

Libish Murugesan - Portfolio

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System for robotic manufacturing of double curved paneling system from self shaping wood fabricated with rough pine offcuts.

More views of a mobius strip - Pg 6

### **Automated Spolia - Pg,7,8,9**

3-D Robotic Perception System for Robotic cladding of an irregular substrate with irregular found objects. 6-Dof Robotic Manipulation Problem.

### **Crease Forming - Pg 5**

Research of geometric affordances of Aluminium in robotic metal forming.  
published paper in eCaadee.

### **Pothole detector- ([link](#))**

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- Prototype. - Software and Hardware.

### **Plant-D- Pg 12 ([link](#))**

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## Robotic Workshops -

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### **Non- Planar Lattice 3-D printing -(onsite) Pg 11**

Lattice 3d printing techniques with PLA in robotic arm , leverageing scale ,

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Human robot collaboration and multiple robot teams.

## Architectural Projects.

### **Metal Cloud. - Pg 12,13**

Material research in exploring auxetic deformation in metal sheets for an interior project.

### **Building for a Billion. - Pg 15**

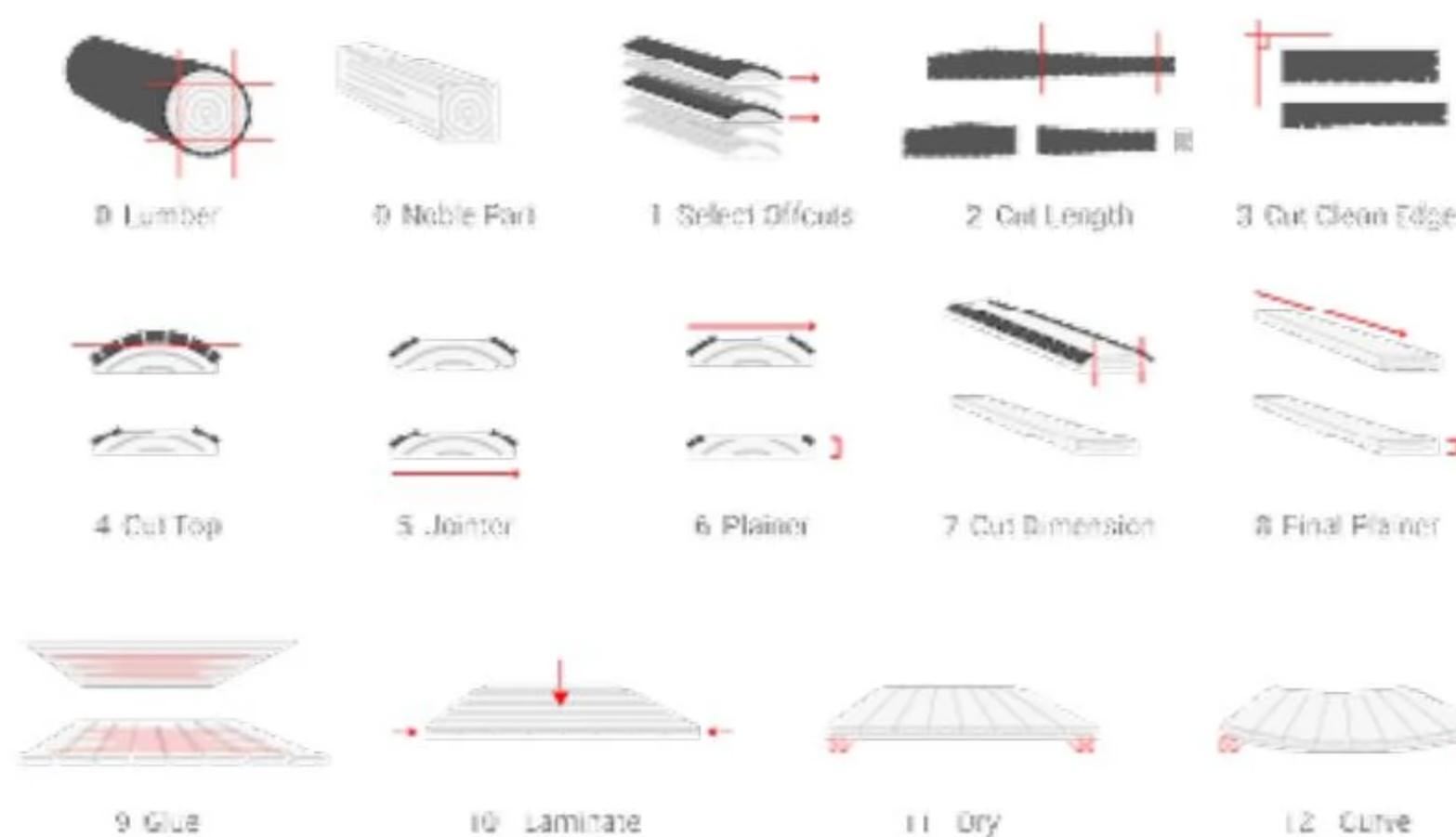
Generative Algorithm for a Ubran commune.

### **Appendix. - 16-22 MIscelaneous Fabrication and Design Projects.**

# CCLT-Curved Cross laminated timber

The project focused on recycling offcuts from wood manufacturing into bespoke products ,

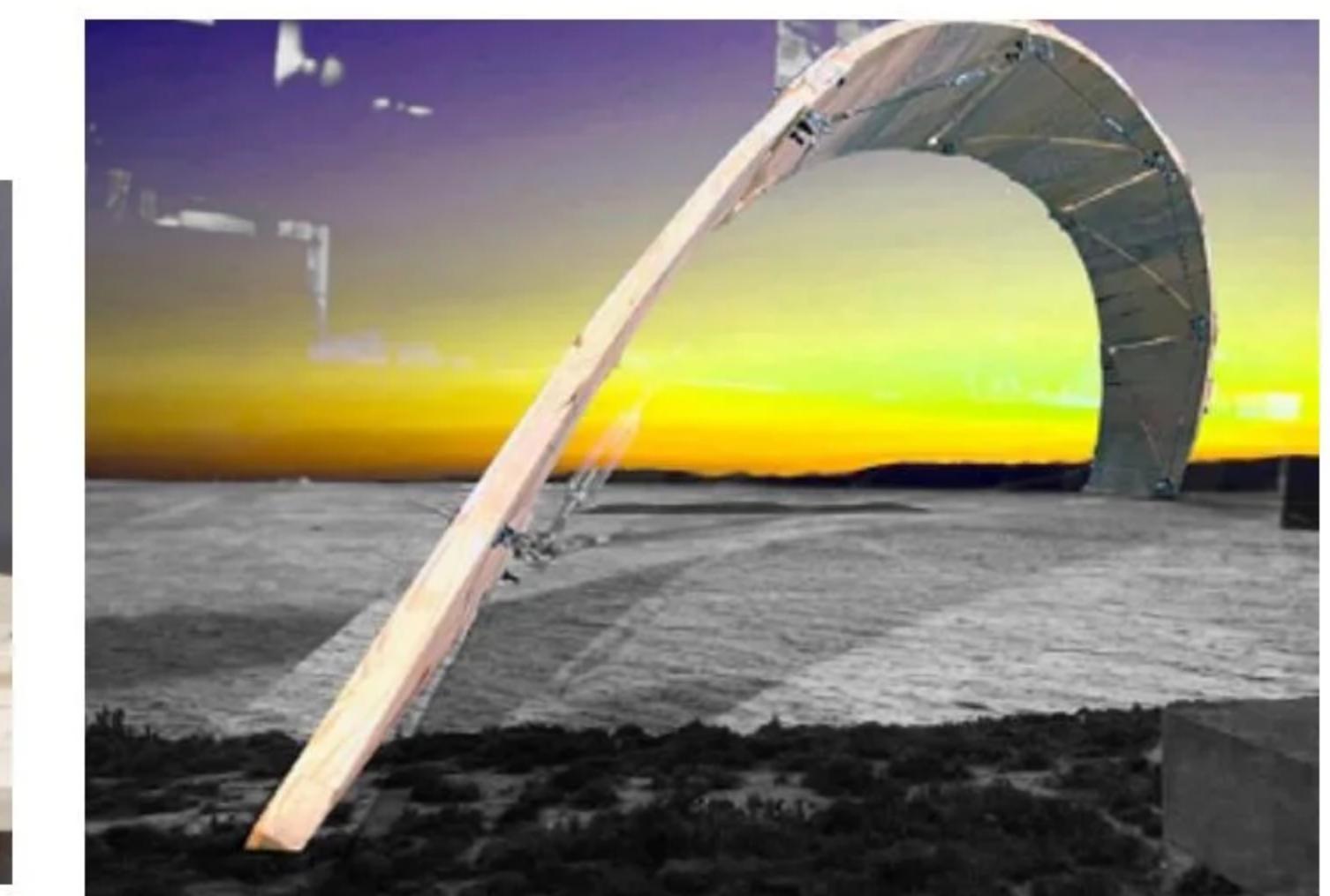
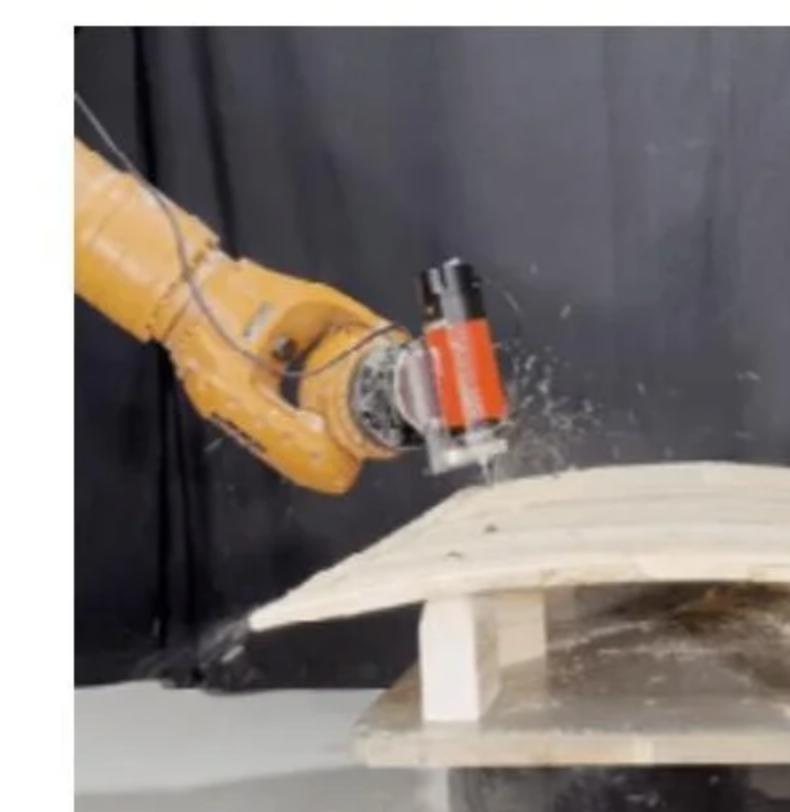
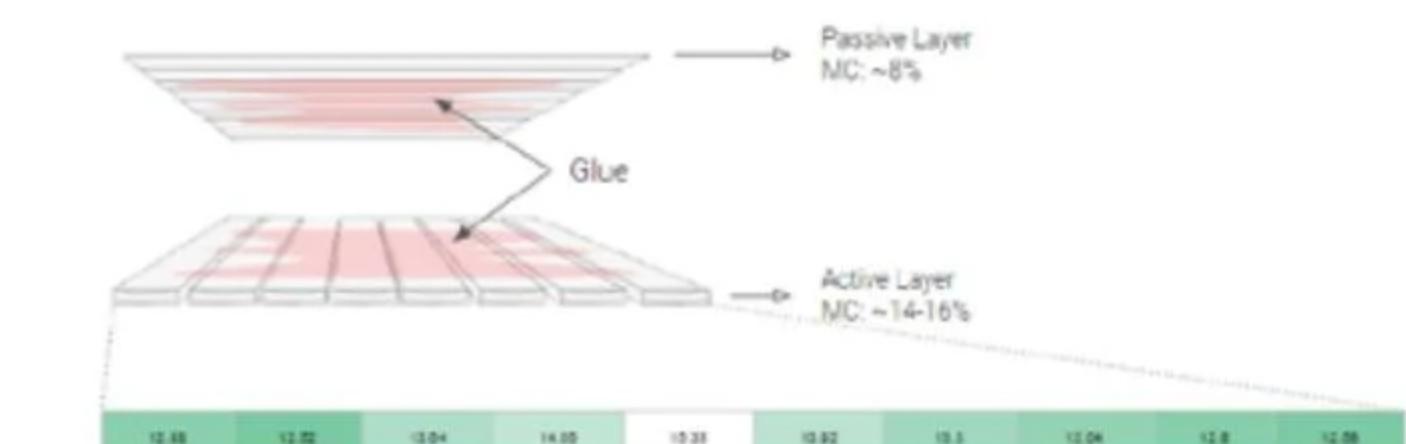
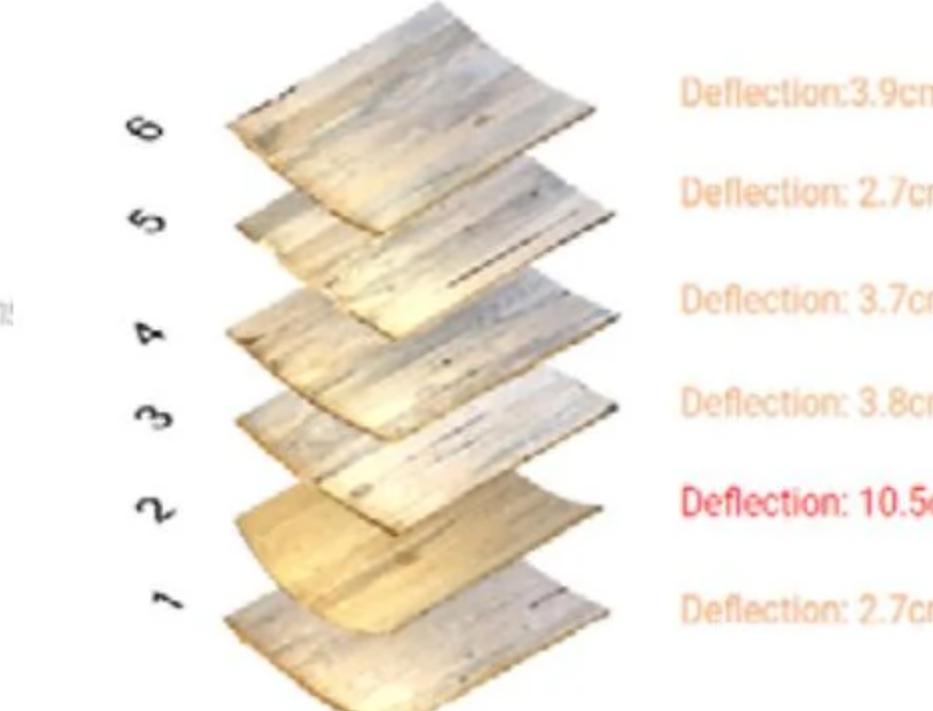
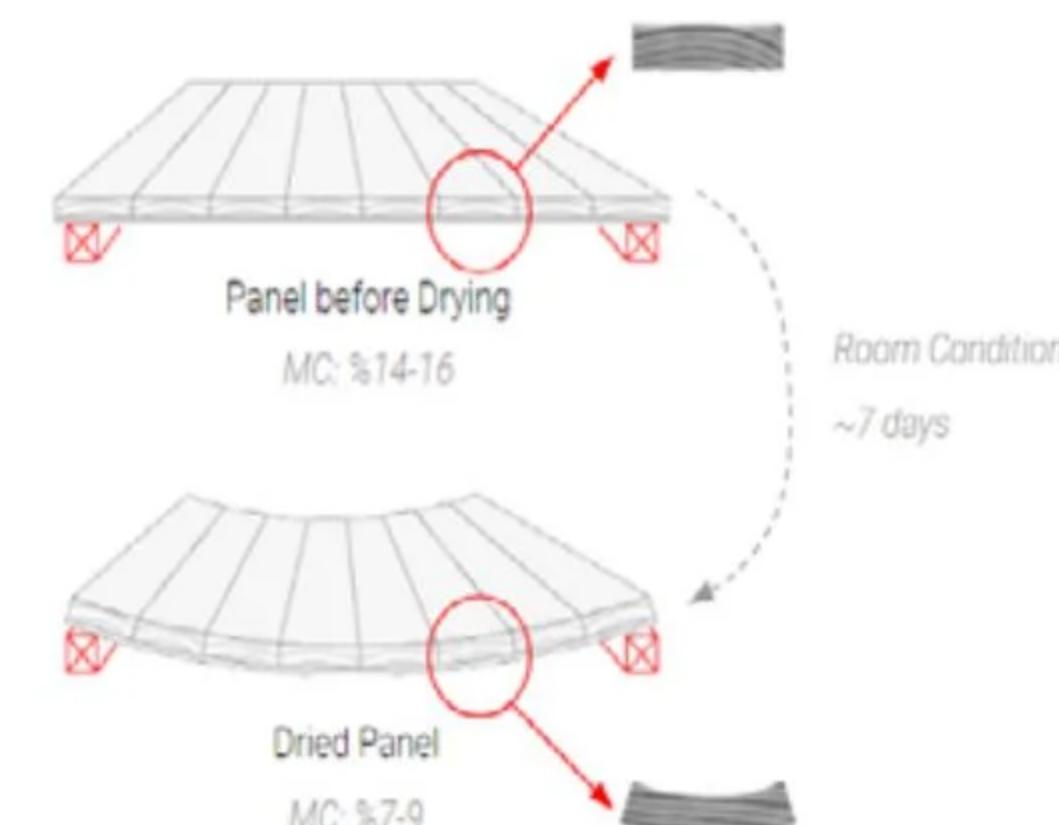
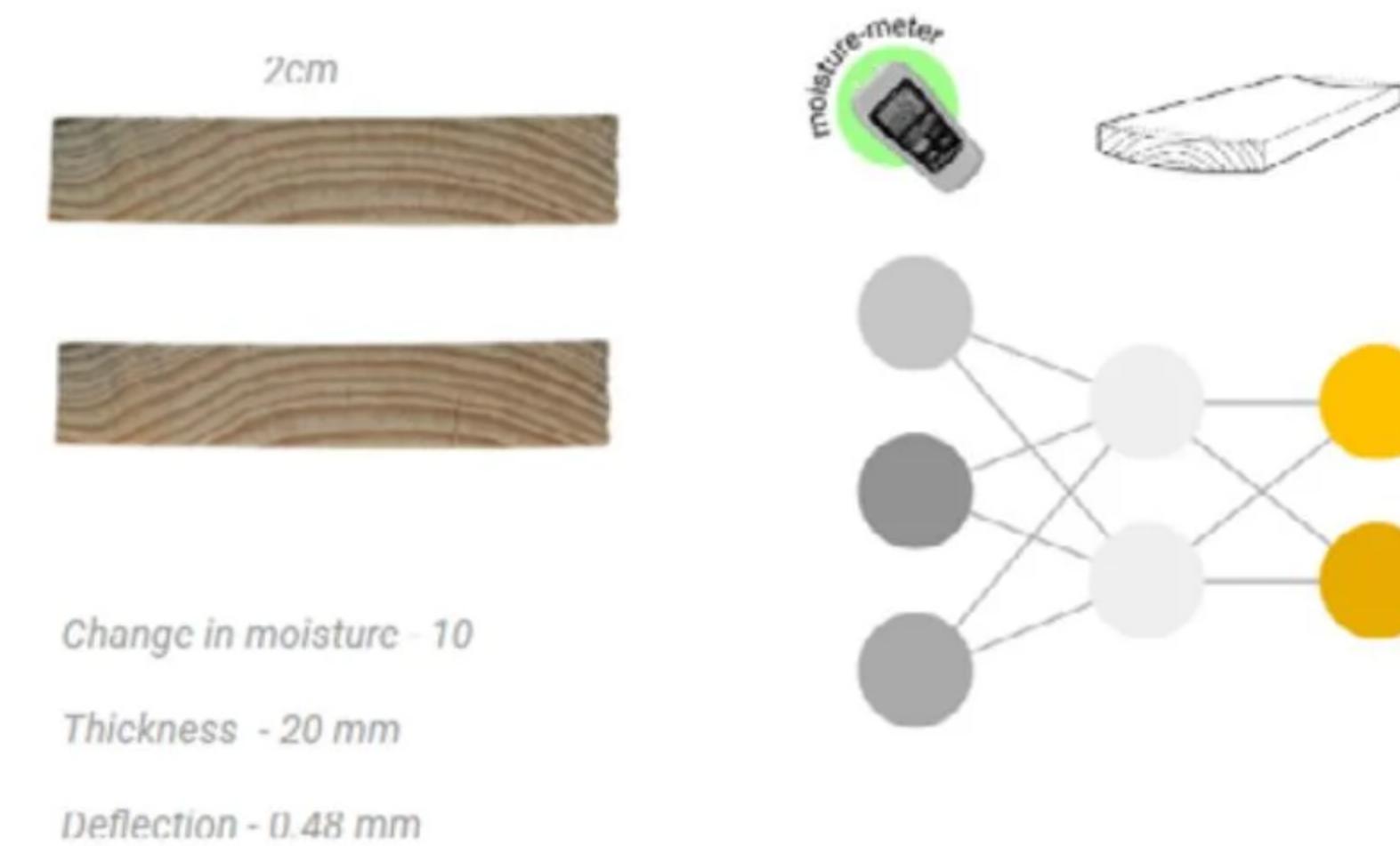
The project explored the themes of material computation and fabrication challenges.



A Bottom-up design approach to mitigate and understand material manufacturing affordances and understanding material effects from the creasing process.

## Studio 3, MRAC01.

My contribution - Material to Design research, Wood working, Scanning & ML, Robot calibration.



Extrapolations on double curvature using curve creasing patterns. and segmented panels.

## Challenges -

Retrofitting irregular material properties  
in self shaping wood to explicit design

Machine learning pipelines to augment  
design selection of curvatures in pan-  
els and

A Narrow design space - to a design  
Algorithm

# Robotic Workshop - Log pavillion

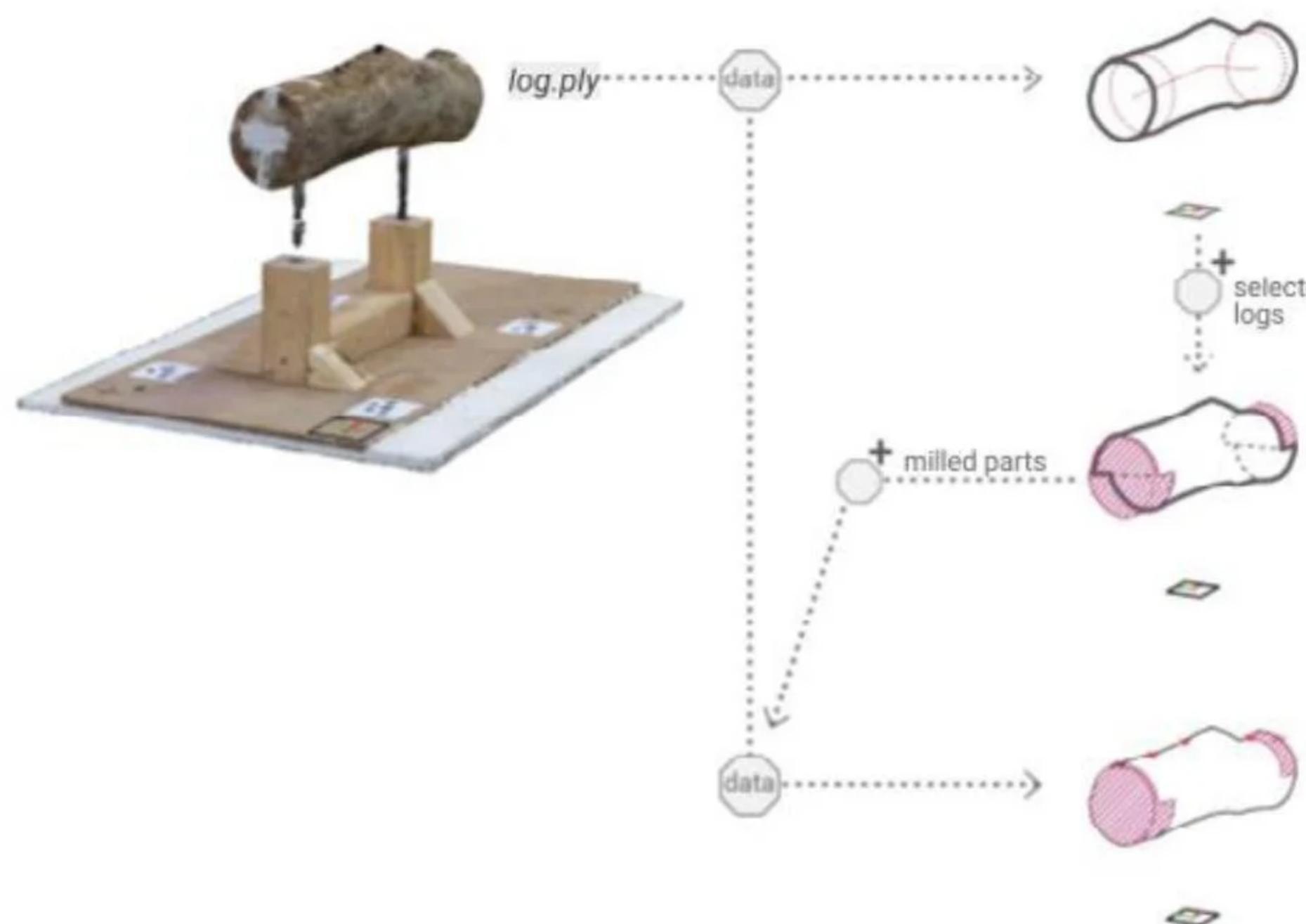
The project focuses on building an pavillion with irregular wooden logs.

Scan to design and fabricate workflows were employed here

## MRAC02- Contributions

- Scan to Design Database Co-ordination and Design Algorithm
- Design to Fabrication Automation.

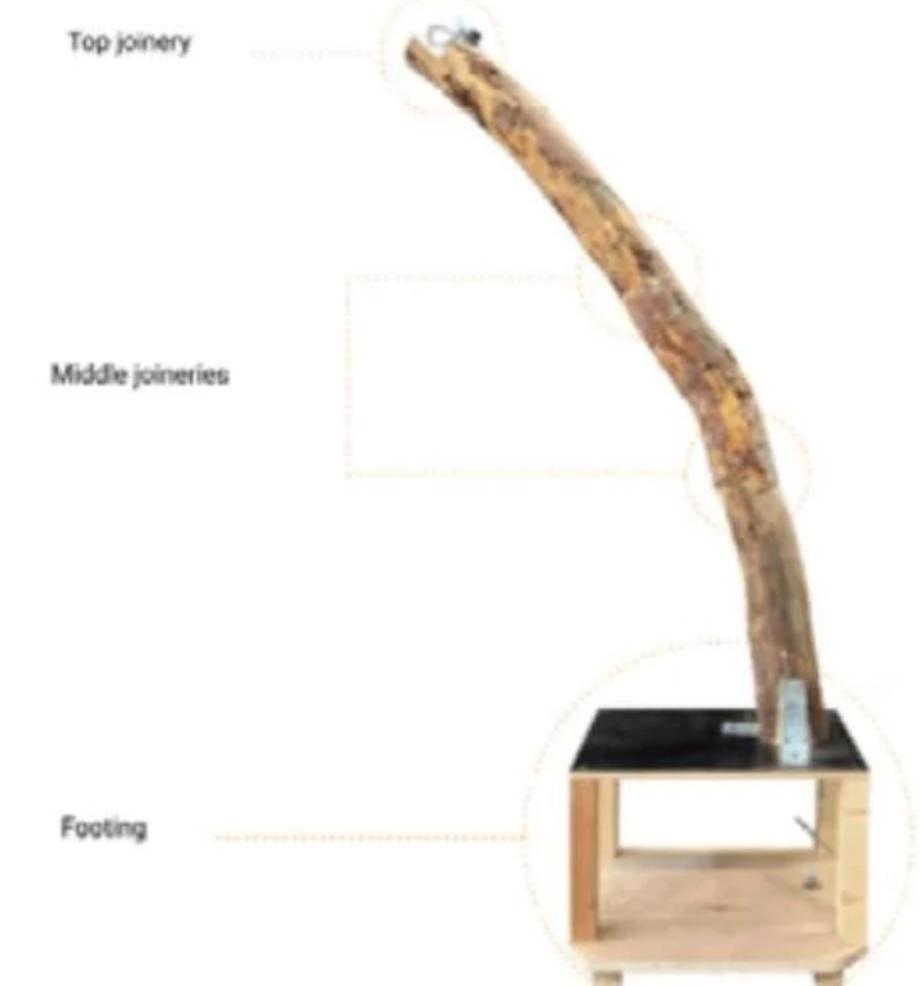
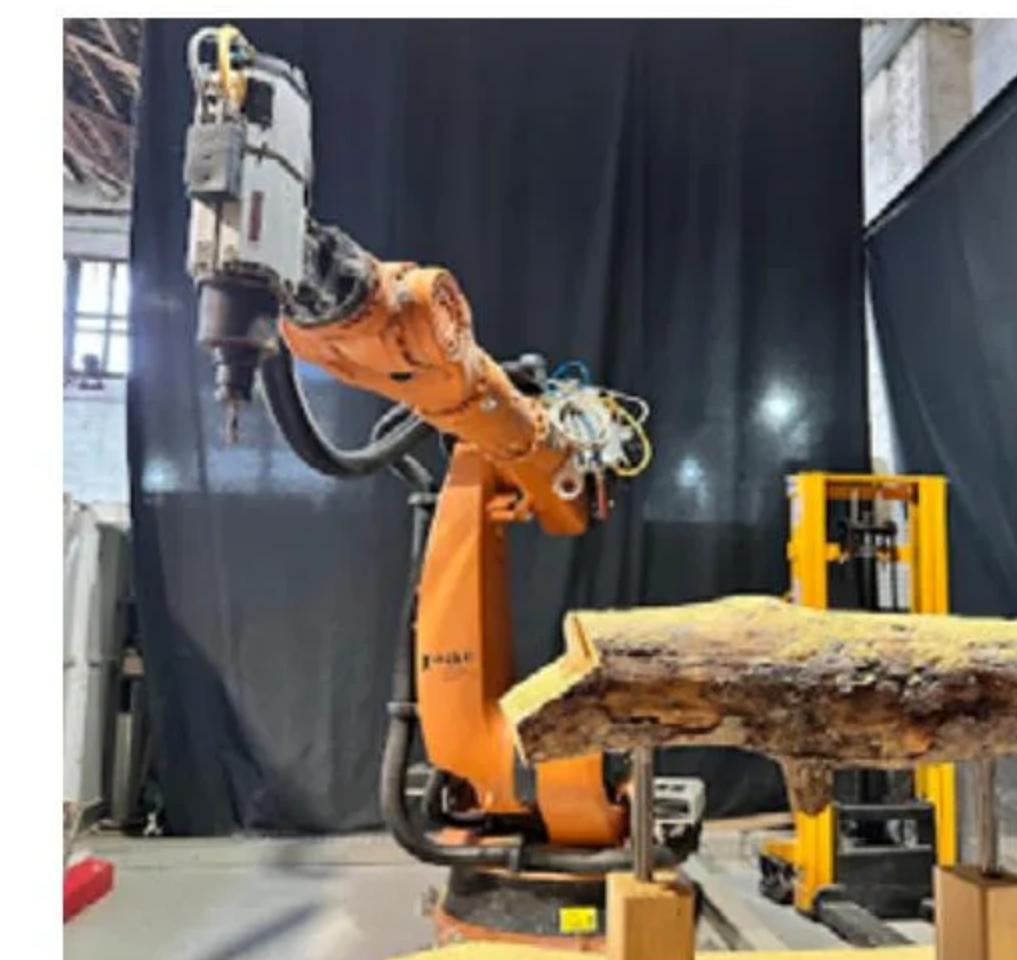
irregular geometry of the logs required scanning of each member to generate a geometry processing pipeline to automate design and planning



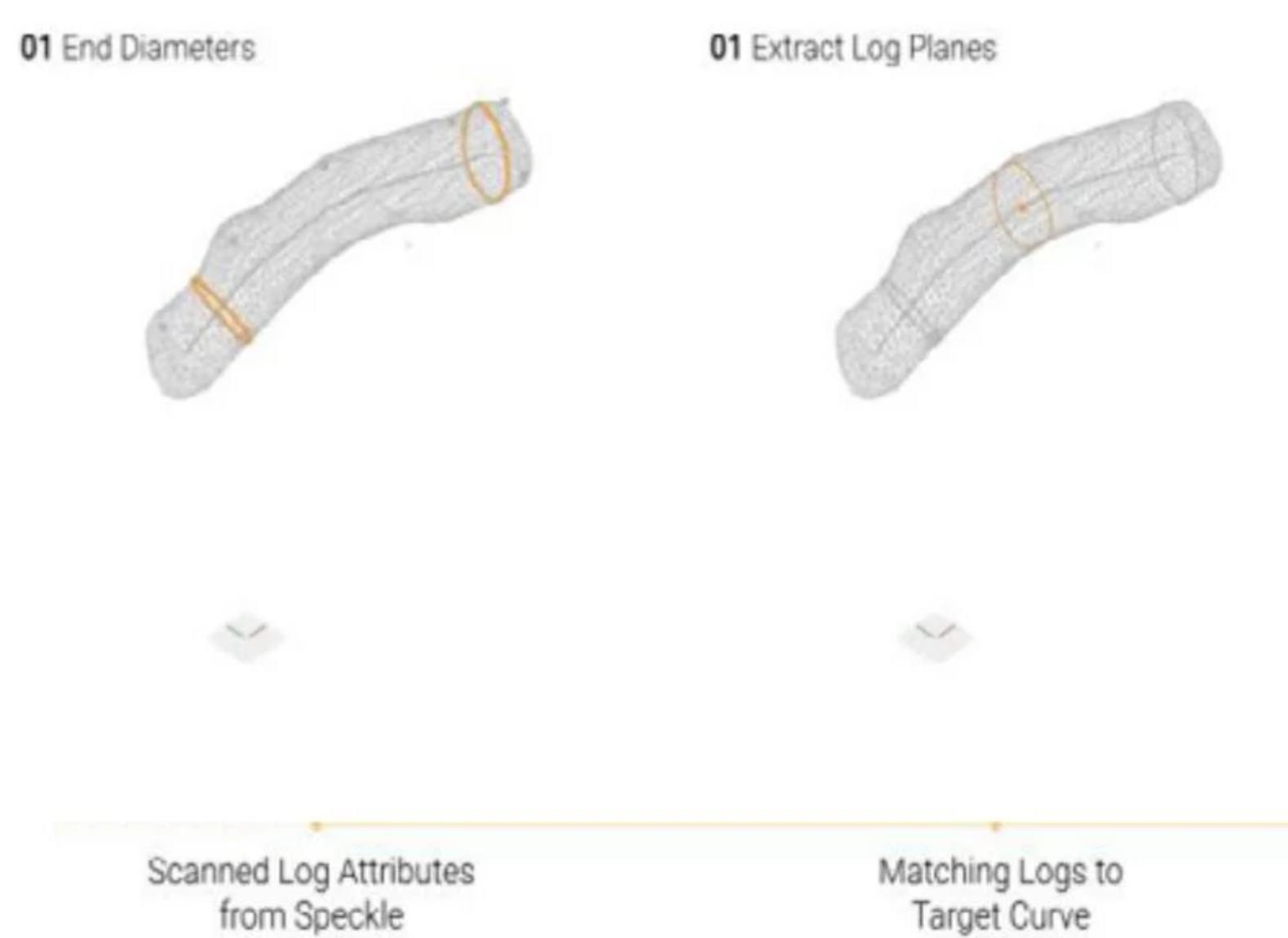
design  
> center axis [crv]  
> end diameters [int] [crv]  
> overall length, width [int]  
> log [mesh]  
<< selected logs [mesh]

detail  
> selected logs [mesh]  
<< milled parts [mesh]

fabrication  
> markers [xyz]  
> selected logs [mesh]  
> milled parts [mesh]



Scan to build workflow encompasses, a complete solution from rawmaterial to processing and assembly.



resolved joinery and design through the computational arrangement of scans, resolving orientation and joint generation.

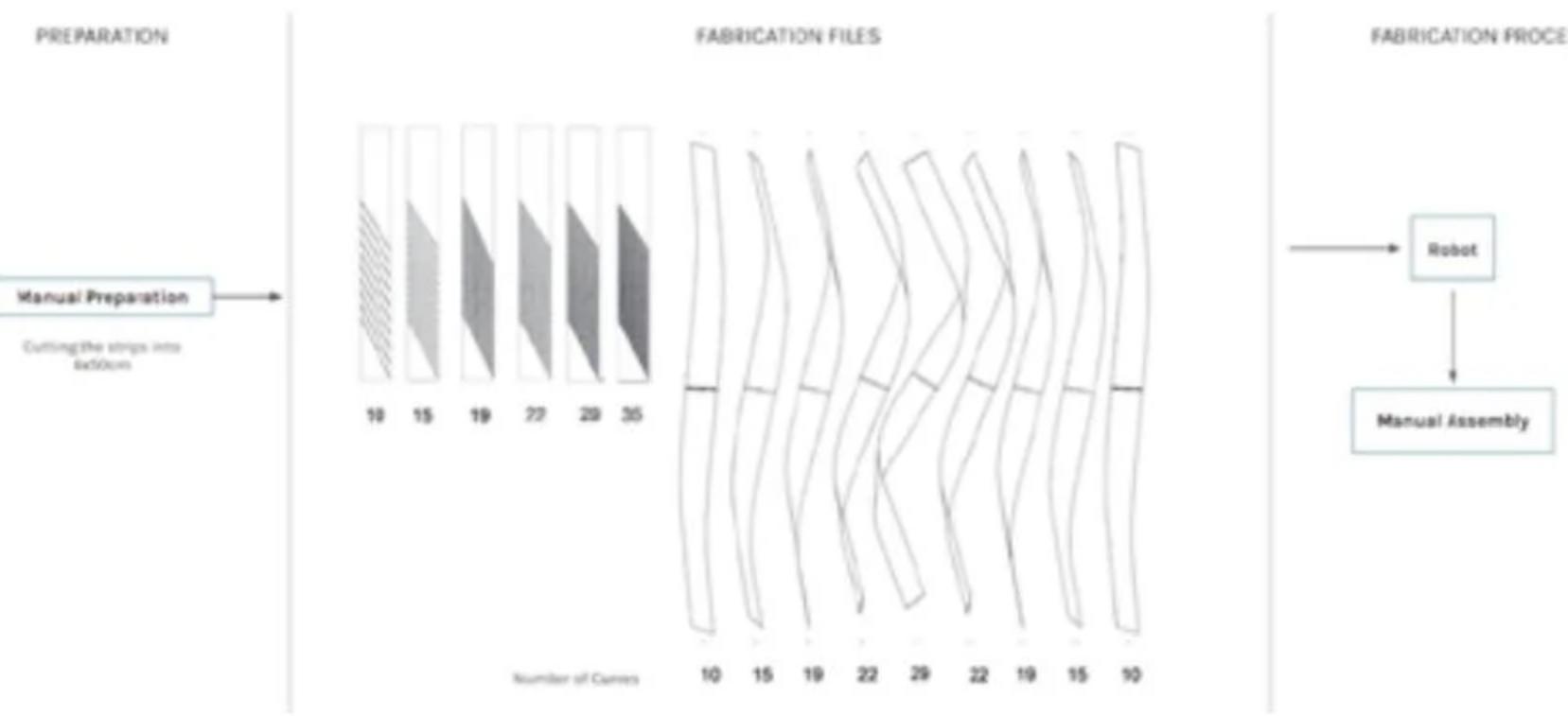
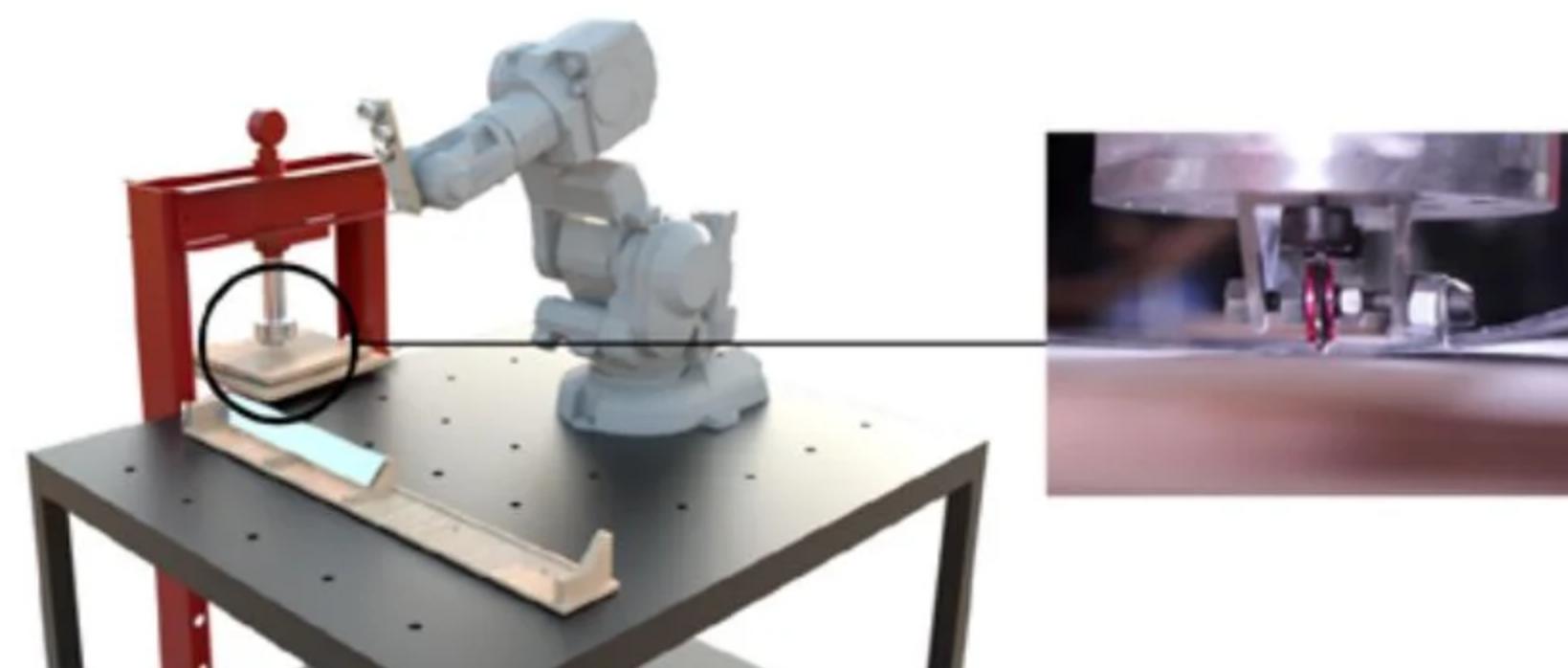
Extracting Information for Detail Matching

# Crease Forming

Studio 1, MRAC01, published as a paper “Programming twists” in Ecaad 2022

The project focuses on producing metal forming workflows on a robotic arm, inspired by traditional forming techniques and the design approximated by origami folding techniques, and rapid physics simulations to iterate ideas.

While adjusting for the fabrication parameters in design and application.



A scaled demonstrator of the fabrication setup.

A Bottom-up design approach to mitigate and understand material manufacturing affordances and understanding material effects from the creasing process.

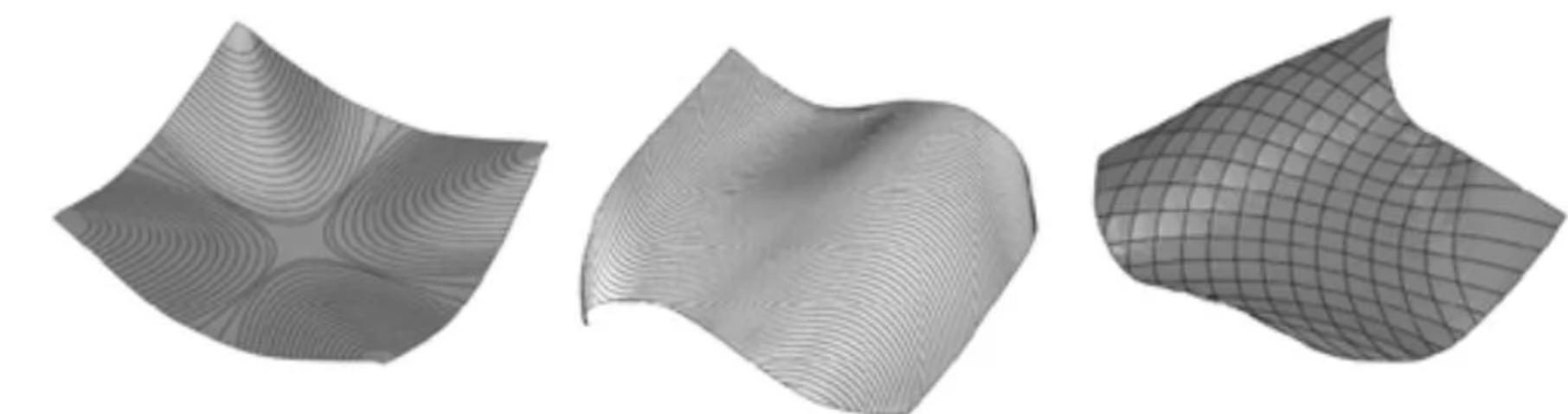


## Programming twists

Exploring the geometric affordances of aluminium through flexible robotic workflows. The fabrication approach refers to a forming process.

This has been achieved by installing a wheel cutter on a small workshop hydraulic press and a robot feeding the material into the forming station.

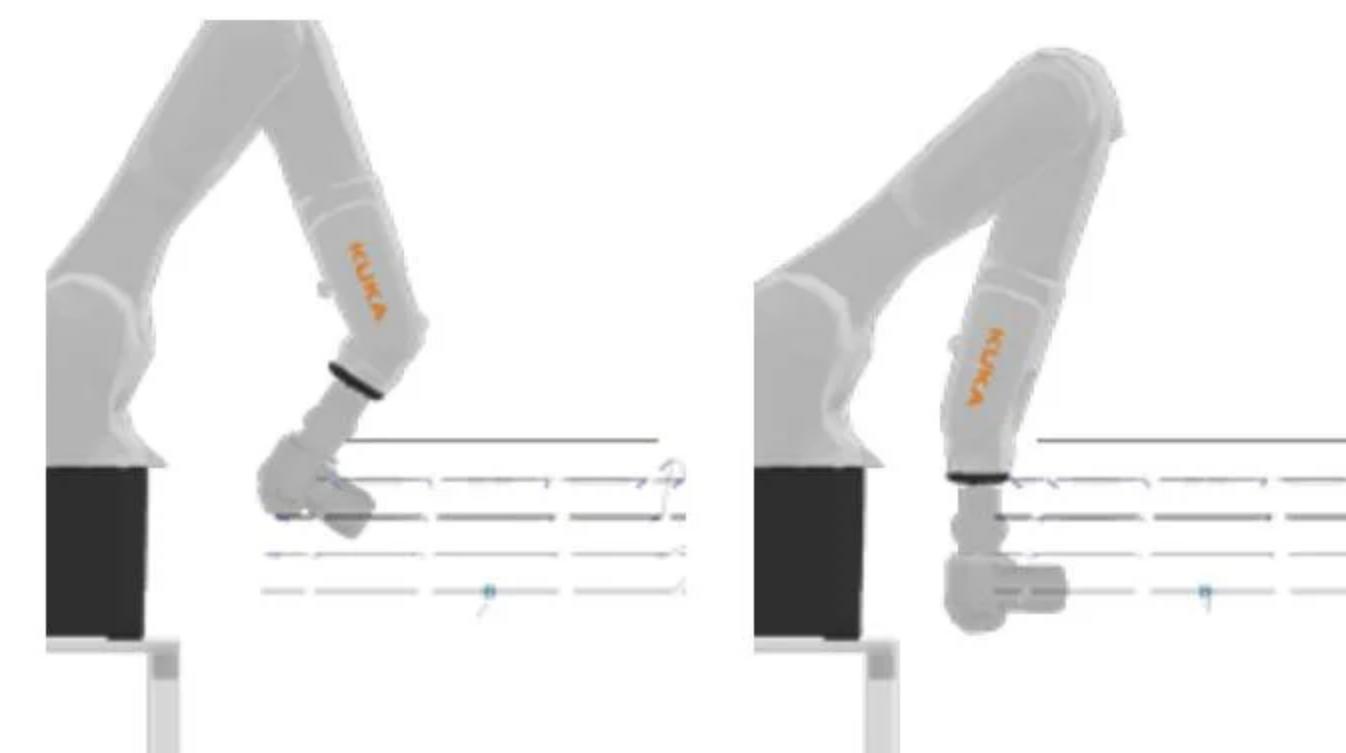
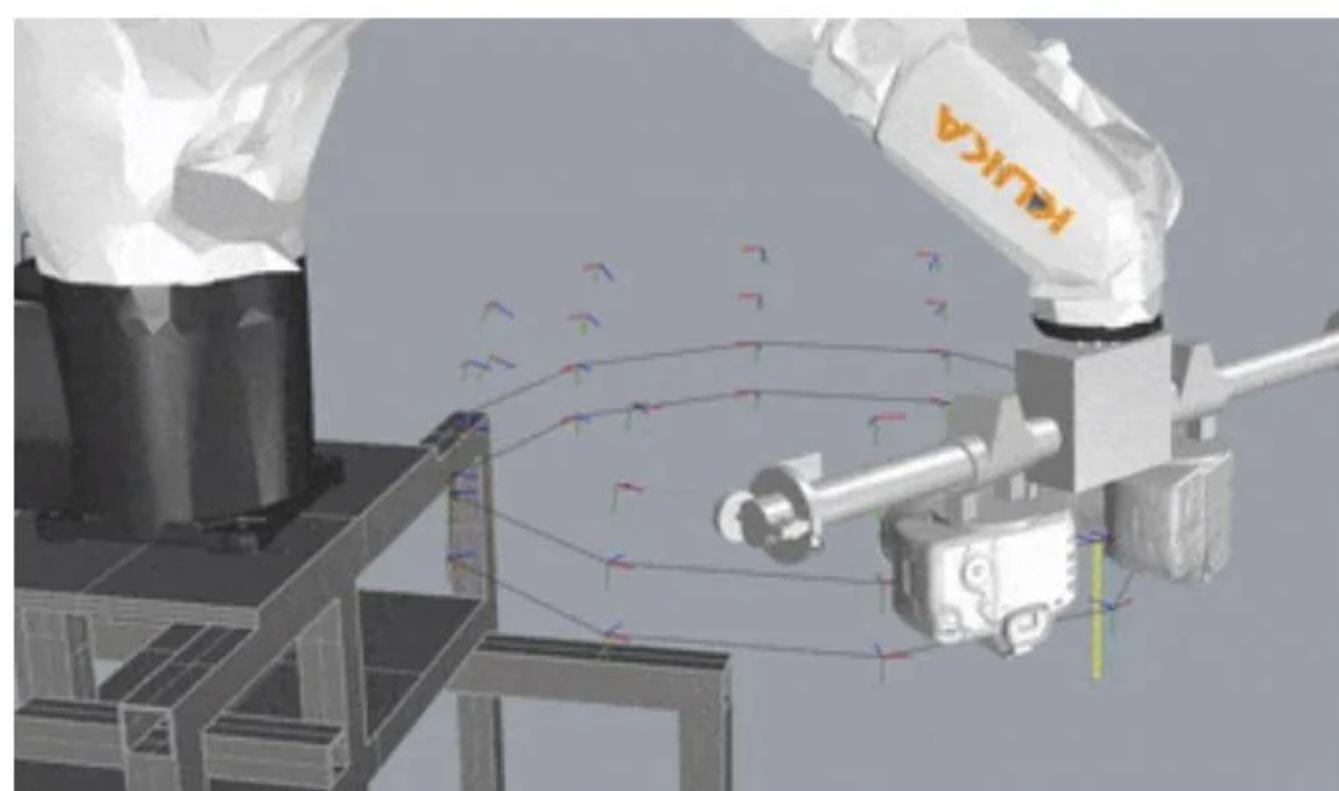
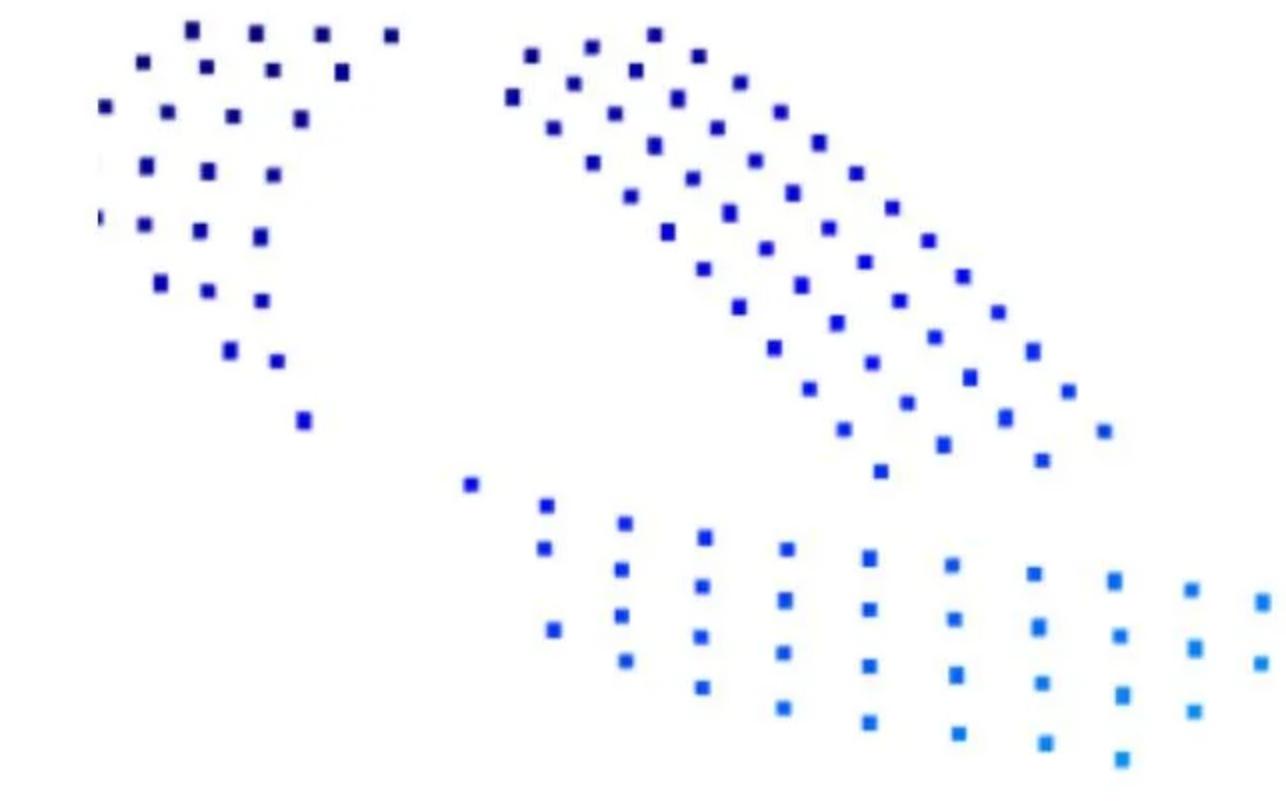
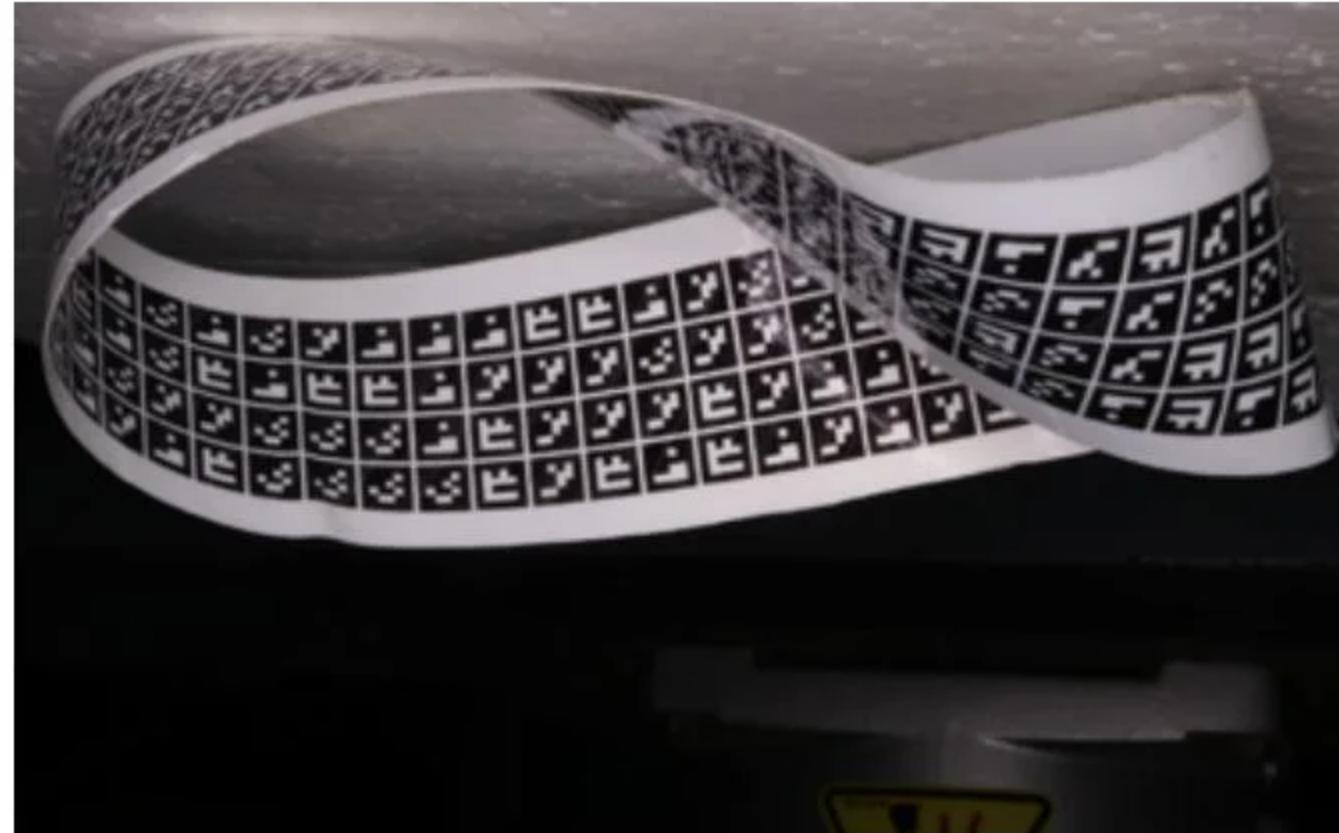
The design-to-production pipelines are automated and designed for a small payload robot that allows for a large variety of geometric possibilities. Fabrication challenges of the process have been documented, such as spring back and elastic/plastic deformation of the material.



Extrapolations on double curvature using curve creasing patterns.

# Robotic views of a mobius strip

Project Associate , IISc ,Banalore  
Experimental methods and robotic workflow in computer vision



## Challenges -

Triangulation of markers on a mobius strip using multiple view geometry for reconstruction using stereo camera system.

Robotic workflow to obtain realtime position of the stereo camera setup mounted on the robotic arm

## Results -

identification and testing of novel computer vision algorithms to reconstruct surfaces.

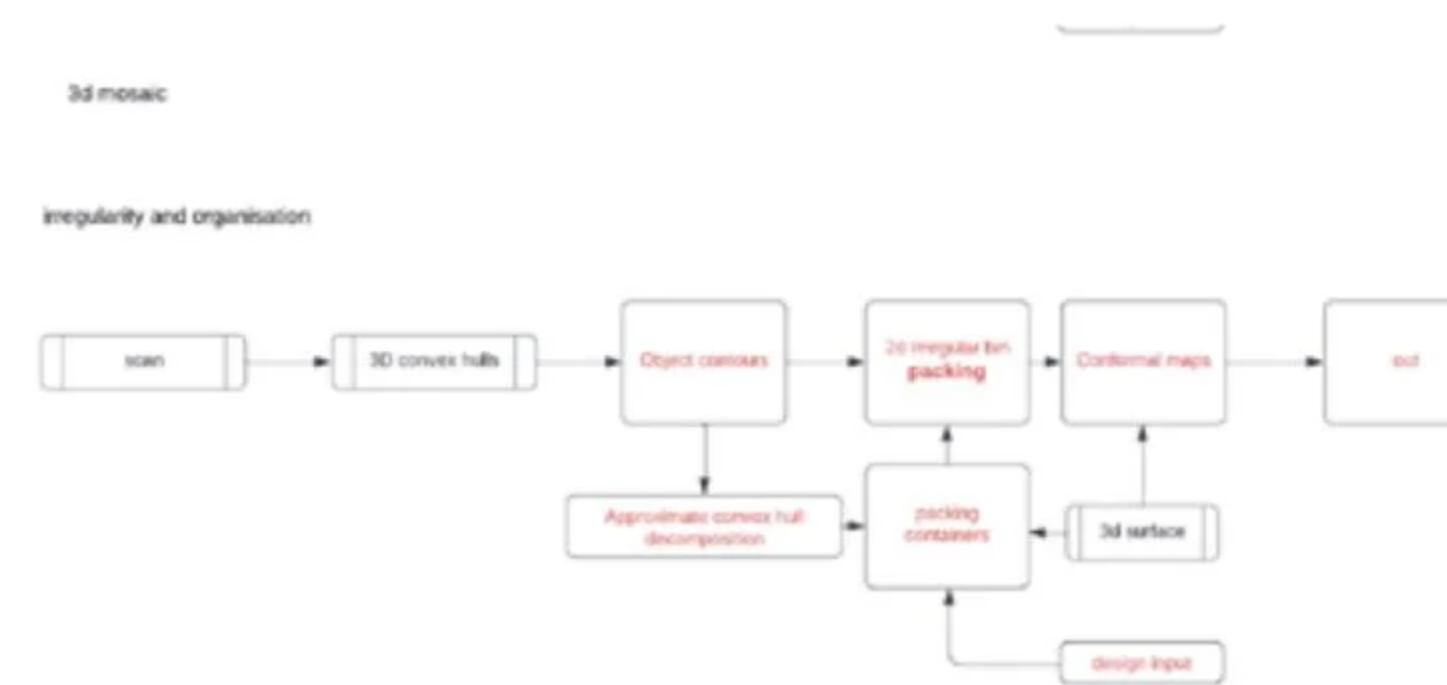
Software pipeline to extract robot poses and camera position for reconstruction;

# Automated Spolia

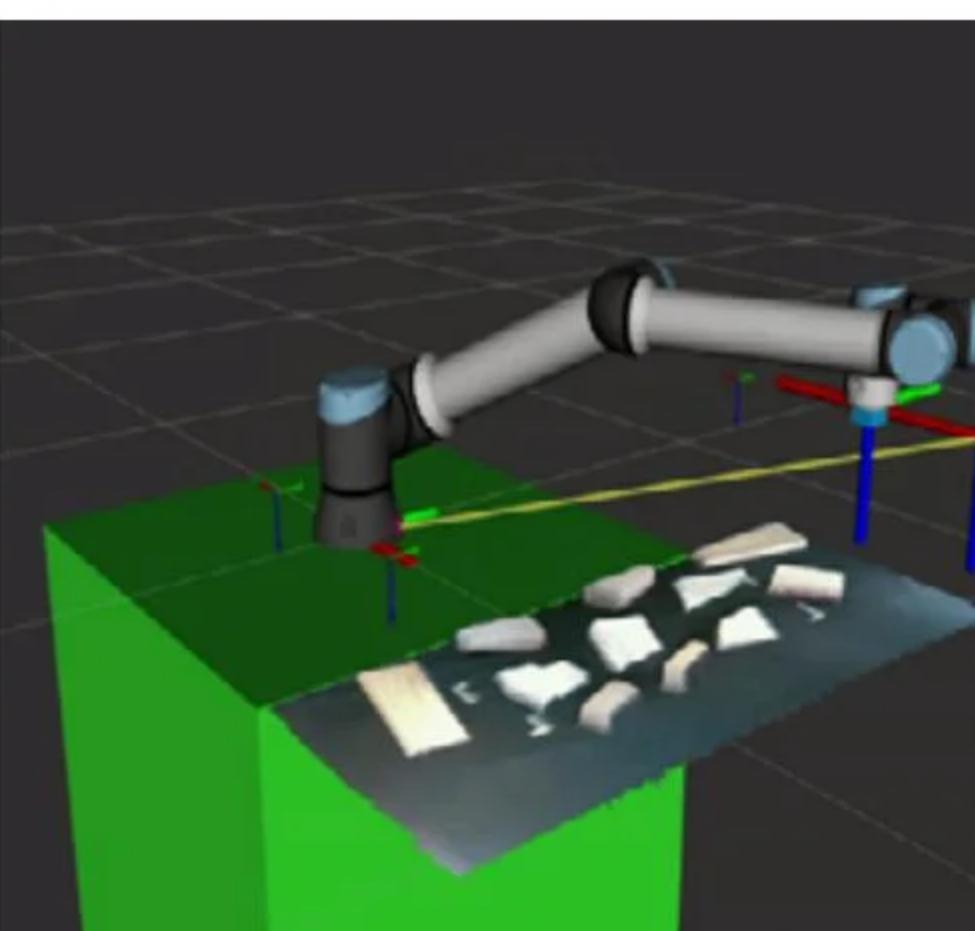
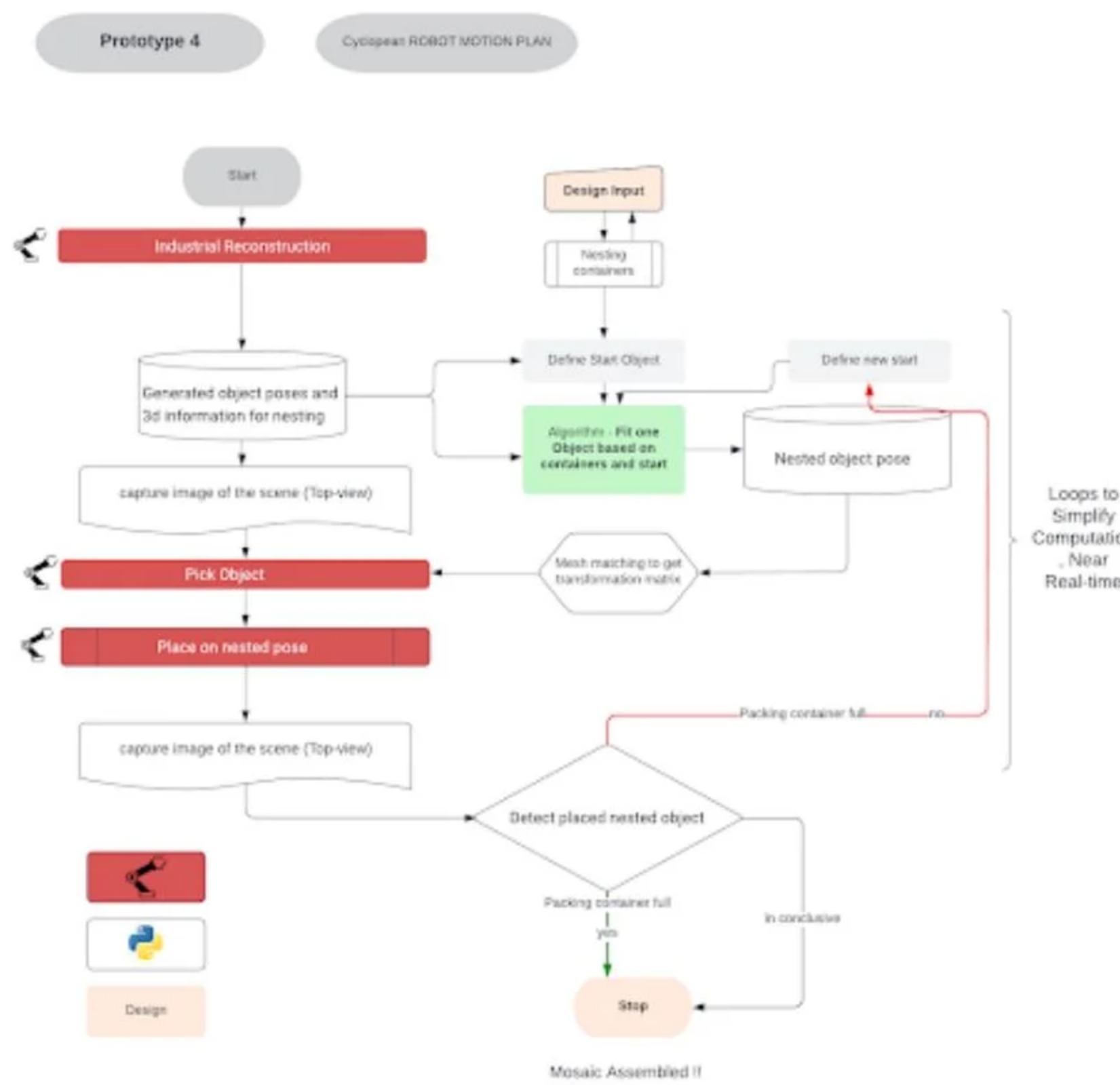
## MRAC02- Graduate Thesis

- Scan to Design Database and Design Algorithm,
- Robotic Perception and manipulation Frameworks

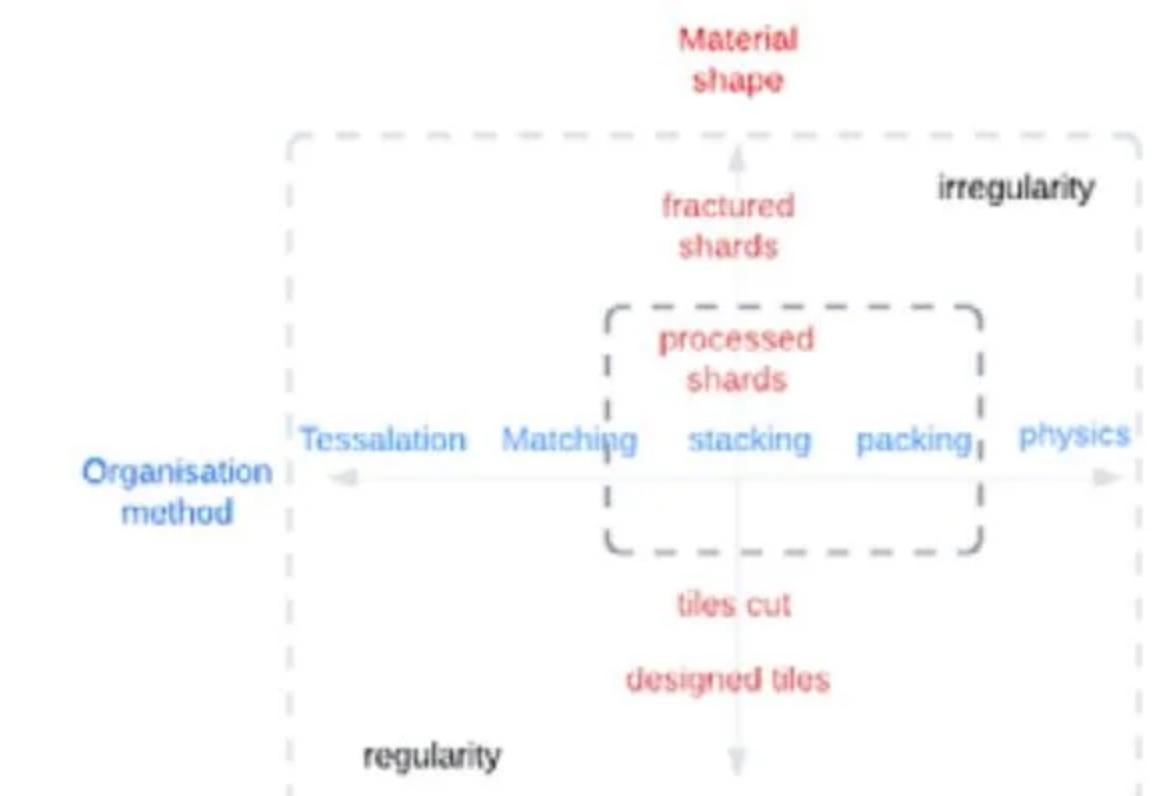
Automation in construction, focused on developing a system for perception-assisted grasping and placement in robotic fabrication. The research deals with the problems in computational design and integration challenges of robotic fabrication with non-standard building materials.



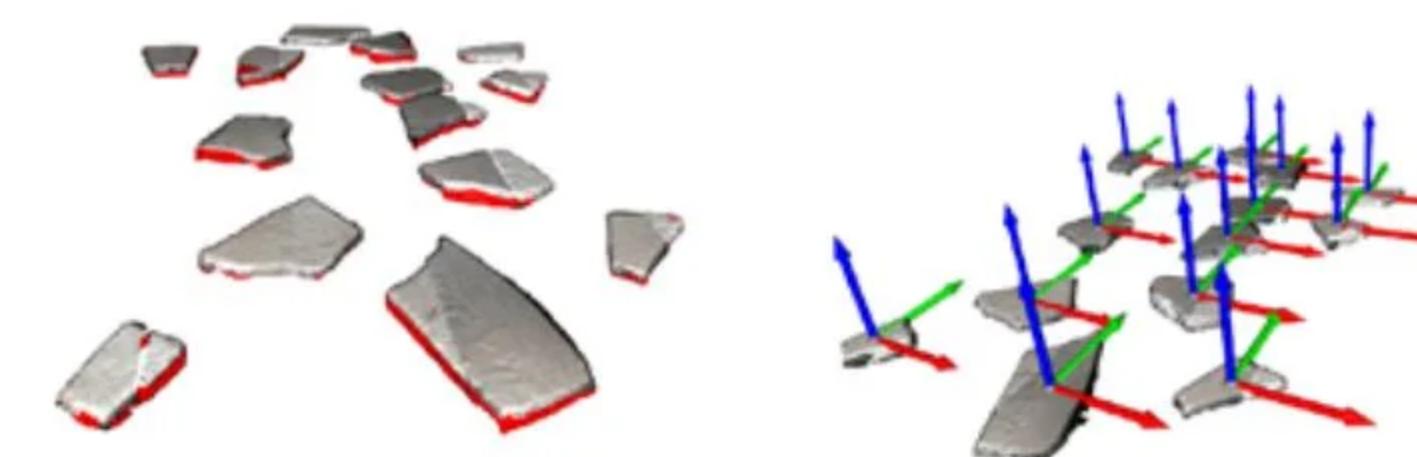
Leveraging design intuition and deployable open-source computational algorithms geared towards generating novel fabrication workflows in design research and automating mundane tasks in construction.



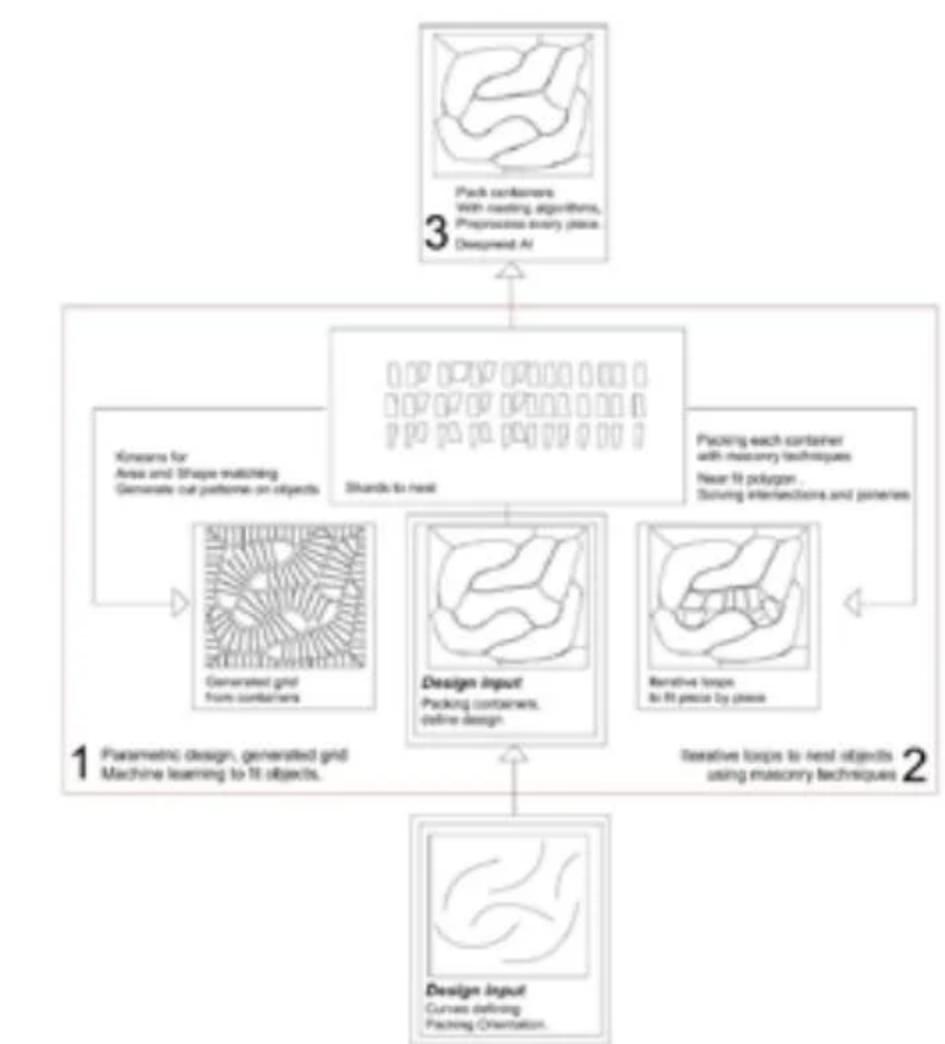
This project explores automation as a collaborative process rather than developing explicit machine intelligence, focused on empowering digital artists with offline and semi-real-time robotic workflows.



Identifying Positions of objects in space using open-3d segmentation



Design Algorithm and Logic to generate fabrication patterns in 2D and 3D.

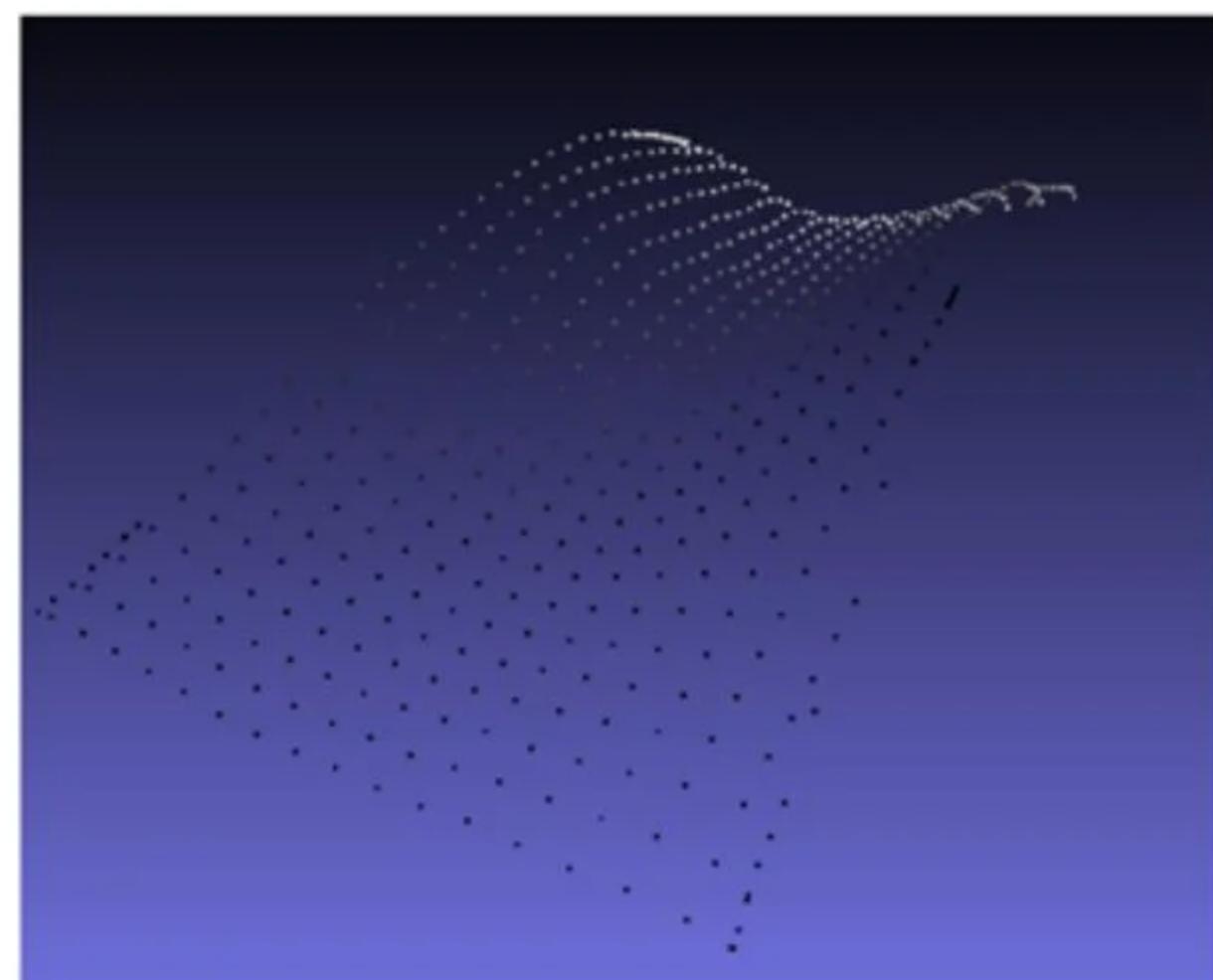


In specific, the tiling of an irregular substrate with stone shards salvaged from demolition waste; solved through visual perception and feedback mechanisms in robot control.

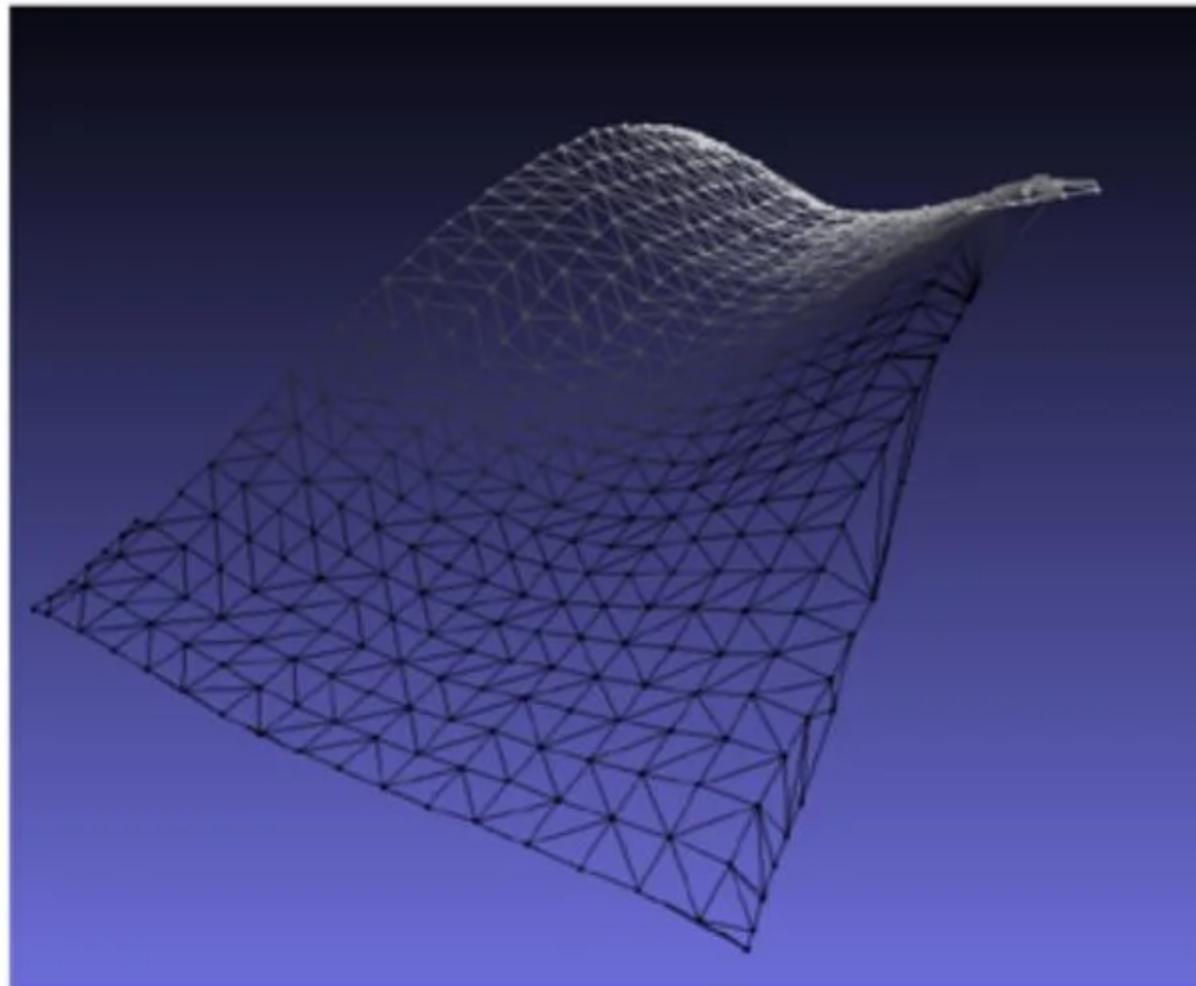
# Automated Spolia



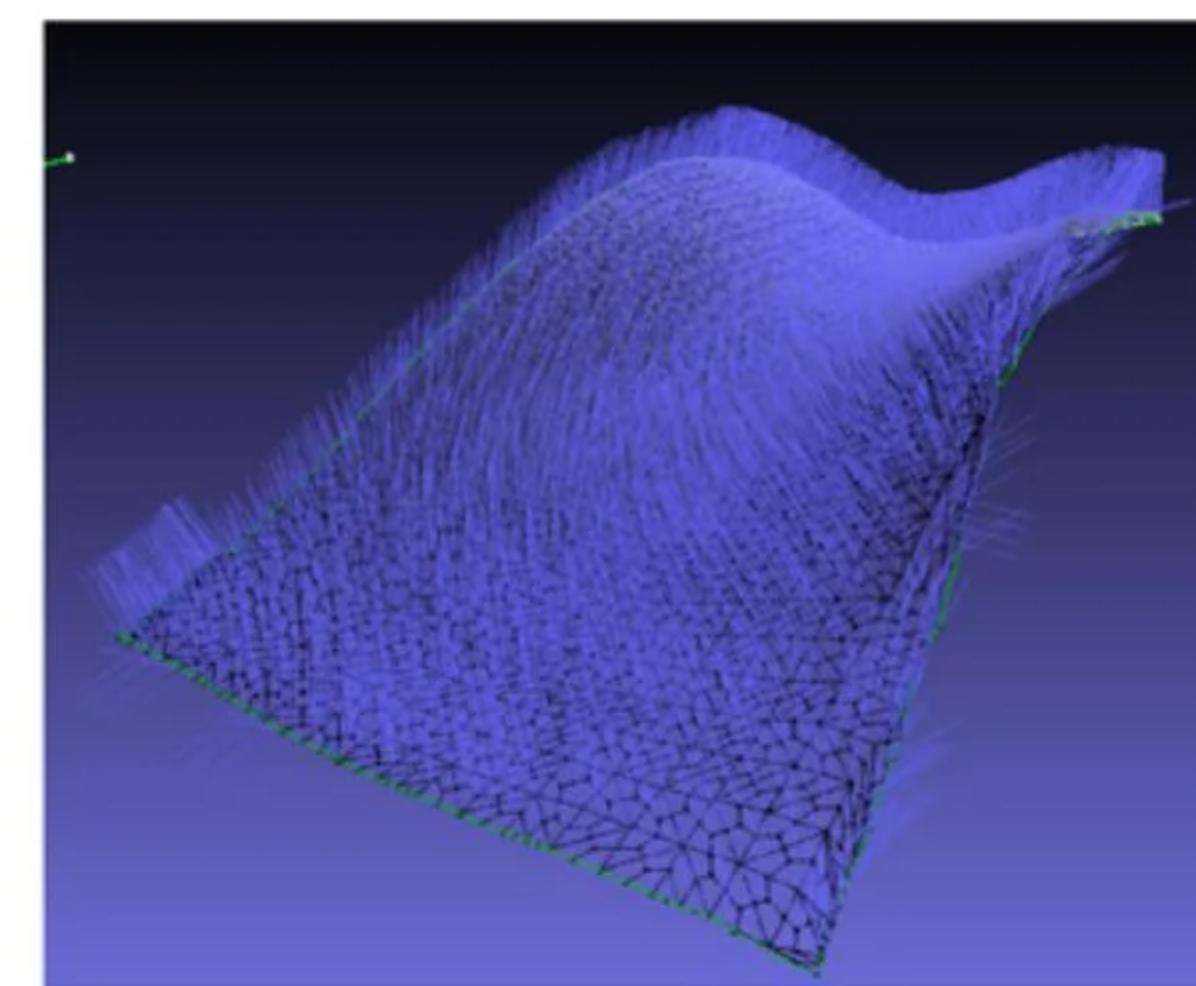
Nosiy mesh from Depth camera



Taubin mesh smoothing



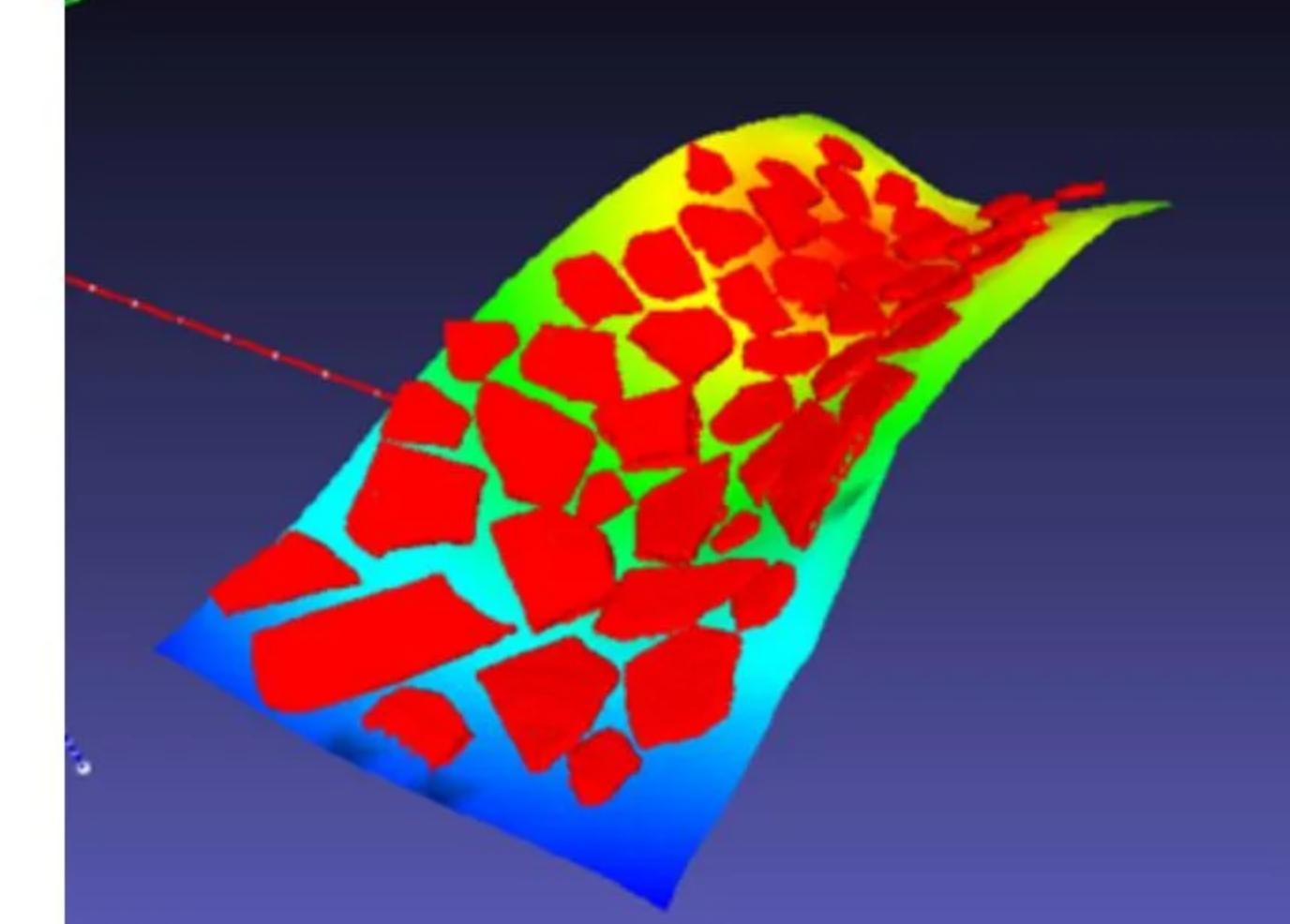
Mesh Downampling



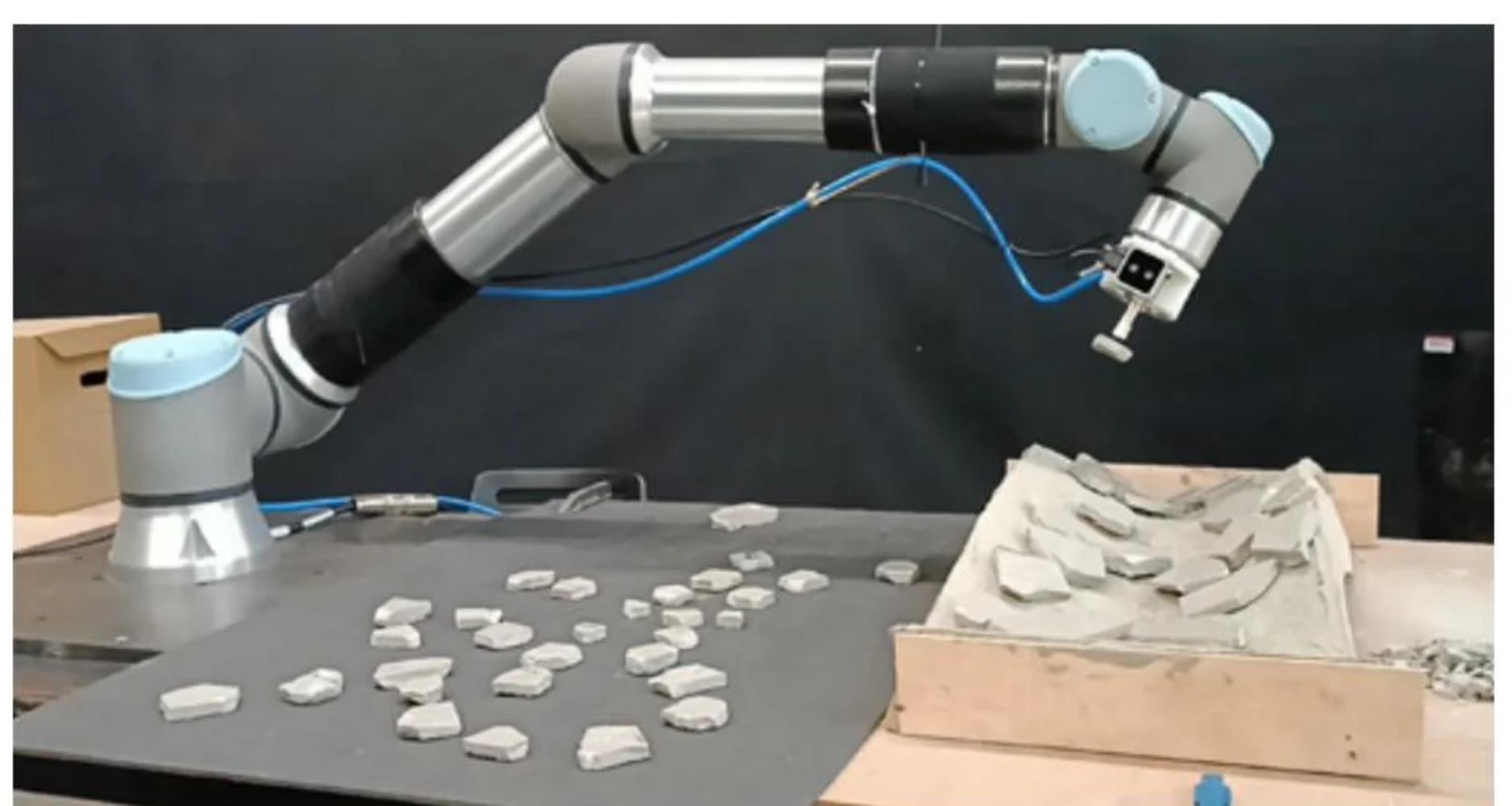
Mesh Face normal computation



Digital Twin with packing instruction



Defined packing centre,



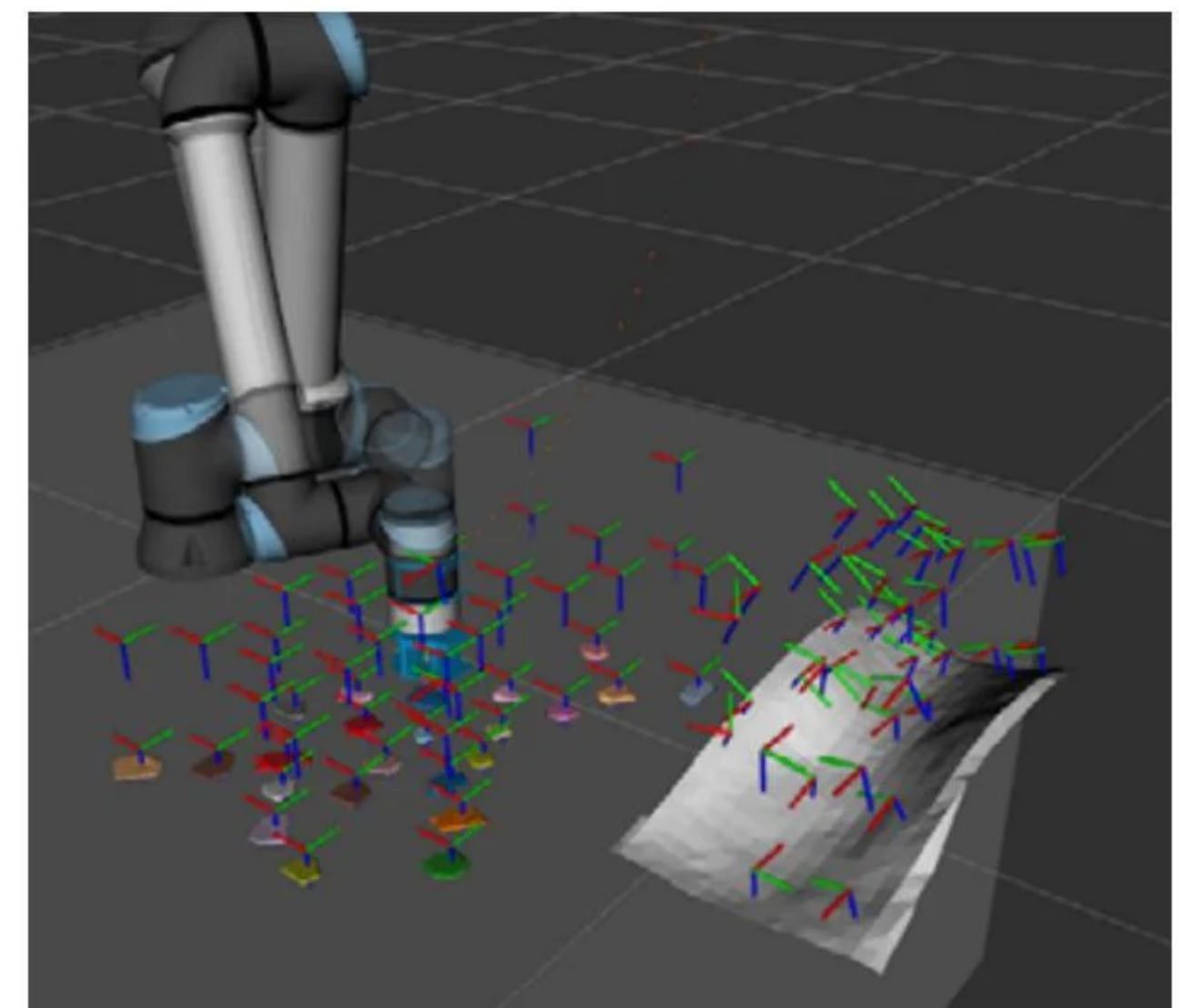
Poison sampling

Low Tolerance fabrication  
Emploting mesh processing technouies and a digital twin for robotic motion planning

Transformations of Objects from the packing algorithms are saved for robot instructions

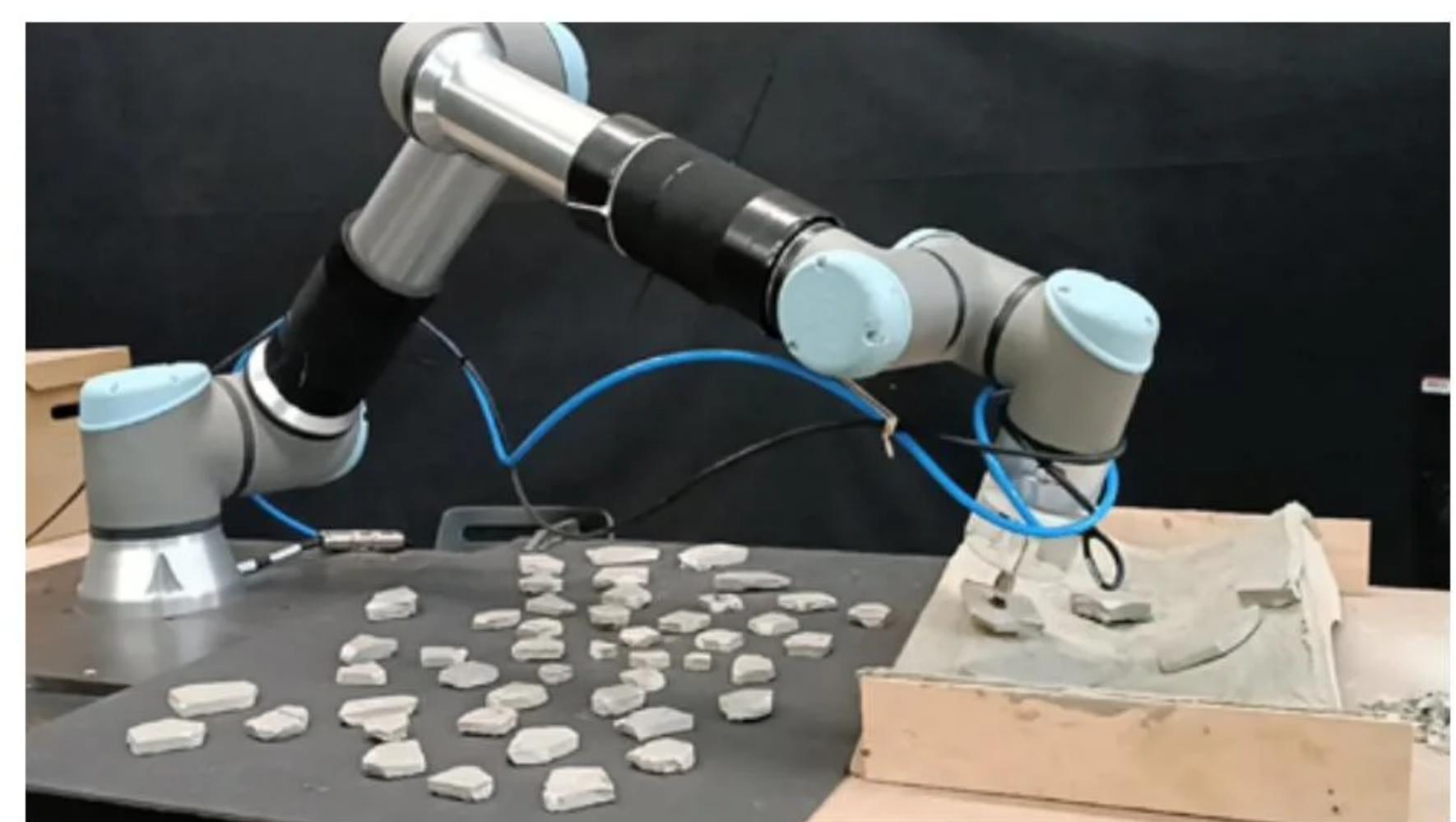


# Automated Spolia



Collision detection in Motion Planning

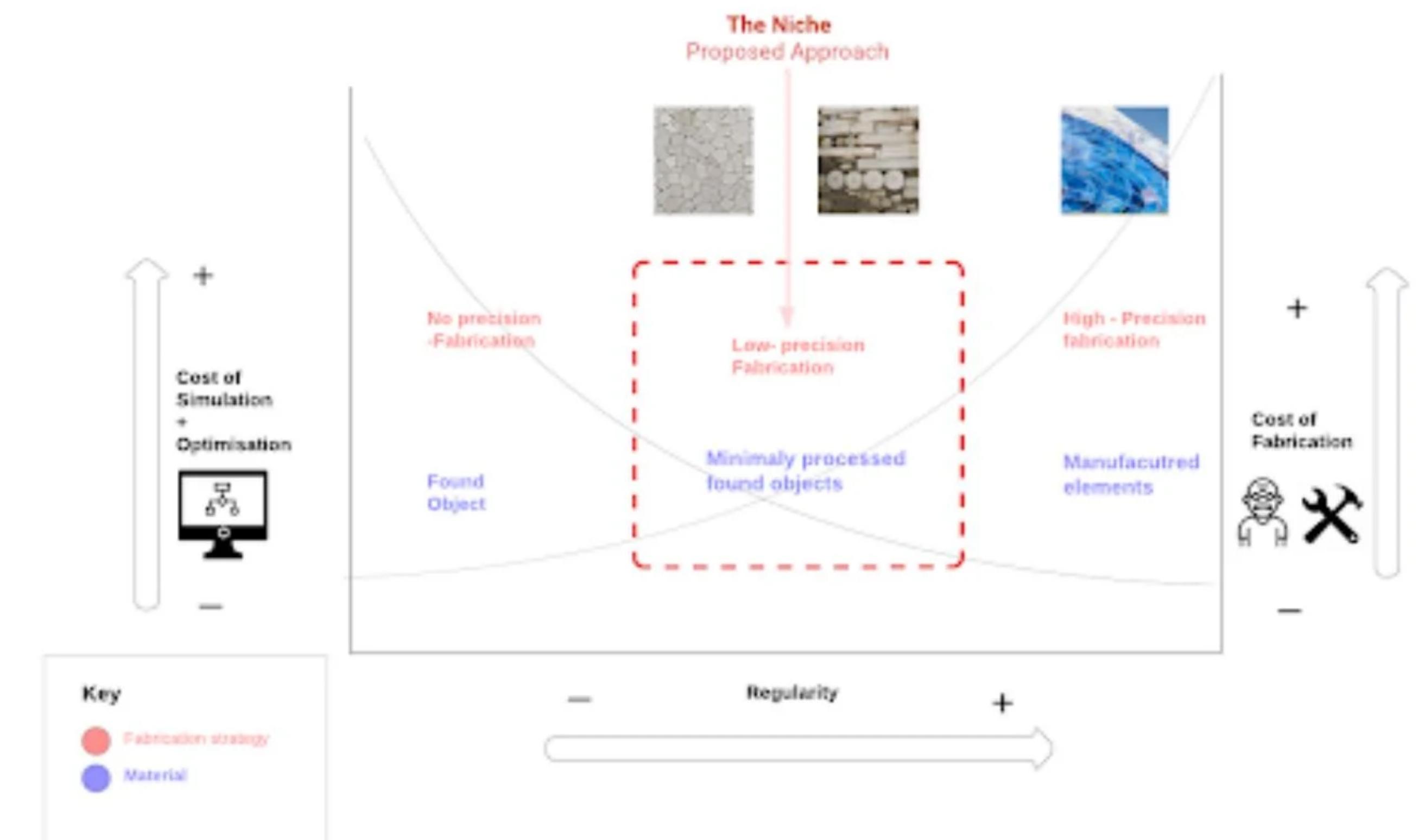
Move group sequences in Pilz motion planner for semi real time motion planning



Adjusting Offsets in Surface direction to avoid collisions

Moving to Servo real-time motion planning for Force-torque feedback

## Fabrication niche Definition



Low Tolerance Fabrication definition has enabled us working with

Irregular scans

Irregular objects

Irregular substrates.



Creating overprint with nonplanar 3d printing for gluing as part of the gluing.

# Multispectral configuration

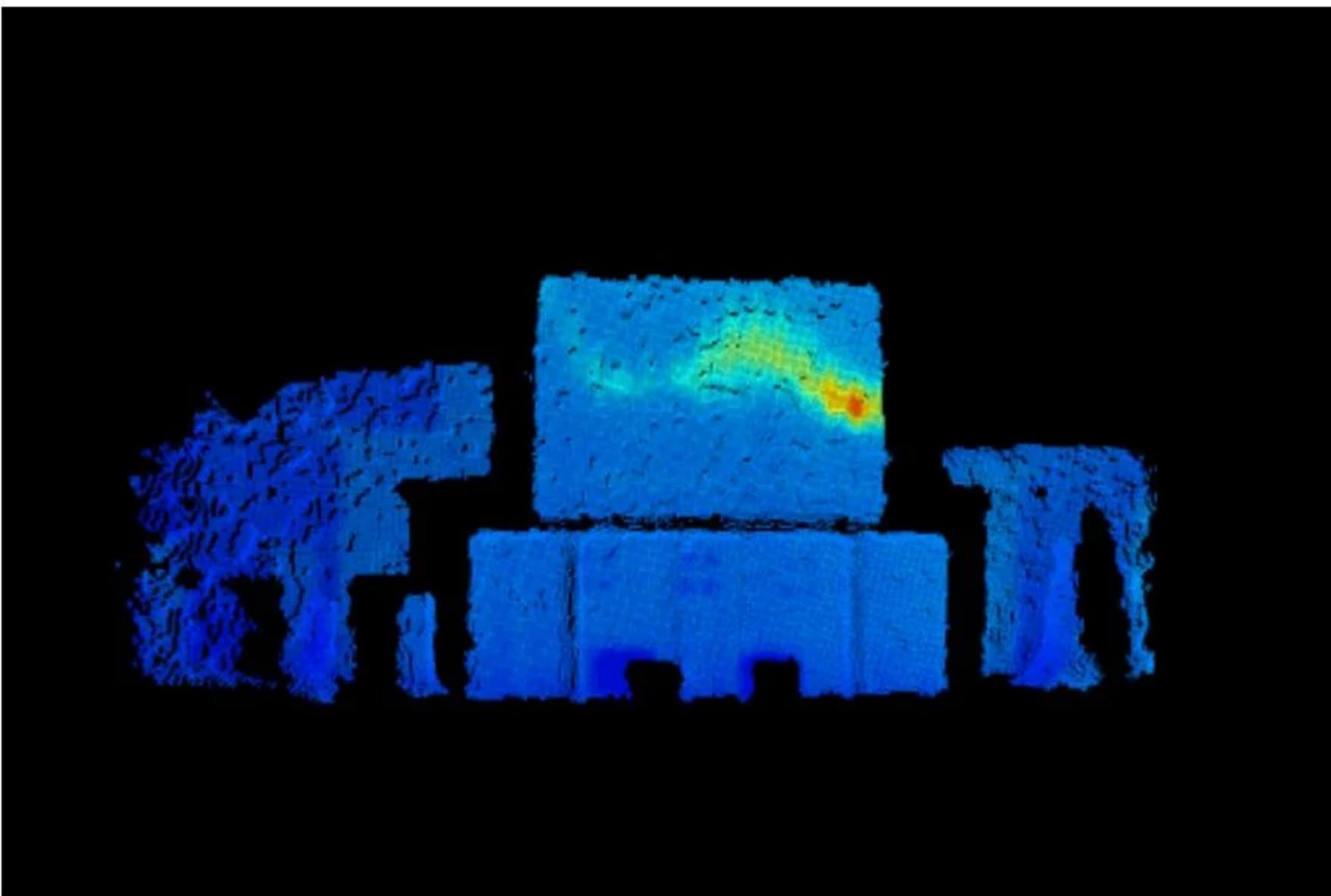
## Workshop 2.2 , MRAC01

### Thermal Point Cloud Acquisition and Assembling

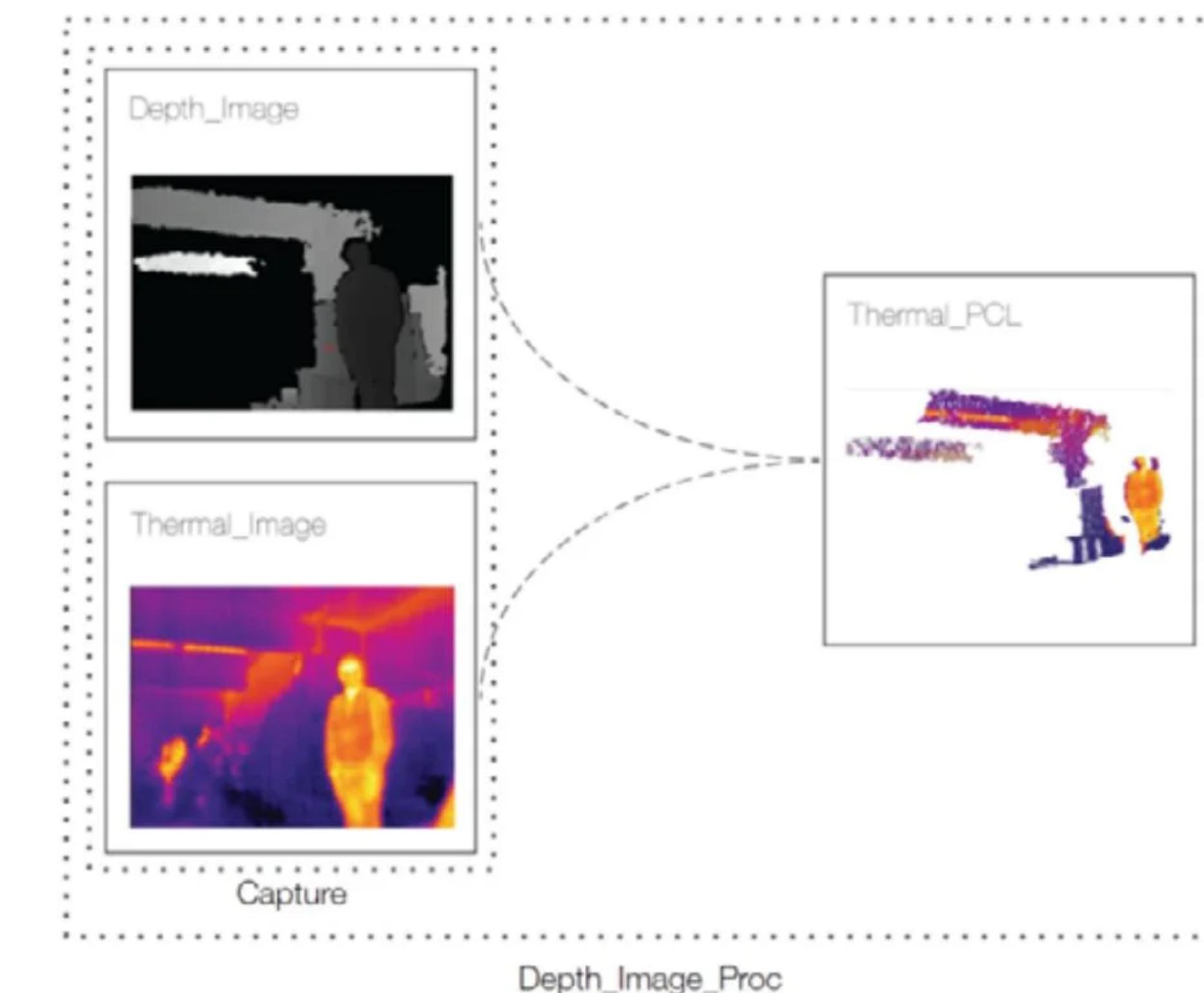
This project is about mapping the thermal environment through mobile robots and drones.

Working with sensors namely, thermal, rgb and depth cameras using a variety of ROS packages and tools such as openCV.

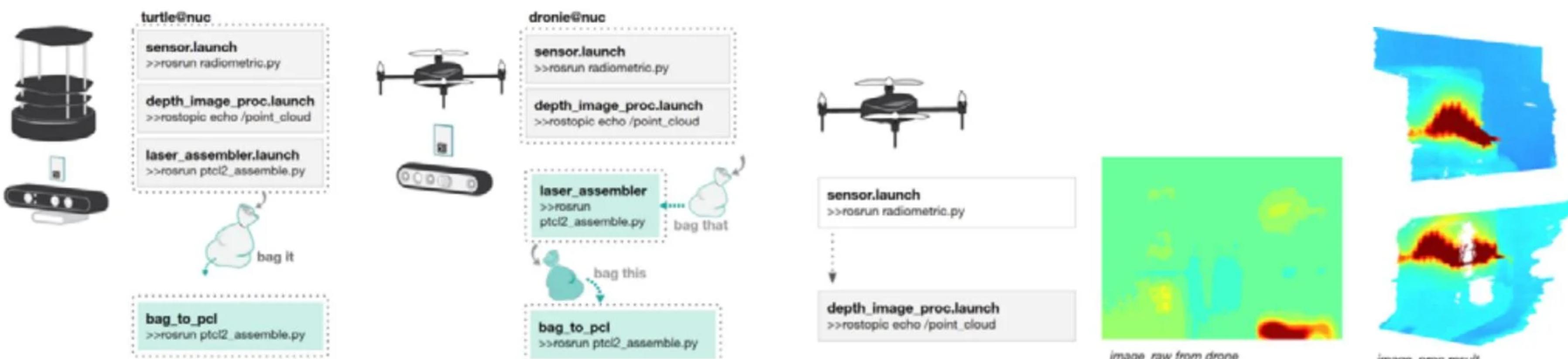
The focus will be on developing and refining capture parameters for the specific applications that will be deployed on the autonomous vehicles.



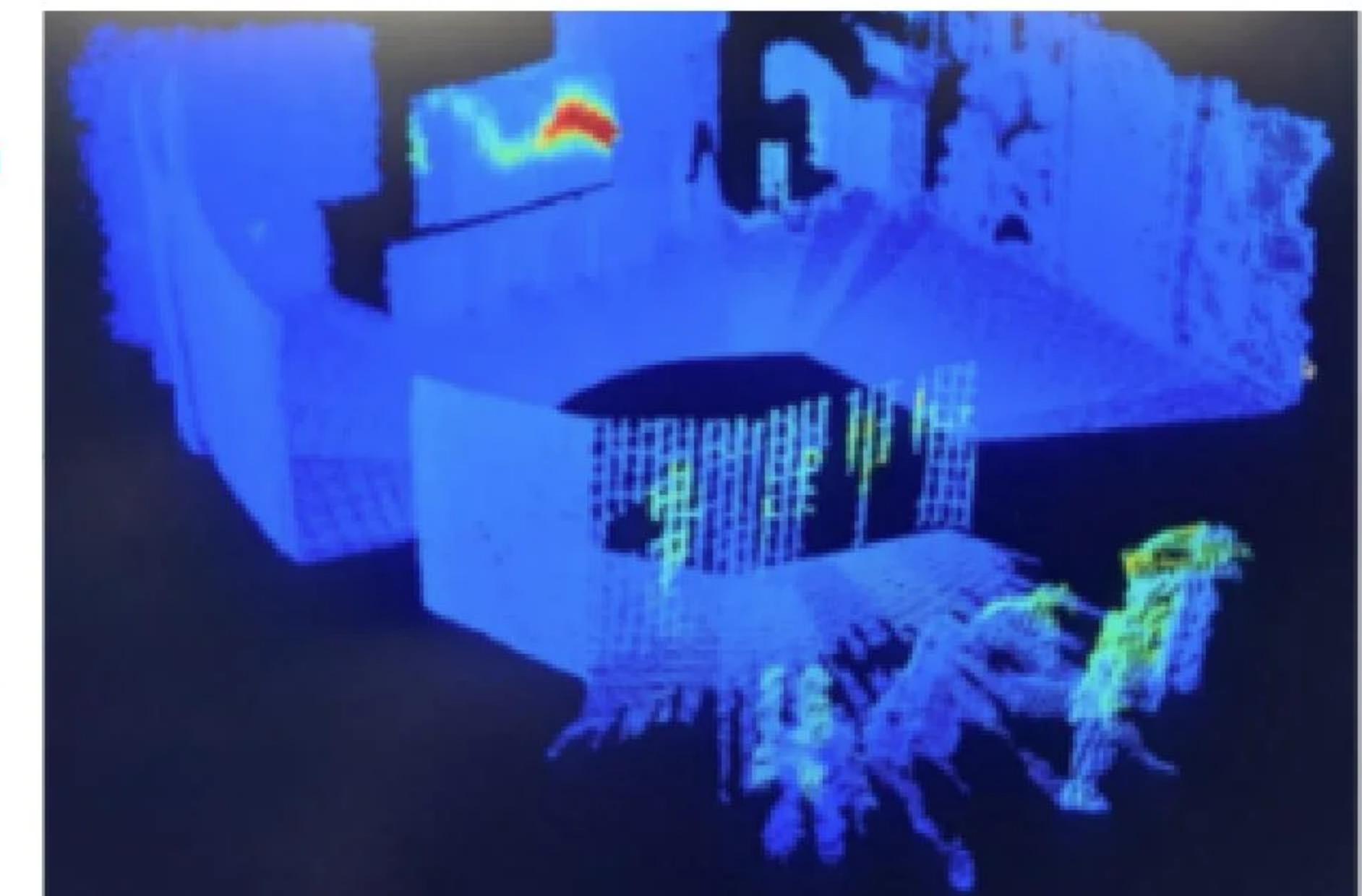
In order to save time and organise works, the turtle-bot was used for testing different parameters and all configurations will be referred to real-sense camera on the drone as final outcome.



Functions include creating disparity images and point clouds, as well as registering (re-projecting) a depth image into another camera frame.



The turtlebot carries astra camera and generates point cloud thorough three main ROS algorithm as sensors bring\_up, depth\_image\_proc and laser\_assembler. using gmapping codes as a interface to map and save the environment for the goal of autonomous navigation then remote control of the robot through 2-D navigation goals in rviz.



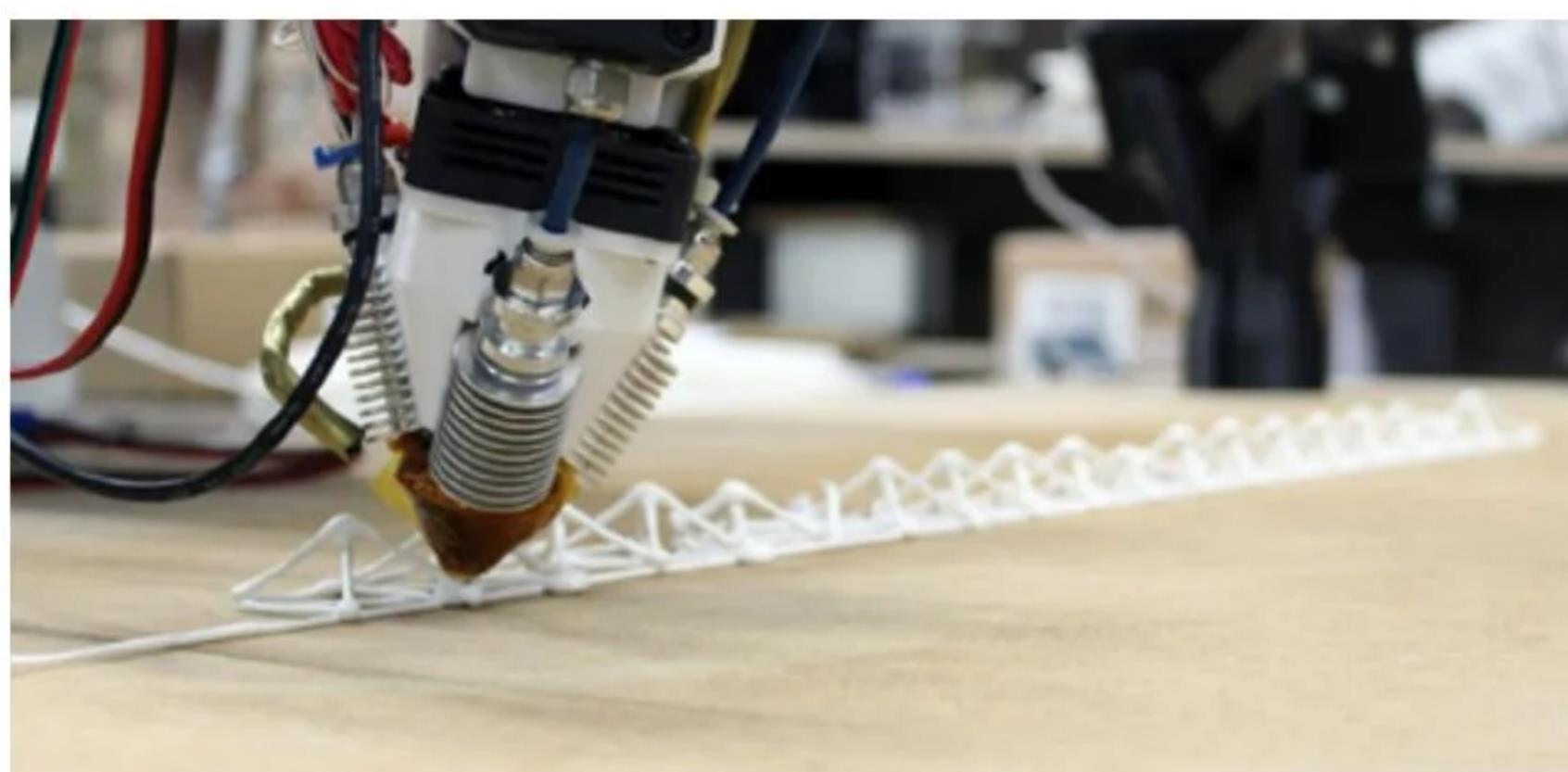
## Non linear- lattice 3d printing

The project aimed at exploring non-linear 3d printing strategies , in particular space-frame lattice structures with 3d printing on a robotic arm.

Leveraging non-planar 3d printing techniques

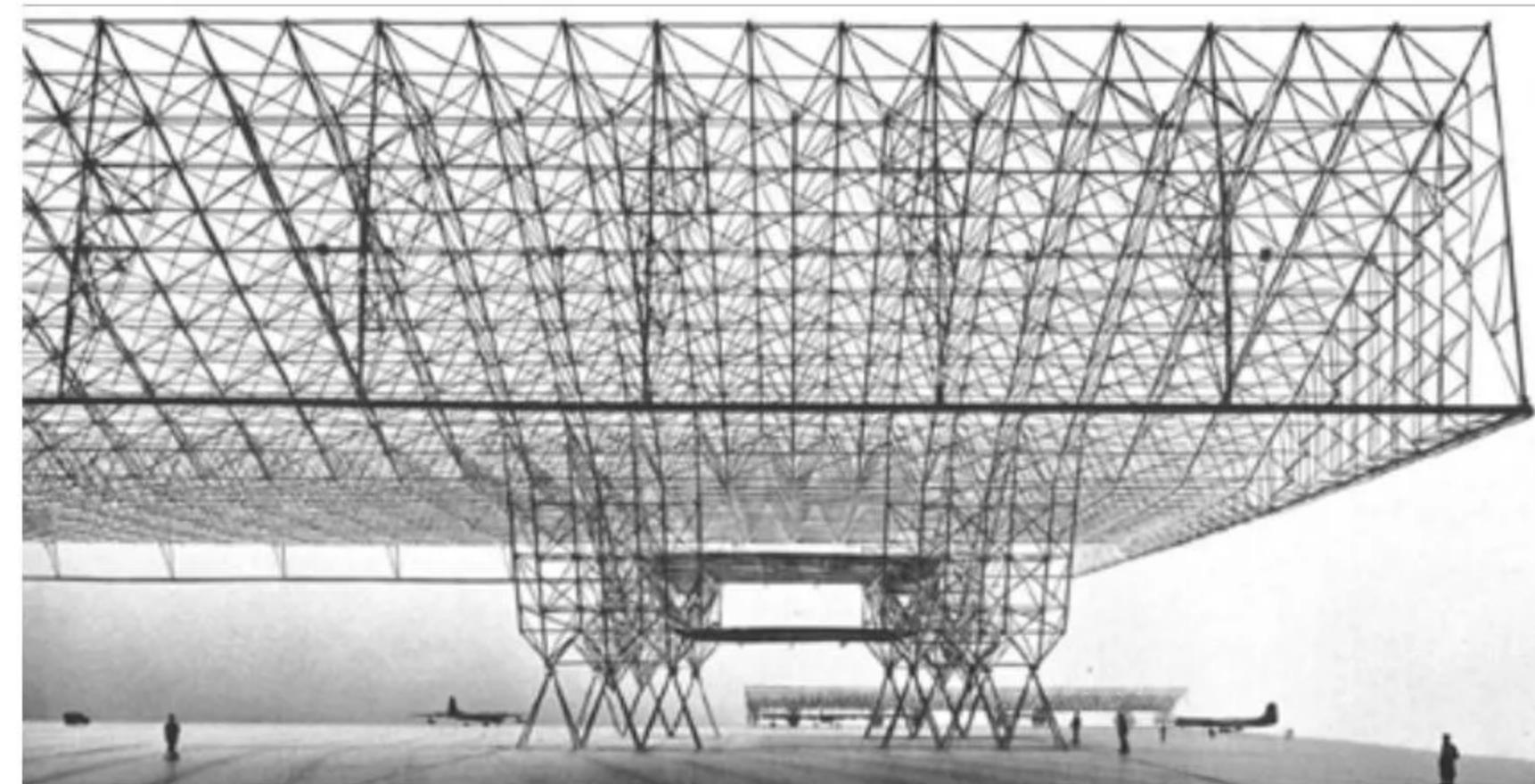


Printing the apex of the pyramid.



Printing the Second layer of the lattice

## Workshop 1.2 , MRAC

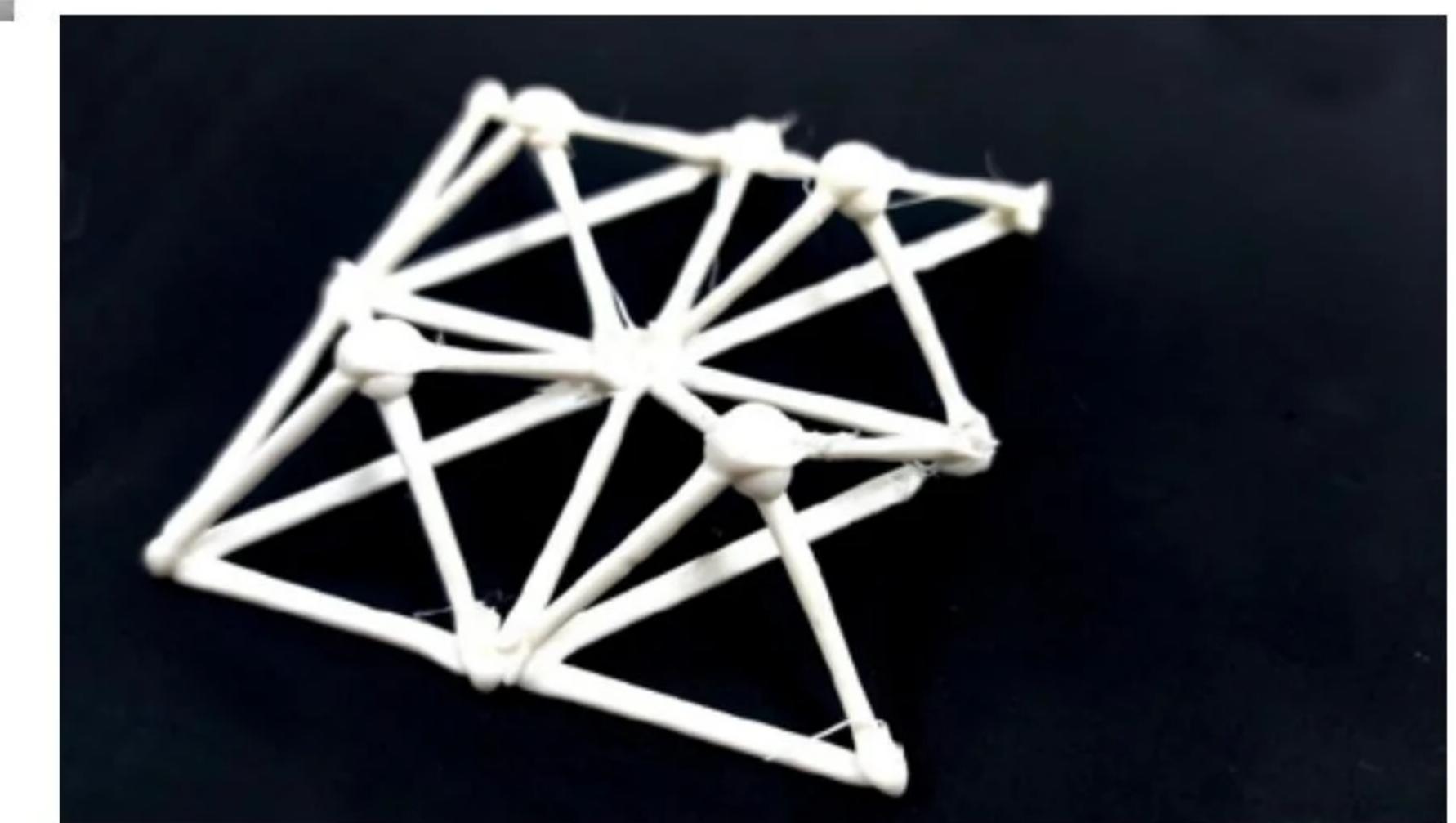


An especially challenging aspect of the design was fine-tuning the apex of the pyramid.

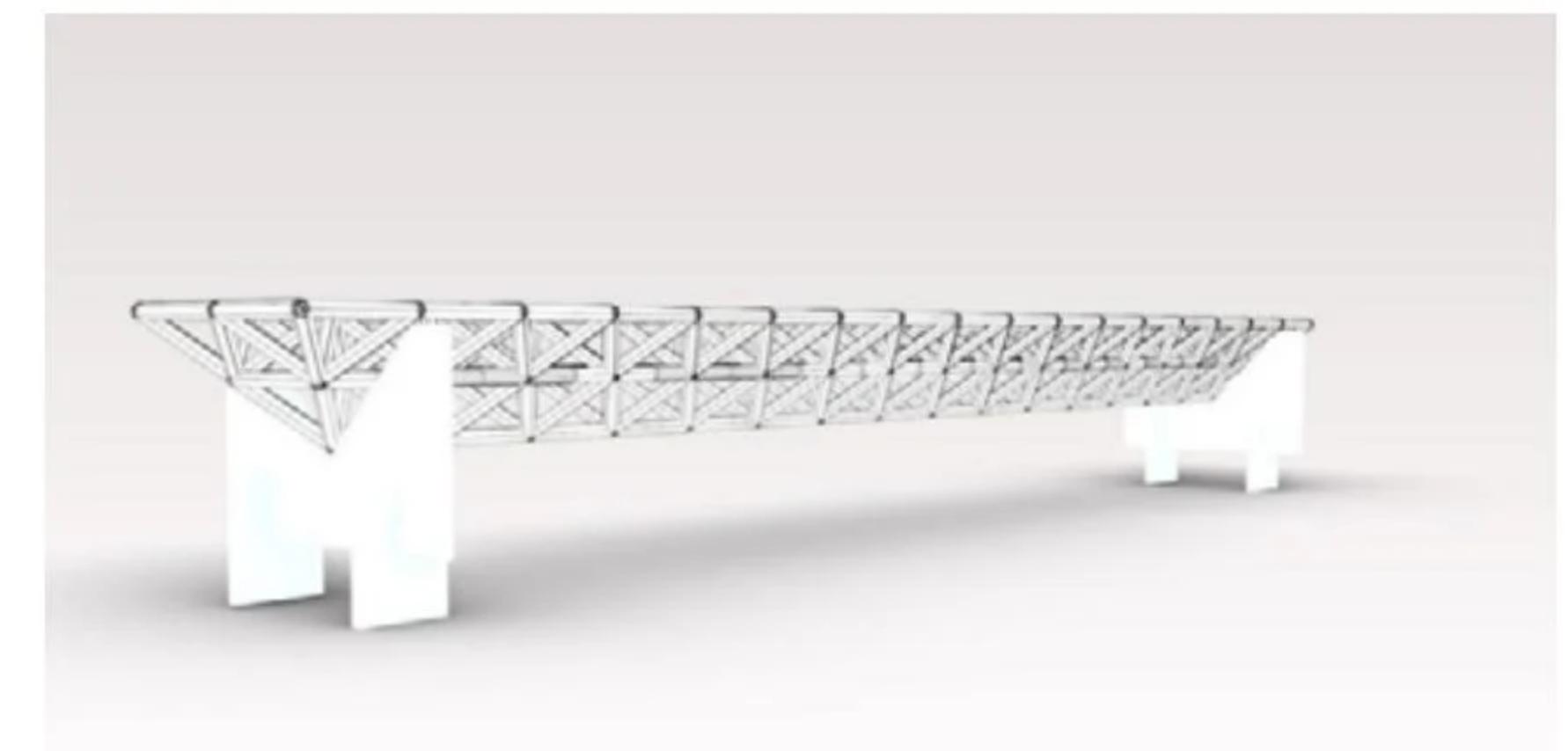
Timing the extruder to stop, wait, and cool was crucial at this moment – if the material cooled too much it would stick to the tip and drag along the rest of the tool-path, if the wait time was too short, the material would not be hard enough to support itself.

An especially challenging aspect of the design was fine-tuning the apex of the pyramid.

Timing the extruder to stop, wait, and cool was crucial at this moment – if the material cooled too much it would stick to the tip and drag along the rest of the toolpath, if the wait time was too short, the material would



The repeatable module.

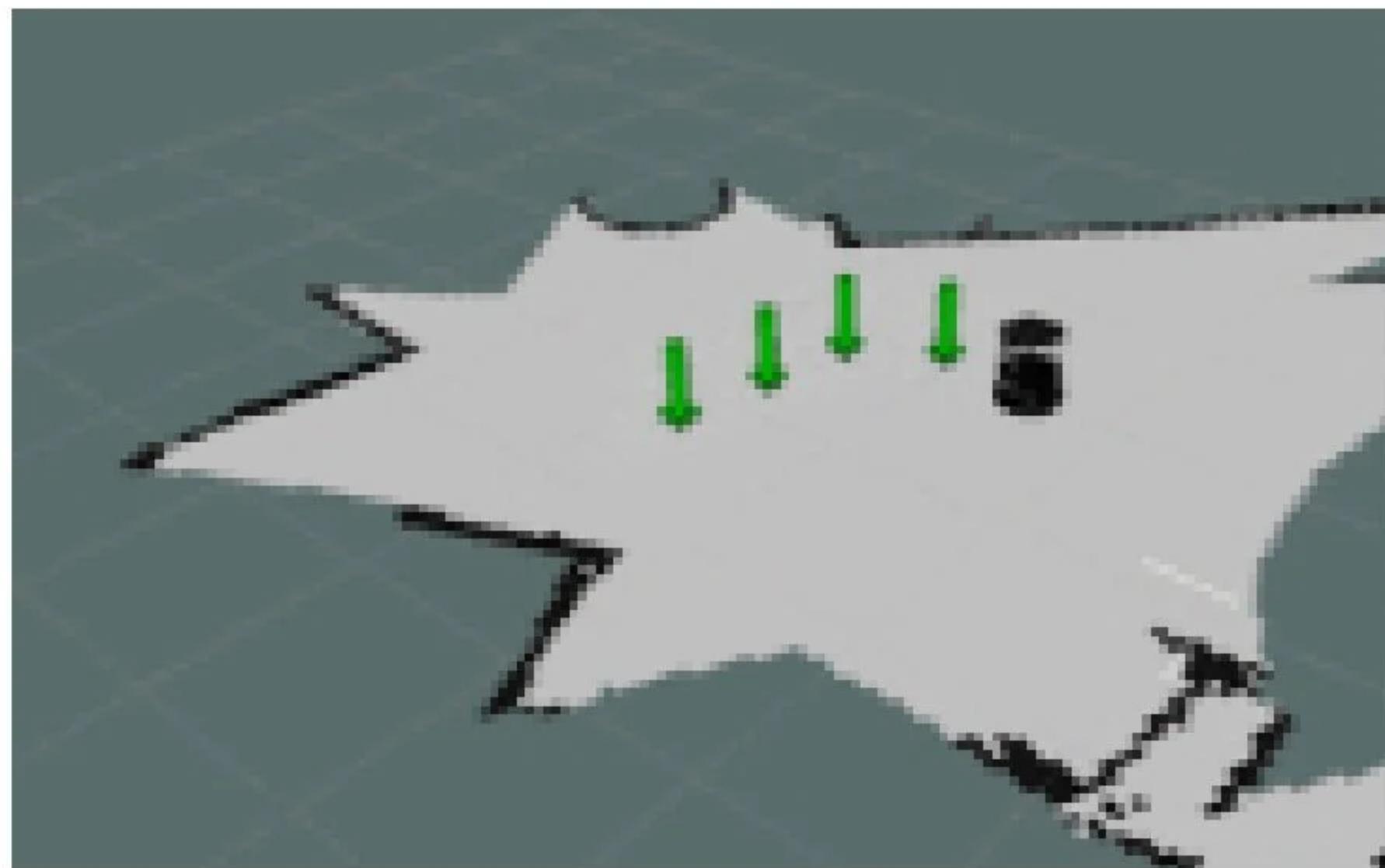
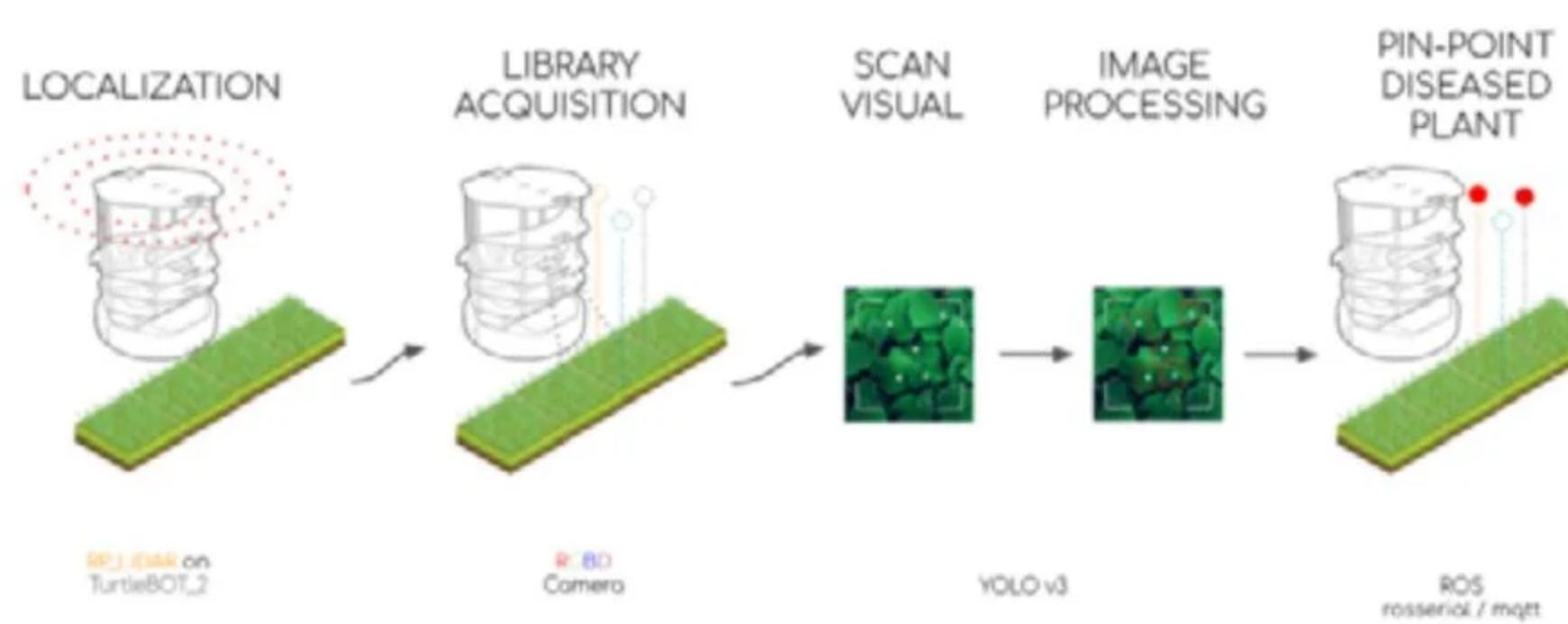


The Space frame prototype fabricated

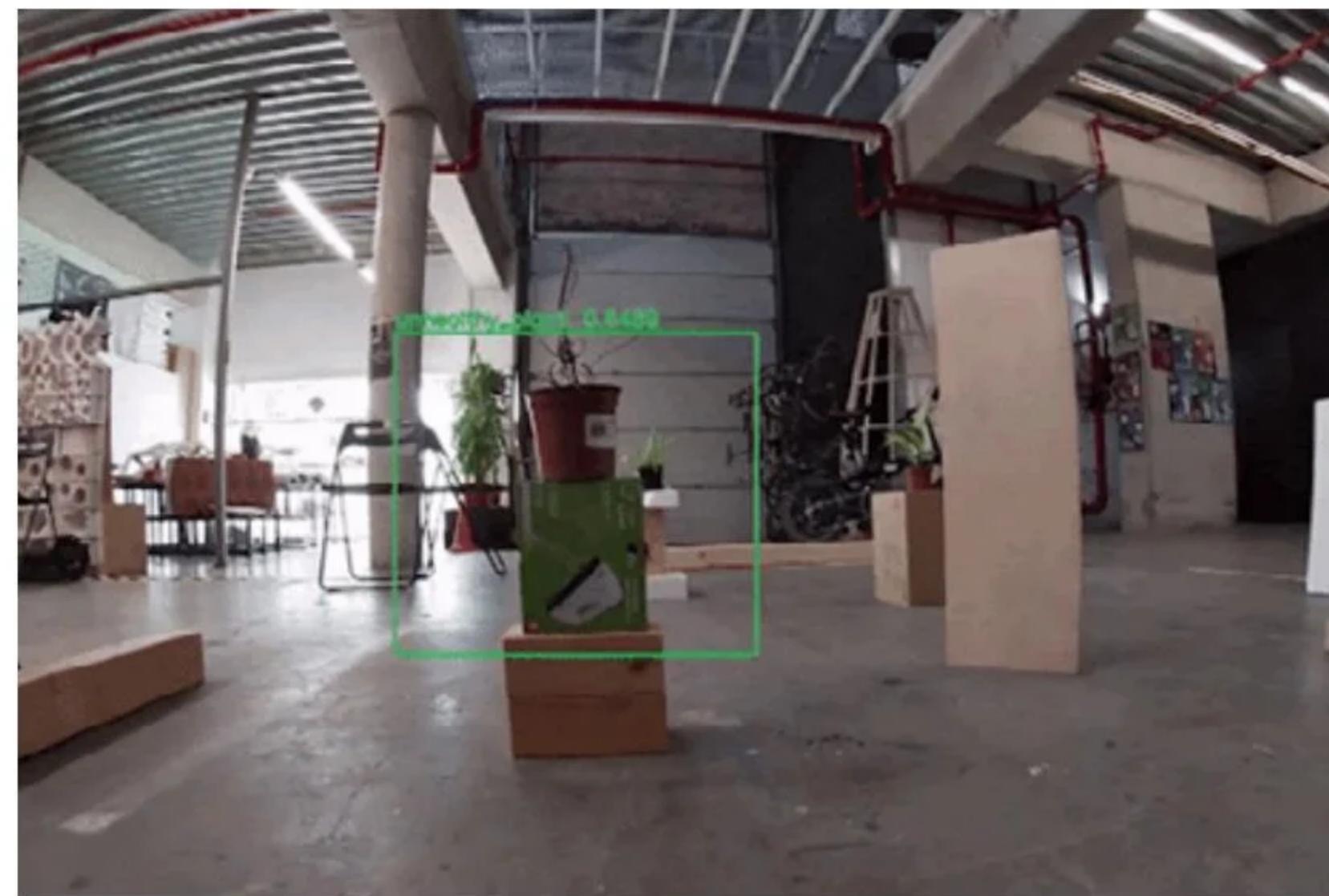
Plant\_D is a rover-based workflow for city-wide application of image processing and machine learning for plants within the city's landscape.

The workflow works around the multi-node system with the ROS middle-ware framework.

The workflow works around the multi-node system with the ROS middle-ware framework.



Gmapping and marking of the scene



plant status detection on the camera feed from the turtlebot

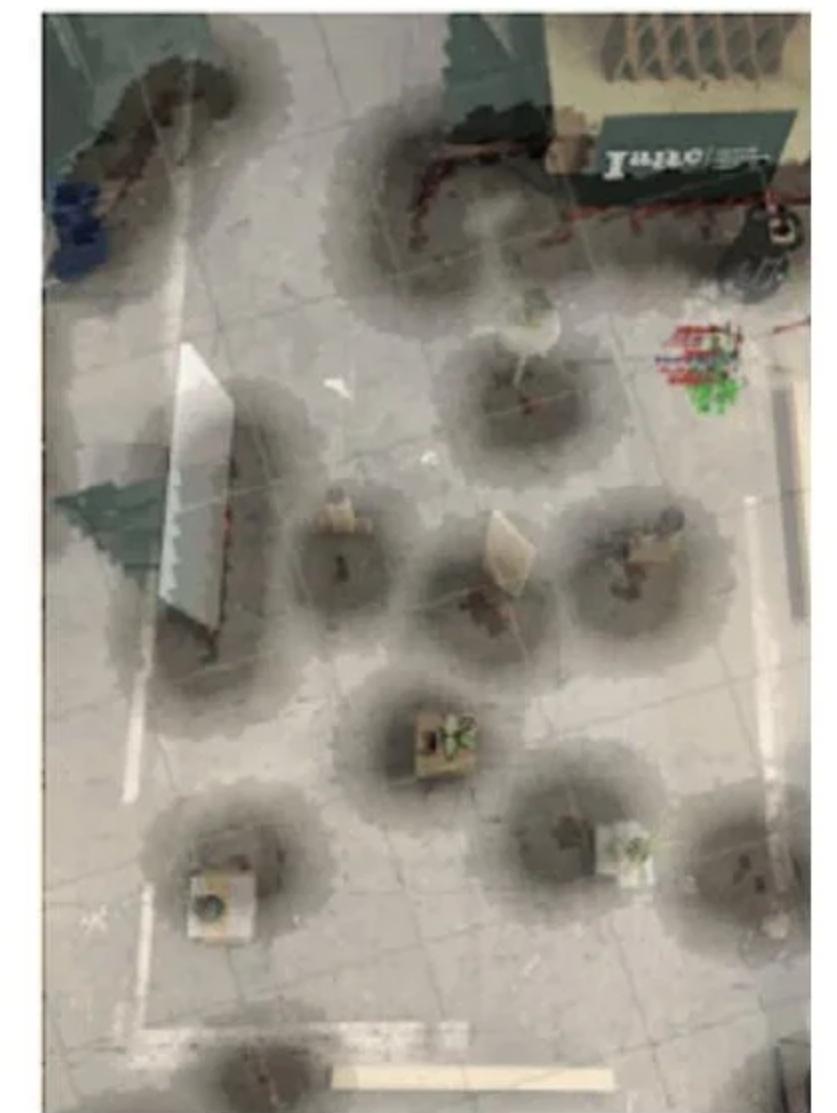
Project objectives

Interfacing with ROS.

Localization and navigation, Gmapping.

Diseased Plant detection using deep learning

Mapping detected plant health in space.

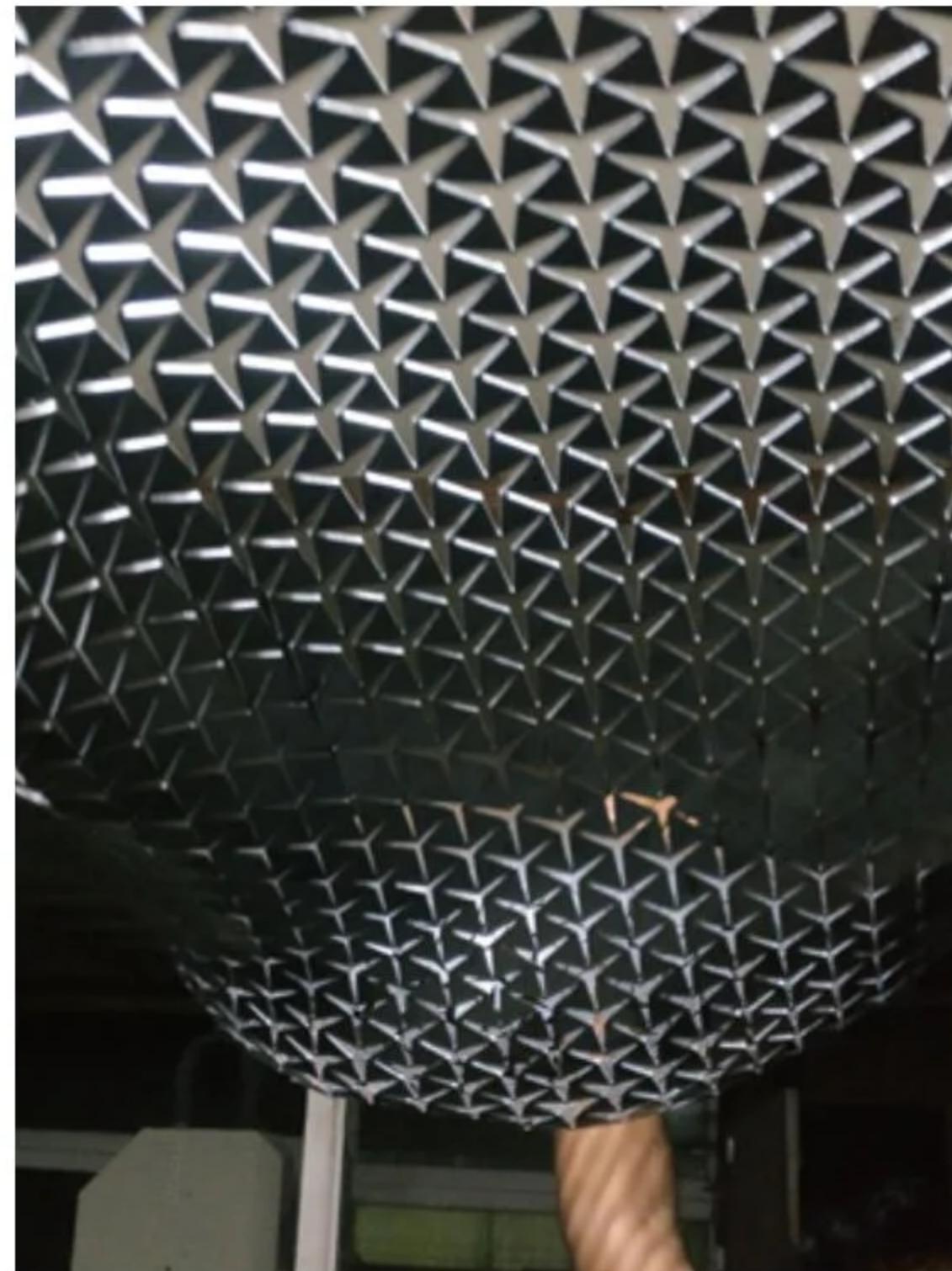
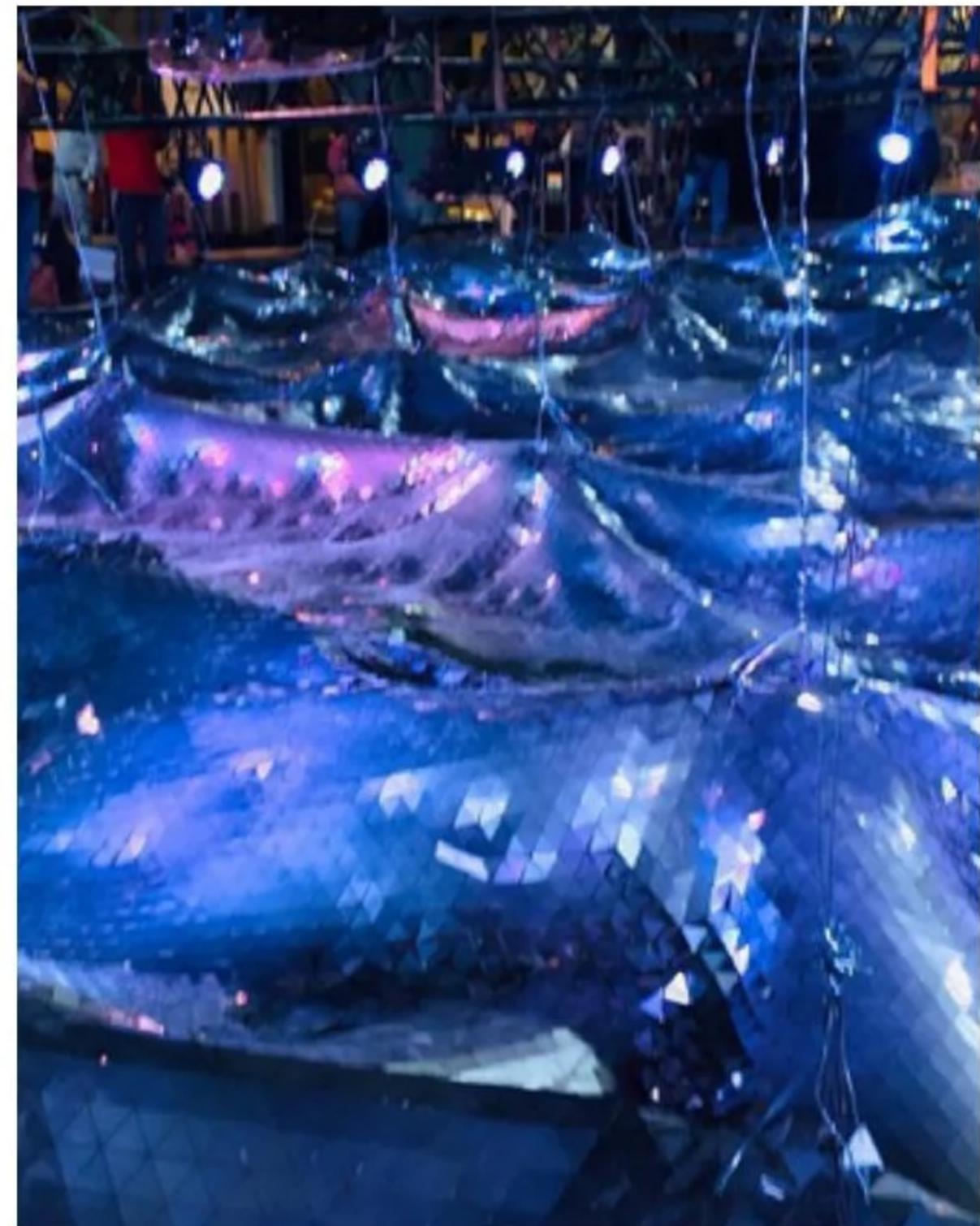


The aims and objective of the project were to create a database of diseased plants and locate them on the scanned map using markers.

The training dataset allowed us to differentiate between diseased and healthy plants based on images labeled in reddit and google search, along with datasets from Kaggle.

# Metal Cloud

Team(2020)- Internship for Folds design studio in collaboration with SRI design lab , Worked as a research assistant on computation and fabrica-

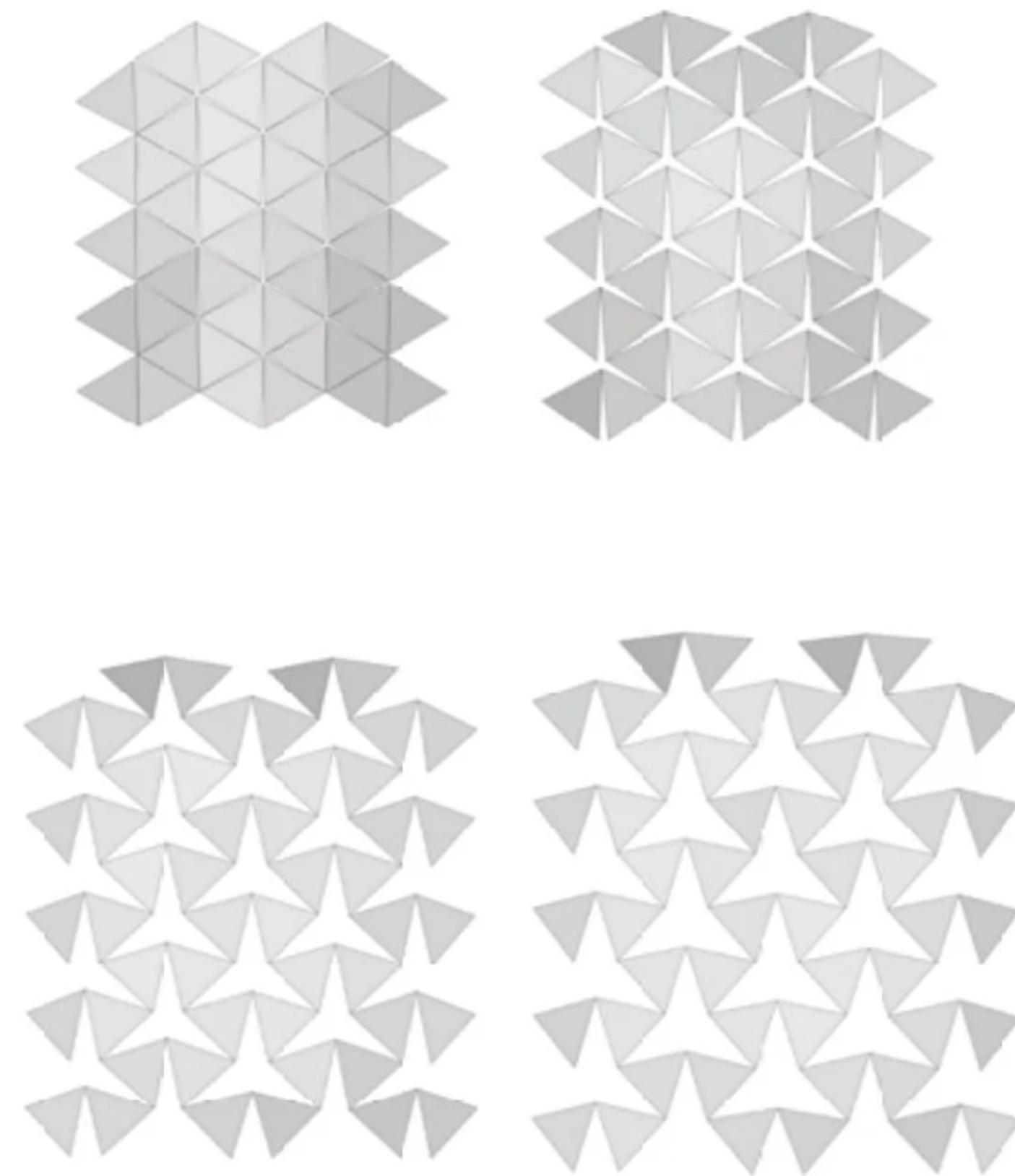


This pavilion represents the exploration of architecture in a manufacturing perspective, exploring materiality and industrial processes. The focus here is on fabrication techniques and intersection of divergent techniques in an architectural element.

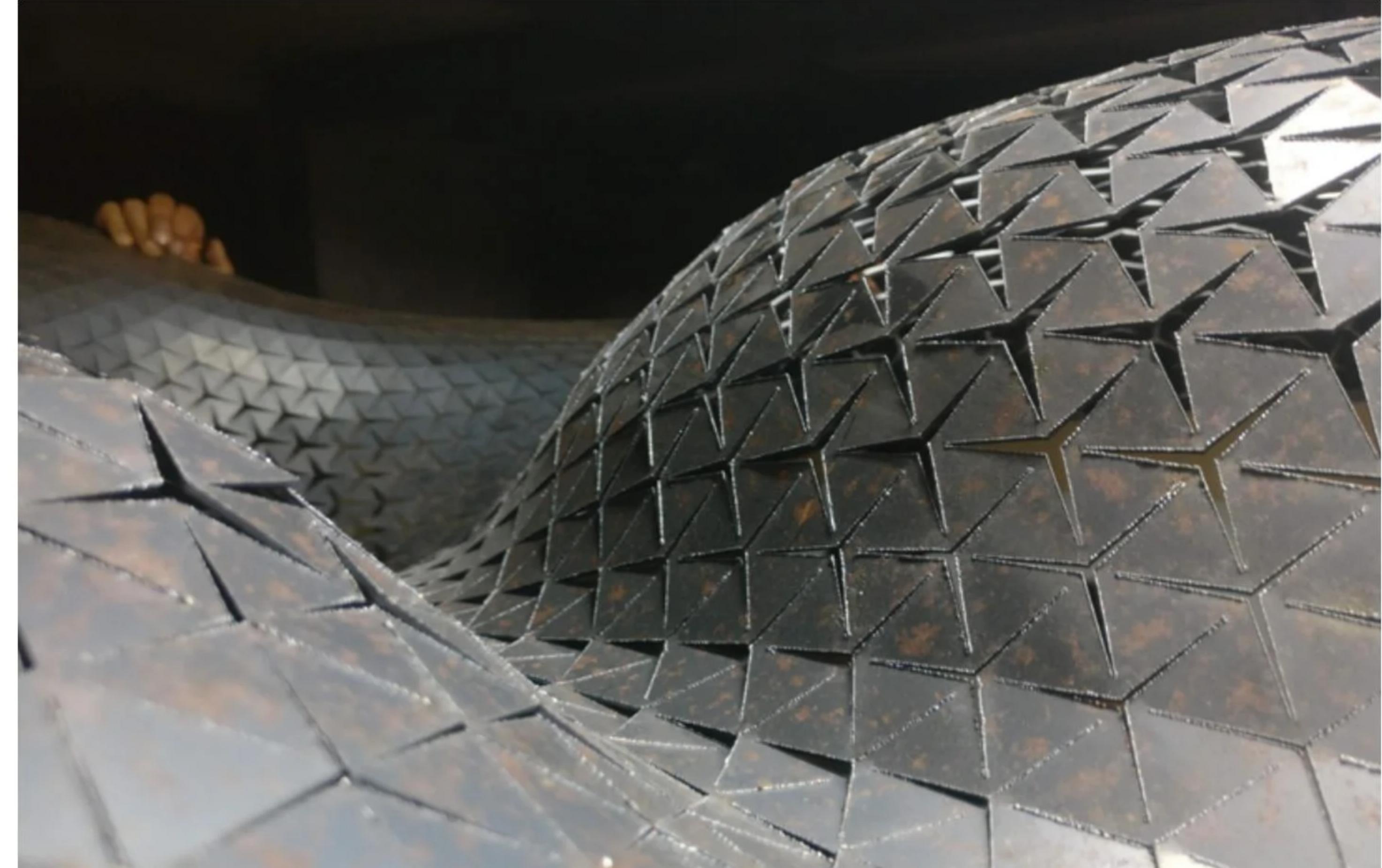
The problem statement incurred was usage of minimal materials to achieve the form using Robotic CNC and hands on fabrication.

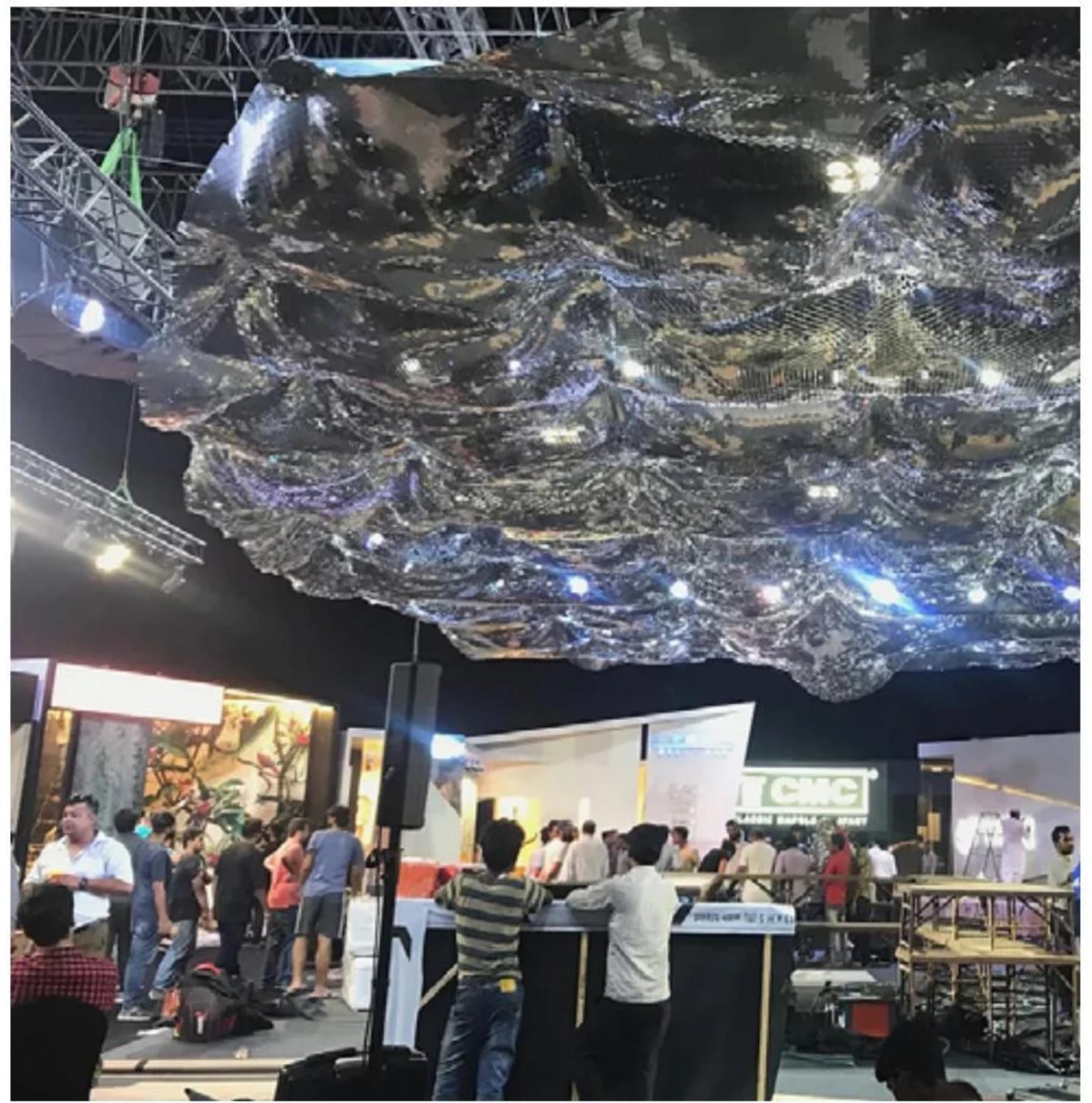
The Principles of modernism have been shifted here utilizing minimal manufacturing, processing raw materials into the finished outputs with minimal wastage.

The Auxetic structure allowed for the determined form to be achieved as the metal behaved as a fabric giving in to the form folded volumes



Auxetic material simulation using Physics simulations,  
Estimating the in-plane expansion of the chosen pattern.

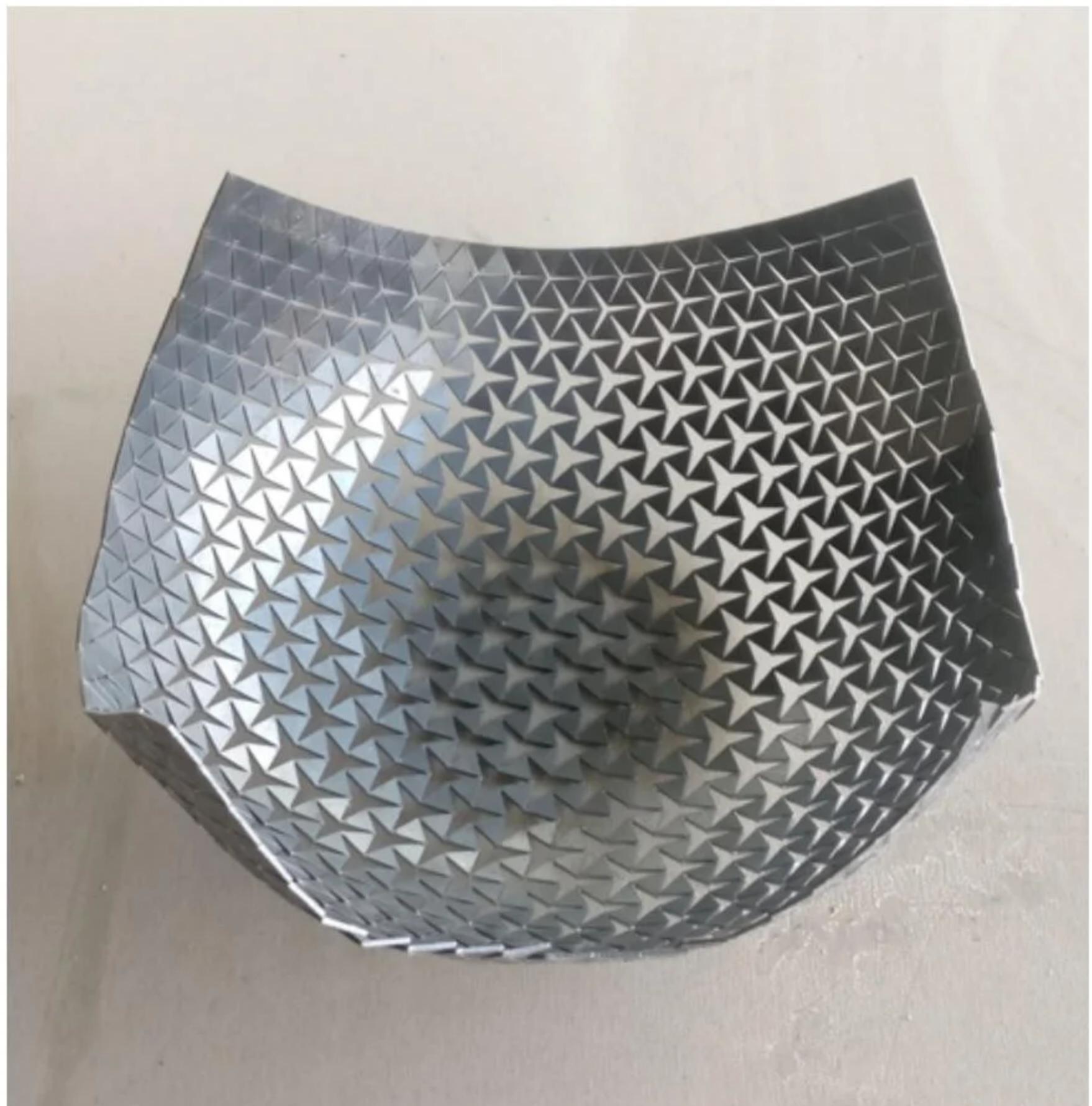
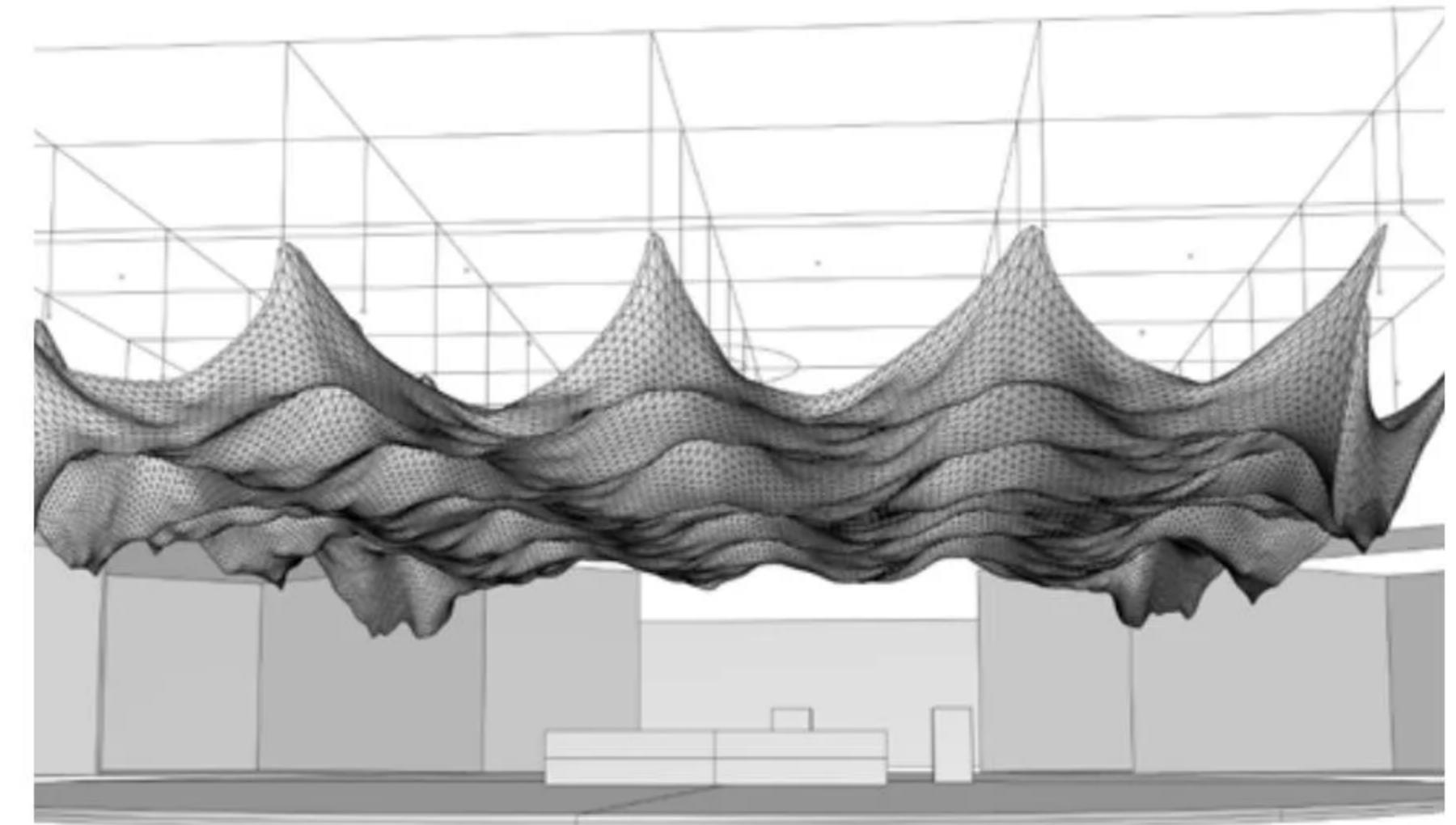




The structure allowed for the determined form to be achieved as the metal behaved as a fabric, with variable rigidity depending on the thickness,- giving form to the folded volumes

Prototyping of intended forms were explored on a programmed cnc router,

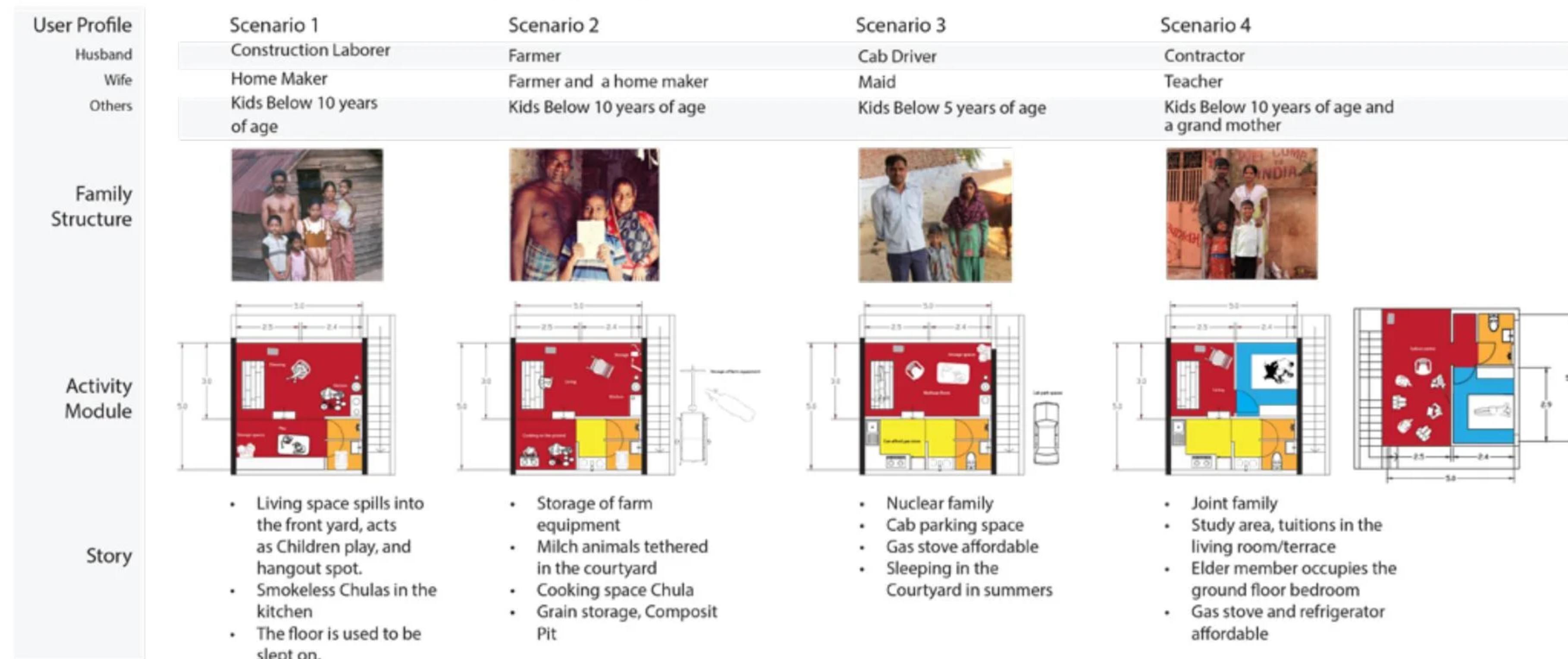
The final pavilion called for an organic structure partly influenced by gravity and by artistic hammering.



# BUILDING FOR A BILLION

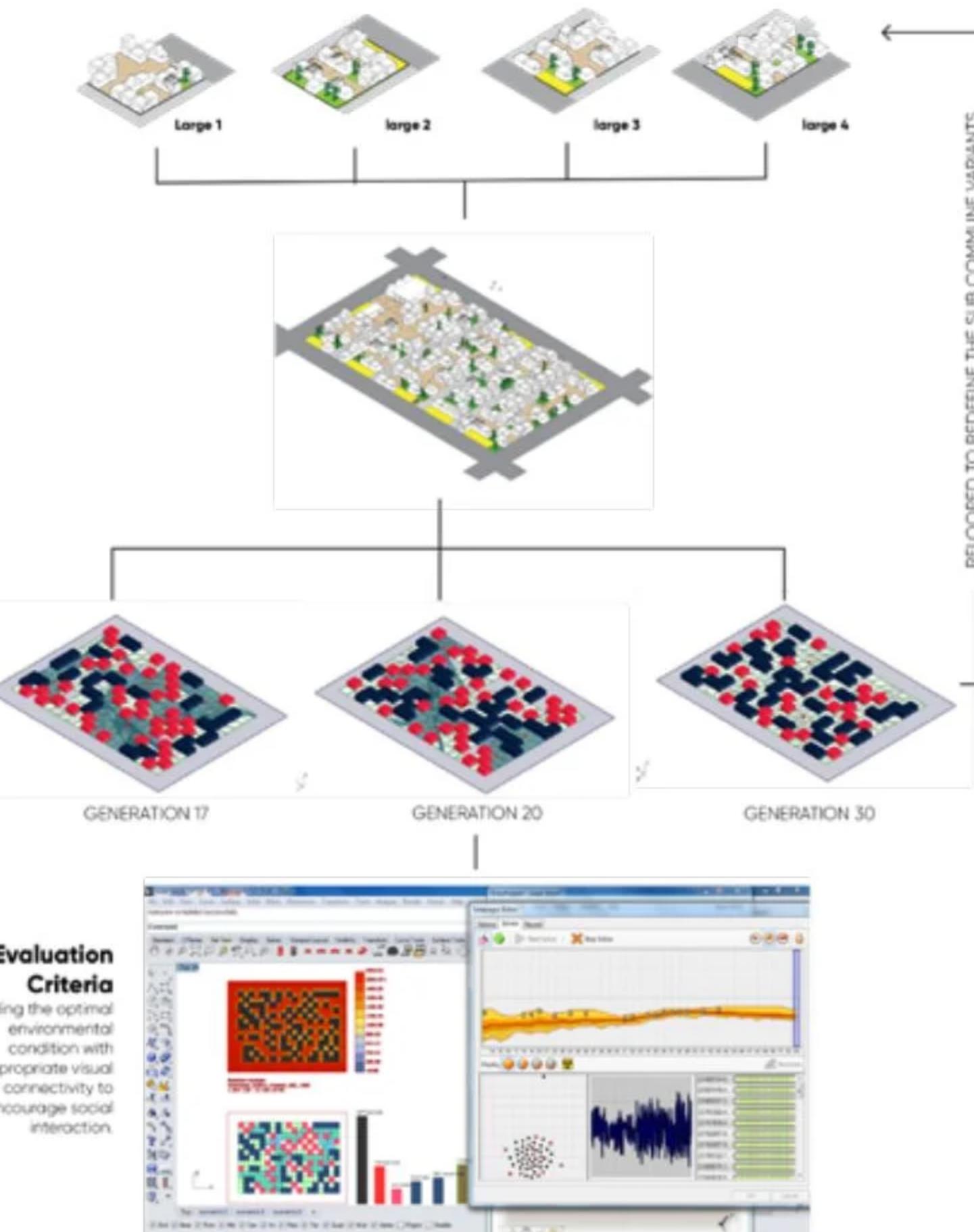
Team(2018)- for Fhd Group ,on computational design ,3d modeling.

Redefining low-cost housing through incremental modules and user defined communes.

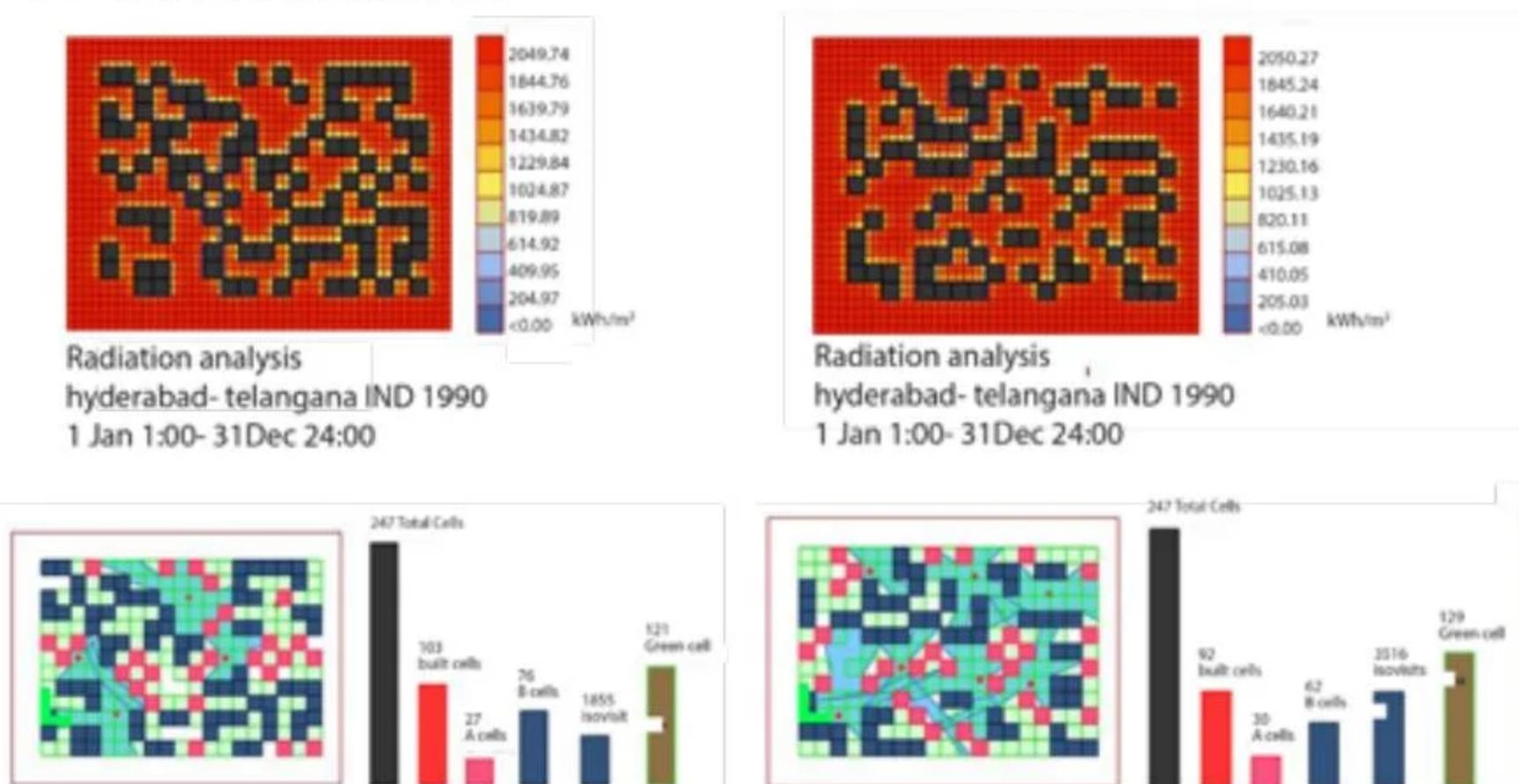


User priorities drive design in a bottom up approach, designed incremental modules for each four typologies have been used to generate communes based on a multi-objective optimization model.

Algorithm Objectives ,Maximizing number of modules , minimizing incident surface radiation,maximizing social space (isovists).



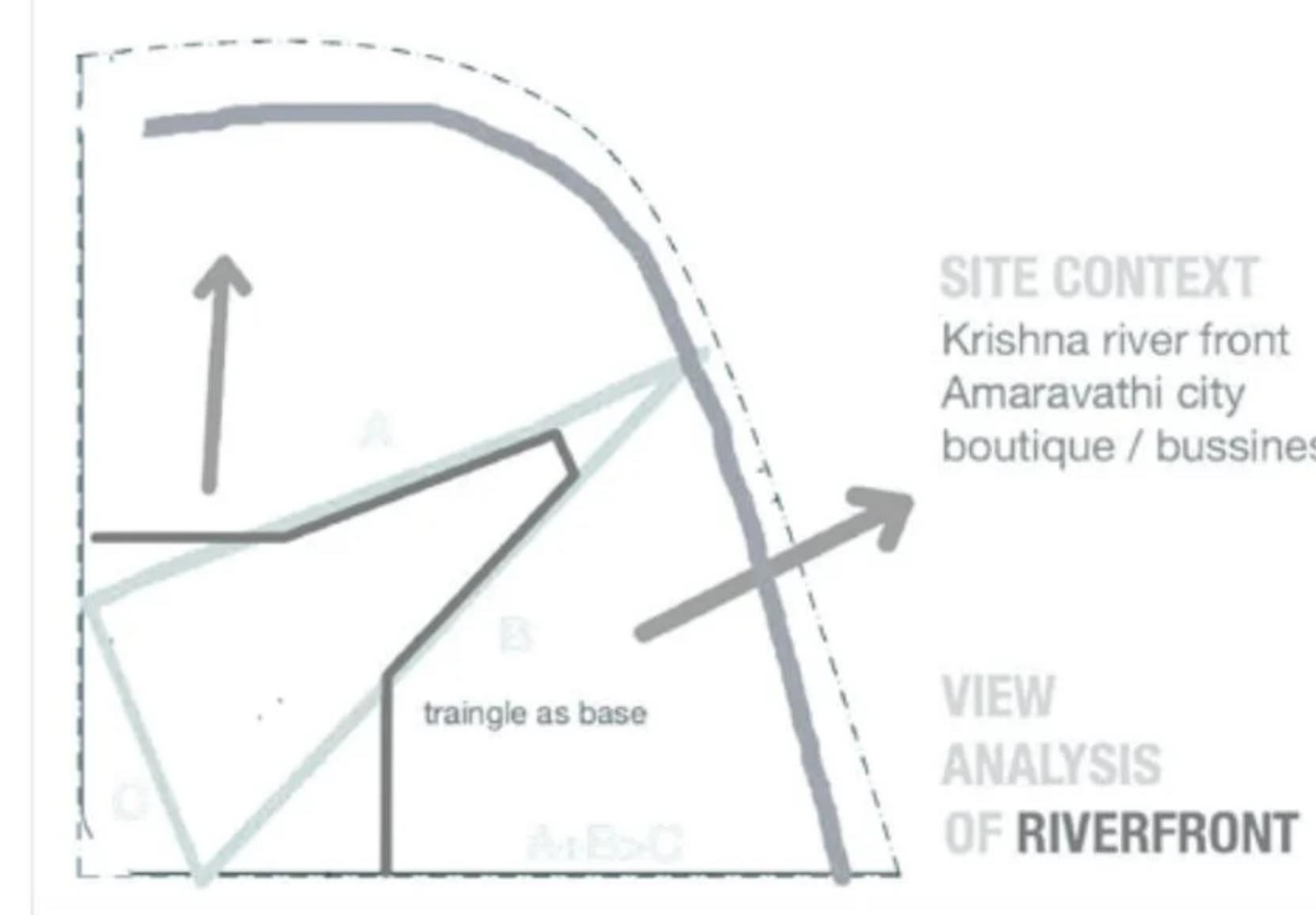
## 3.1 Commune variants



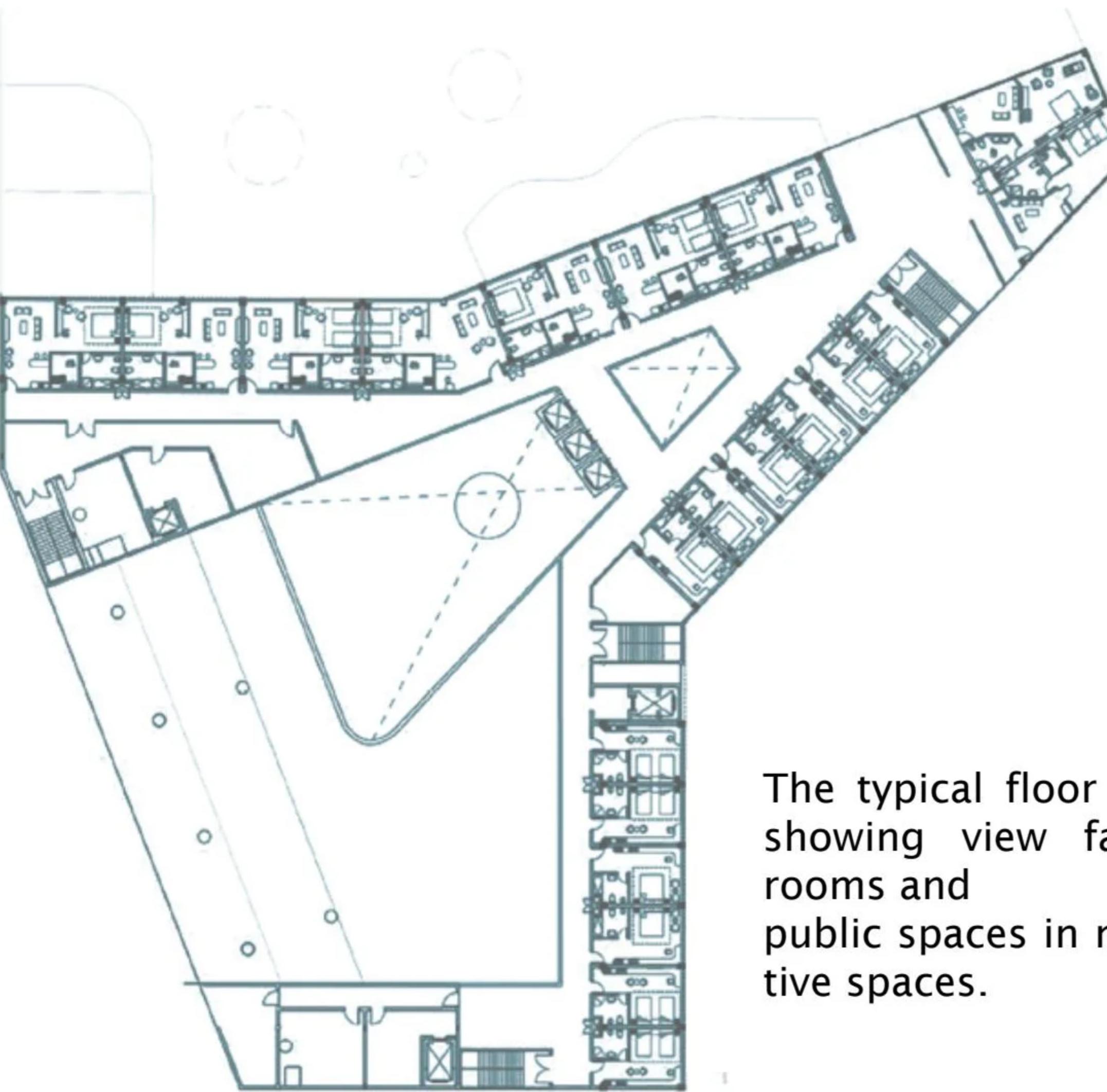
Aggregation of modules into communes that defines the planning of the entire settlement.



# Bhavan - Hotel design

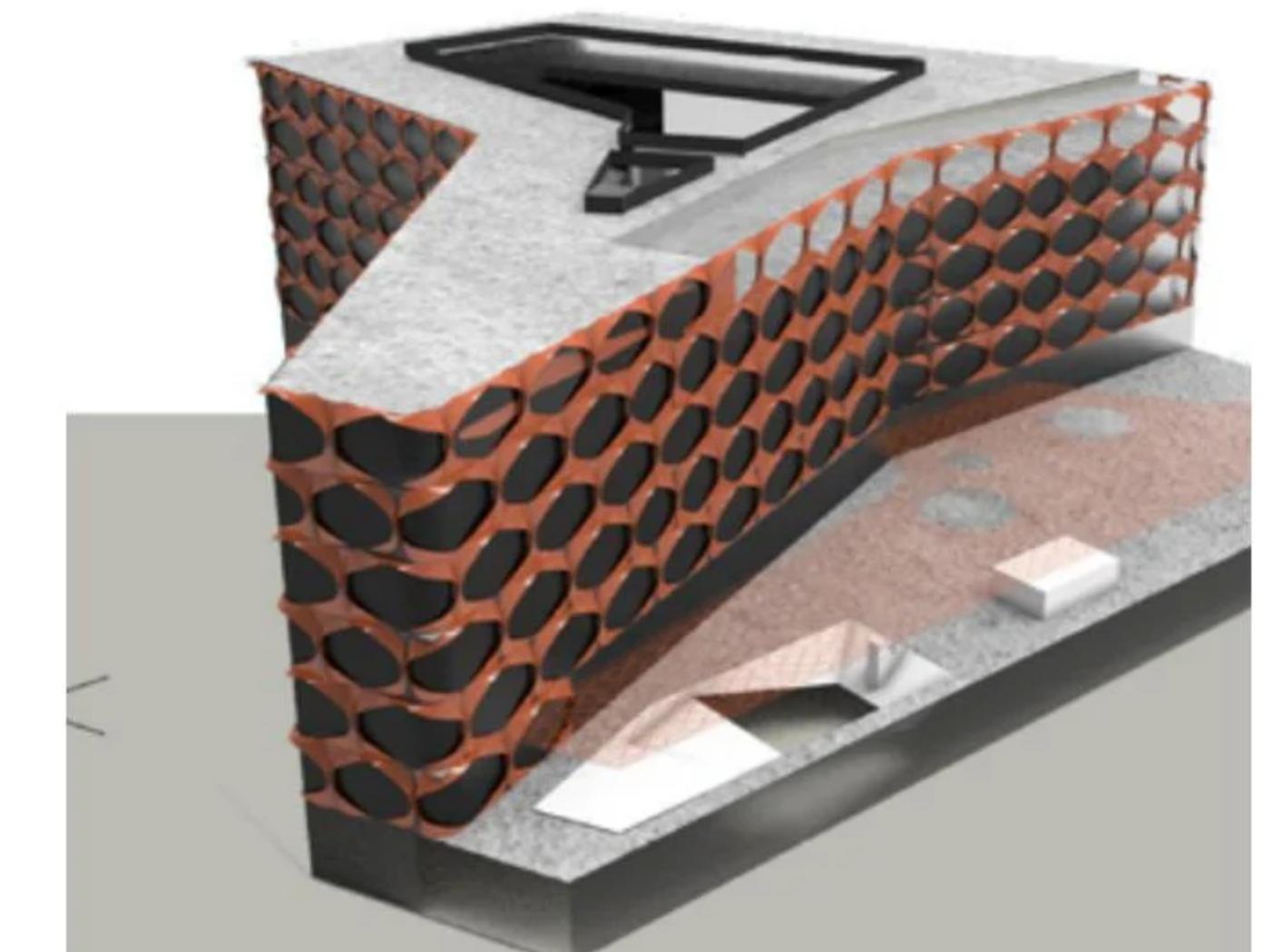
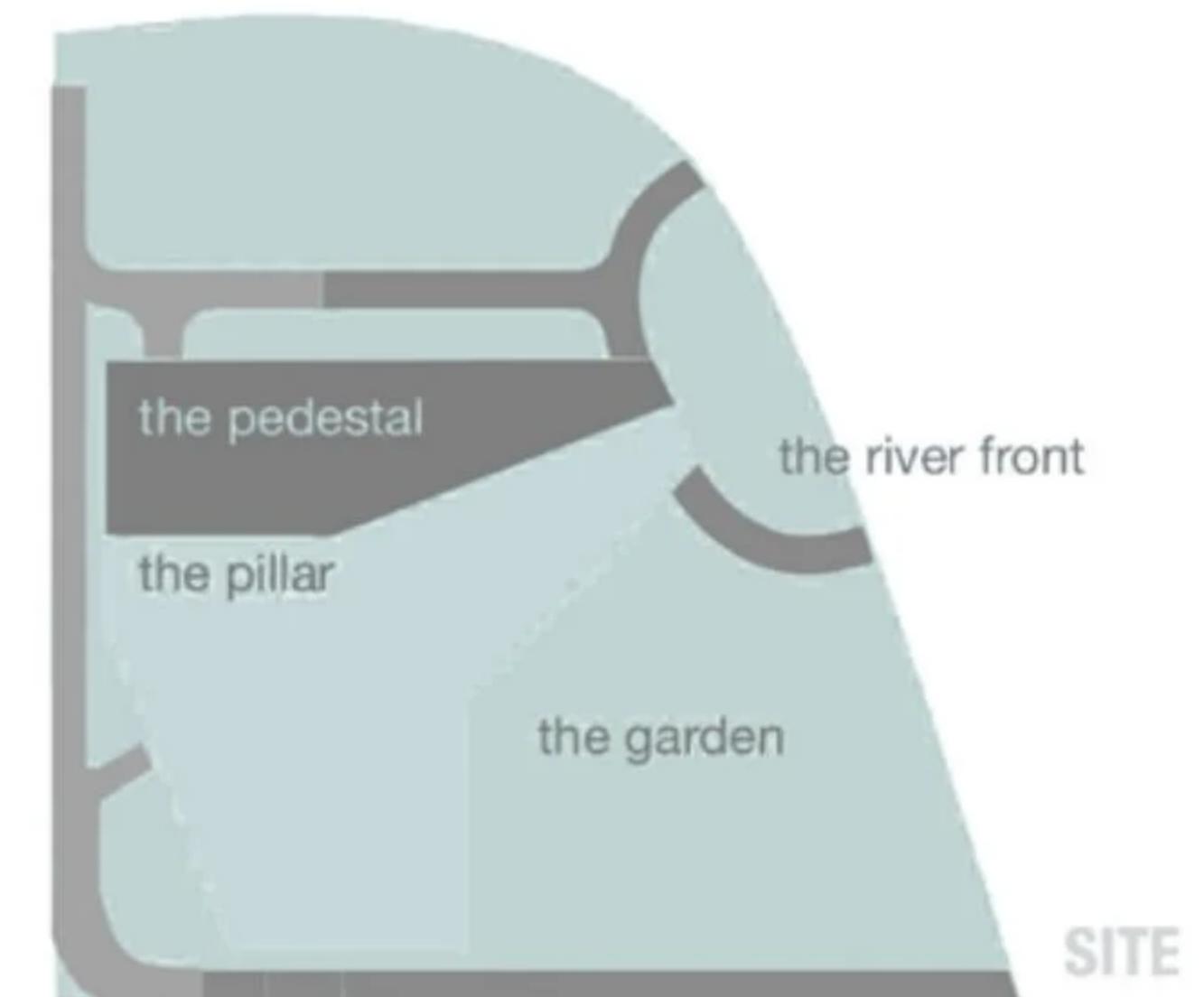


Algorithmic optimization of the length of the facade facing the river front , ensuring that all the rooms offered have a unobstructed view.



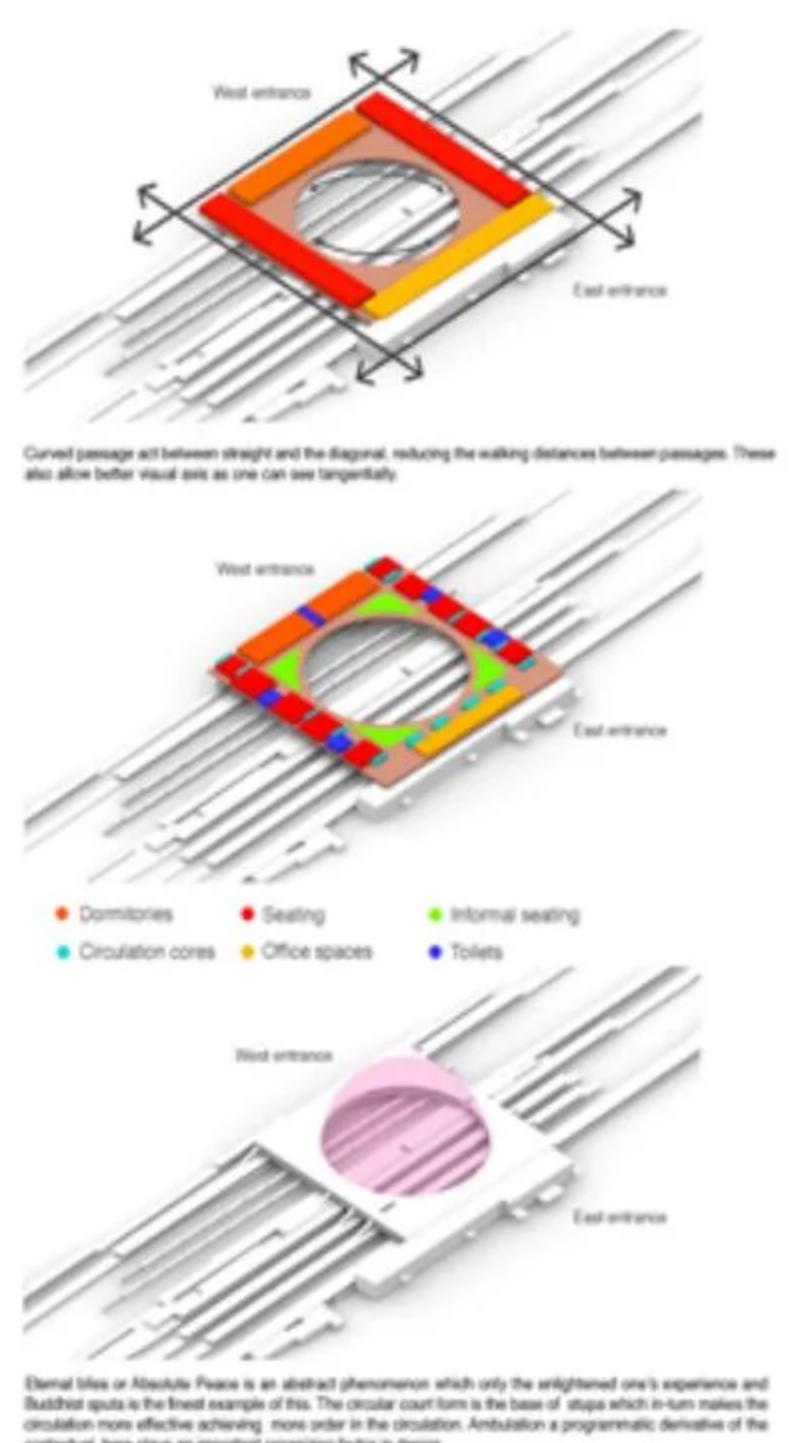
The typical floor plan showing view facing rooms and public spaces in negative spaces.

Semester project 2017, as part of academic exercises, studied and documented and designed a 5-star hotel.



# Urban Rejuvenation- Urban design studio

Semester project 2019, as part of academic team exercises, studied and documented and designed a intervention to the Vijayawada railway sta-

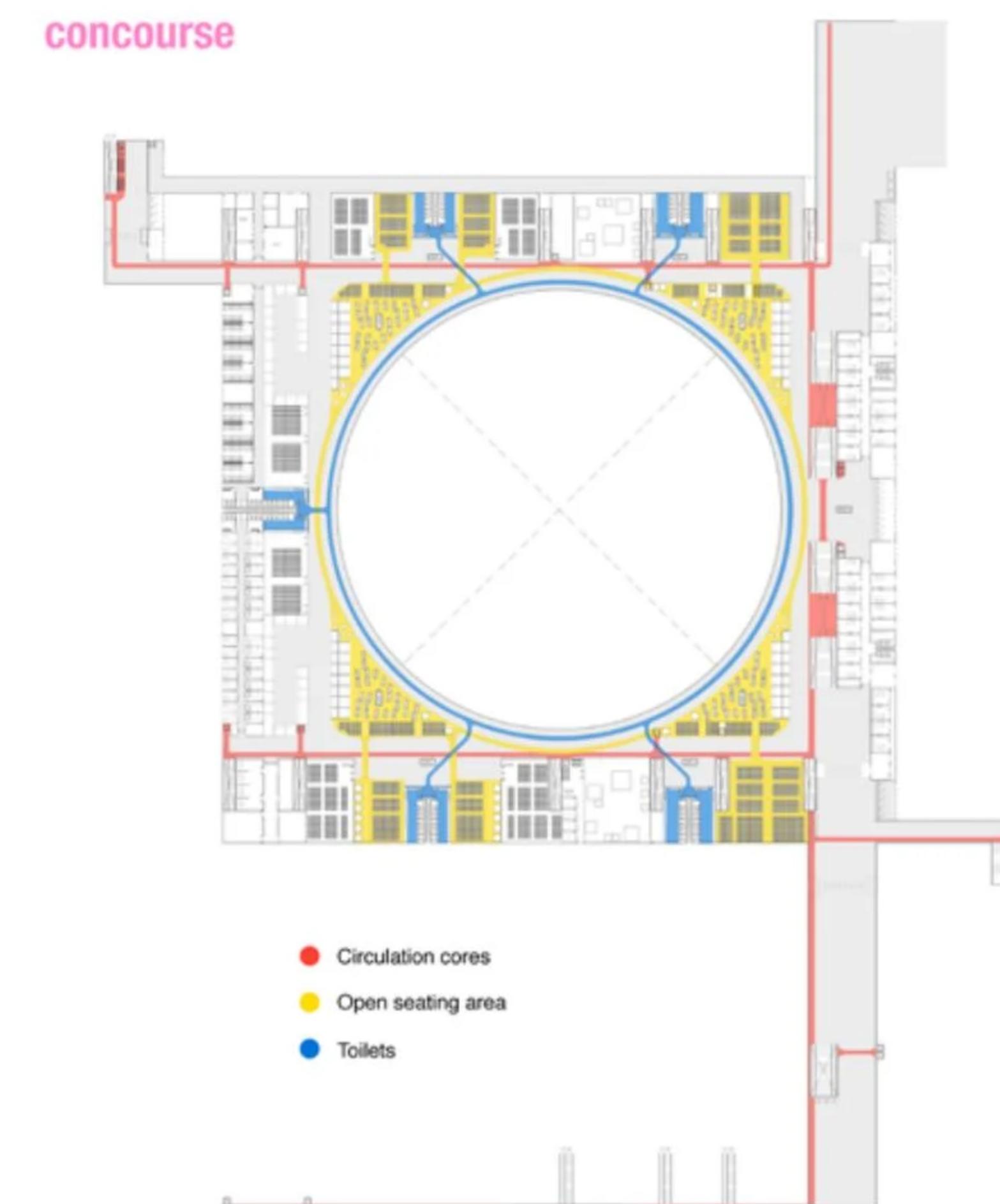
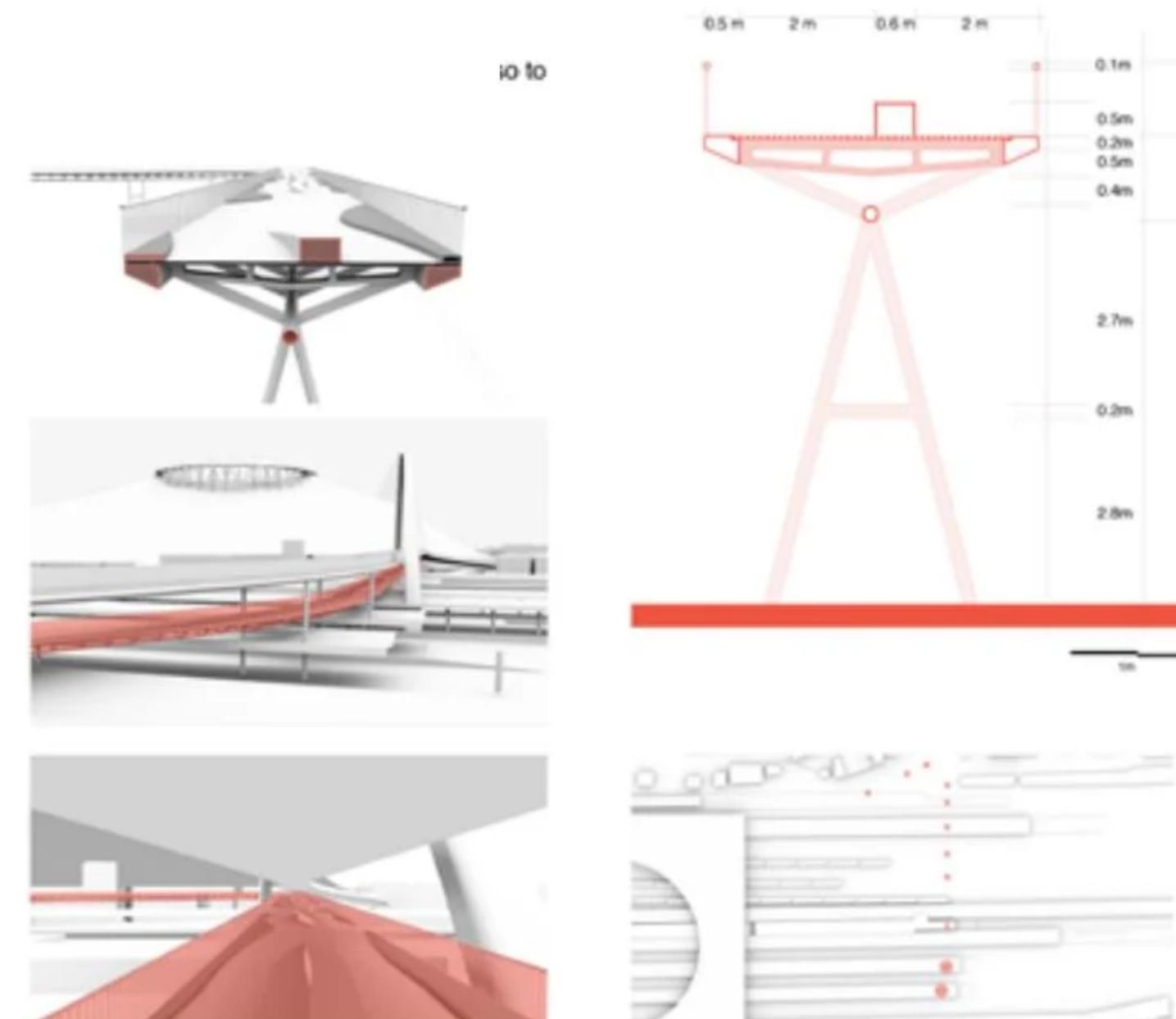


As a major civic, Center , the development of character and a parallel overhead structure along intersecting transit routes were crucial to the organization.

The spatial solution lies primarily in the making of a parallel space devoid of rush on the platforms

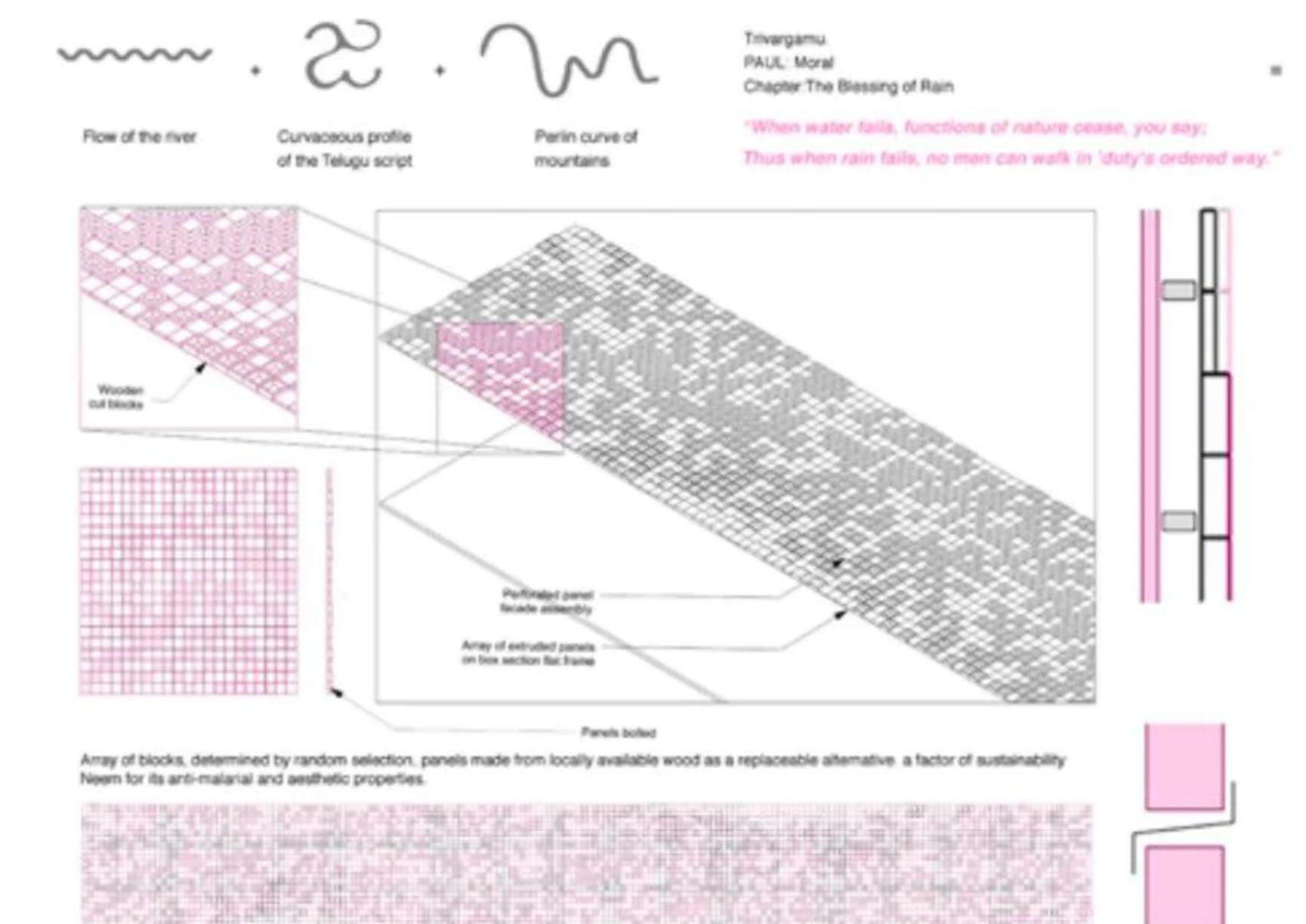


Intervention of public infrastructure, By providing adequate pedestrian spaces and supporting amenities, For a transit center in-situ. Recreation as a necessary intervention in the dense urban Fabric.



## breatable envelope design parameters

The Facade represents the character and the first impression of a built experience, forming a landmark in the image of the city. The resulting dexterity and precision in ornament making a statement of culture informed by climate and availability of local material.



# Mixed use development - Amaravati

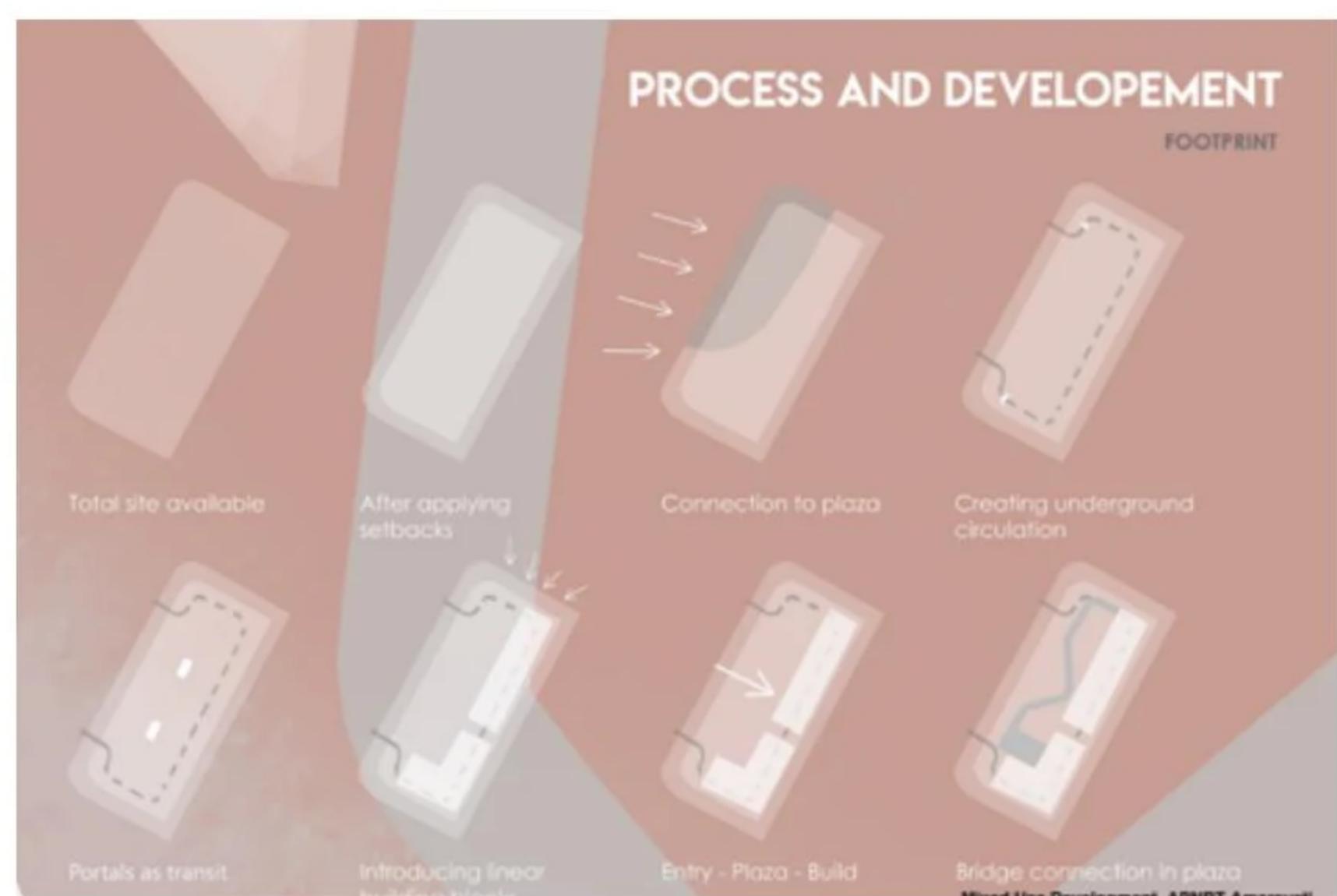
The Street as a urban landscape has been explored within the built structure and the edges of the mixed use itself, as it bleeds into the city streets.

Based on principles from Pattern Language by Christopher Alexander, building heights and Spatial characteristics are explored into the interface between residential ,commercial and recreational spaces, negotiating with building by-laws.



The site was developed in accordance with constraints of the neighborhood and the program.

The mixed use typology resolves the residential street, the street side shopping centers, malls and workspaces in a single typology of built environment.

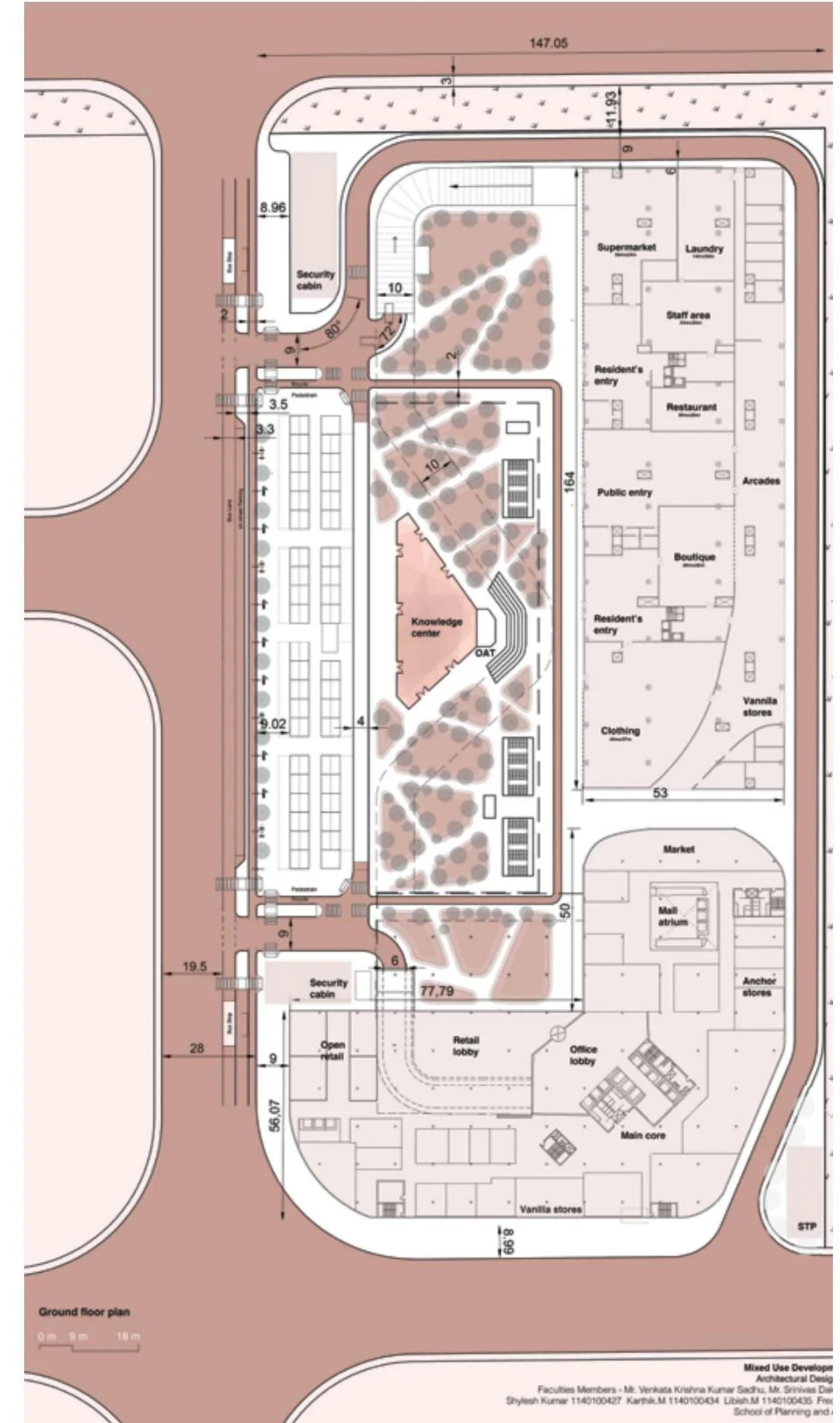


The residential street

Semester project 2018, as part of academic project, developed a mixed use development in the new city of amaravathi.

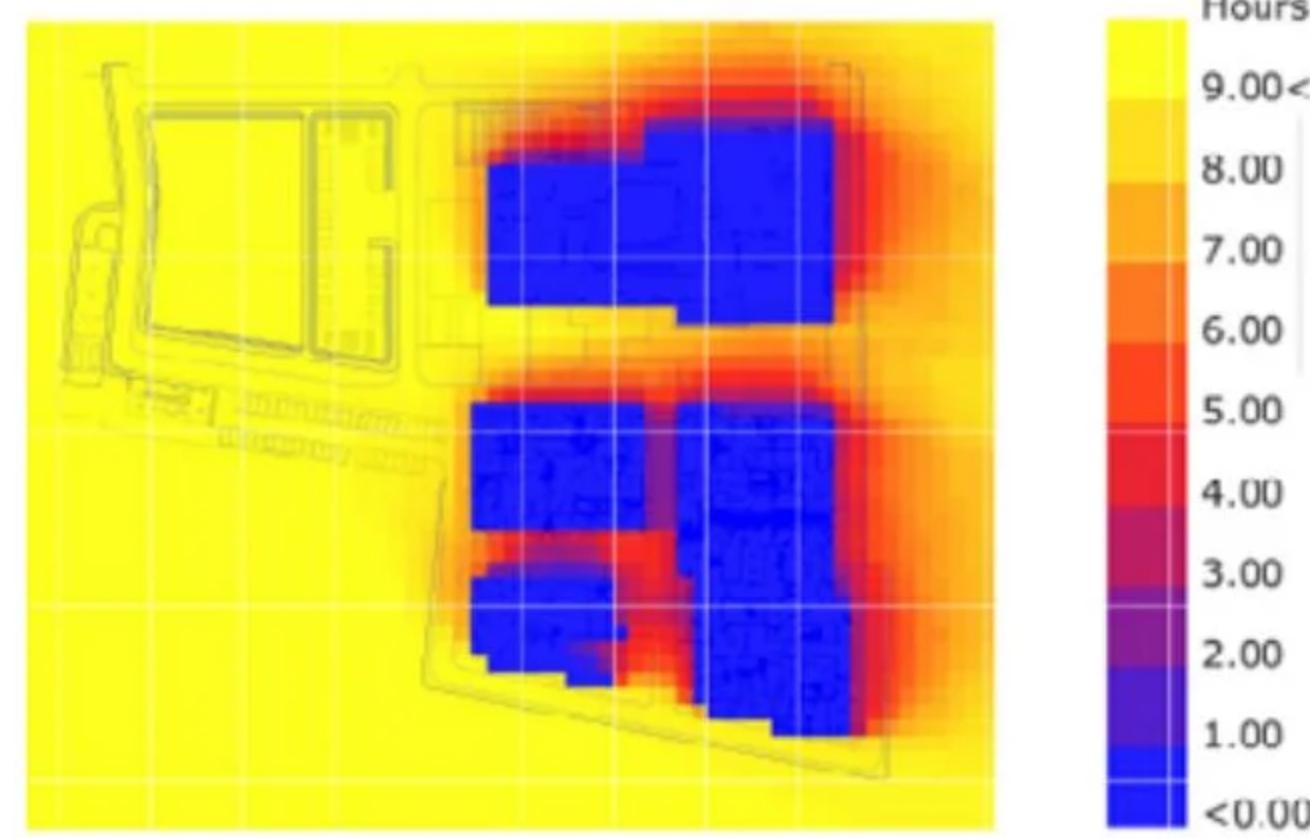
## CONCEPTUALIZATION

- HIGHER DENSITY**  
Opportunities for increased residential densities
- NEARBY AMENITIES**  
Reduced distances between residential and commercial uses
- PEDESTRIAN FRIENDLY**  
Supporting pedestrian and bicycle-friendly
- SOCIALISING**  
Away from sophisticated jail
- ACTIVE DESIGN**  
Inducing people to have a better healthy life

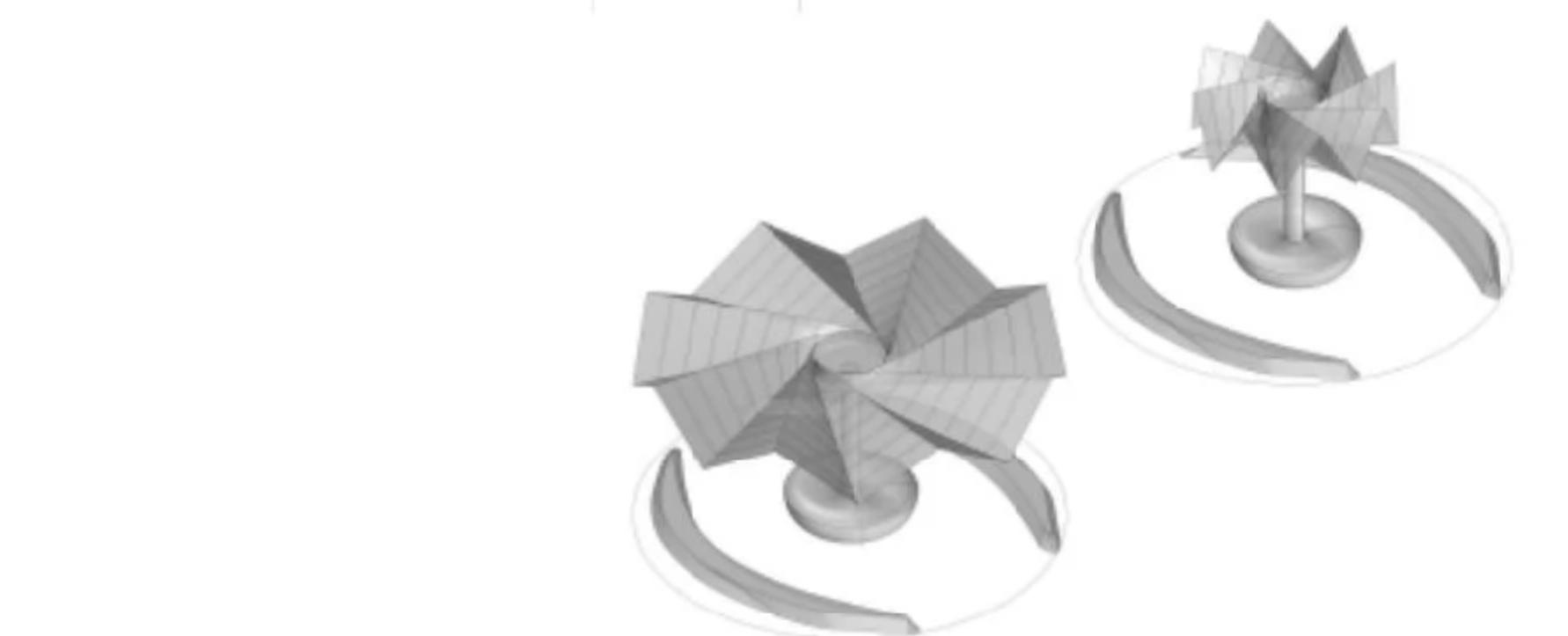
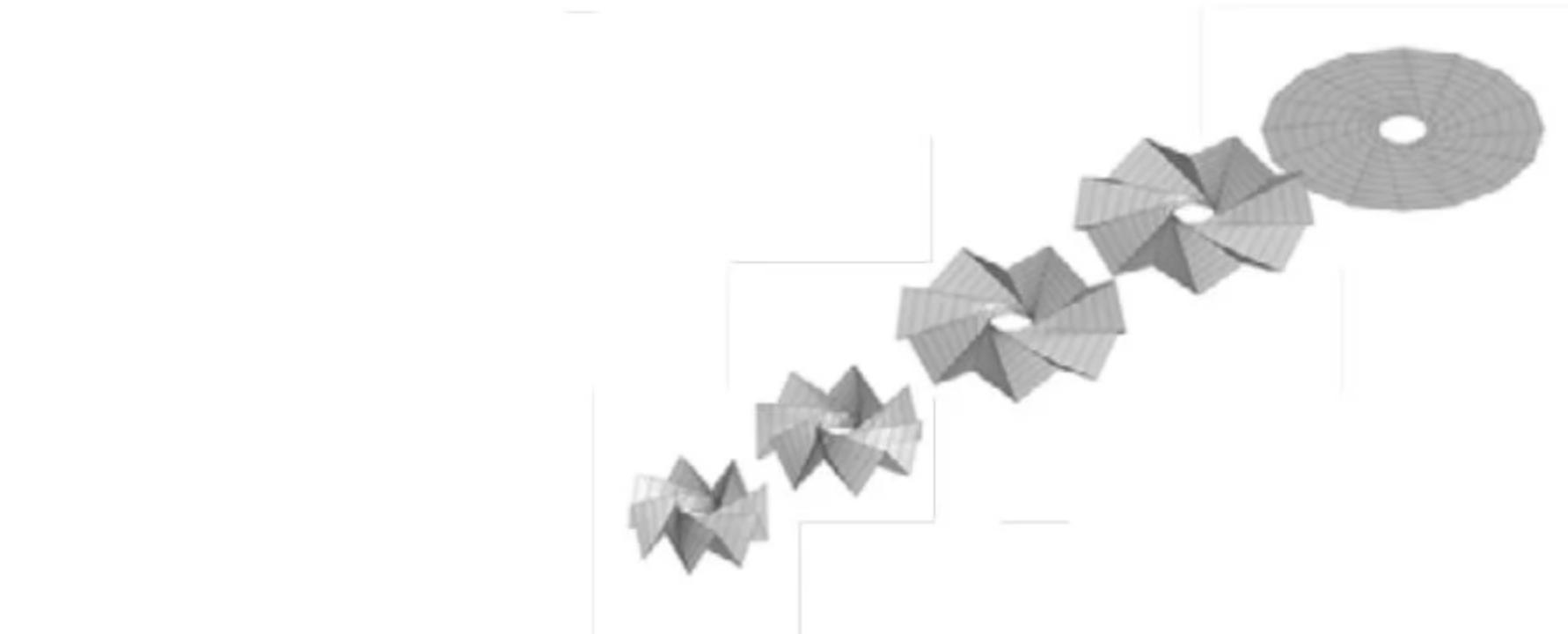
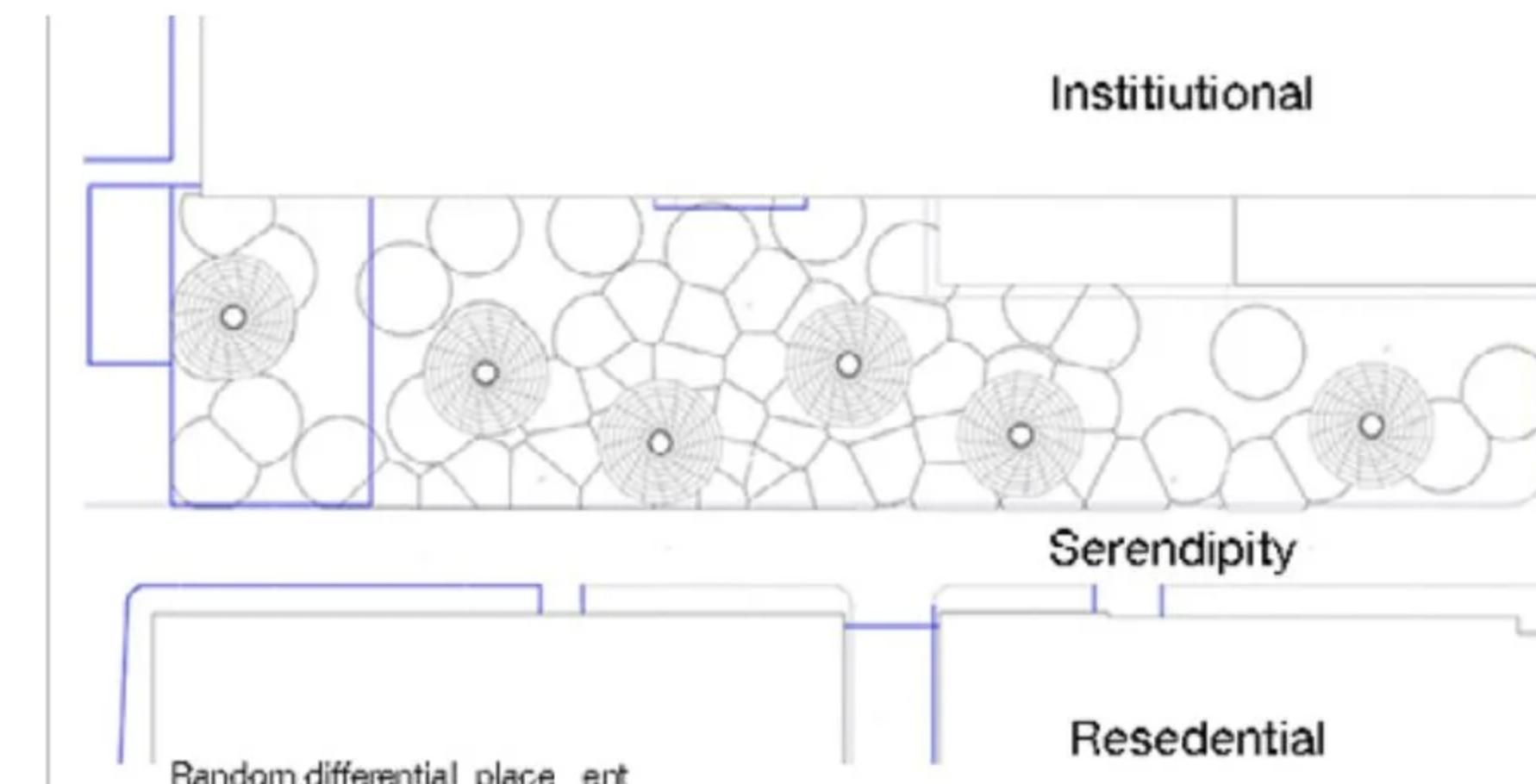
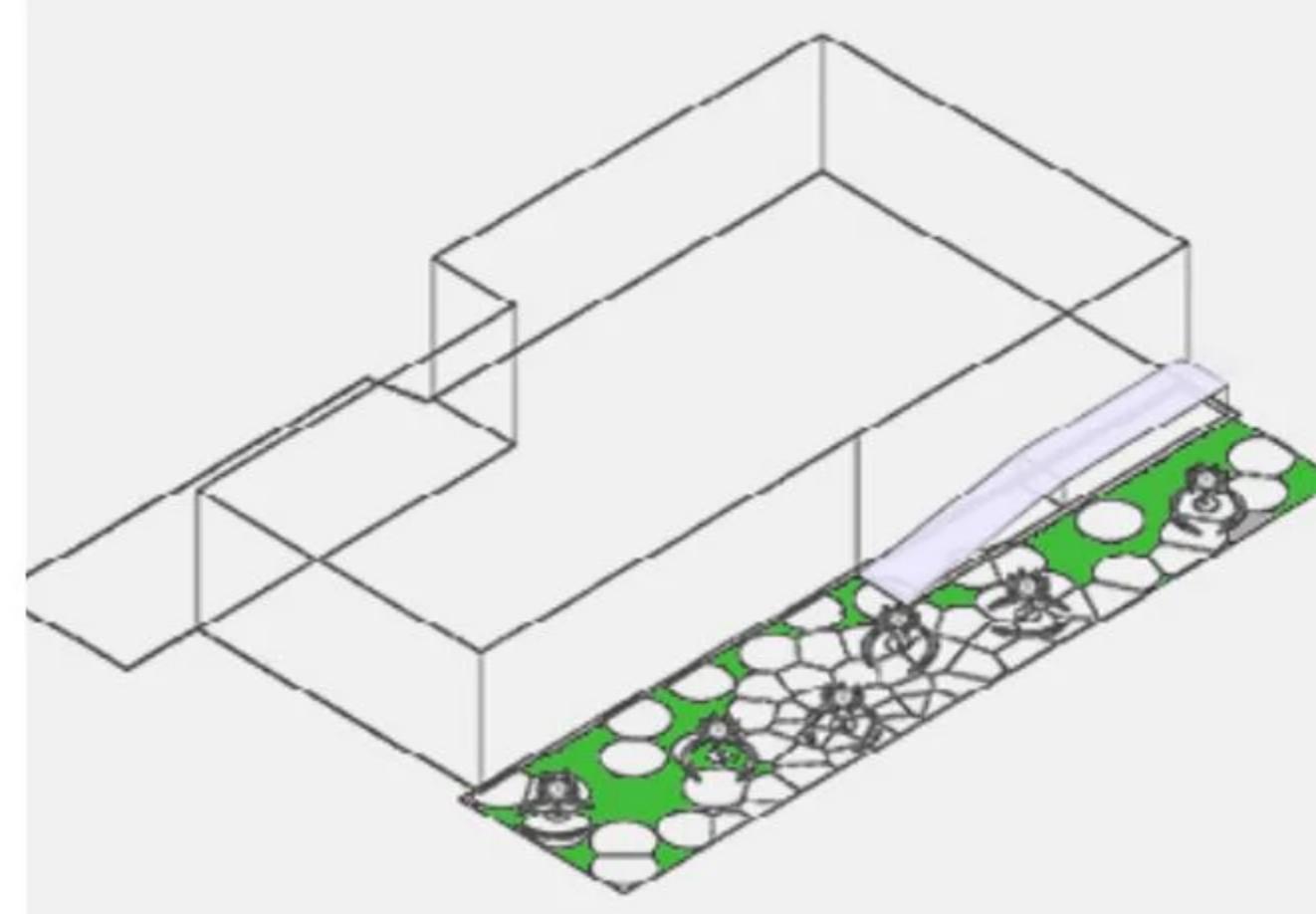
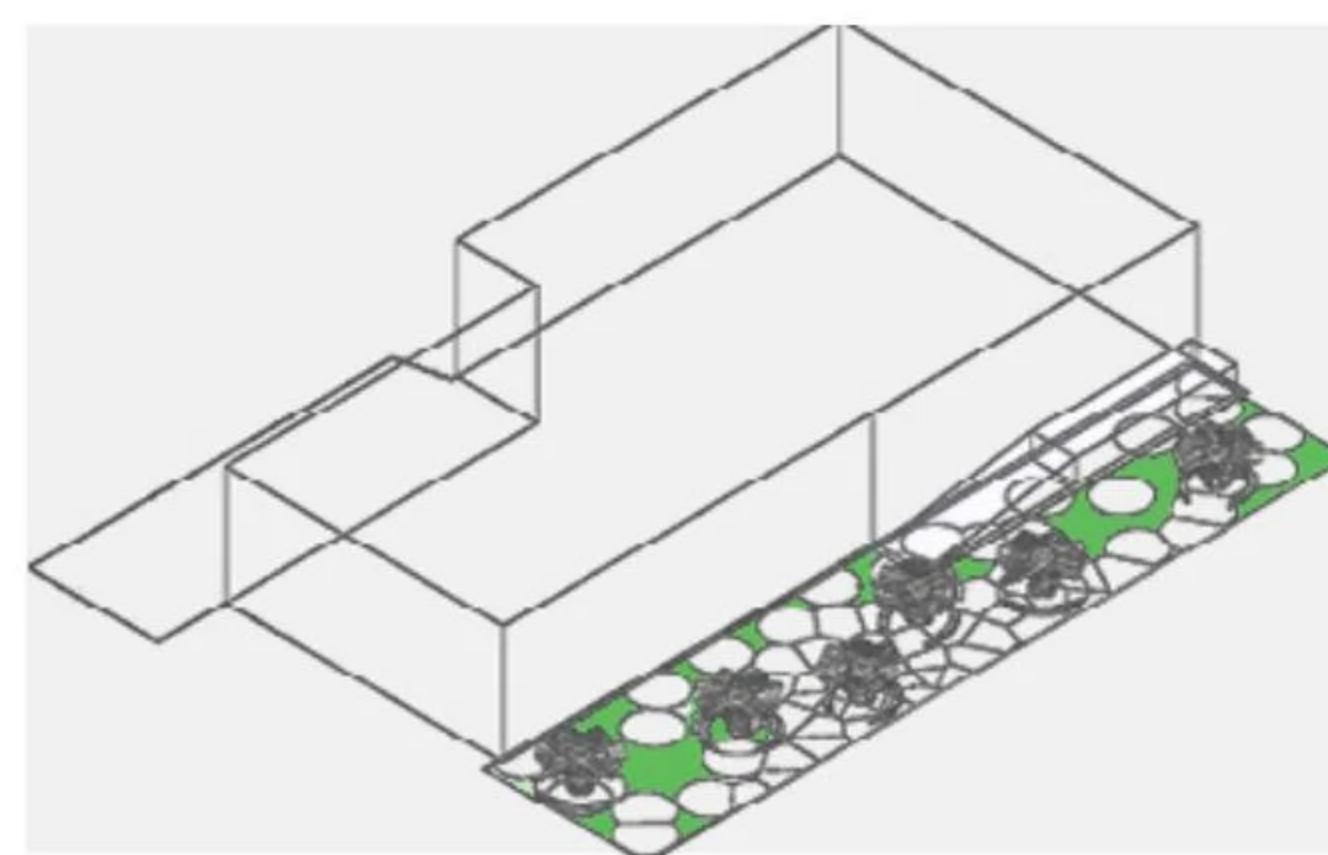


# Chatras - Landscape Design-

Semester project 2018, as part of academic exercises.



Annual daylight analysis indicated a need for shading between the residential and institutional blocks of the campus

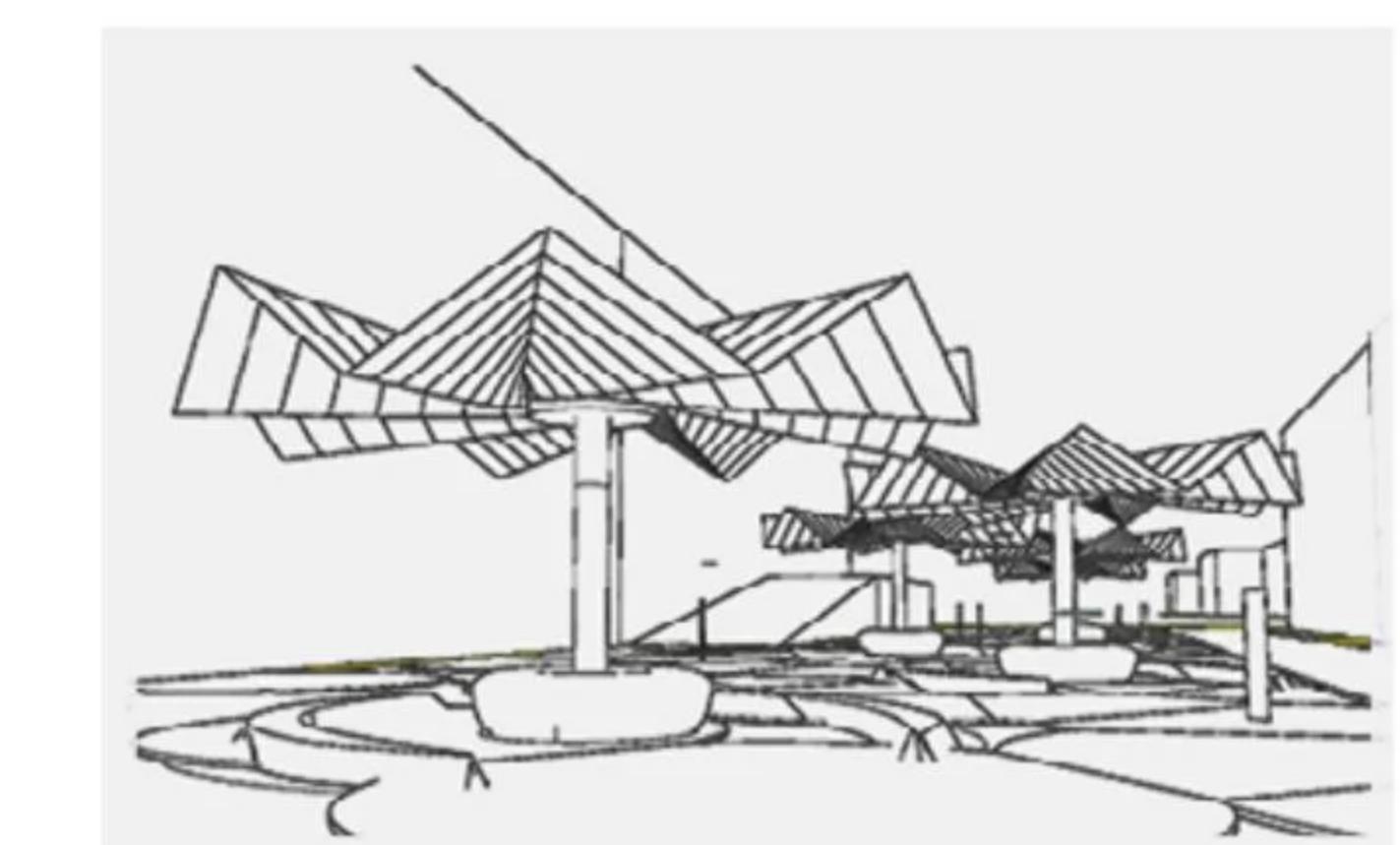
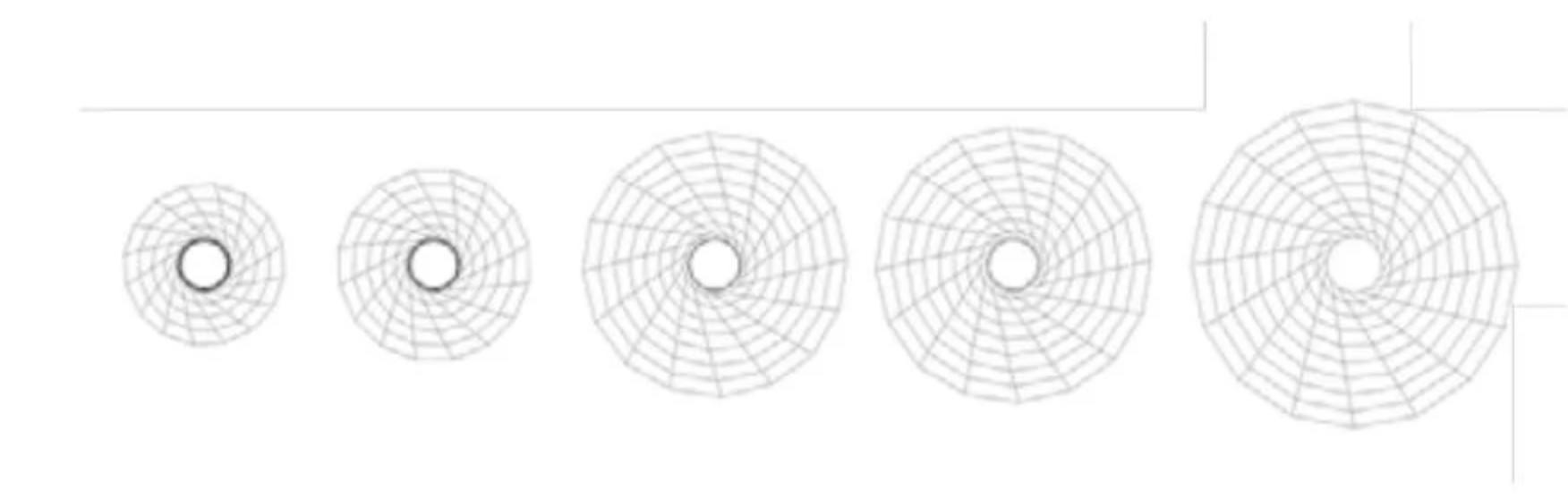


On exploration of shading devices ,deployable origami structures employed by the solar sails in satellites were an inspiration.

A Physics simulation was employed in the design of the folded plate structure with radial piston actuators.

The responsive design, allows for retraction and expansion of the shades in accordance with varying light intensities during the day.

Providing a natural enhancement in social character of the space in the hot summer afternoons and the evenings

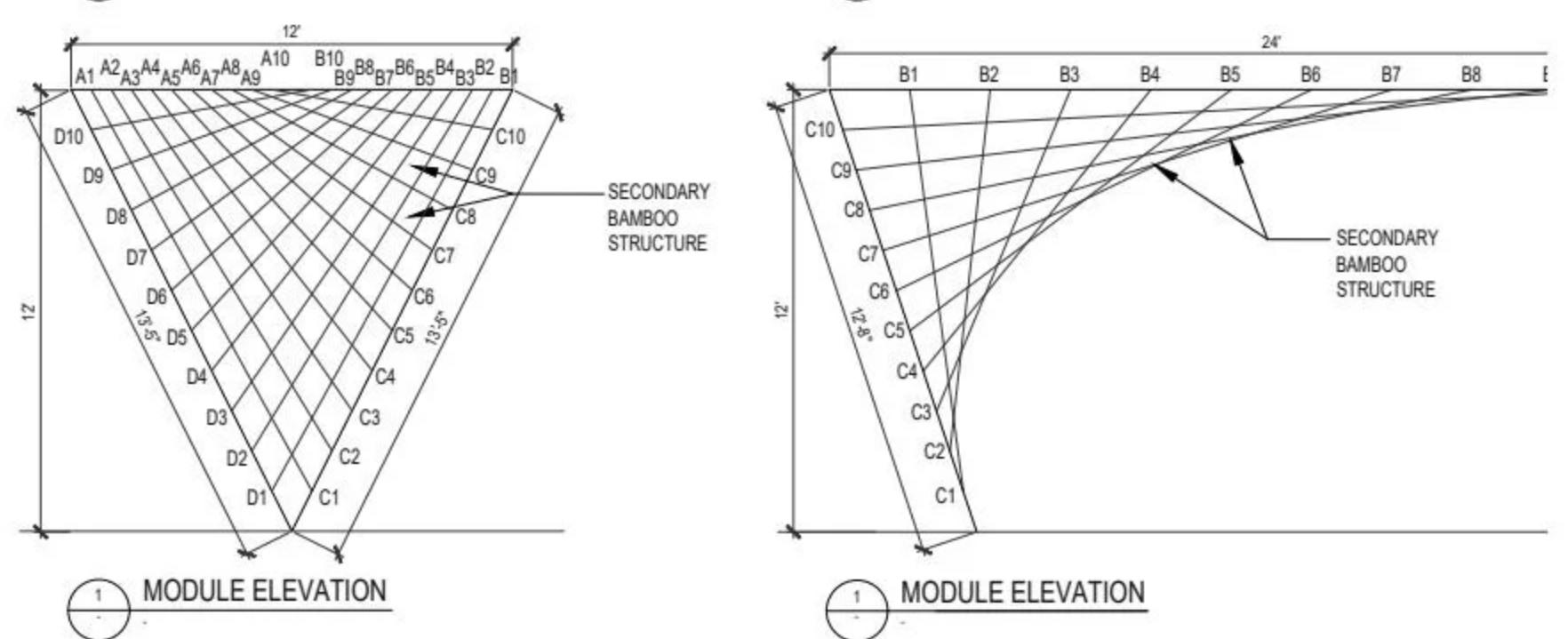
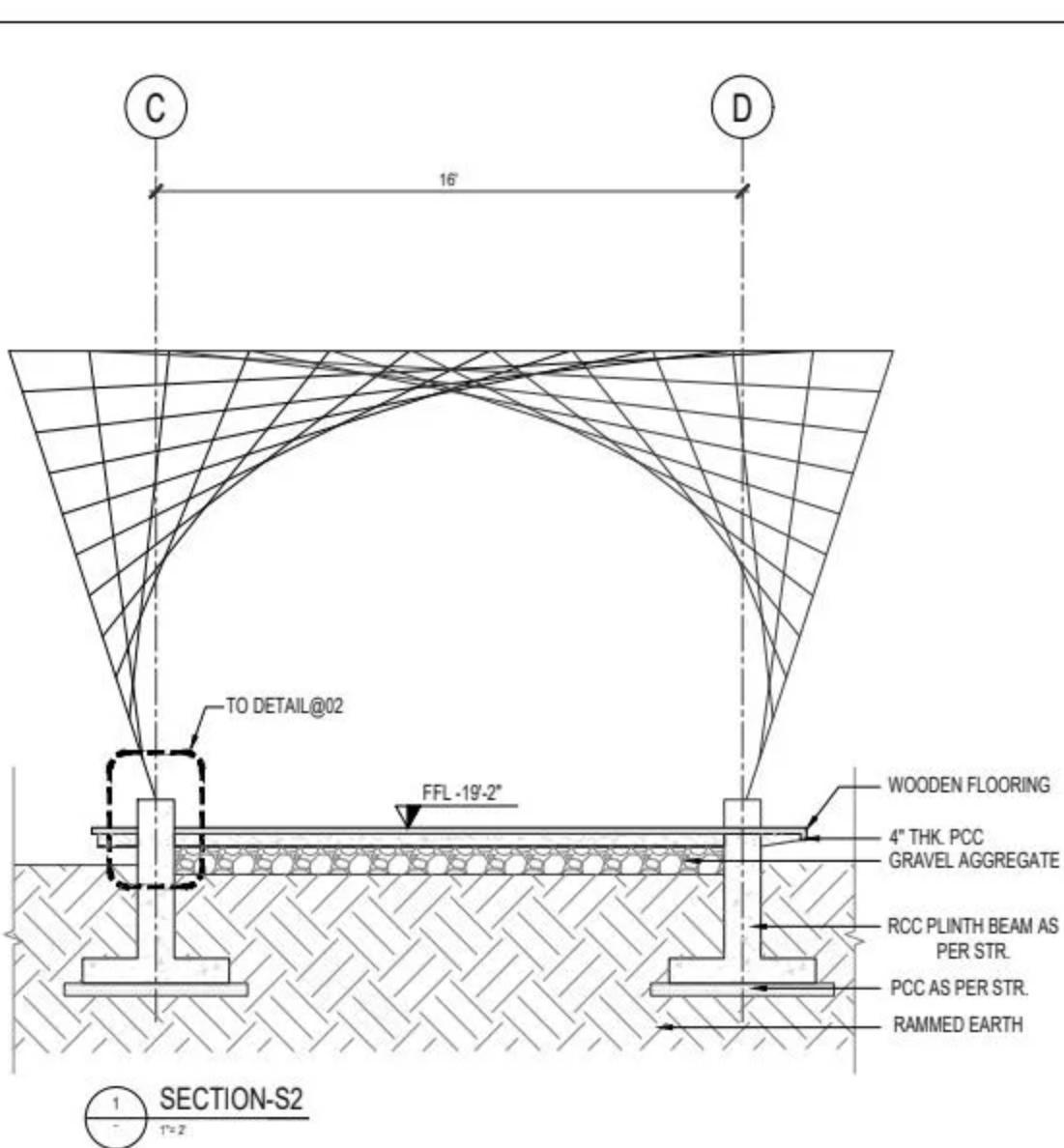
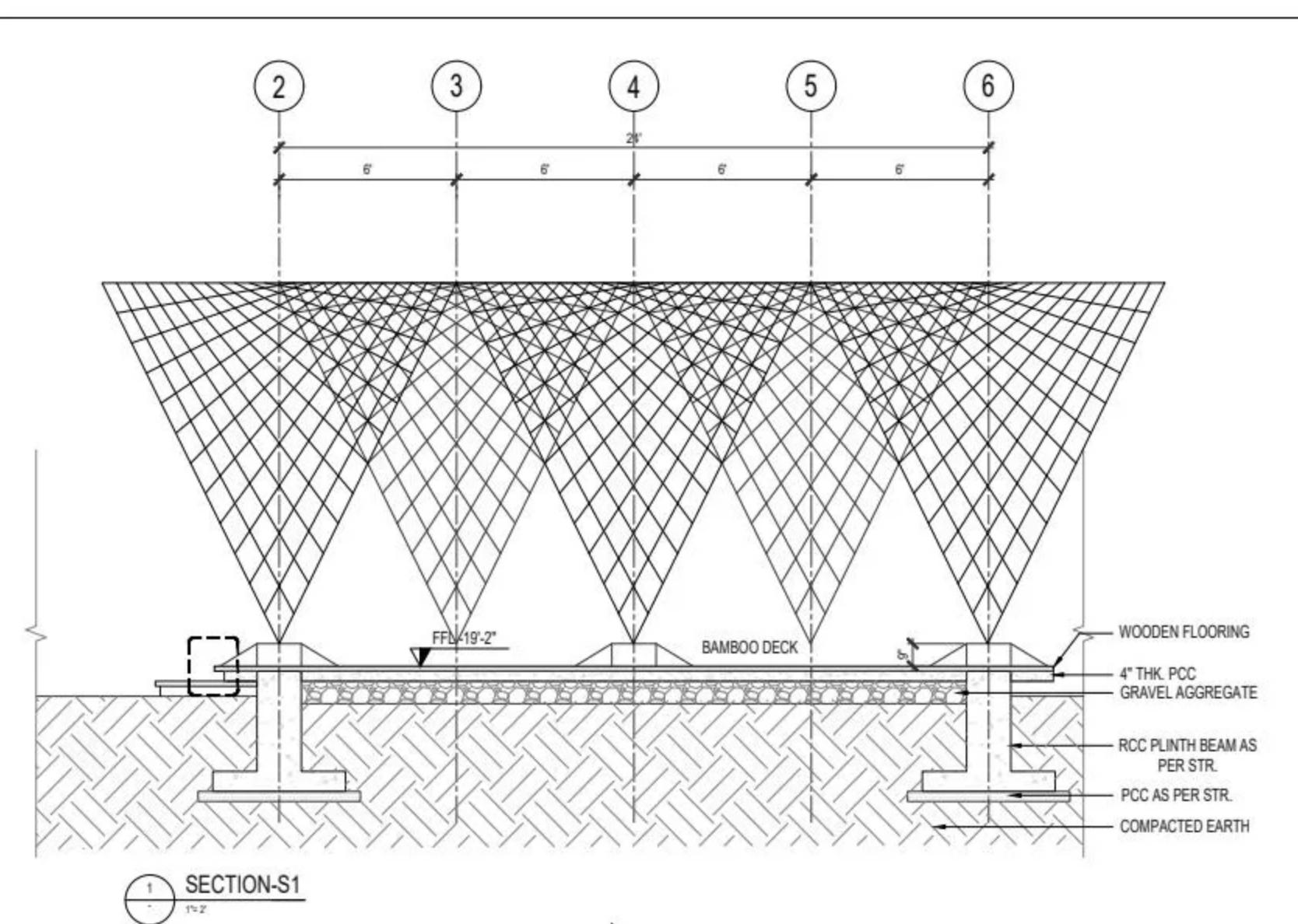


# Bamboo Pavilion

For FHD group (2019)

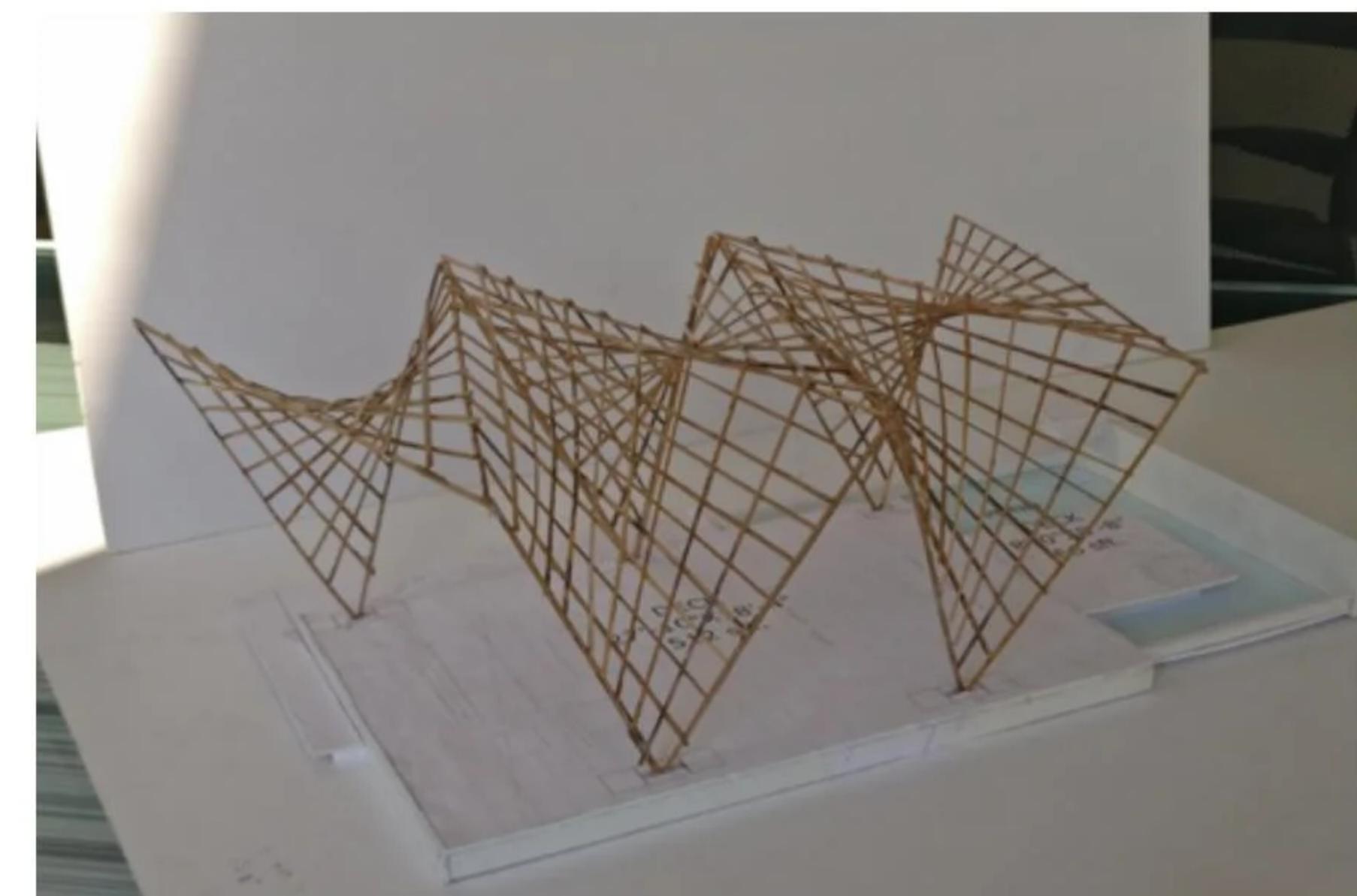
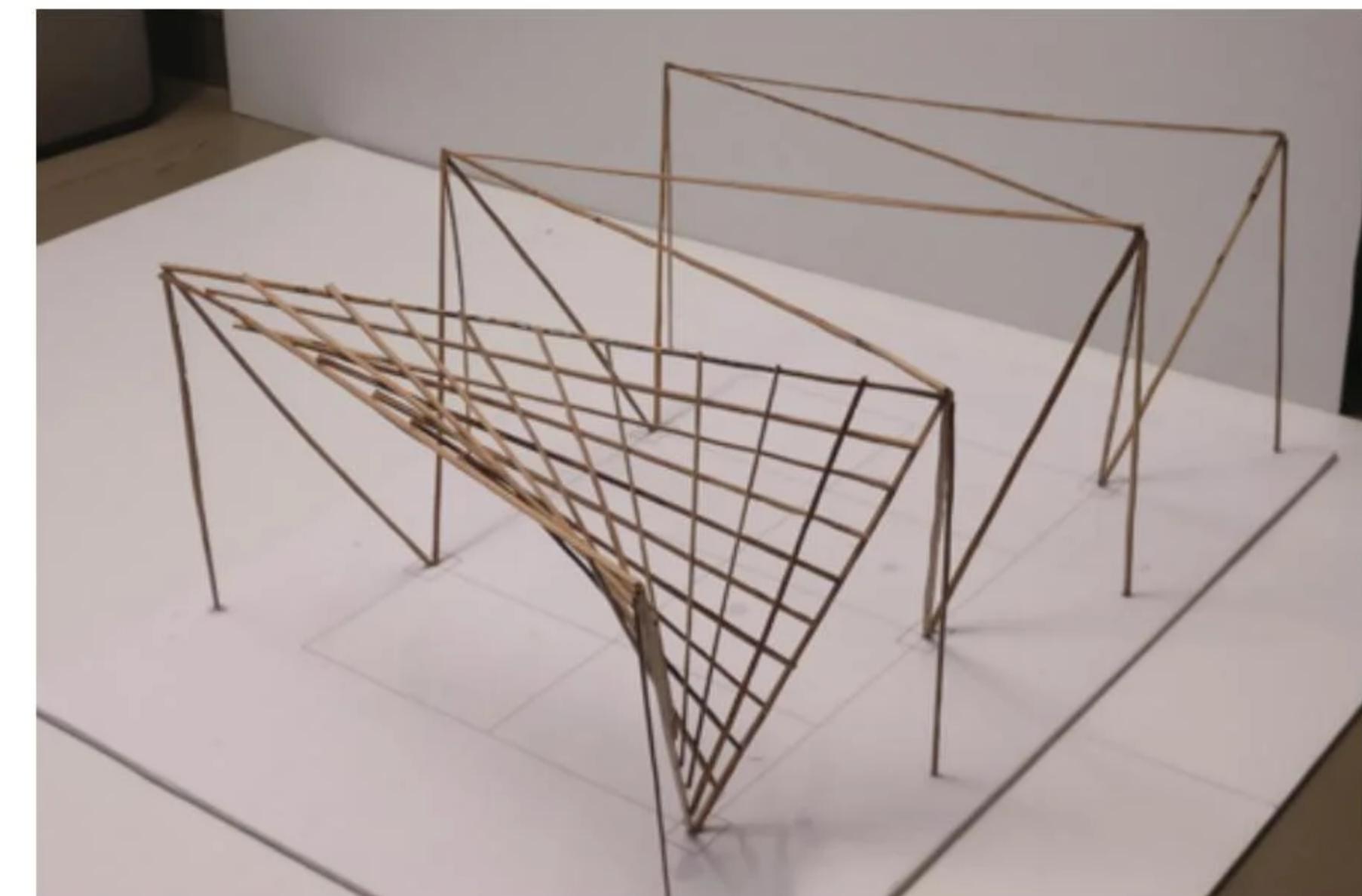
The Bamboo shelter was developed after prototyping several anti-clastic and syn-clastic structures and forms, which lead us to the desired geometry ,desirable for manufacturing.

Shading in the outdoor pool deck is crucial while also allowing ventilation through the tatch of the shelter, The porosity of the tactt allows for a cool shade with the warm and dry climate of Hyderabad , India.



Joints and markings were optimised for rope-knots and a traditional labour workforce. Interfacing with non-conventional joint systems and non-dimensional material called for a flexible design with affordable tolerances,

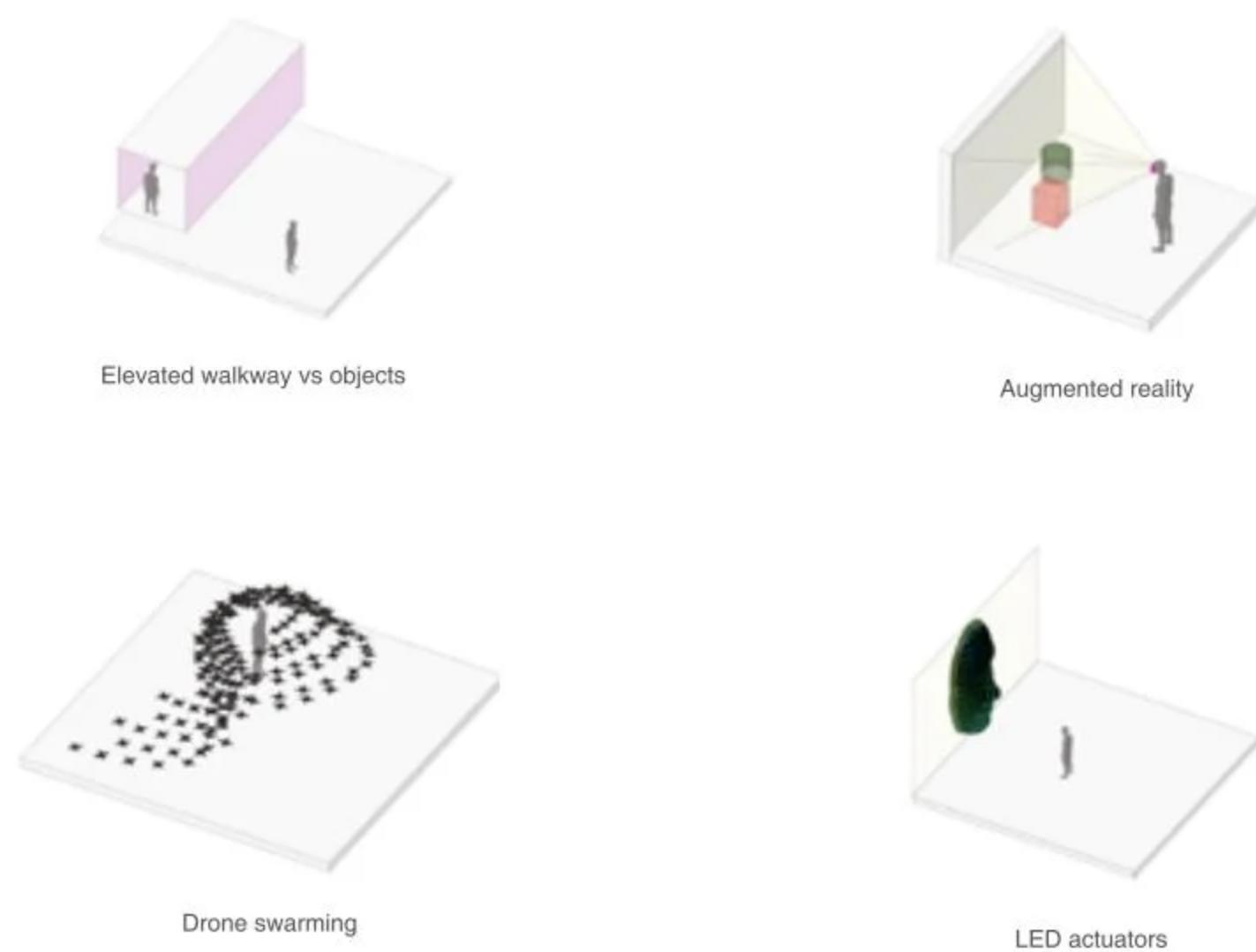
And flexible communication channels on site. with the design dictating the overall structure and form, the design itself is realised by assembly and a equilibrium achieved in assembly



# Exploratorium of new media and art

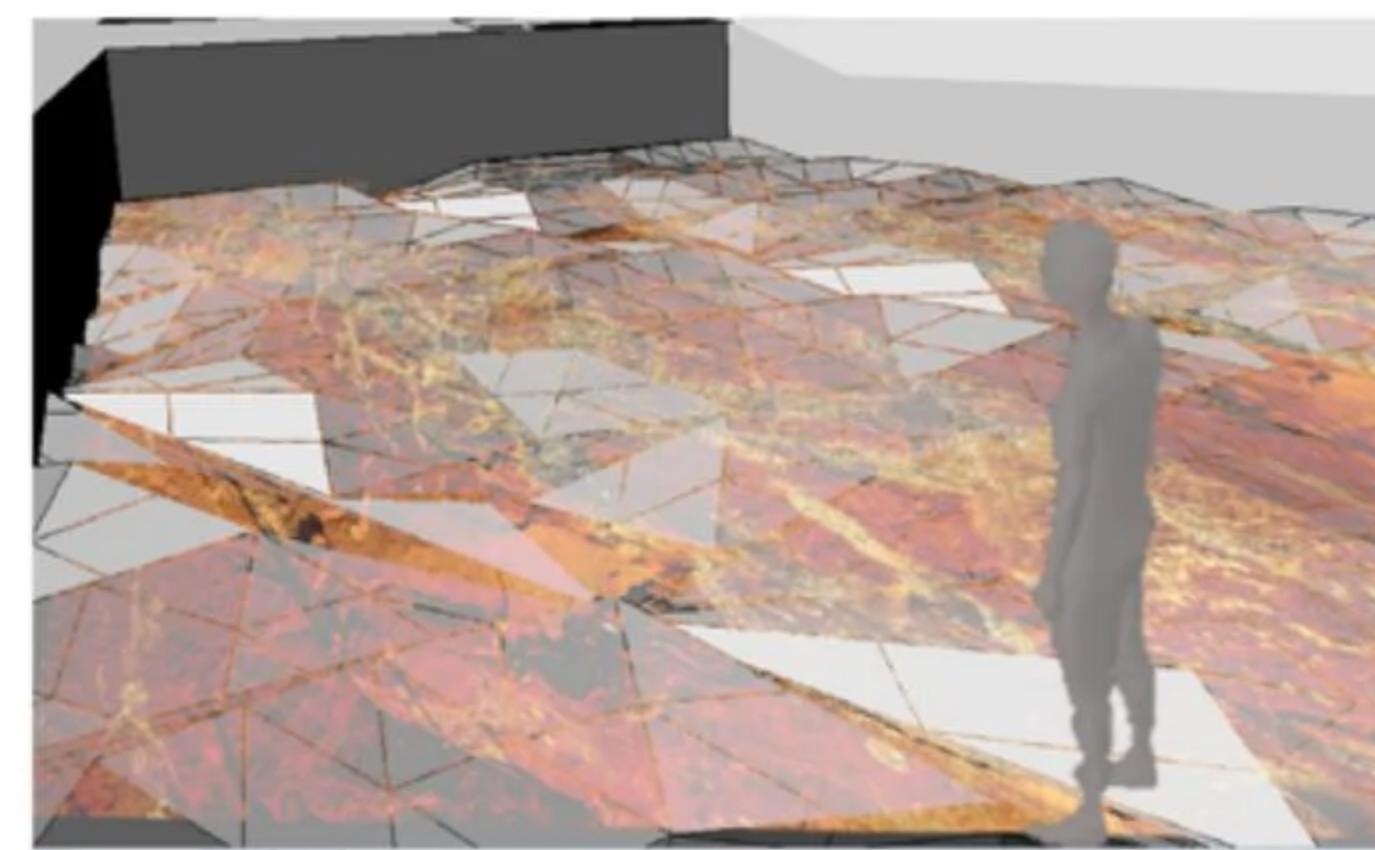
The exploratorium redefines museum in the context of new media installations, the point of focus here being the development of new media experiences and ways in accommodating them in the typology of a public space.

And explores questions on what is the Appeal of modern art in the digital age and rises questions on ownership and public domains

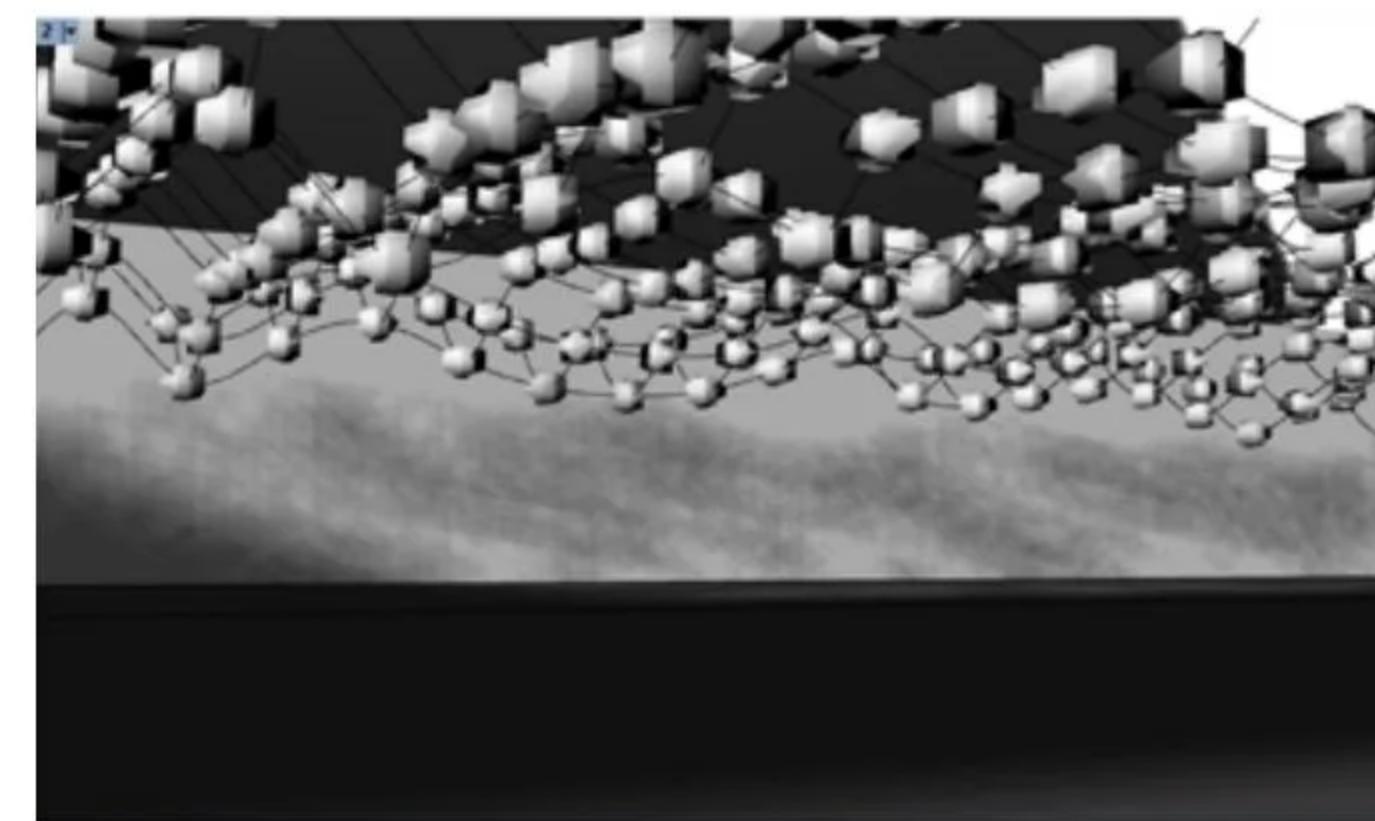


The Atrium being the central focus of the spatial program, necessitated in a unique structure.

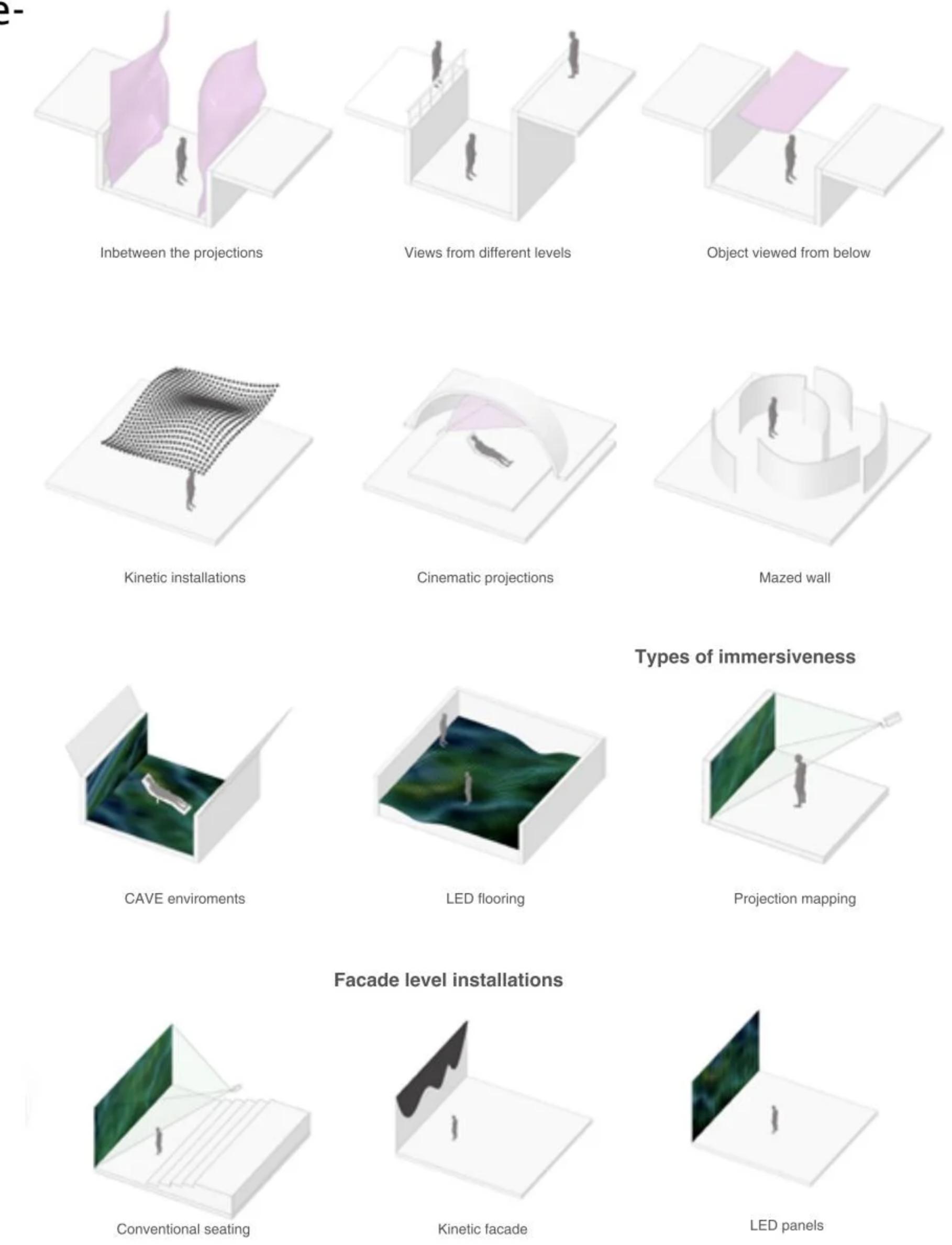
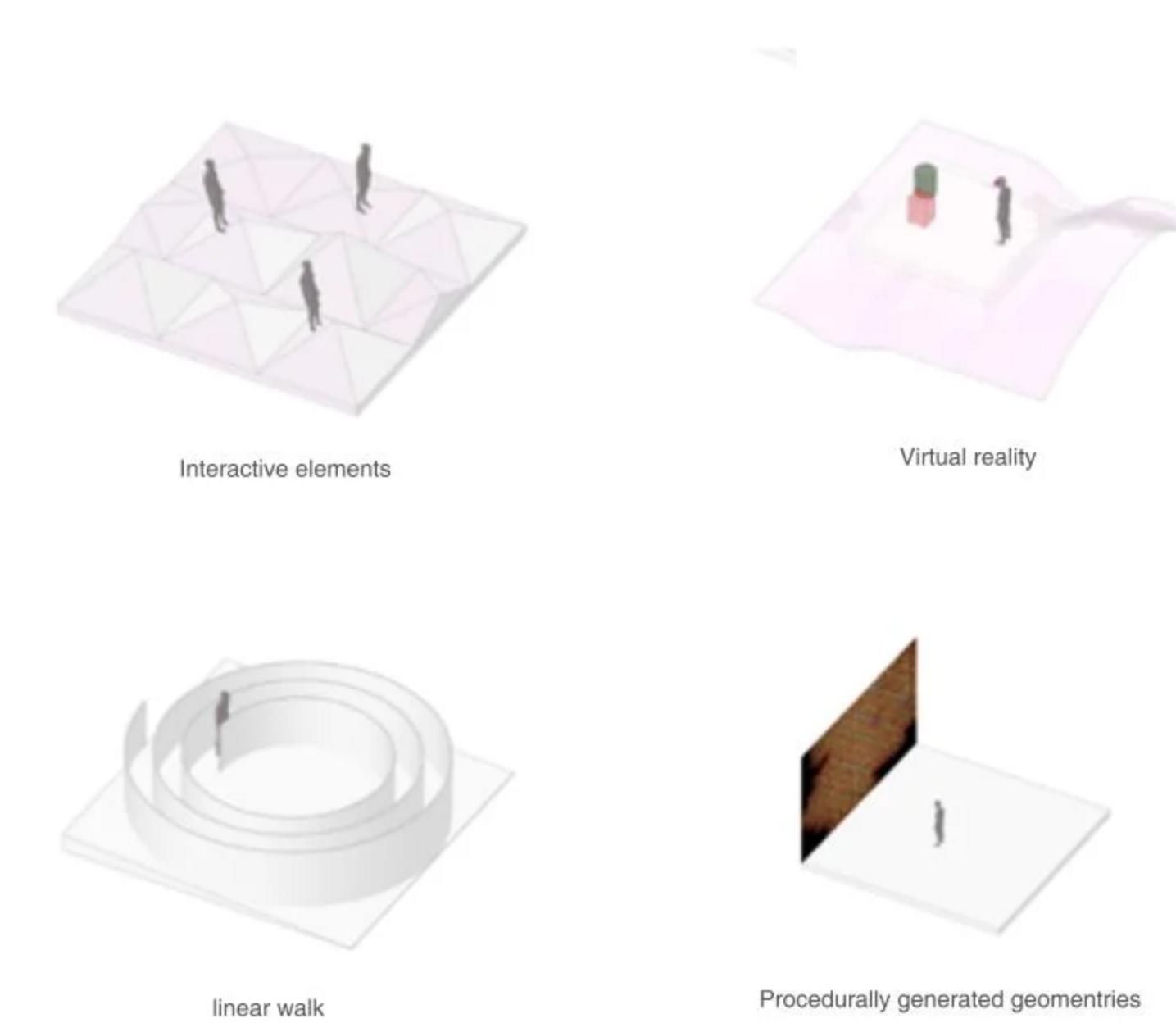
Semester project 2019, as part of thesis , developed a new-media Museum project.



Expericene centre - augmented with projection



kinetic ceiling - augmented spatial sense



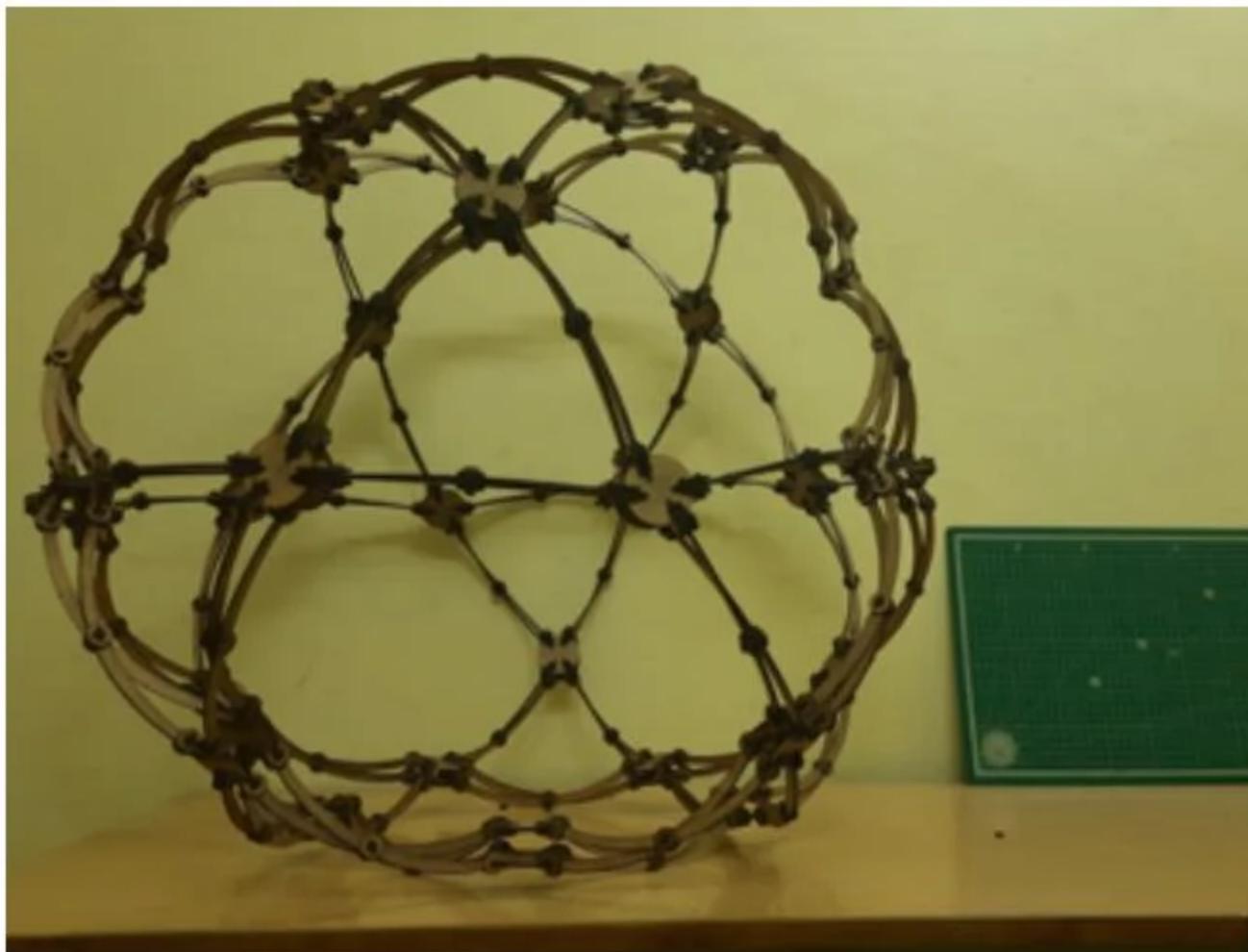
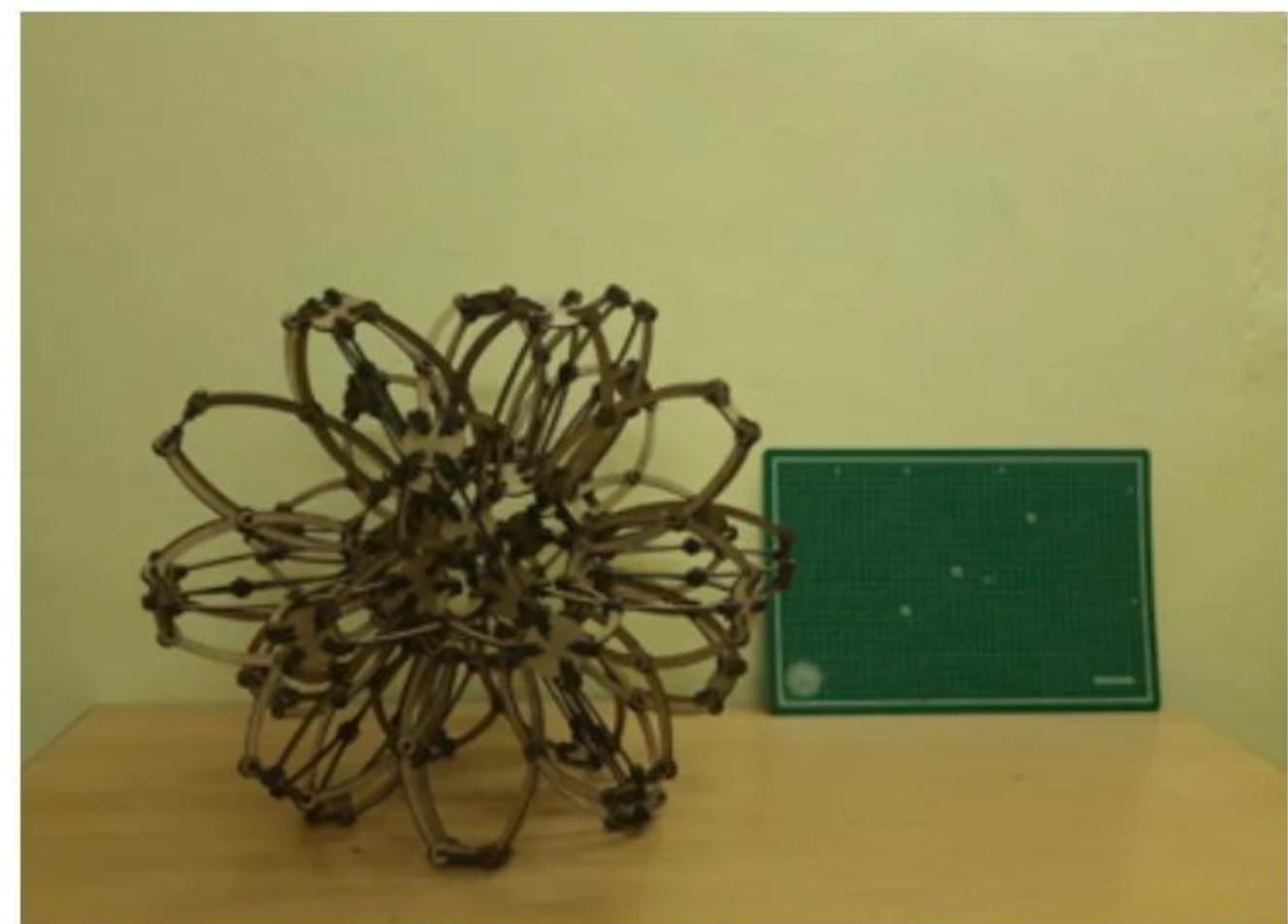
what is art in this age of digital media?

Spatial experiences and the journey through a building is being explored through several interfaces and media.

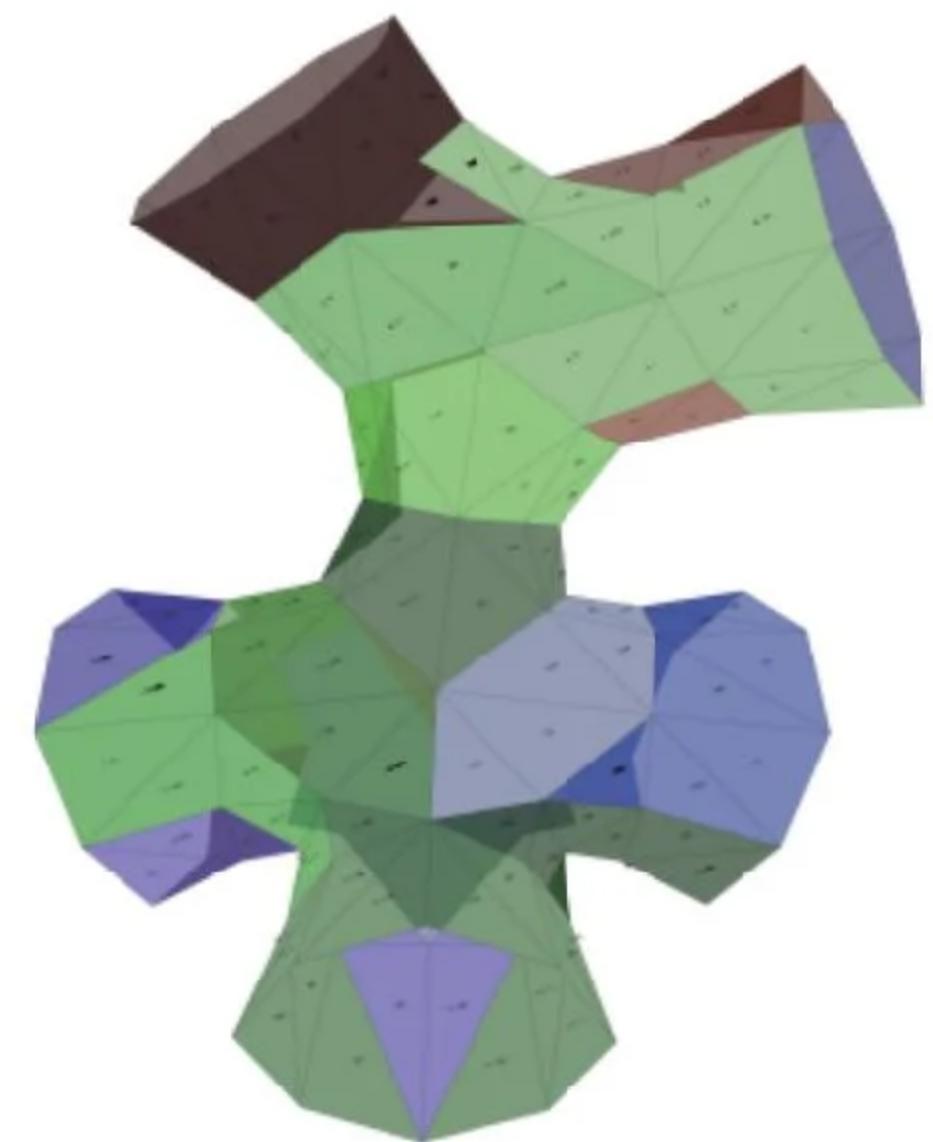
The question of physical objects as a specimens and objects of attraction is being questioned through virtual reality and new-media art.

## Miscellaneous Prototyping projects

Prototyping exercises (2020),

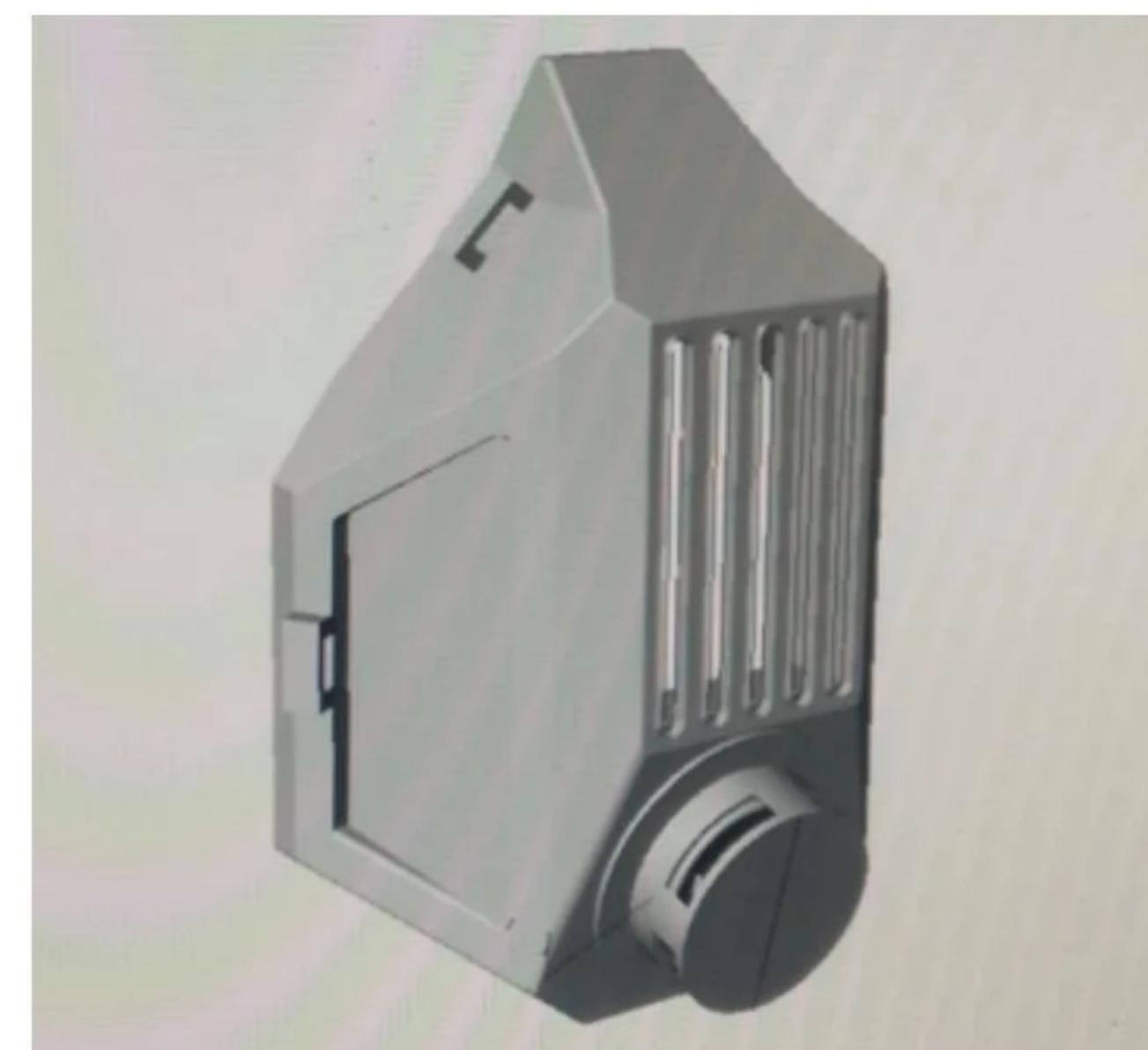


An Icosadodecahedron (20 triangular faces, 12 pentagonal faces) with each side being a scissor joint makes this transformable-structure, inspired by the Hobberman sphere, manufacturing affordances for sliding joints,



The prototyping of a unit of a pavilion, generation of fabrication drawings by grouping faces and unrolling through graph theory and physics simulation.

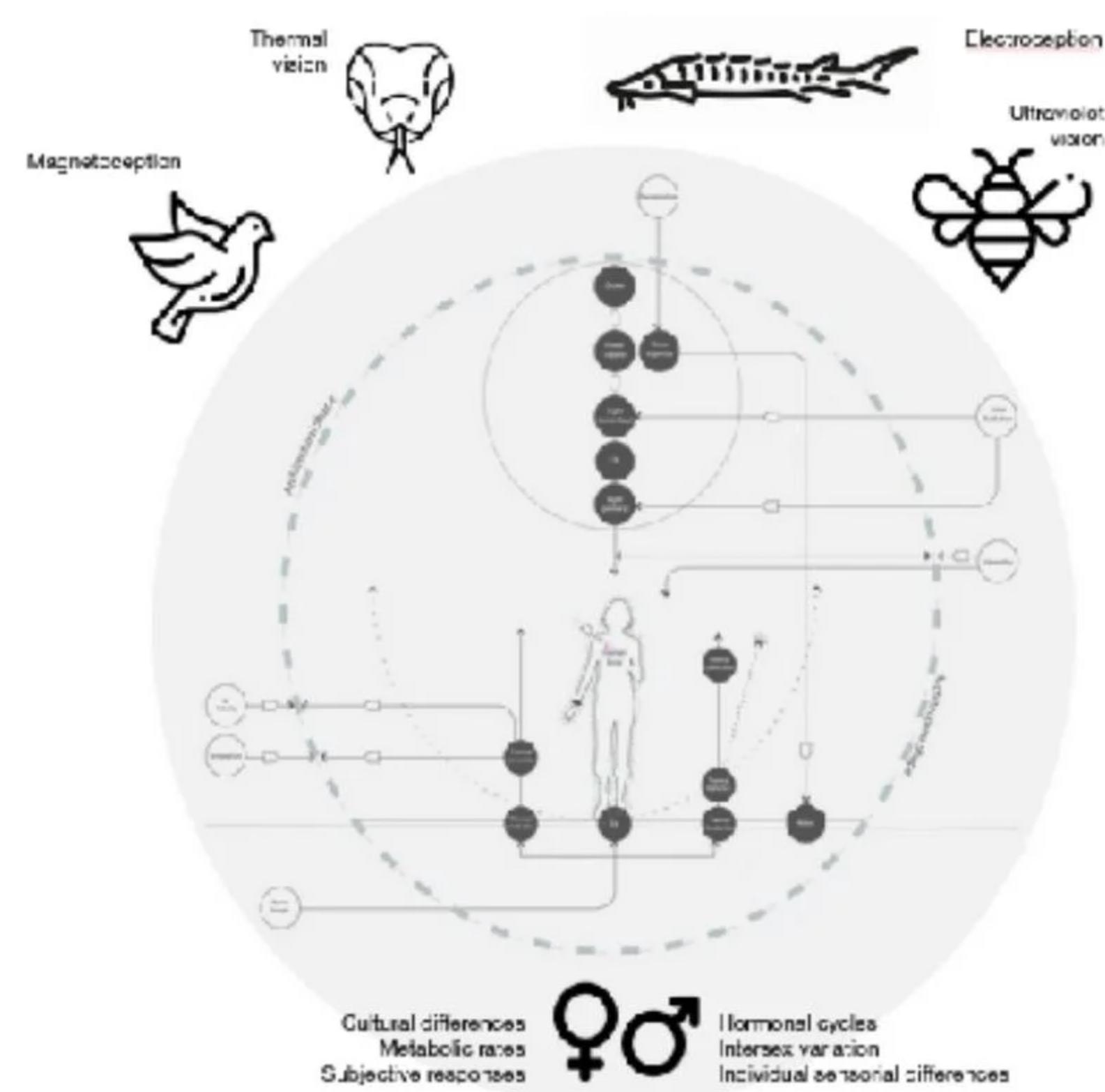
In view of the pandemic and Acute shortage of medical masks and supplies, we developed several components and manufactured them through 3d printing PLA plastic for masks and laser cutting to make face shields



The masks and were fitted with Hepa filters which can be replaced and the contraption reused after disinfection.

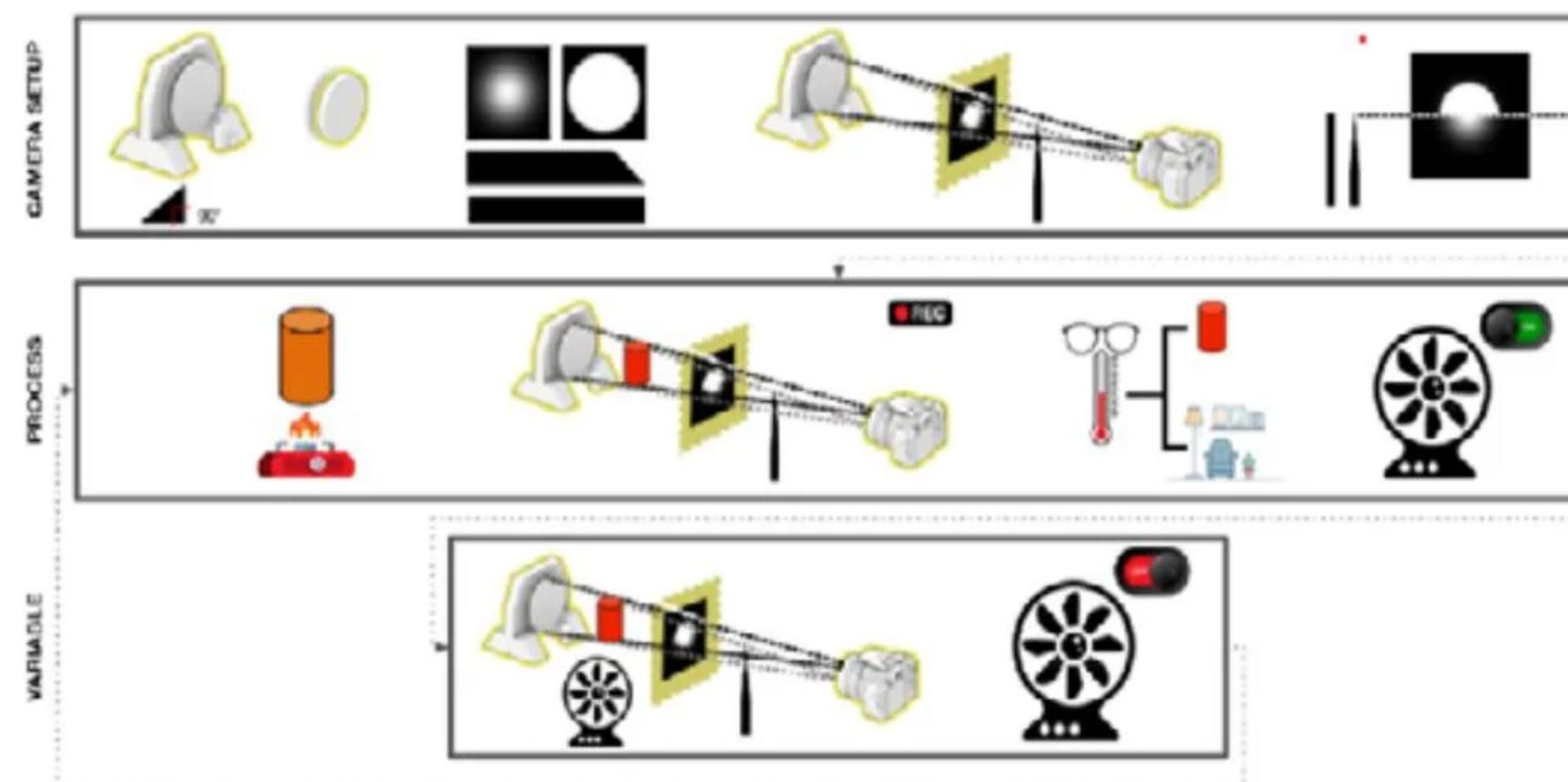
# Sensing the thermal environment

Sensing the thermal environment especially convection in buildings was a key challenge of this seminar, with various complimentary techniques explored in this regard.



## Studio Seminar 2, Sensing Machines, MRAC01

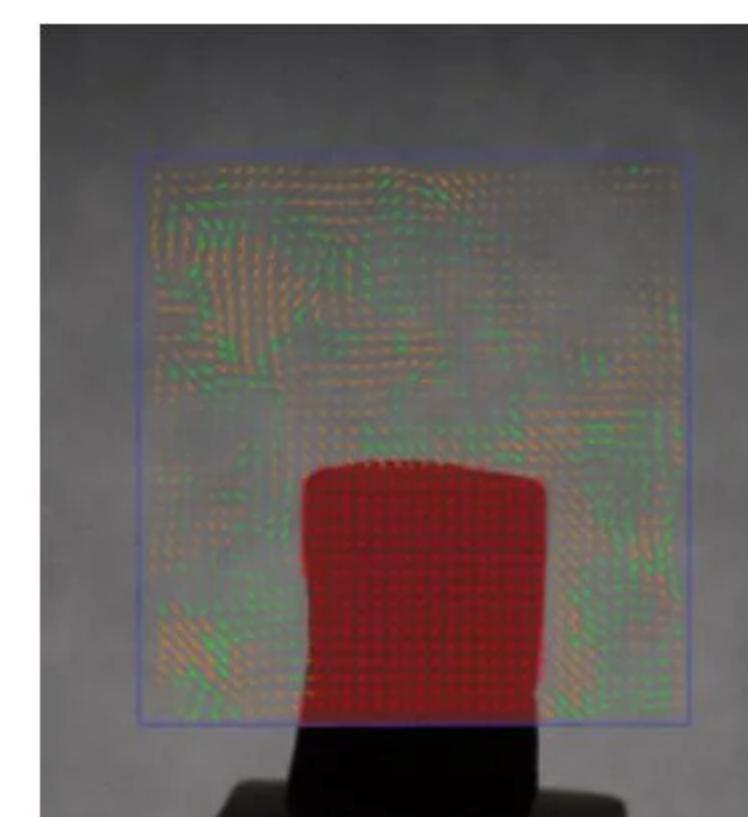
### Schlieren imaging



Schlieren Imaging to understand movement of hot air around objects, here the camera as a sensor leveraged our understanding of flow with optics.

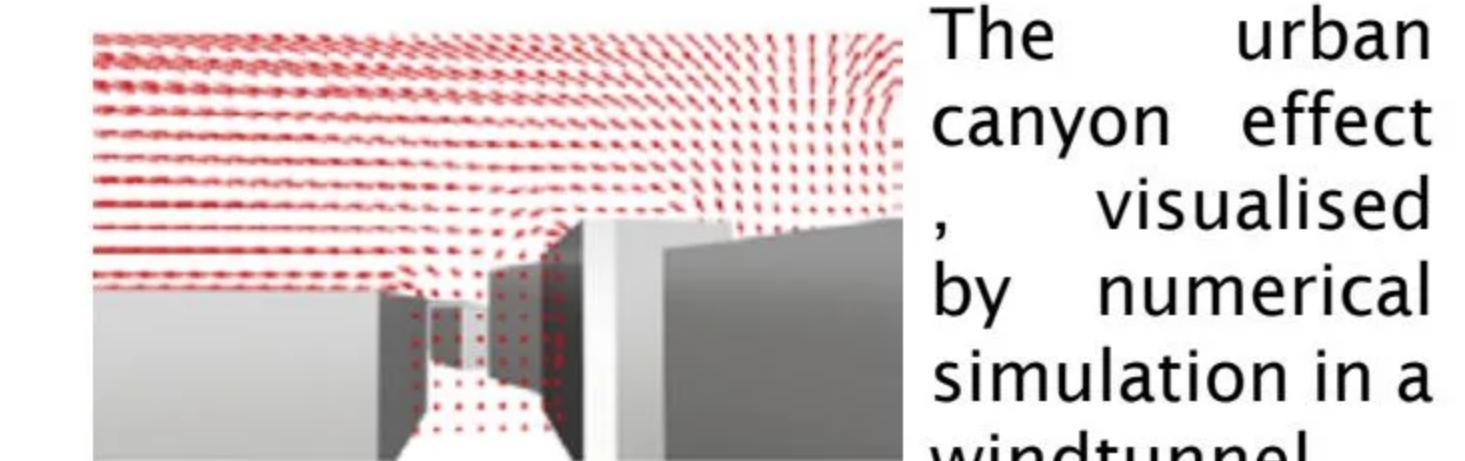
Computer-vision algorithms like optical-flow and histogram of gradients are applied here to visualise the vector fields generated around the flow.

Mapping convection using Background oriented schlieren imaging,  
Imaging technique without reliance on optics

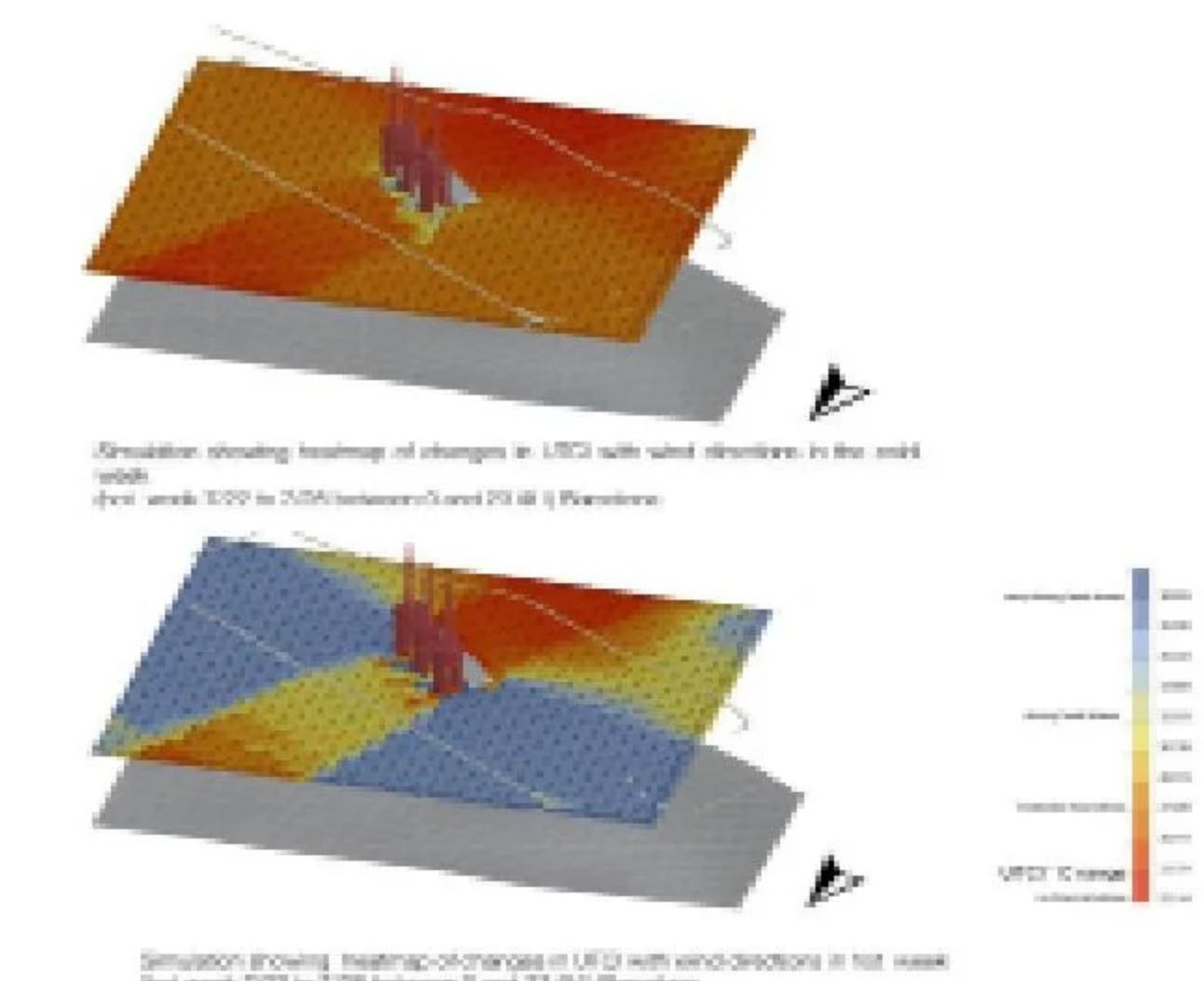


The change in pixels across each frame of a video and direction of flow is mapped in vectors. the speed and velocity is thereby measured across a vector field.

flow patterns around forms mapped by Schlieren imaging and the HOG algorithm



The urban canyon effect , visualised by numerical simulation in a windtunnel.



Mapping UTCI based on Vector fields generated by Urban Scale CFD simulations, - Studying thermal comfort in the Hottest and coldest weeks on site.