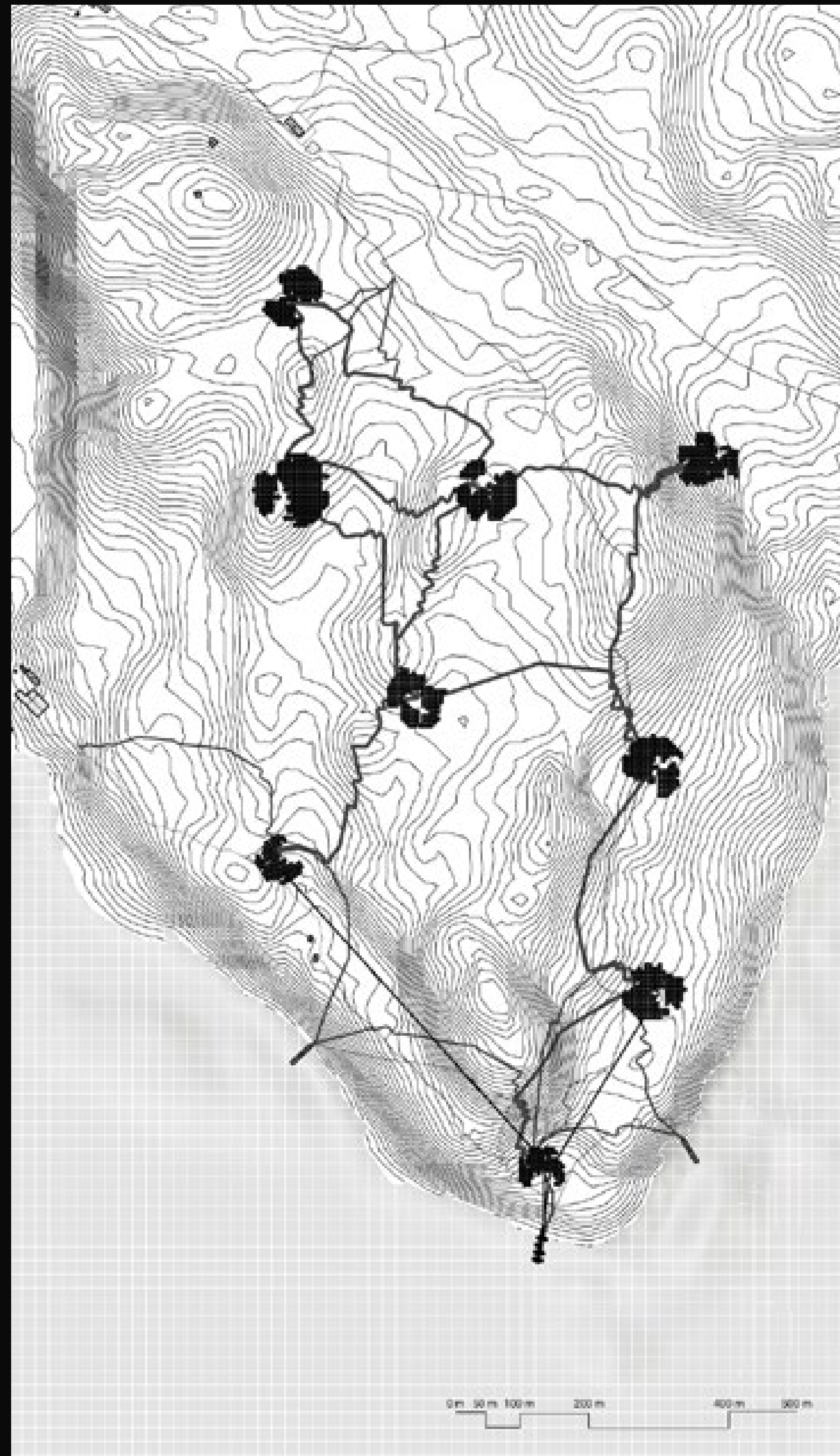
The main area of interest in this project was the utilization of computational methods in response to environmental and contextual changes. Hence, a multitude of different computational methods were employed to form a procedural workflow. Particularly, a DEM-based analysis informs a ranking system for the allocation of well-performing locations for each cluster. A modified voxel aggregation script was developed to respond to structural and orientation criteria. Moreover, a space colonization algorithm was used for the generation of internal networks. Finally, wave-function collapse, in conjunction with genetic algorithms aided in the precise allocation of functions and aggregation of the discrete parts.



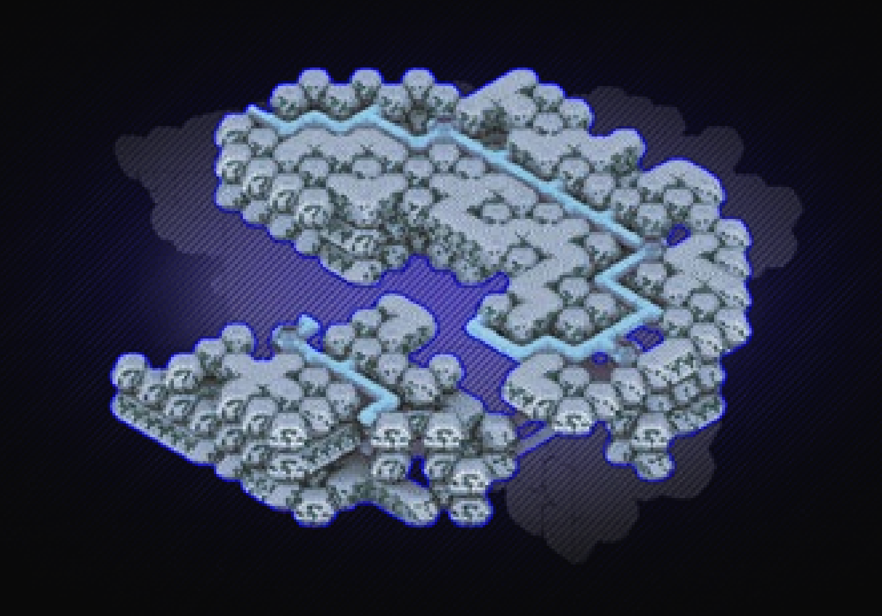
analysis of site



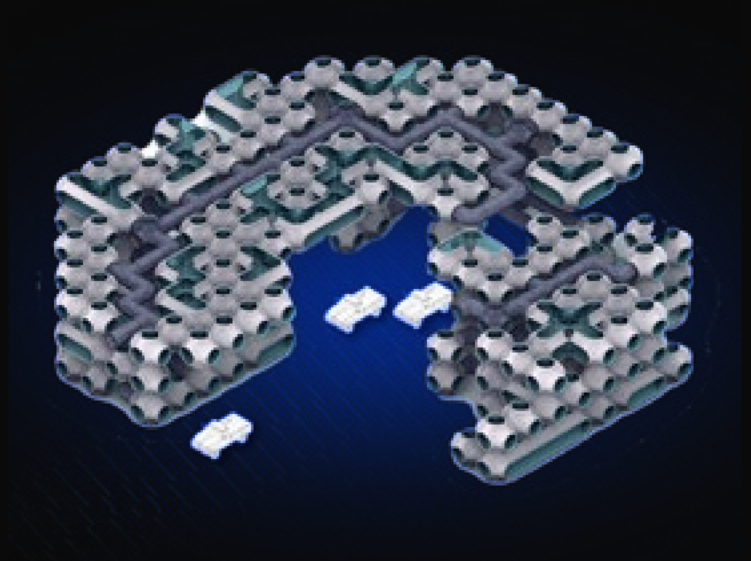
cluster placement according to location rating



settlement masterplan



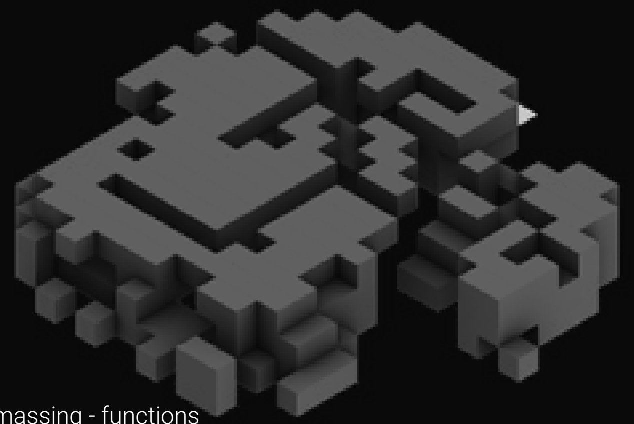
isometric diagram of cluster



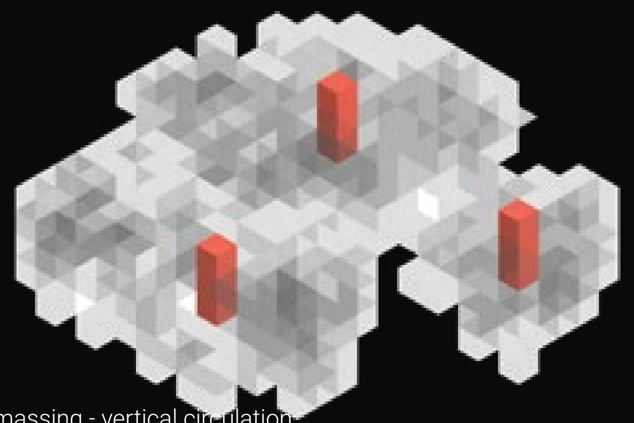
isometric diagram of cluster

The masterplan of the projected consists of nine clusters that cater to the different needs of the settlement. In particular, the clusters host housing units, atmosphere, marine and terrestrial laboratories, a small power plant and utilities, such as waste water treatment and biomass treatment.

The generation of the clusters was done utilizing a generative algorithm that produced massing volumes. The generative algorithm was developed in C# to iteratively place a voxel module according to a set of pre-defined criteria. In particular these criteria were proximity, structural integrity, orientation and solar gain. The aforementioned voxel formation were further categorized into categories of functions within the cluster. Finally, wave function collapse was employed as an algorithm to locate the appropriate placement of prefabricated modules in the massing slots.

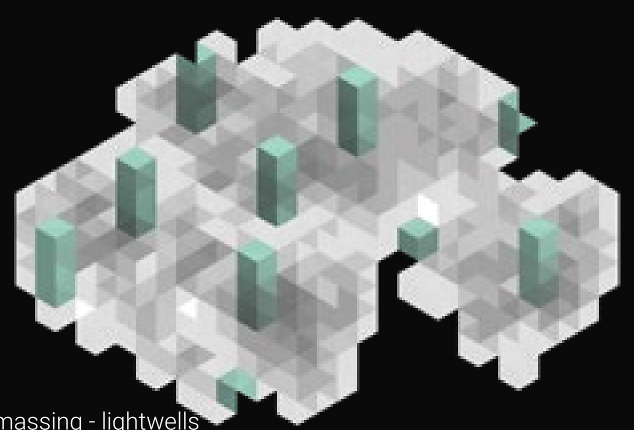


massing - functions



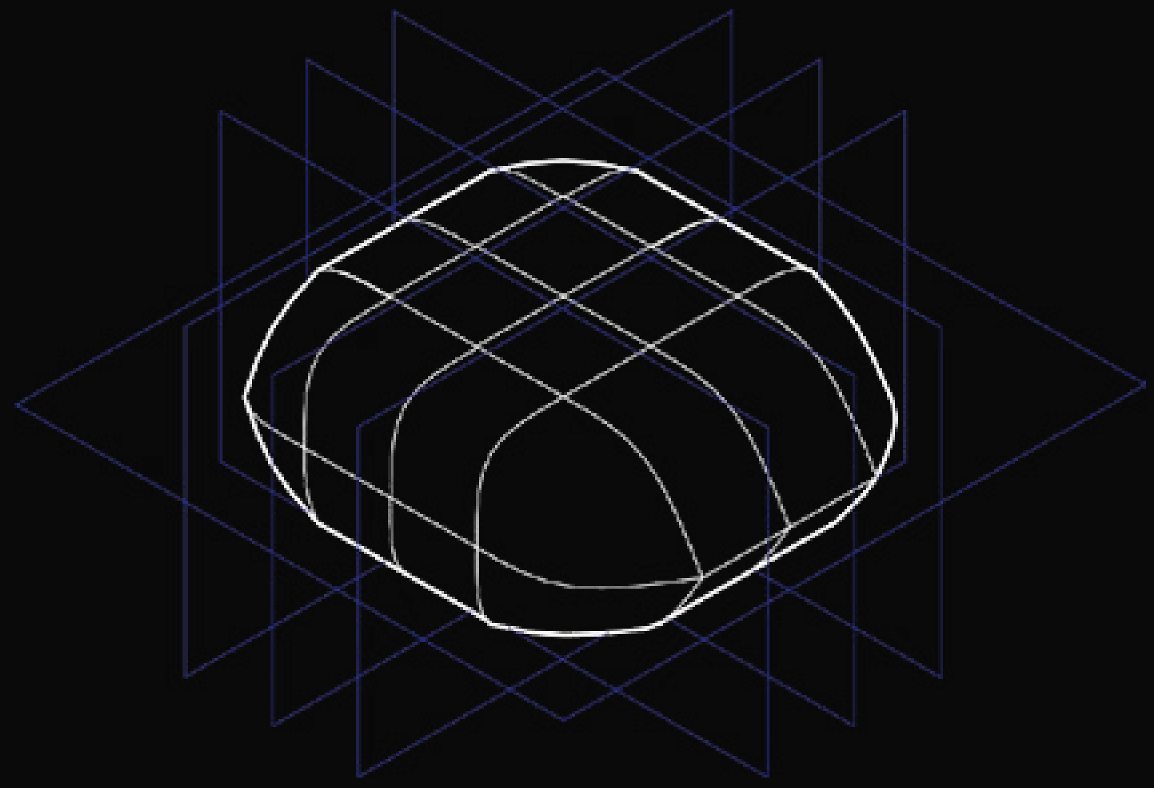
massing - vertical circulation

massing - horizontal circulation

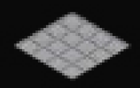


massing - lightwells

cluster generation processes



module division into prefabricated parts



flooring / ceiling

wall | generic

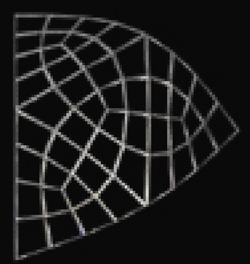
wall | wind resistant

corner | wind resistant

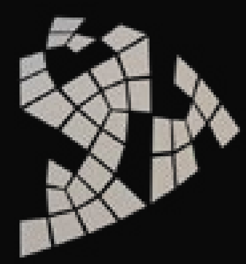
corner | wind resistant

corner | generic

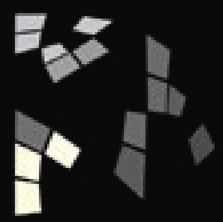
catalogue of prefabricated parts



aluminum frame

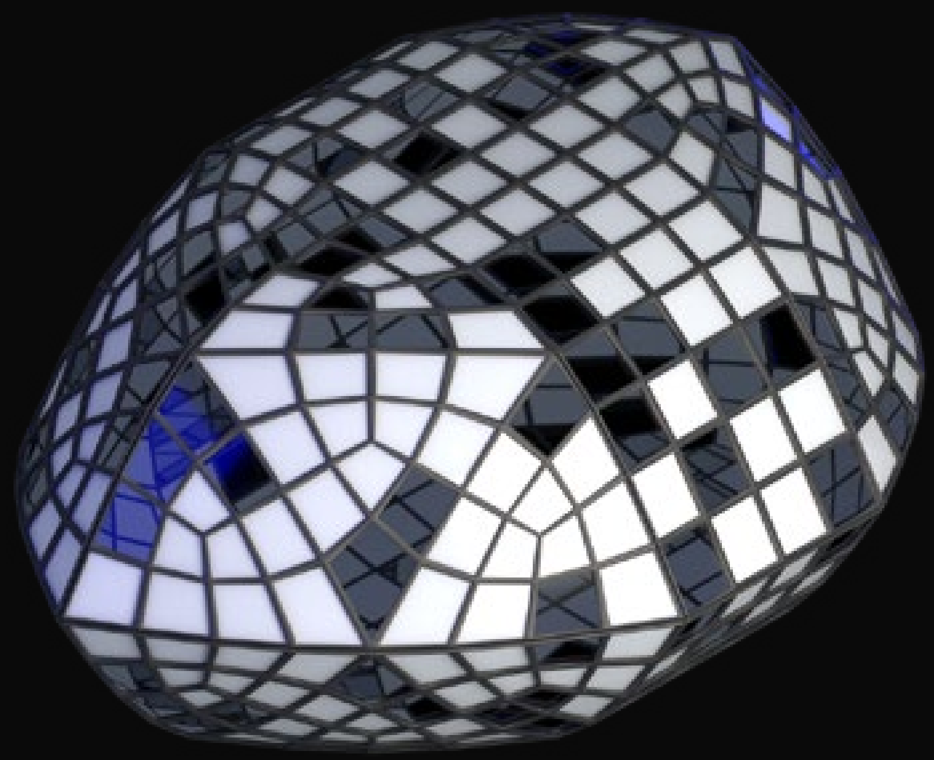


aluminum panels



tempered glass panes

material specification of prefabricated parts



rendering of prefabricated module

For the fabrication of the clusters, a material system of prefabricated parts was selected, due to its transportability and ease of modification in future scenarios. The modules were designed to adapt in an efficient manner to the harsh climatic conditions of the arctic and, particularly, strong winds and heavy precipitation.

The volume of the designed module was divided in parts 1.5m x 1.5m x 1.5m to facilitate their transportation. They were further subdivided to produce an overarching structural frame. The infills of the frame were split into categories of solid aluminum panels and tempered glass window panes. The placement and the patten of the window panes was produced computationally and controlled by percentages. Consequently, the appropriate percentage for each part can be determined according to subsequent thermal analyses.

2020

POTENTMORPH

academic work

Potentmorph was developed as part of the advanced material systems agenda of the Emergent Technologies and Design post-graduate course at the Architectural Association.

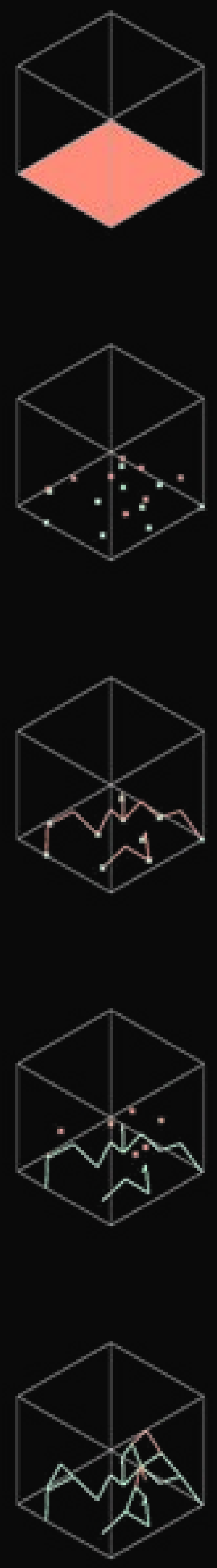
Through a multitude of computational tools and experiments, a form-active structure was proposed, contained in a volume of 3m by 3m by 3m. The final construct constitutes an aggregation of discrete bending-active elements, constructed using robotic fabrication processes. Specifically, the technique of robotic winding was introduced, so as to render the structure form-active.

Due to the complex nature of the structure, generative design techniques were employed. Particularly, a custom script was written to generate the initial forms of the aggregation.. An additional algorithm generates the necessary winding in an automated manner. Finally, the form is relaxed, using physics simulation during which phase, material specifications were introduced to test the efficacy of the system.

Consequently, the algorithmic workflow followed allows for numerous digital experiments and applications in different scenarios.

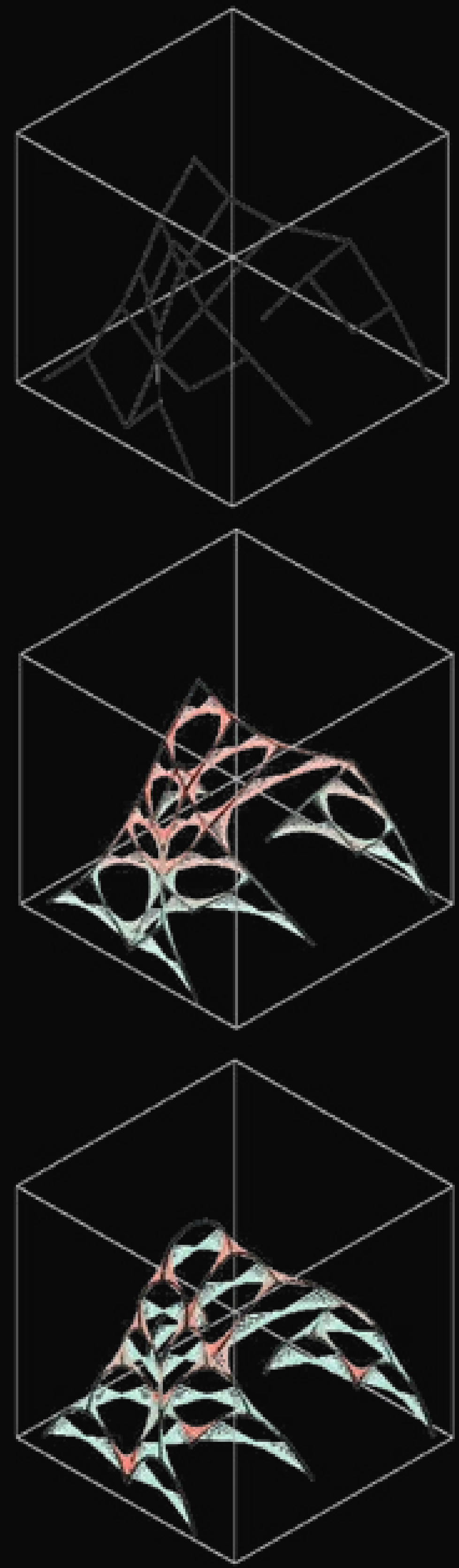
This project employed generative algorithms developed in C#. The first generative algorithm is responsible for the generation of the discrete bending-active elements. The algorithm utilizes a random assortment of points on the ground level as input to generate aggregations of triangulated elements in a recursive manner. A subsequent algorithm developed in C# utilized the generated aggregation to integrate three sets of winding patterns, to ensure structural integrity.

The form-active result of the generated aggregations were simulated using the Kangaroo 2 physics engine inside the environment of Grasshopper. Furthermore, material attributes and further structural analysis was achieved by integrating the K2 Engineering plug-in, which allowed the examination of compression, tension and bending moments in the generated structure.



generative algorithm pseudocode

catalogue of generated forms

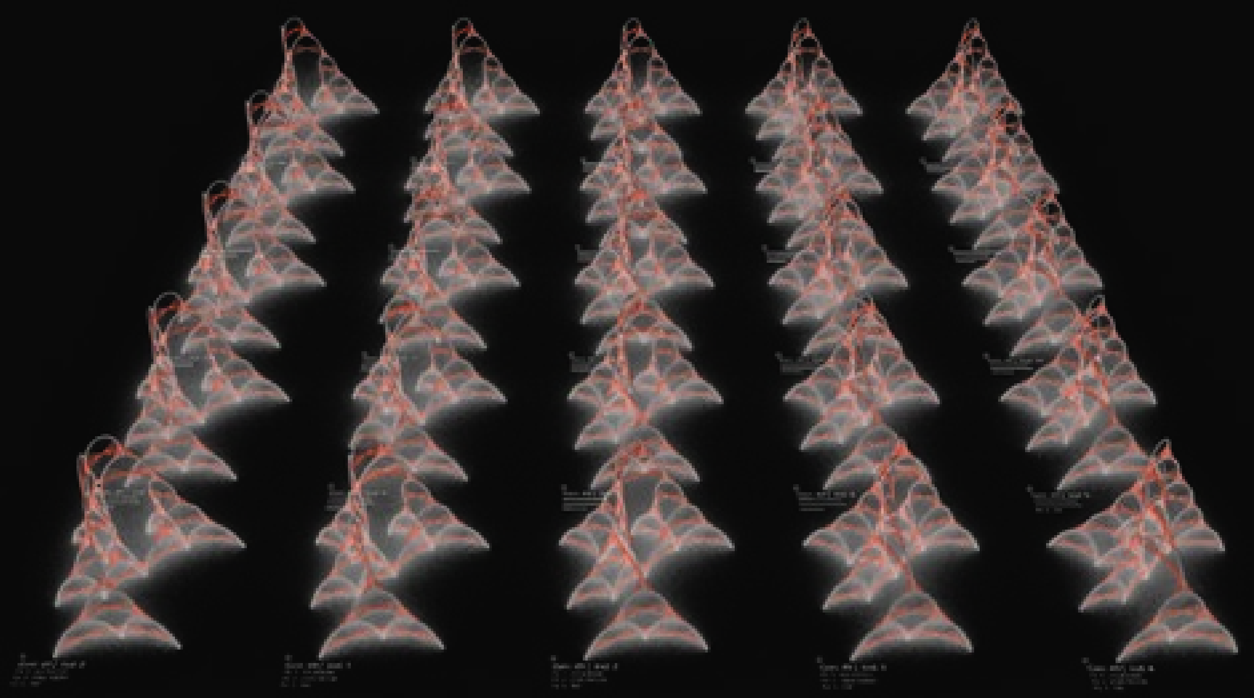


winding pattern generation and simulation

Genetic algorithms were utilized as a multi-objective optimization method. In particular, the Wallacei plug-in for Grasshopper was utilized in two distinct stages. The first round of optimization was applied to the results of the generative algorithm. The goal was to maximize the amount of bending-active elements, while ensuring their proper connection and reducing the amount of winding needed. The second round of optimization was integrated during the simulation stage. Specifically, its goal was to minimized the tension applied to the tension cables of the structure, while maintaining its structural integrity.

The proposed structure was visualized and explored in a custom application developed in Unity. In particular, through the application, the user can visualize and explore the design in 3D space, while also visualizing the assembly sequence and the robotic fabrication process.

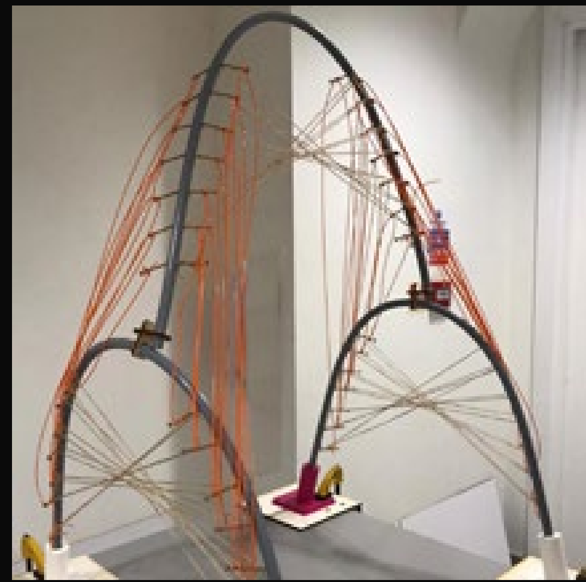
active-bending experiments



multi-objective optimization results

application developed in Unity

installation elevation



physical prototype images

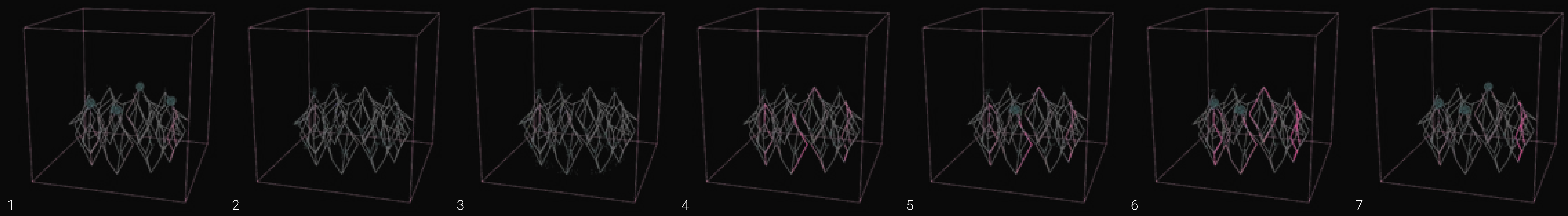
2020

HORMONERGY

academic work

This project constitutes a study on the application of natural behaviors observed on social insects on architectural cases. The end product of the process is an installation bound in a 3m x 3m x 3m volume.

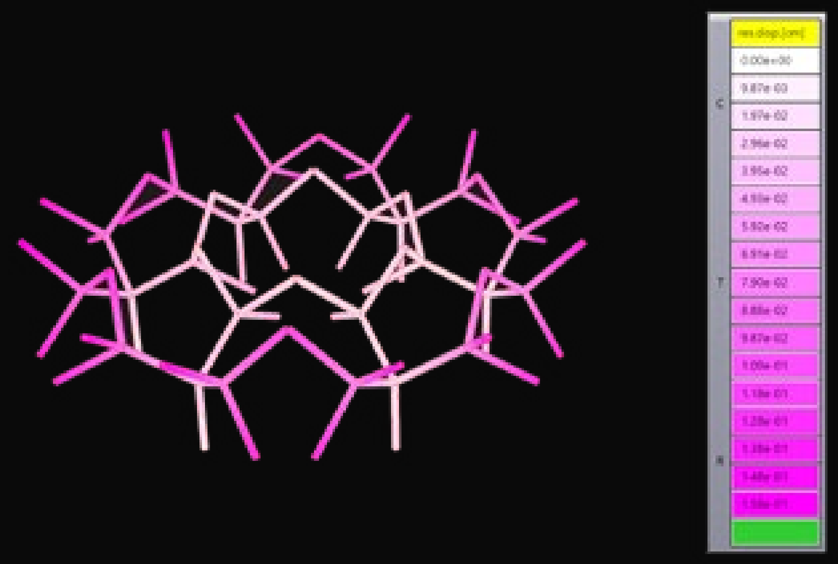
For the development of the project, a workflow comprising of a multitude of computational tools was followed. In particular, an underlying L-system is generated, informed by structural data. This consists a network of potential routes that the agents can follow. Using the L-System, a custom agent simulation is run, following the studied behavior of ants and principles of stigmergy, such as pheromone secretion. Finally, the final form is generated utilizing a marching cubes algorithm.



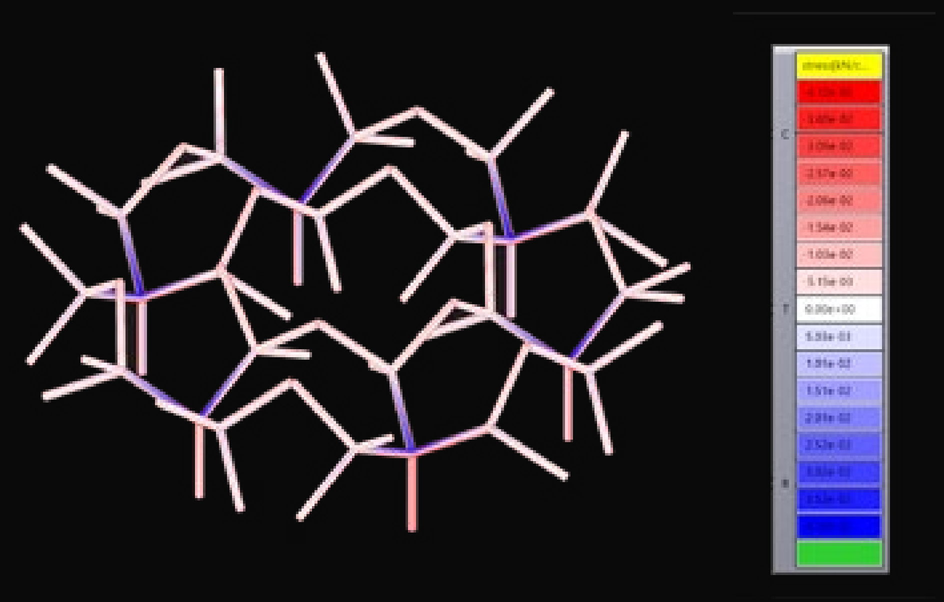
pheromone trails on l-system

The generated L-system was analyzed using Karamba 3D (Grasshopper) to determine the failure-prone locations of the structure. These locations were set as the attractor points, so that they attract more agents and, thus, result in more concentrated material placement.

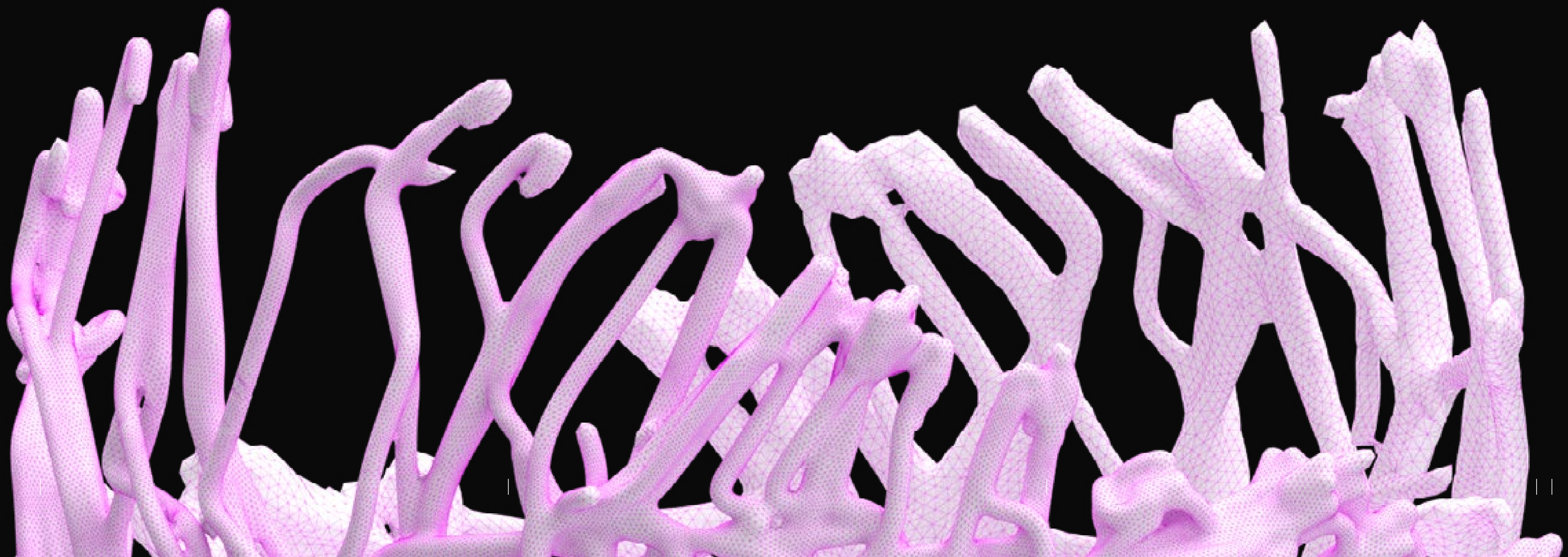
The structurally-informed L-system was used as the basis for the agent-based simulation. The agent-based simulation was scripted in C#. According to it, the agents moved along the paths defined by the L-system according to proximity. Detection of an attraction point resulted in the secretion of pheromone and the preference of the particular trail by the subsequent agents. Both the pheromone trails and the agents have a lifespan of a few frames, rendering the simulation mostly time-based.

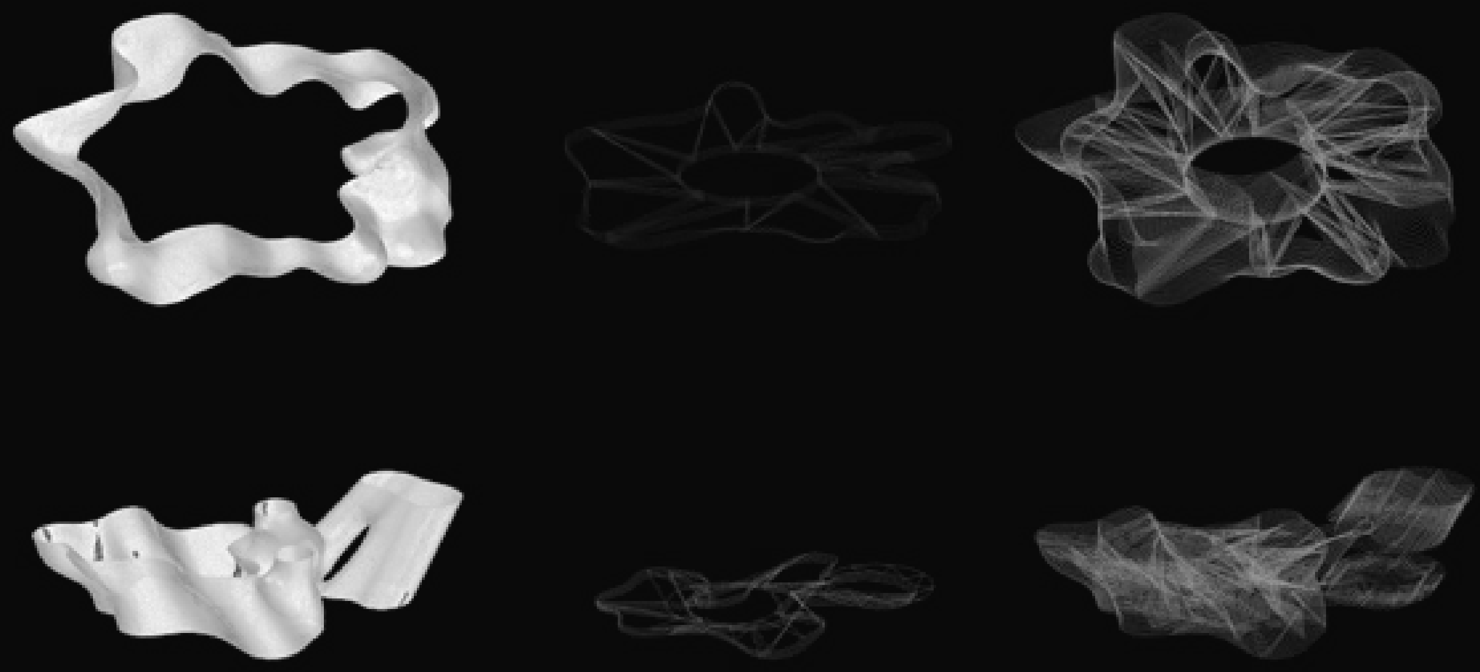


structural analysis (deformation) using Karamba 3D



structural analysis (stresses) using Karamba 3D





toolpath generation for robotic clay printing

For the fabrication of the pavilion, the form was divided into parts. Each part was set to be fabricated using robotic clay printing. The mesh of the digital model was divided into manageable parts, to facilitate fabrication. Each mesh was used as an input to generate the robotic toolpath. In particular, the toolpath was generated according to the extrusion height of the clay extruded along with the creation of a central core, to reinforce the stability of the structure.

A scaled physical model was fabricated using 3D printing to test the needs for supports and failures during the 3D printing process.

3D printed model of pavilion


ELEFTHERIOS KOURKOPOULOS