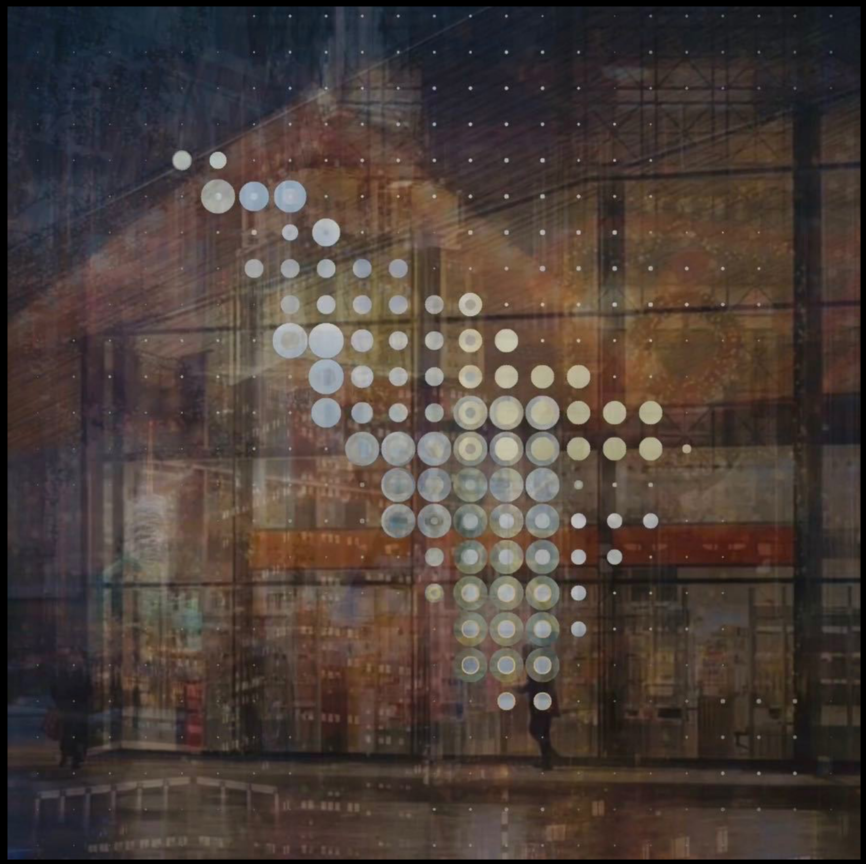
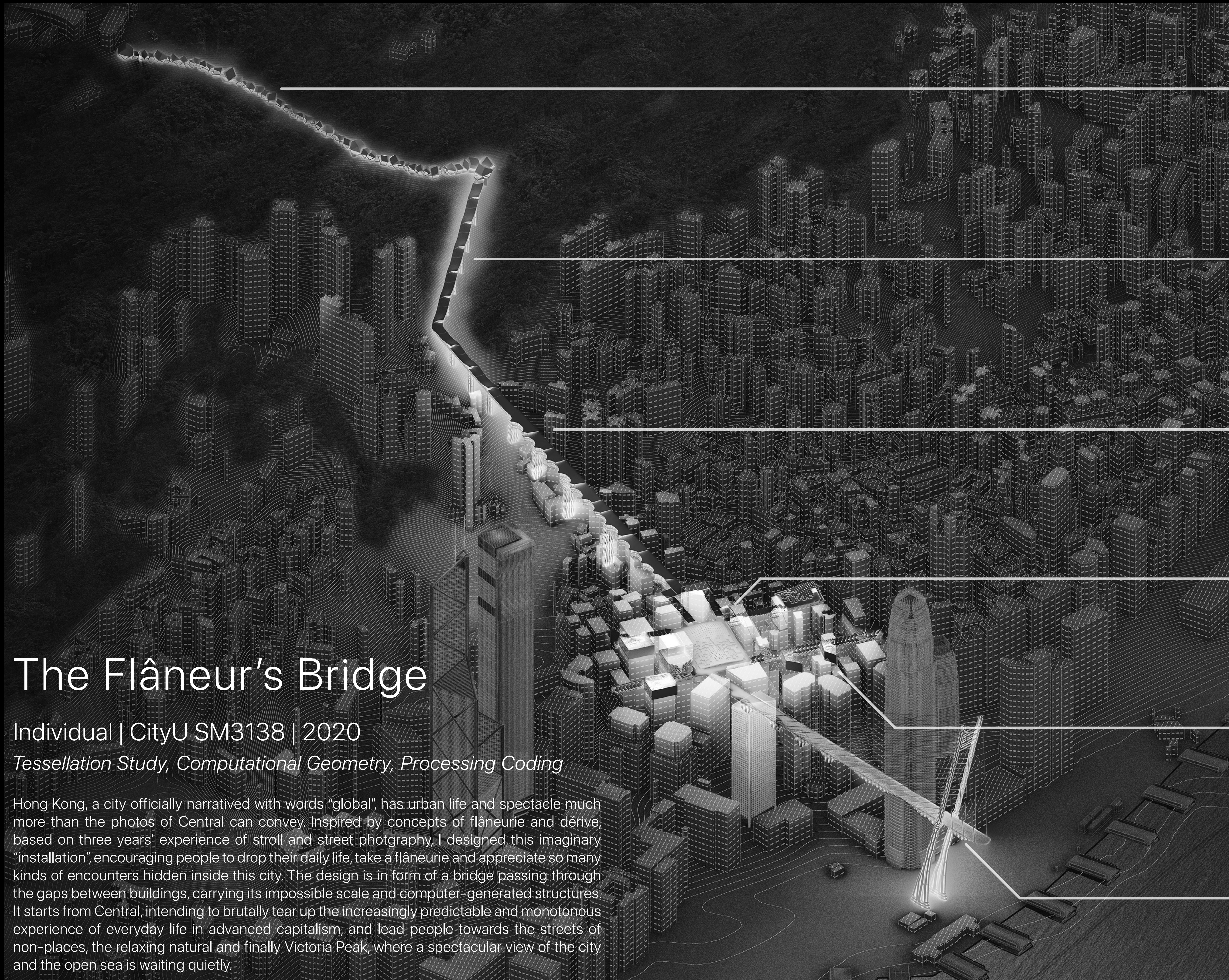


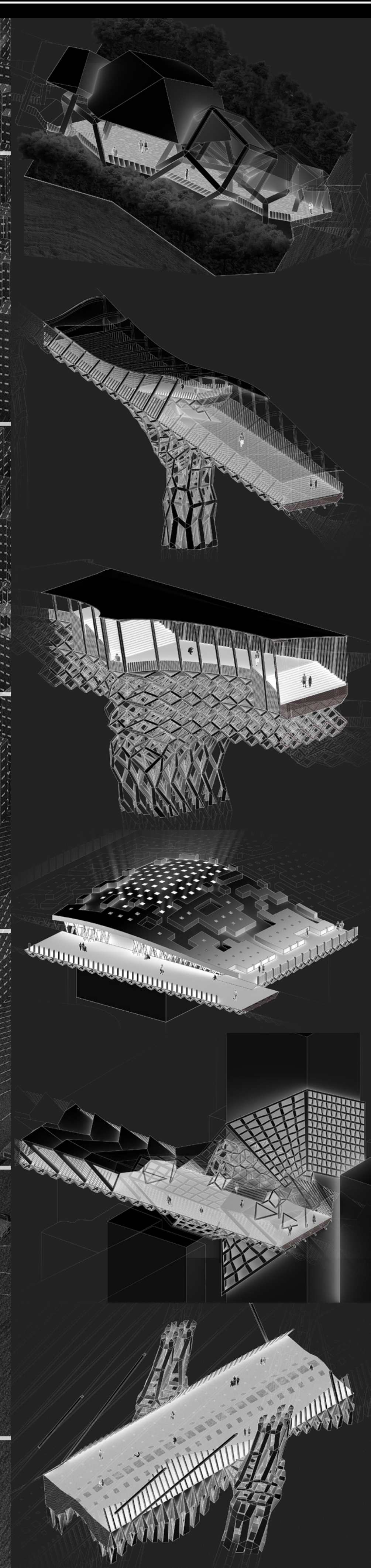
Portfolio in Computation

Chenyue “xdd44” Dai

Design Experiences, Design Tools

Aesthetical	*The Flâneur's Bridge* *A Study of Windows* *Computed Transparency* *Minimum Spanning Erosion* *Unfamiliar Familiarity* *AngleCAD*
Tangible	*Geometric Fidelity*





The Flâneur’s Bridge

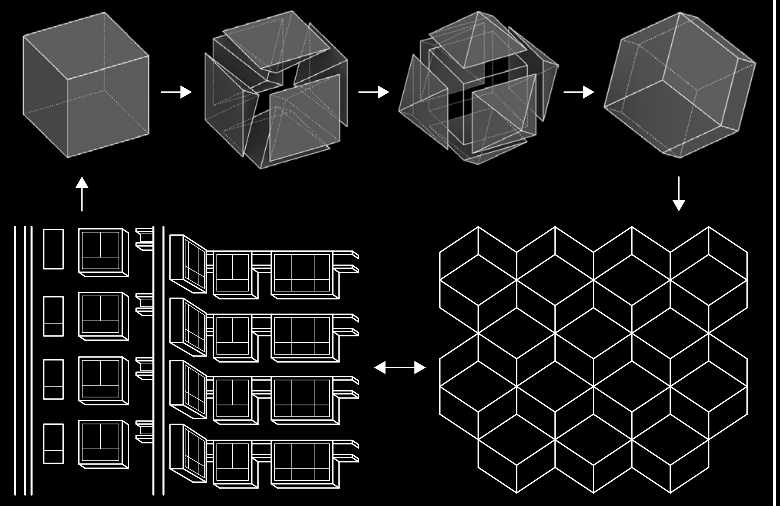
Individual | CityU SM3138 | 2020

Tessellation Study, Computational Geometry, Processing Coding

Hong Kong, a city officially narratived with words “global”, has urban life and spectacle much more than the photos of Central can convey. Inspired by concepts of flâneurie and dérive, based on three years’ experience of stroll and street photgraphy, I designed this imaginary “installation”, encouraging people to drop their daily life, take a flâneurie and appreciate so many kinds of encounters hidden inside this city. The design is in form of a bridge passing through the gaps between buildings, carrying its impossible scale and computer-generated structures. It starts from Central, intending to brutally tear up the increasingly predictable and monotonous experience of everyday life in advanced capitalism, and lead people towards the streets of non-places, the relaxing natural and finally Victoria Peak, where a spectacular view of the city and the open sea is waiting quietly.

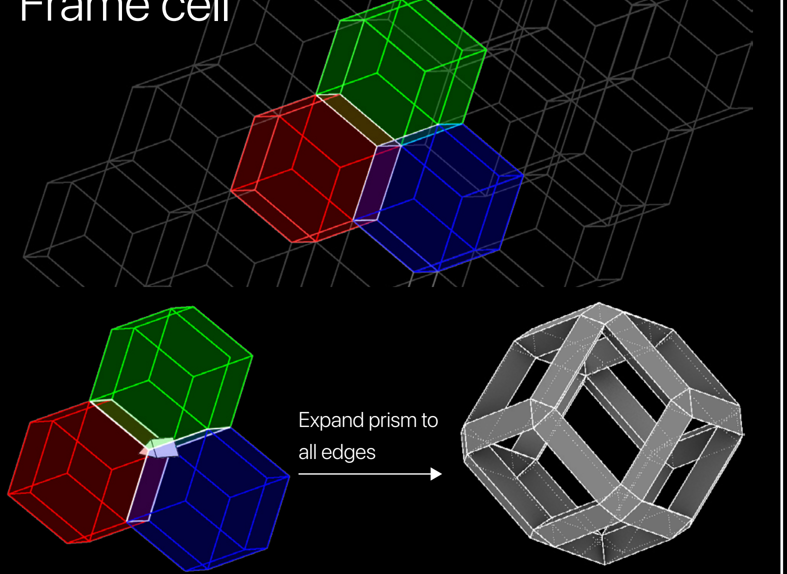
Rhombic dodecahedron

Inspiration



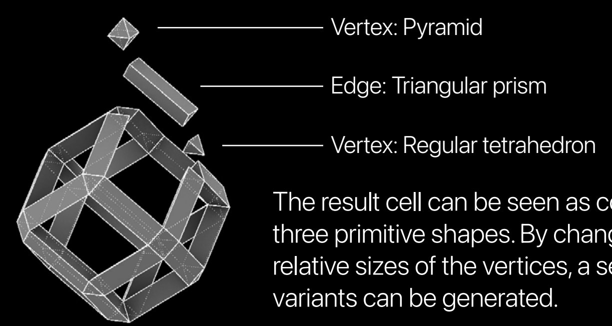
The structure passes all kinds of modern buildings, which share same features of grid form and repetition. So, I choose rhombic dodecahedron as the base of structure to bring a kind of derived grid that contrast with the local buildings.

Frame cell

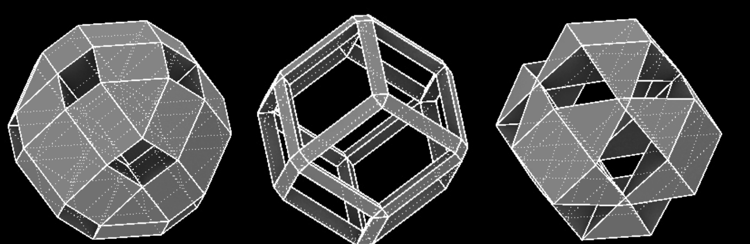


Each edge is shared by three units. Thus, triangular prism is used to construct the edges of the whole frame. On the right above shows a whole cell of the frame.

Cell variants

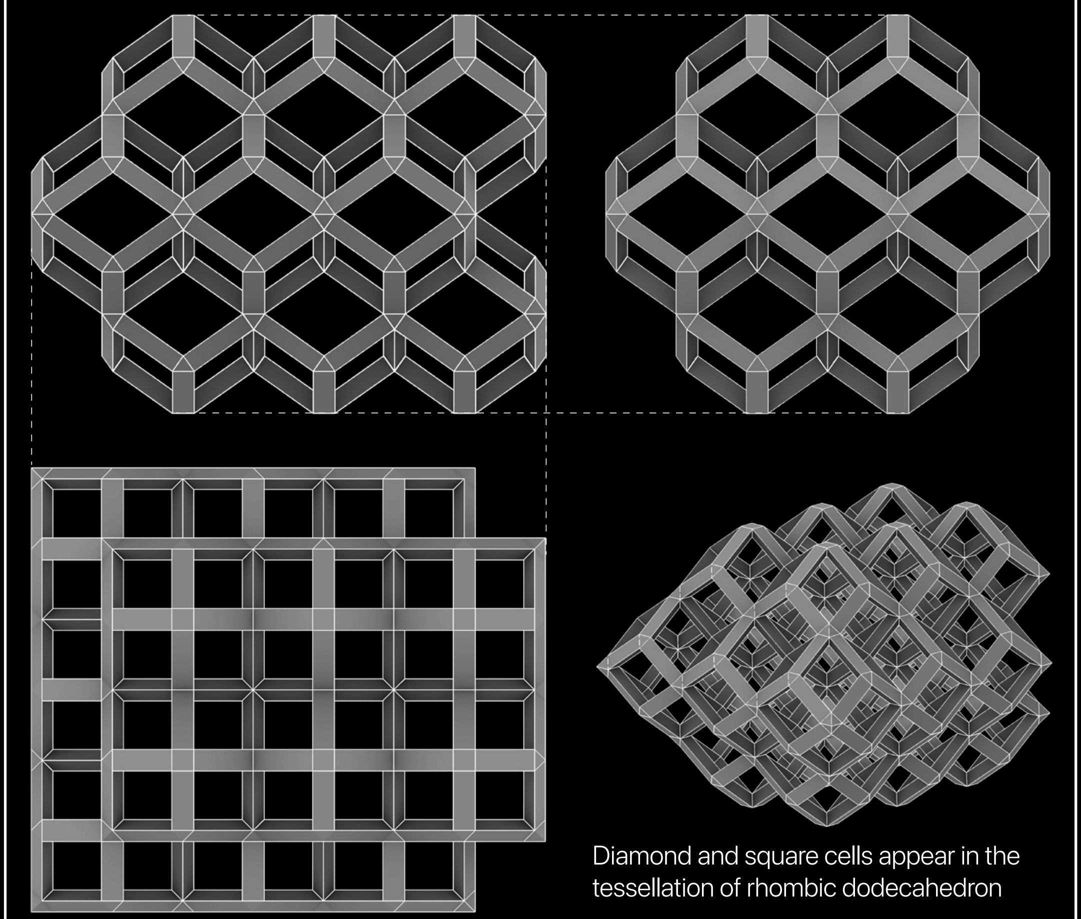


The result cell can be seen as composed of three primitive shapes. By changing the relative sizes of the vertices, a series of variants can be generated.



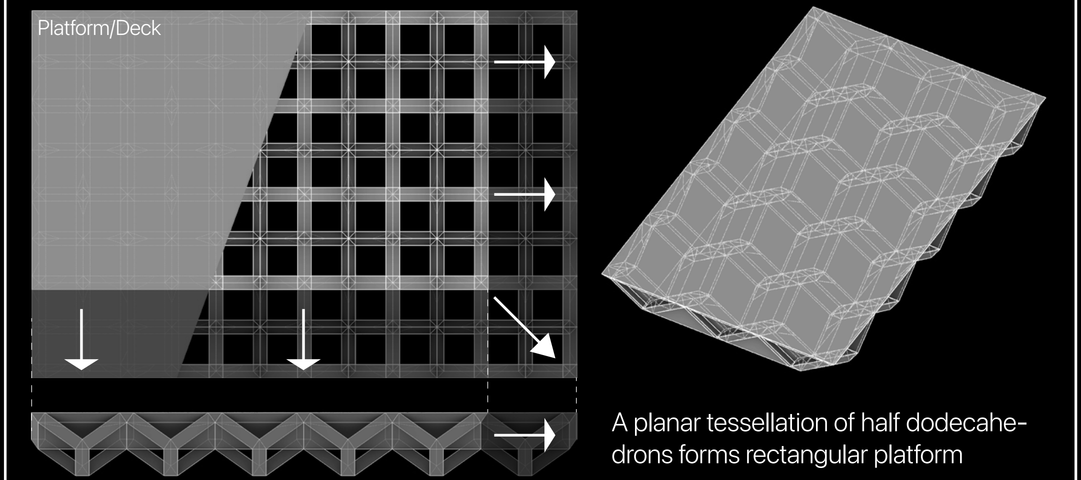
Tessellation

Original form

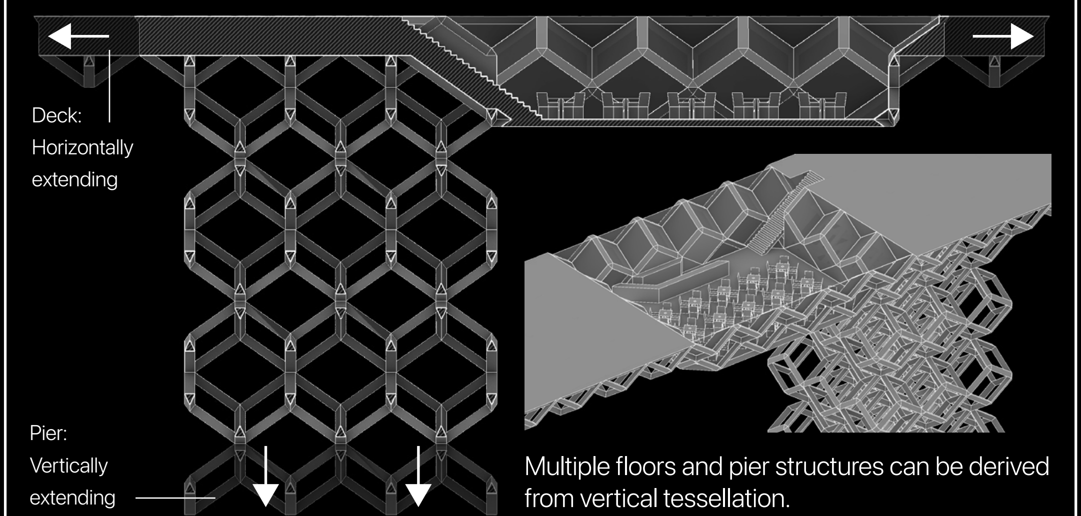


Diamond and square cells appear in the tessellation of rhombic dodecahedron

Simple Implementations



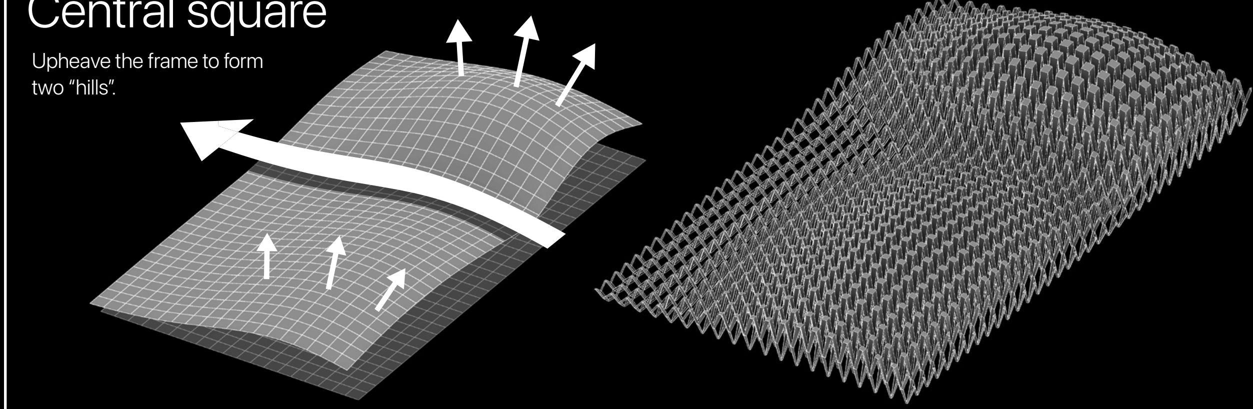
A planar tessellation of half dodecahedrons forms rectangular platform



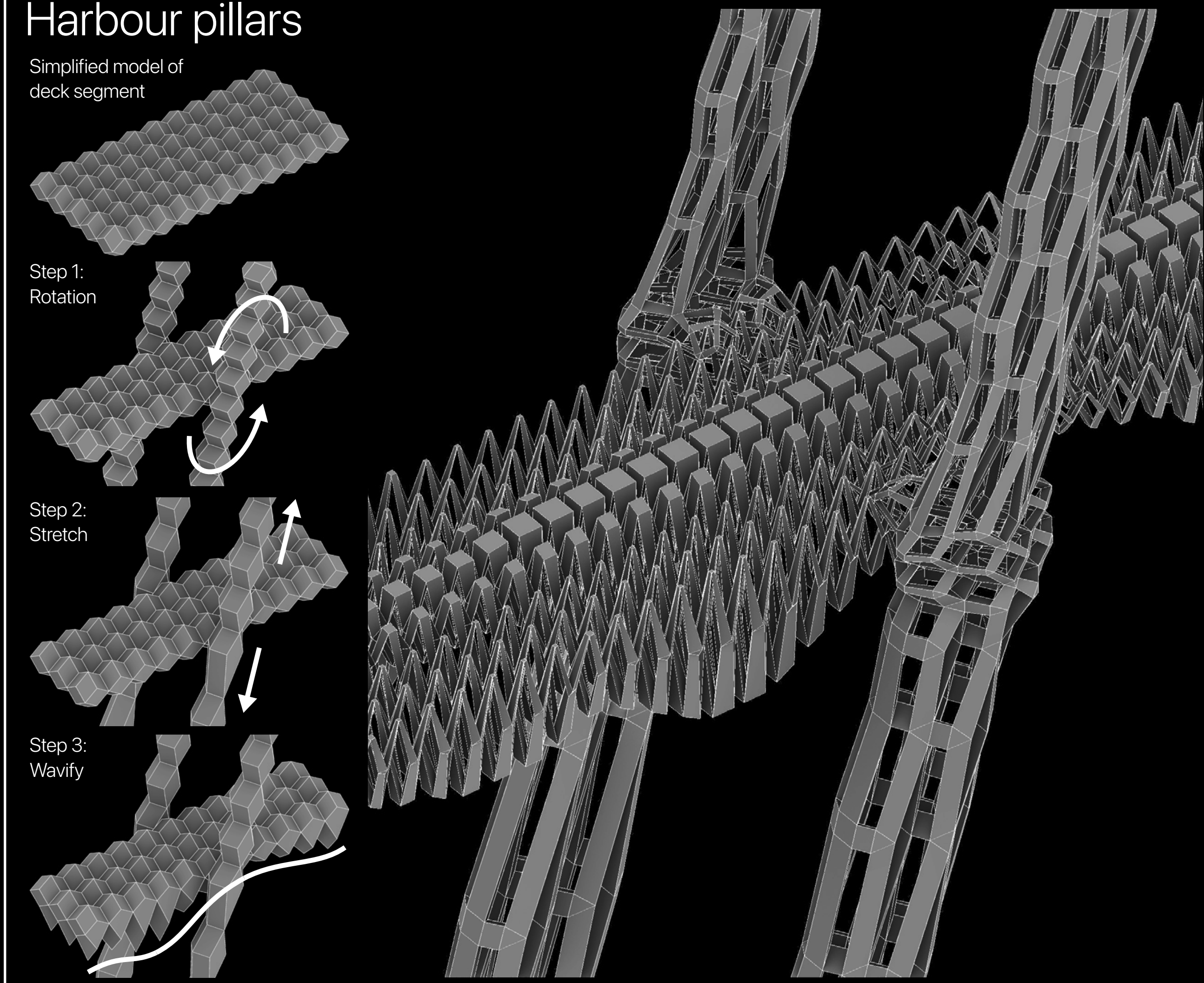
Multiple floors and pier structures can be derived from vertical tessellation.

Variants from distortion

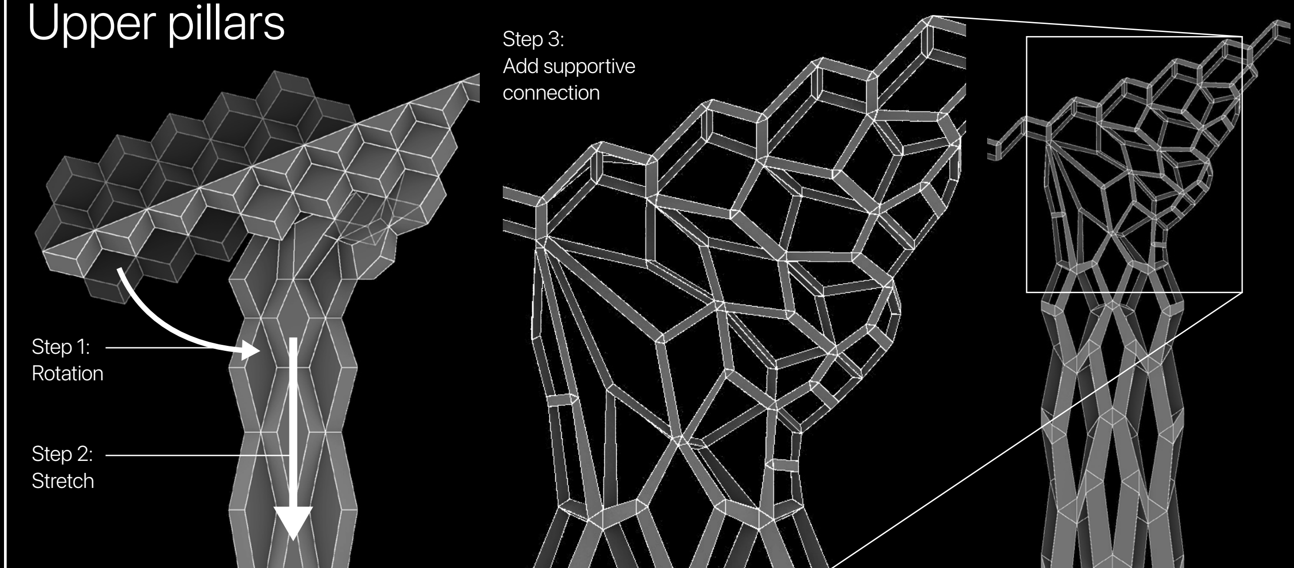
Central square



Harbour pillars



Upper pillars



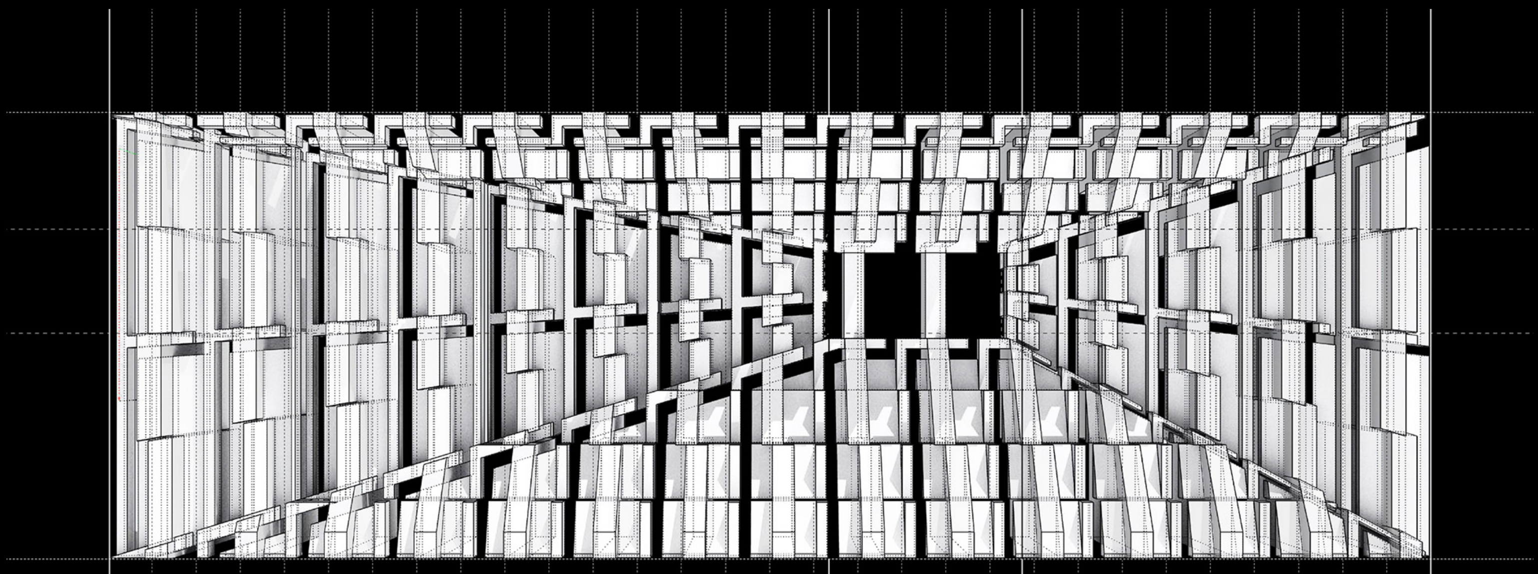
A Study of Windows

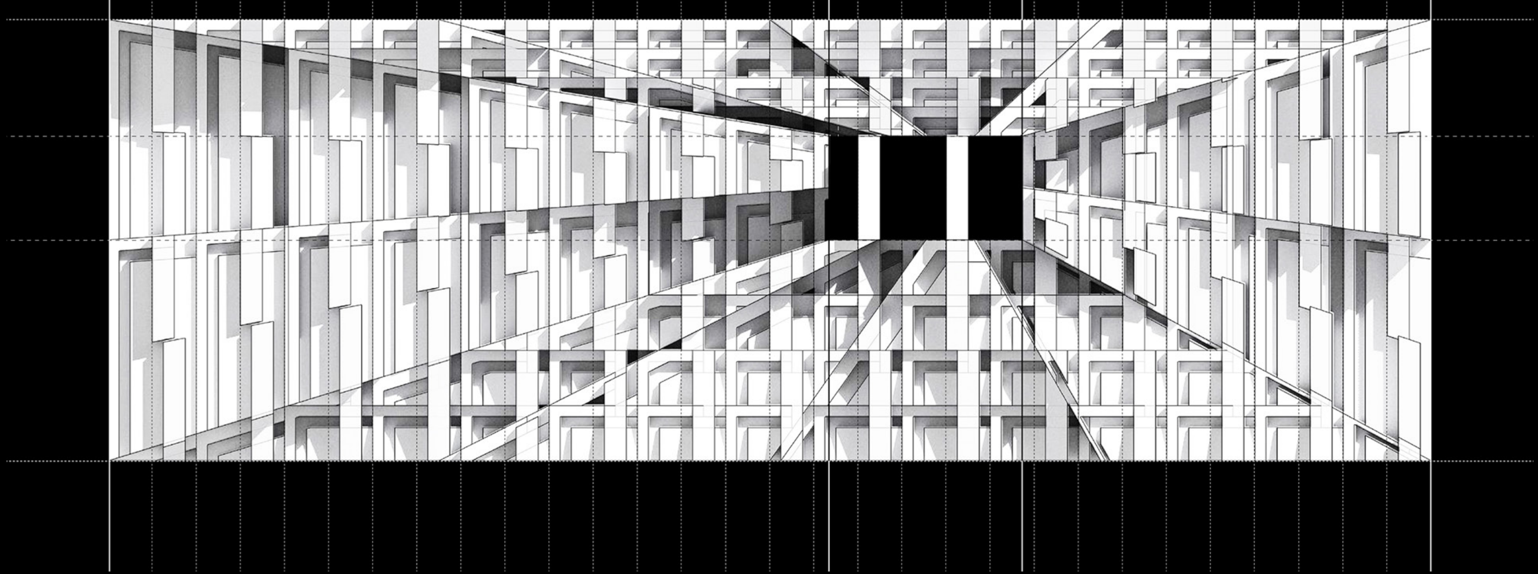
Individual | Cornell ARCH 1110 | 2021

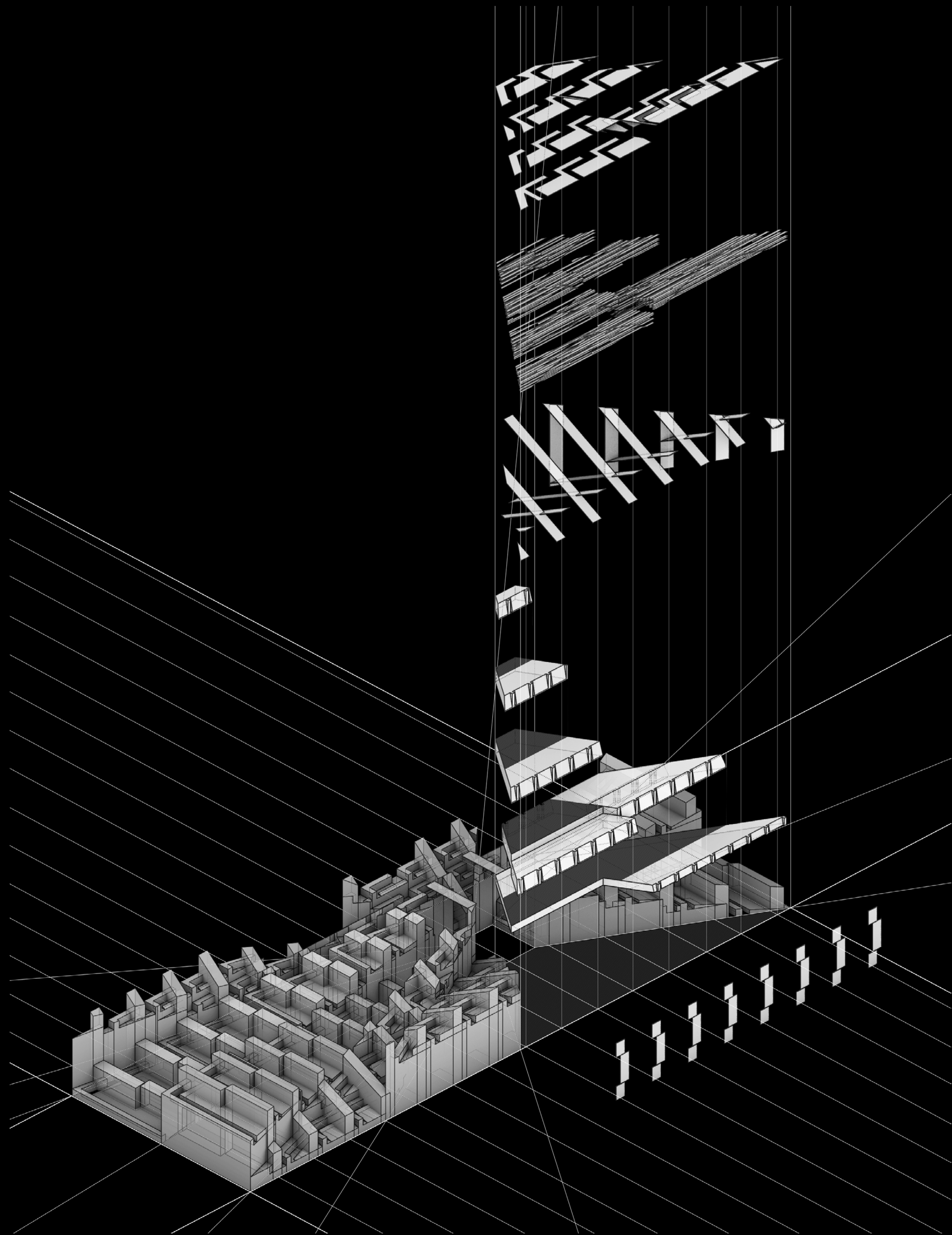
Shape & Form Study, Conceptual Design | TA'd by Carla De Haro

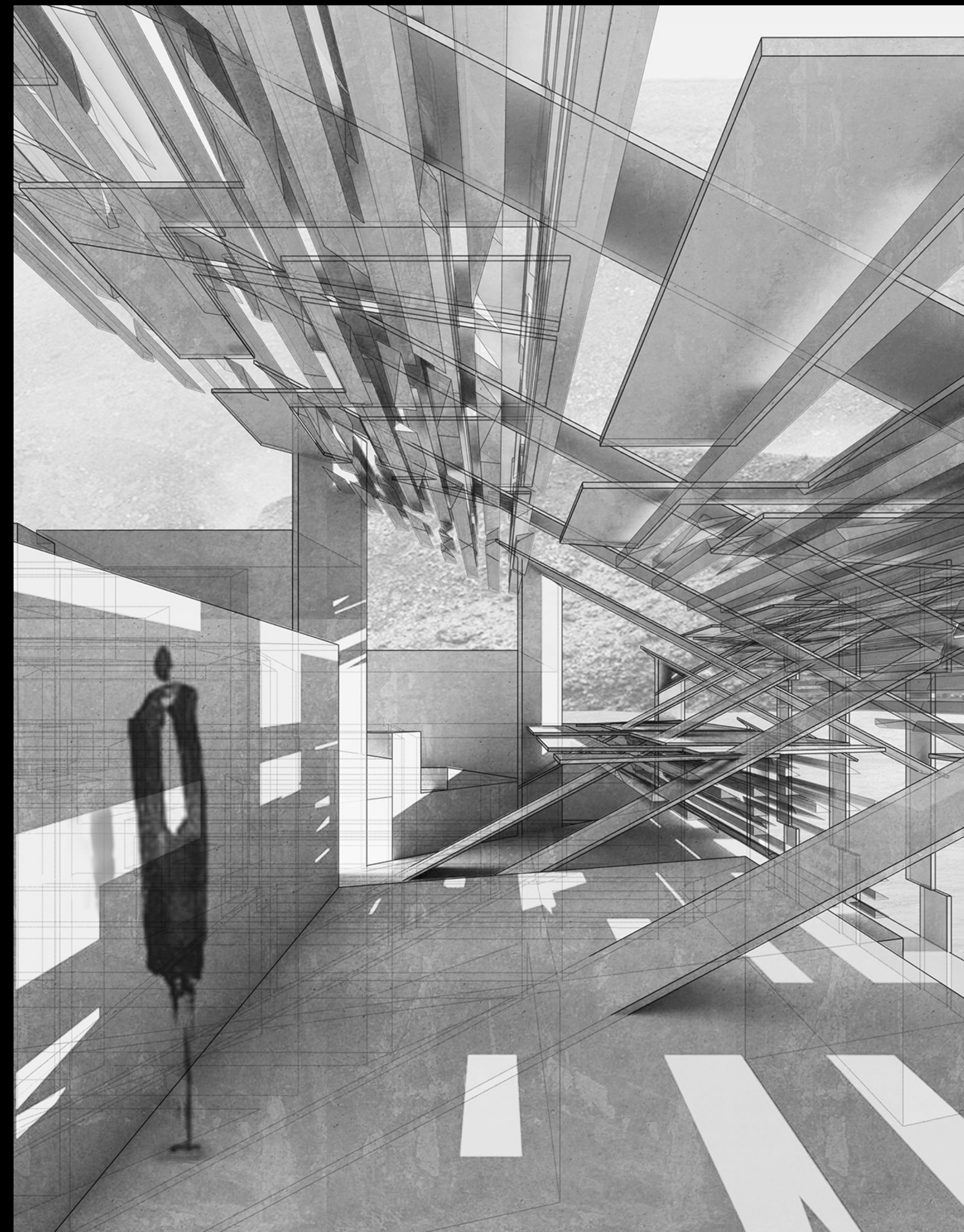
In this four-week studio, I capture the transient essence of subway life, translating the relative movement of trains and platforms into a visual language of horizontal blurs and impermanence in my photographs and collages. This theme is further explored through surface collages that introduce uncertainty with mirrored fragments and semi-transparent layers, and in my spatial constructs, which simulate the dynamic environment of a subway station. By transforming these elements into objects and installations, I create a harmonious blend of chaos and order, echoing the interplay of movement and fleeting moments in urban spaces, ultimately reflecting these themes in my bas-relief designs that incorporate levels, parallel bars, and the transformative use of space and light.

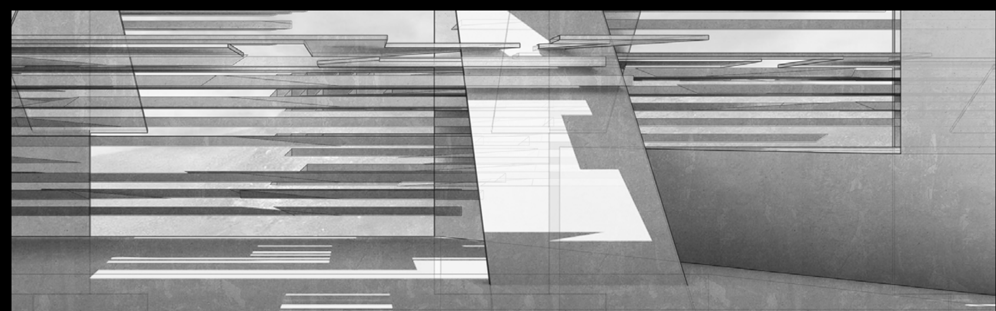

彩虹
Choi Hung









Computed Transparency

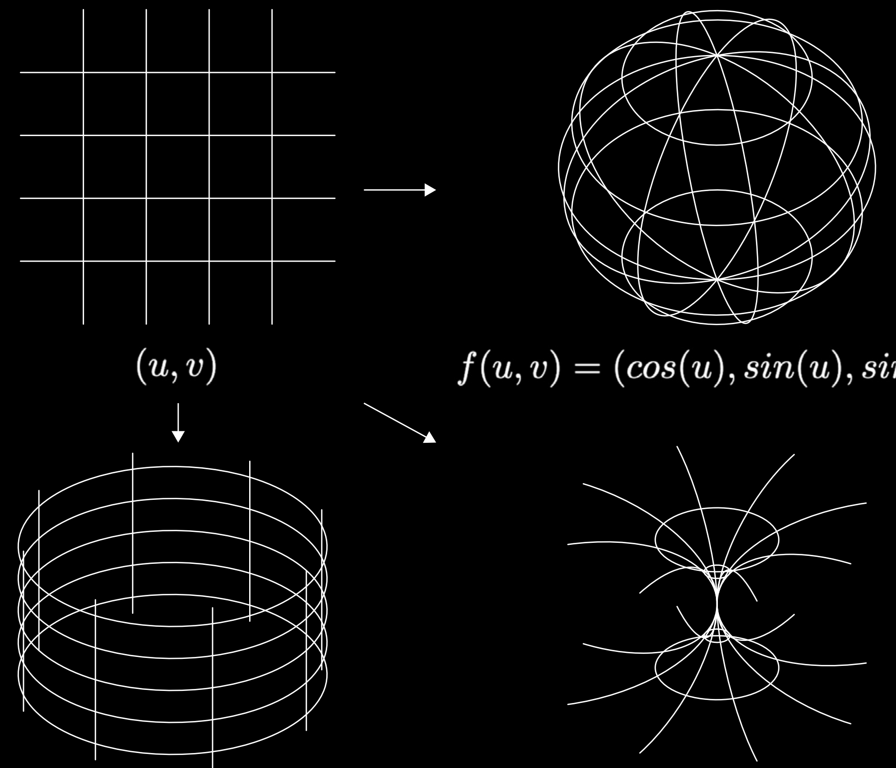
Individual | MIT 4.105 | 2022

Parametric Design, Python in Rhino, Fabrication | Taught by J Jih

This project emerges at the intersection of mathematics and material, experimenting a harmonious blend of intricate computation and tangible craft. Utilizing a sophisticated formula infused with trigonometric functions, I crafted a distinctive form using metallic and transparent sheets. Curved folding plays a pivotal role in this venture, shaping and confining the materials into a three-dimensional structure. Precise manipulations of parameters seek to create a visual symphony within the sculpture. The creation is complemented by a series of photographic documentations, with a lighting stick highlighting the piece's vivid glare and spatial illusions, unveiling its profound depths.

Trigonometric functions

Mapping 2 Variables to 3D Space



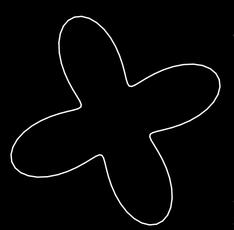
(u, v)

$$f(u,v) = (cos(u), sin(u), sin(v))$$

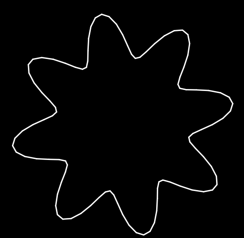
$$f(u,v) = (cos(u), sin(u), v)$$

$$f(u,v) = (cos(u), sin(u), cos(v))$$

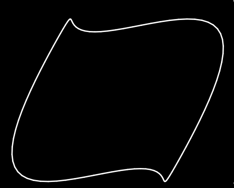
2D Operations



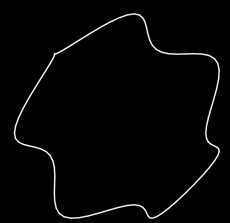
$$f(u,v) = \left(\left(\frac{sin(4u)}{2}+1\right)cos(u), \left(\frac{sin(4u)}{2}+1\right)sin(u), v \right)$$



$$f(u,v) = \left(\left(\frac{sin(8u)}{4}+1\right)cos(u), \left(\frac{sin(8u)}{4}+1\right)sin(u), v \right)$$

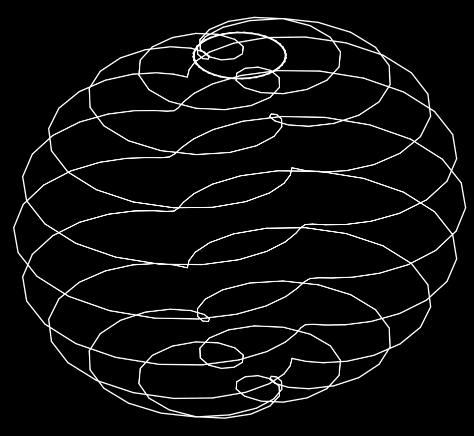


$$f(u,v) = \left(cos(u)+\frac{sin(3u)}{4}, sin(u)+\frac{sin(3u)}{4}, v \right)$$

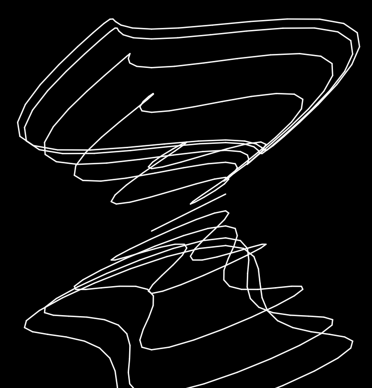


$$f(u,v) = \left(cos(u)+\frac{sin(3u)}{4}, sin(u)+\frac{sin(3u)}{4}, v \right)$$

3D Operations



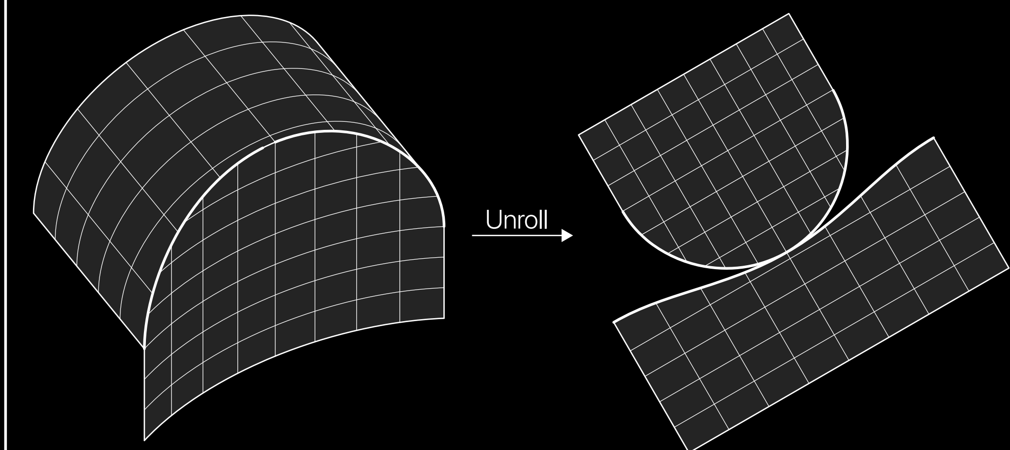
$$f(u,v) = \left(cos(u)sin(v)+\frac{cos(3u)}{4}, sin(u)sin(v)+\frac{sin(3u)}{4}, sin(v)\right)$$

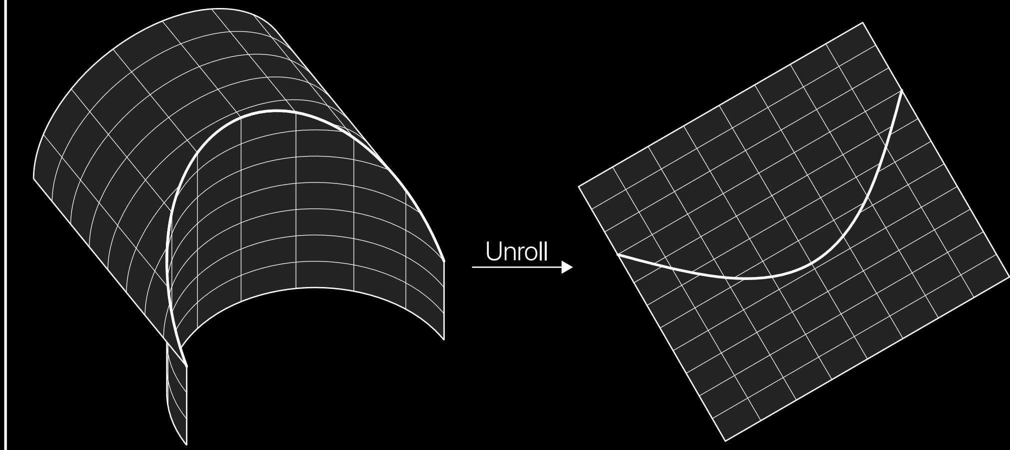


$$f(u,v) = \left(cos(u)sin(v)+\frac{sin(3u)}{4}, sin(u)sin(v)+\frac{sin(3u)}{4}, cos(v)\right)$$

Curved Folding

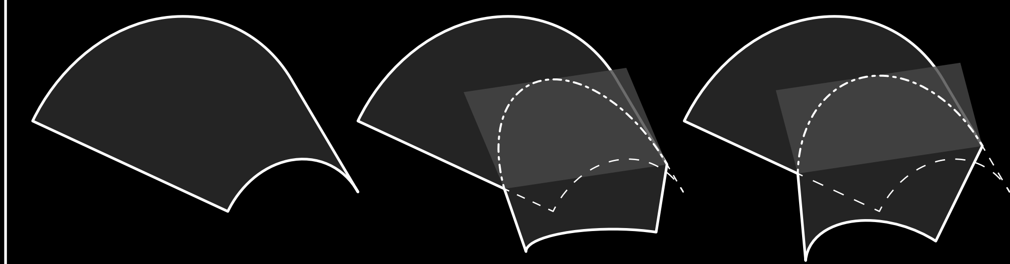
Foldability



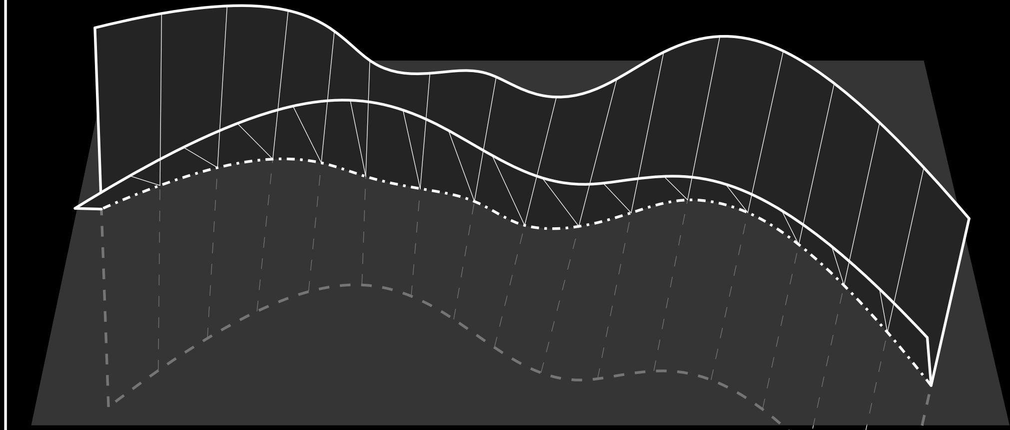


A pair of intersecting curved surfaces may not be able to obtain from physically folding. As the examples show, by unrolling the surfaces, we canvalidate the "creases".

Curved Folding by Mirroring

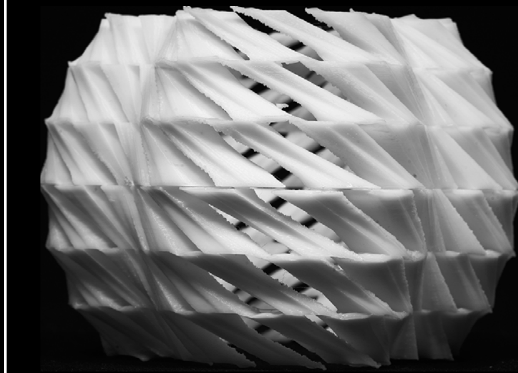


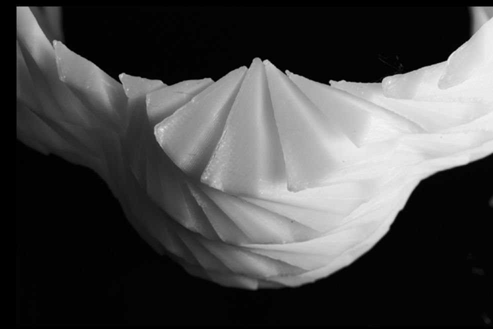
By mirroring part of a curved surface, it is guaranteed to obtain a physically foldable pair of surfaces.

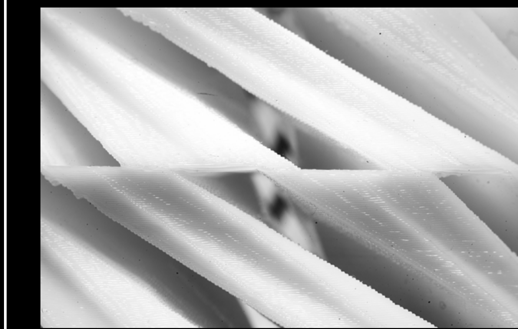


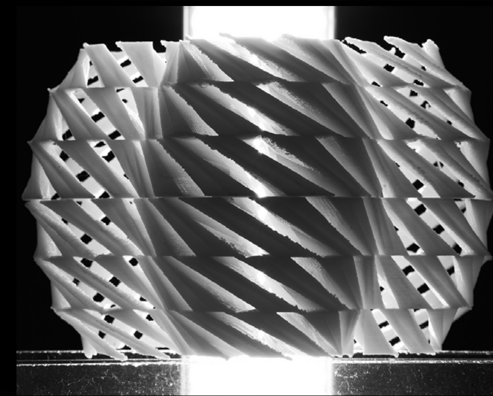
Similarly, it is possible to obtain a folded shape by treating the plane on which the arbitrary curve lies as the mirror plane

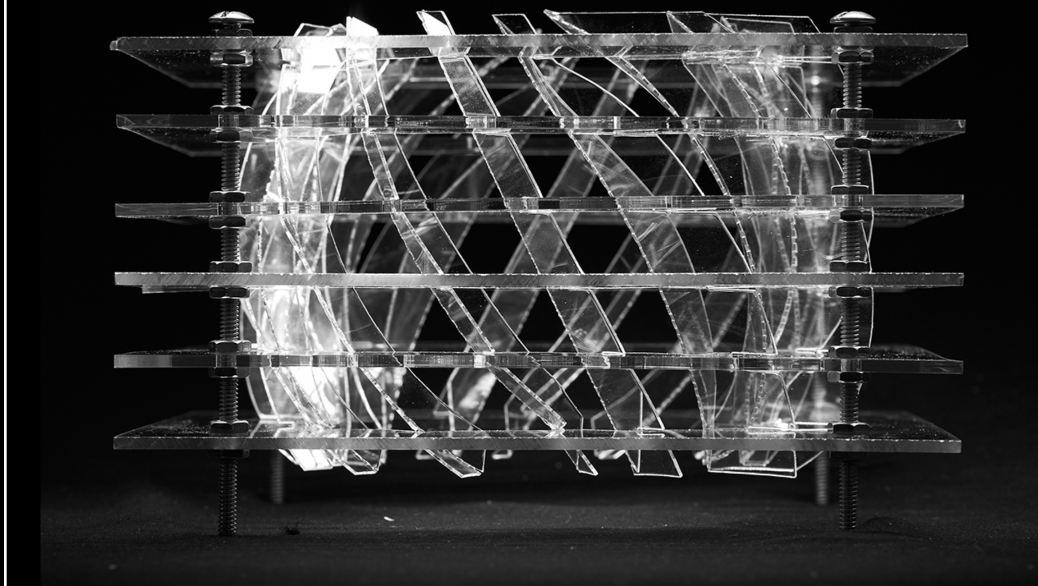
Prototypes

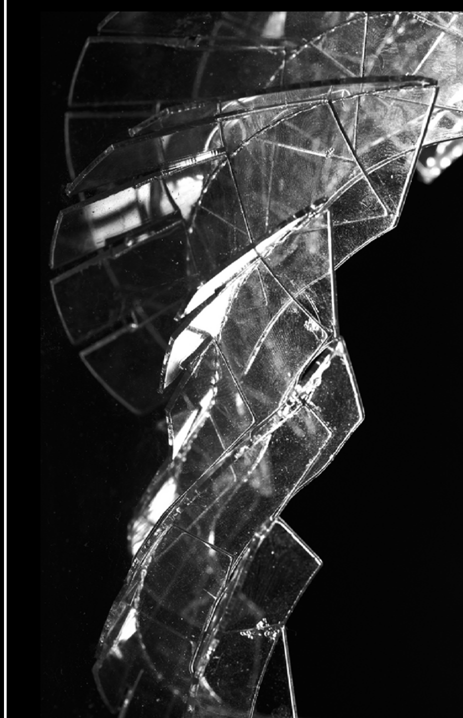








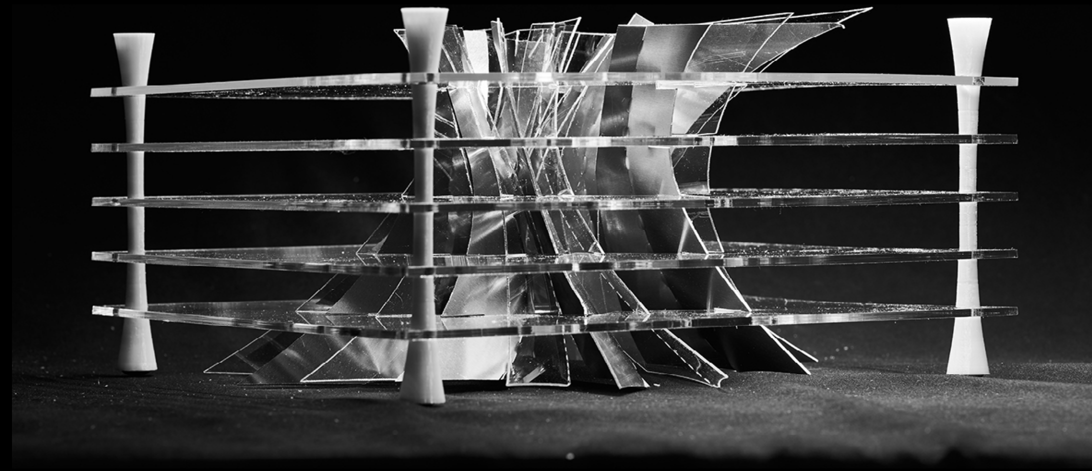


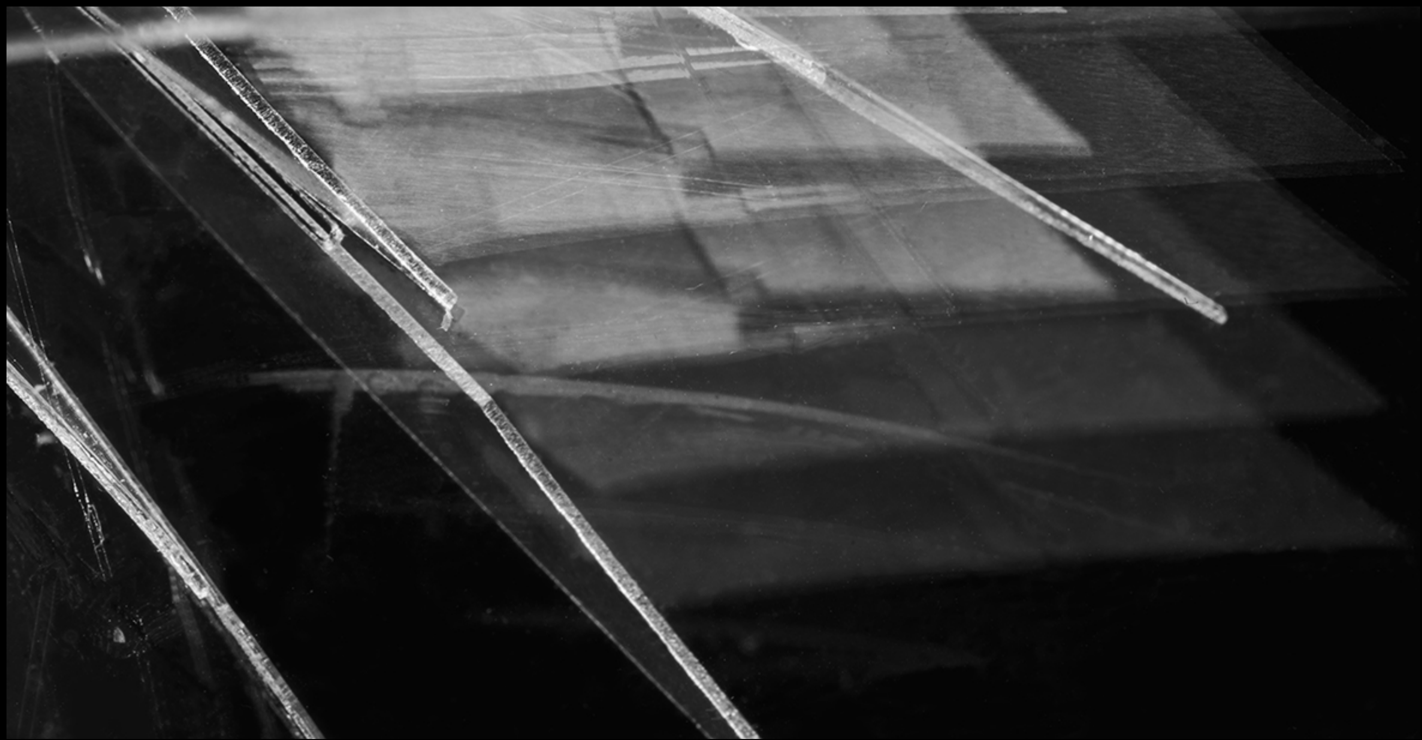


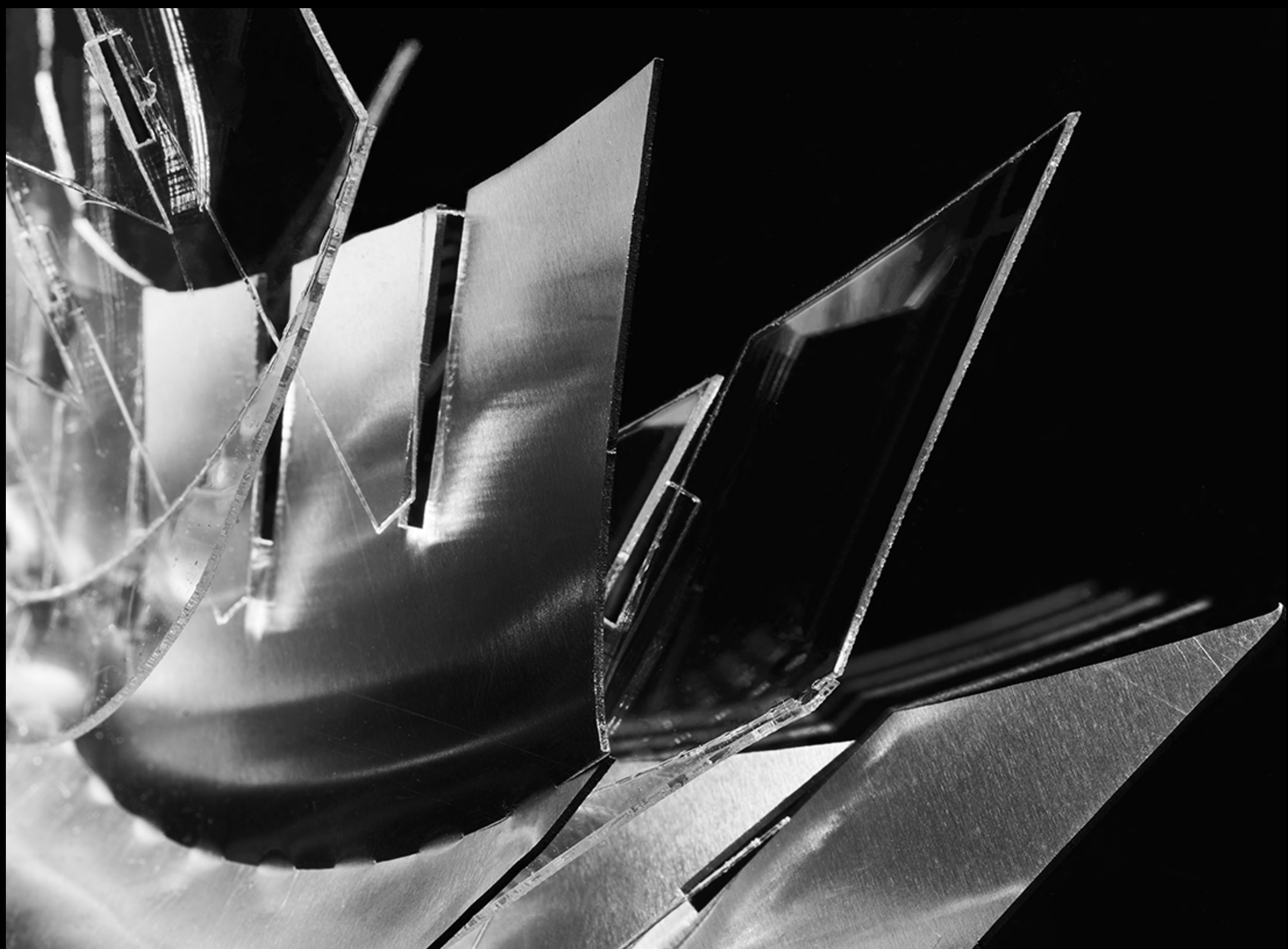
Final Mapping Formulas and Product

$$f_{\text{Crease}}(u,v) = (\\
cos(u+0.5v)(0.8|v-0.5\pi|^{1.5}+0.2\pi)+0.33cos(0.25uv+0.125v^2),\\
sin(u+0.5v)(0.8|v-0.5\pi|^{1.5}+0.2\pi)+0.33cos(0.25uv+0.125v^2),\\
cos(v)\\
)$$

$$f_{\text{Edge}}(u,v) = (\\
cos(u+v)sin(v)+0.25cos(3u+3v),\\
sin(u+v)sin(v)+0.25sin(3u+3v),\\
cos(v)\\
)$$







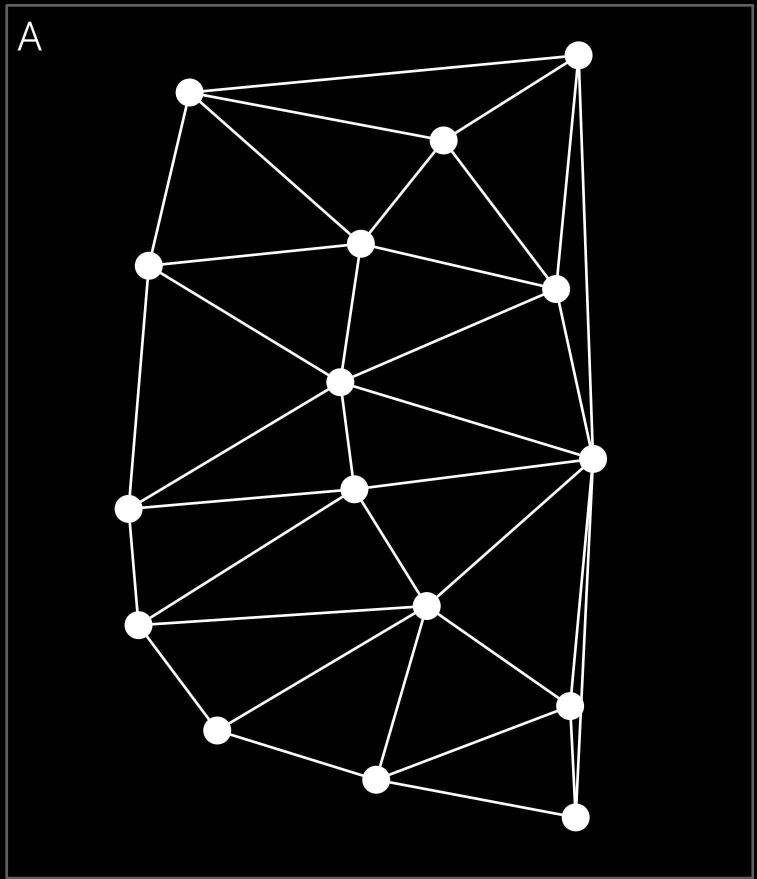
Minimum Spanning Erosion

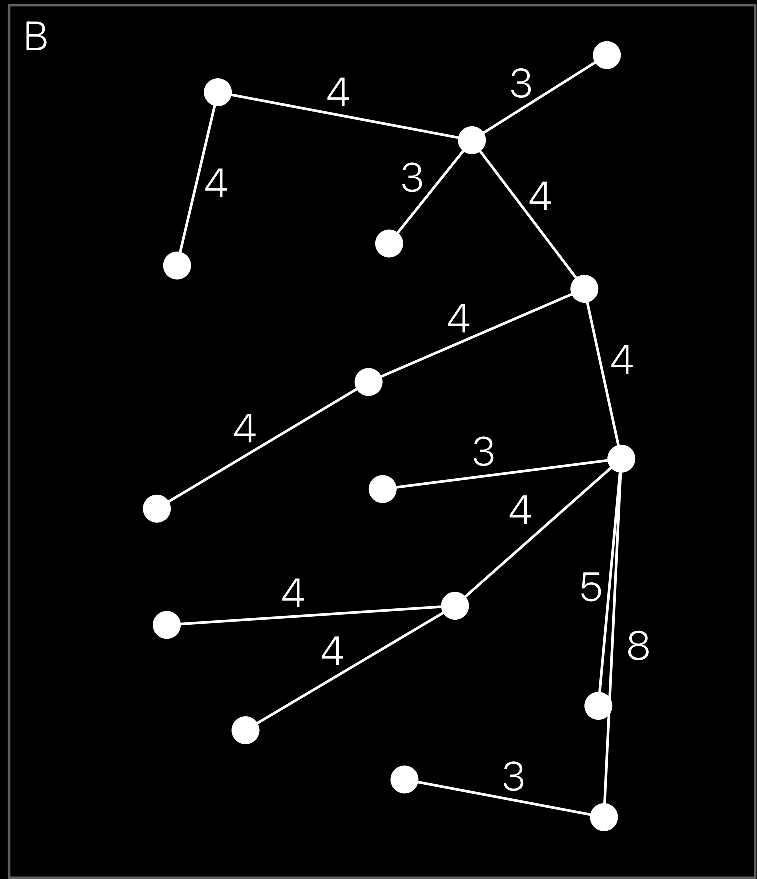
Individual | Independent Work | 2023

Algorithmic Design, C# in Grasshopper, Fabrication

This project is an extension of *Computed Transparency*, where I explore the fusion of parametric modeling with tangible materials. I experimented with the application of graph theory algorithms from computer science to the design and fabrication of decorative objects. Specifically, I transformed the 'minimum spanning tree' algorithm into a tangible tree form that artistically erodes the shape of a cube. The crafted negative spaces are dynamic, evolving from a unified space on one side to a fragmented composition on the other. Additionally, I harnessed the unique properties of layered acrylic sheets, which reflect and transmit light, to create captivating visual effects within these hollow spaces.

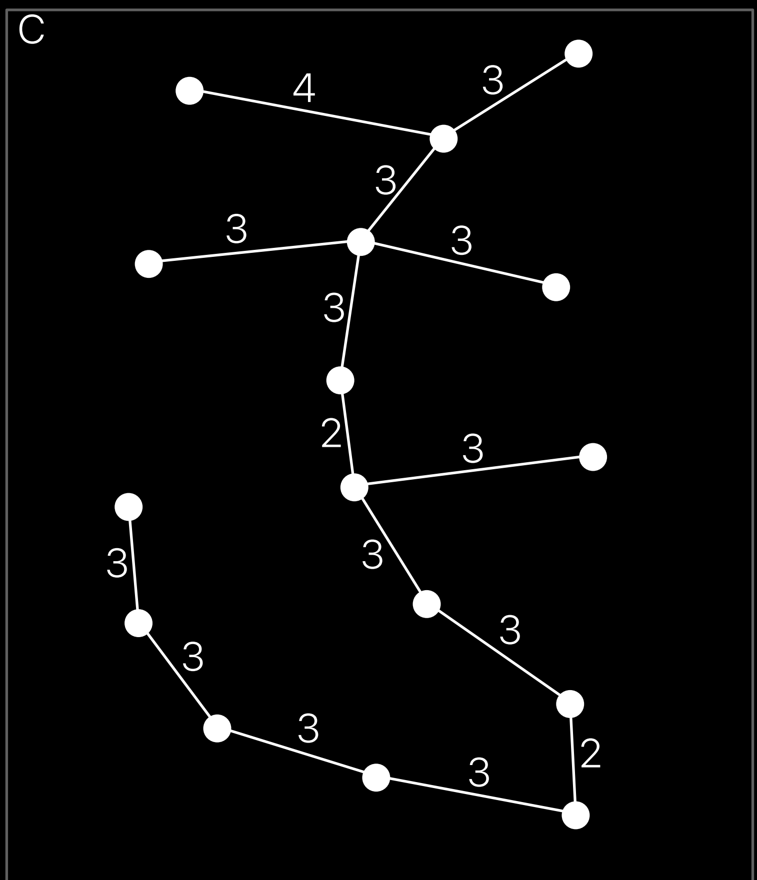
Minimum Spanning Tree

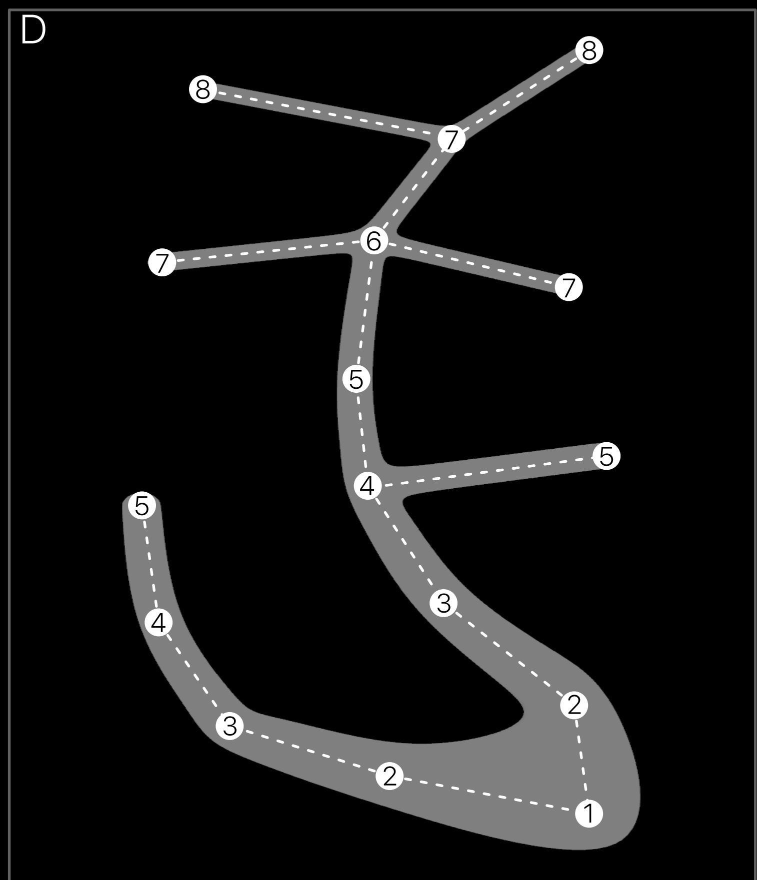




In computer science, **graph** is an abstract data type that contains a set of **vertices** and a set of **edges** that connects these vertices. Here, I associated vertices with **physical points** populated in 2D space and generates edges with **Delaunay triangulation algorithm**.

Tree is a graph that contains no cycles. Through visualization, it also looks like branches of actual bush or tree. A **spanning tree (ST)** of a graph refers to **a subgraph that includes all vertices of the graph**. In this diagram, I noted lengths of the constructued edges for next step.

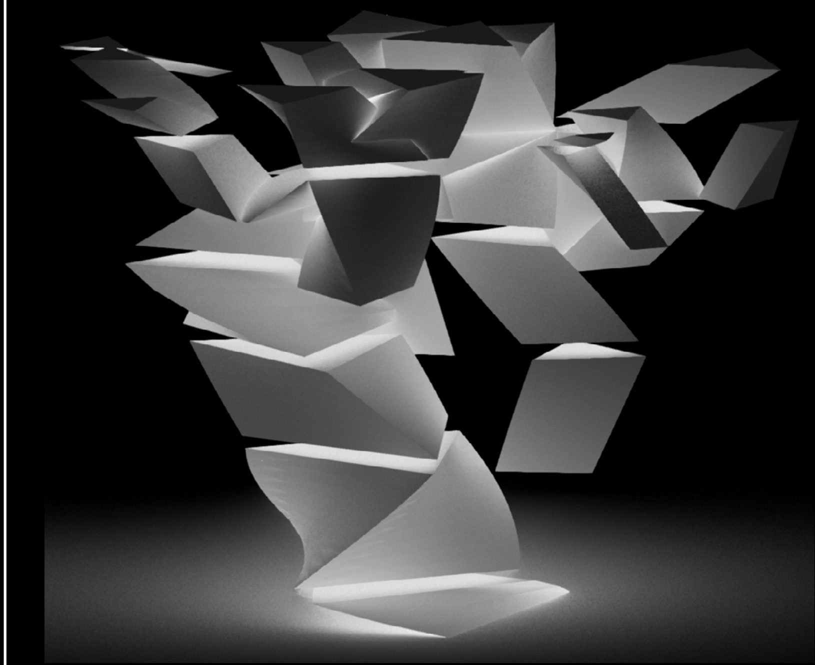


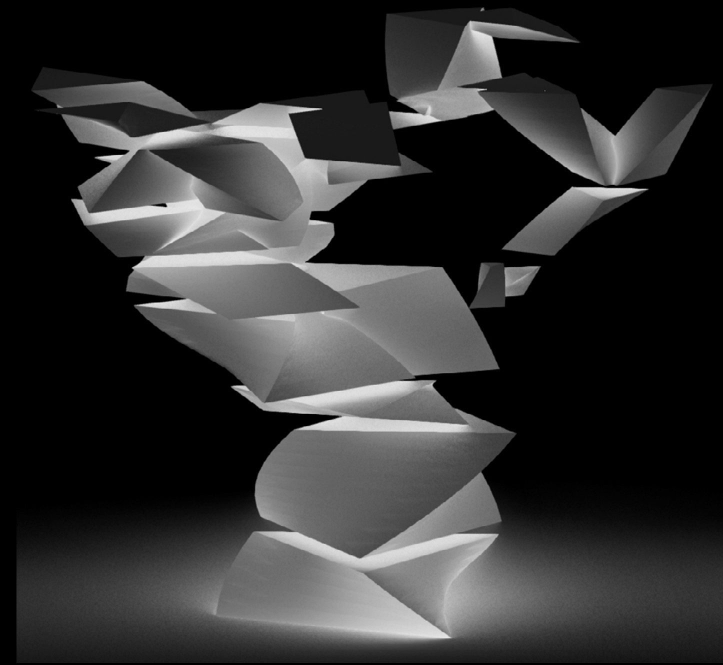


A **minimum spanning tree (MST)** is one of the spanning trees of a graph that has a **minimum possible total edge weights**, or distances in this scenario. This diagram shows the MST of the graph in diagram A, having a total distance of 44 (61 for the ST in diagram B).

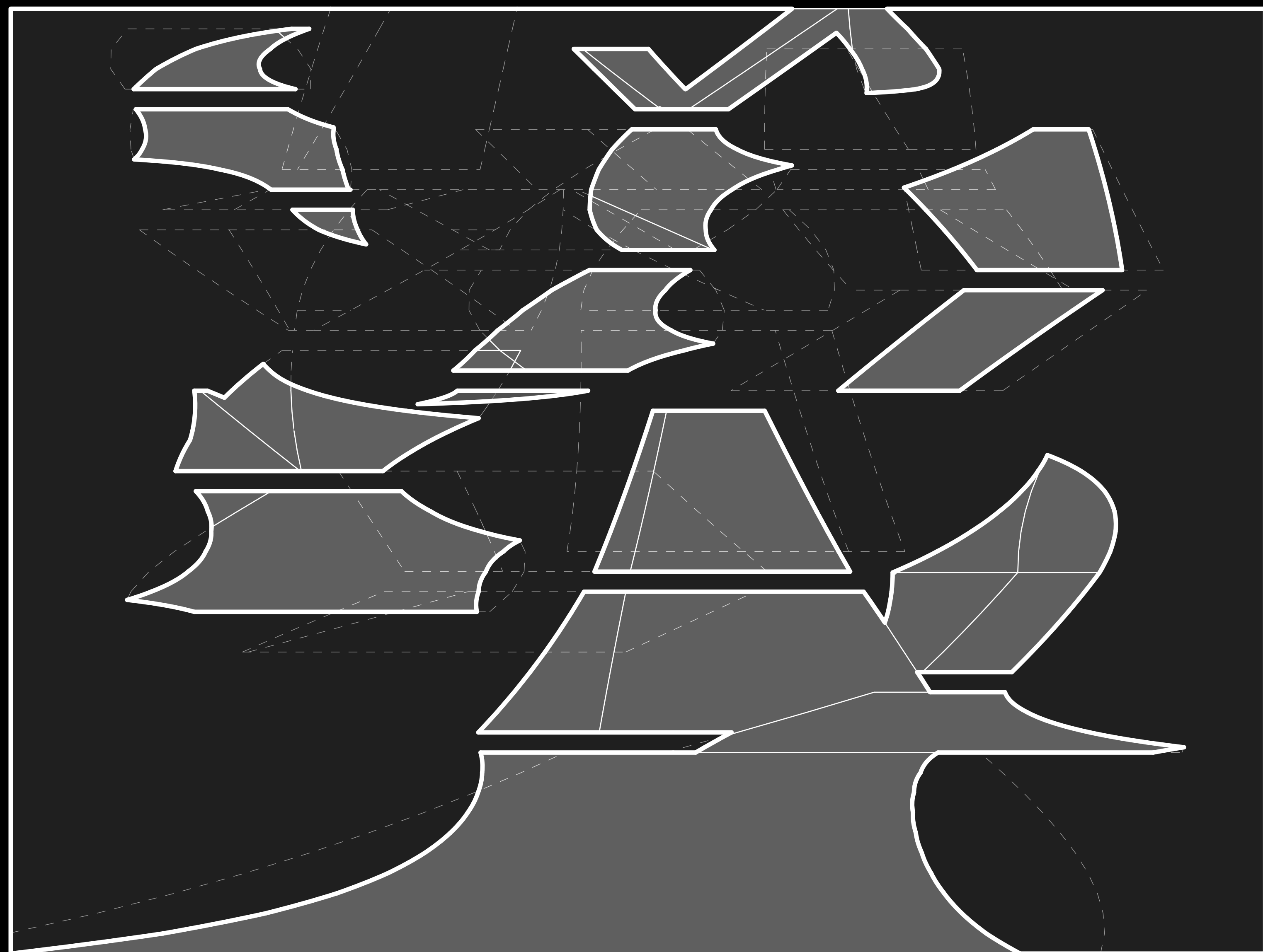
Through a **breadth-first search**, it is easy to calculate depth from the root to each vertex. By mapping depth to radius, I created an organic structure that mimics the form of trees as well as preserve the features of pre-defined points.

Prototypes

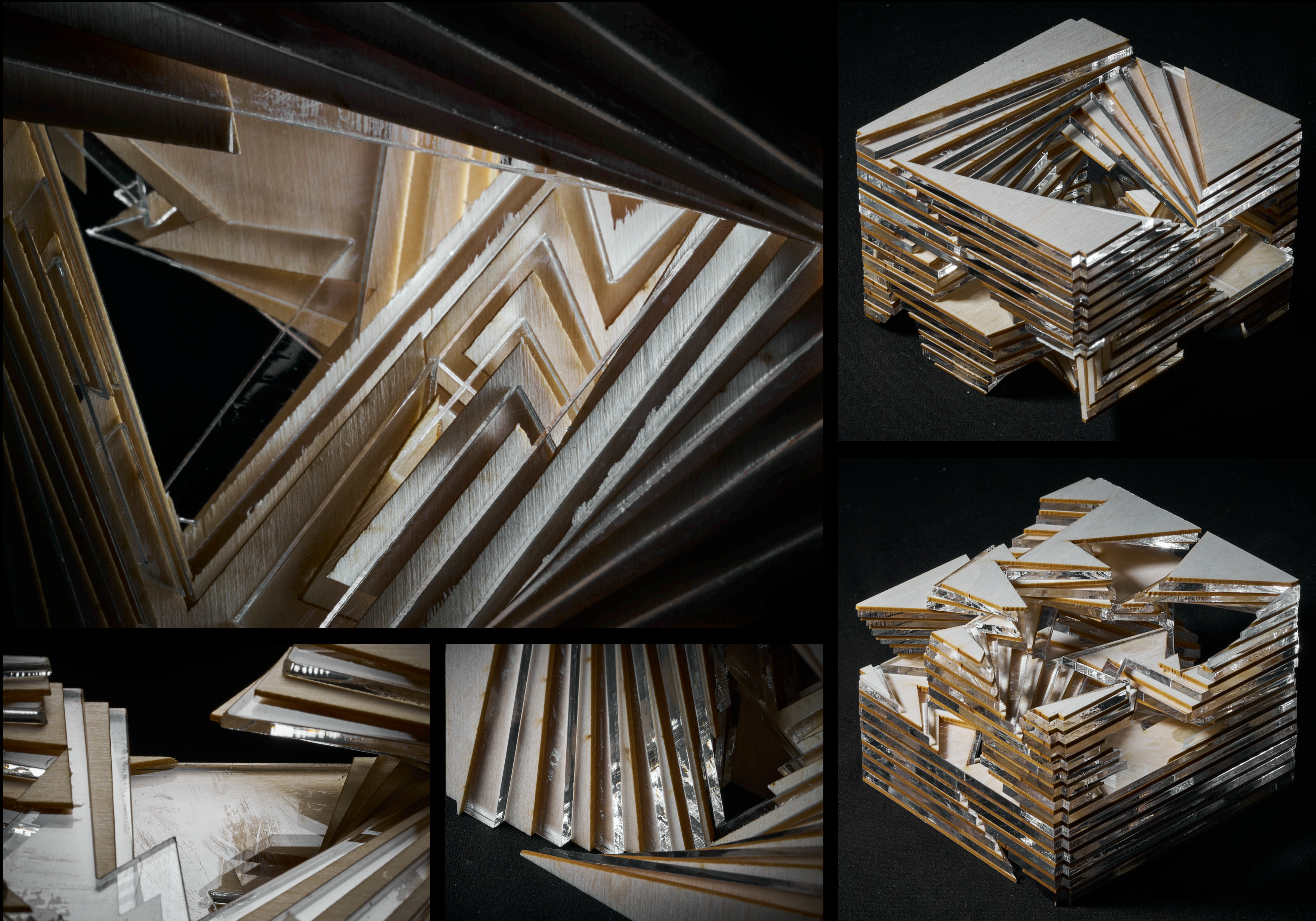




Utilizing the algorithms, I designed a system that generates tree-like physical structures. This system automatically generates intricate forms that mimic the organic complexity of trees. The 'branches", twisting triangular prisms, weave together to form a dynamic dance of geometries. marries the elegance of natural forms with the structured precision of computational principles.



By boolean subtracting the generated tree stucture from a cube, the tree's volumes are transferred into captivating hollow spaces within. While the primary focus of this project lies in the artistic sculpting of these forms, its potential extends far beyond. The unique interplay of space and structure opens up possibilities in spatial design, making it a valuable asset for architectural explorations.



Unfamiliar Familiarity

Individual | CityU SM3138 | 2021

Photography, Computer Vision, Image Editing, OpenFrameworks

During three years of life in Hong Kong, I have taken a large amount of photos of the streets here. As I gradually formed my own habits of composition and post-processing, I noticed a unique rhythm appearing across my photos. Vignetting effect, similar perspective, avoidance of obstructions... All these factors together defamiliarized my subjects from the reality in our eyes. In this project, I further explored the rhythm in my photography works by deepening the sense of unfamiliarity through digital processing methods and creating a series of artistic images. Then, I imagined an installation that reconstructs my rhythm in reality and creates an experience that can perceive such unfamiliar familiarity.

In this project, I mainly focused on my photos of cheap stores and fruit stalls around Sham Shui Po and Mong Kok District. There are lots of shops and stalls selling cheap goods. Around dinner time every day, the streets are always chaotic and noisy as local people coming to have meals and buy stuffs are crowded with passing cars and stalls on the road.

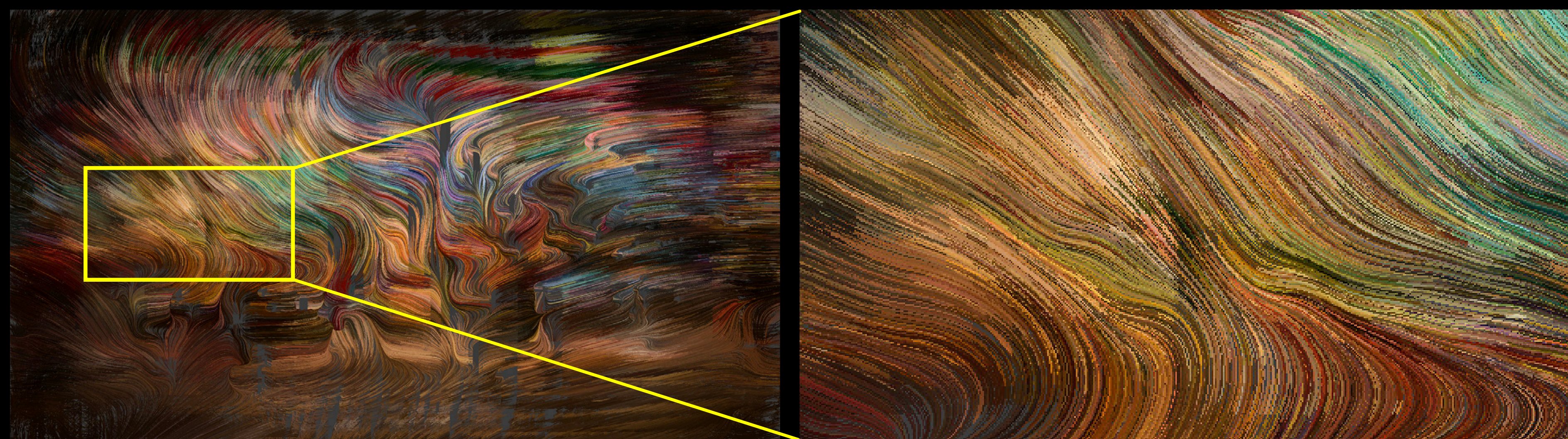
On the contrary, the streets in my photos tend to be unusually deserted, since I often go for a walk there at later night. Combined with my habit of front-view shooting instead of our normal perspective, a sense of unfamiliarity was created contrasting the usually crowded streets that local people are familiar with.

I mainly used feature extraction and optical flow from OpenCV for extracting the pedestrians motions.
For two consecutive frames, first, feature extraction algorithm will find and record all “trackable” points, the feature points (in yellow).

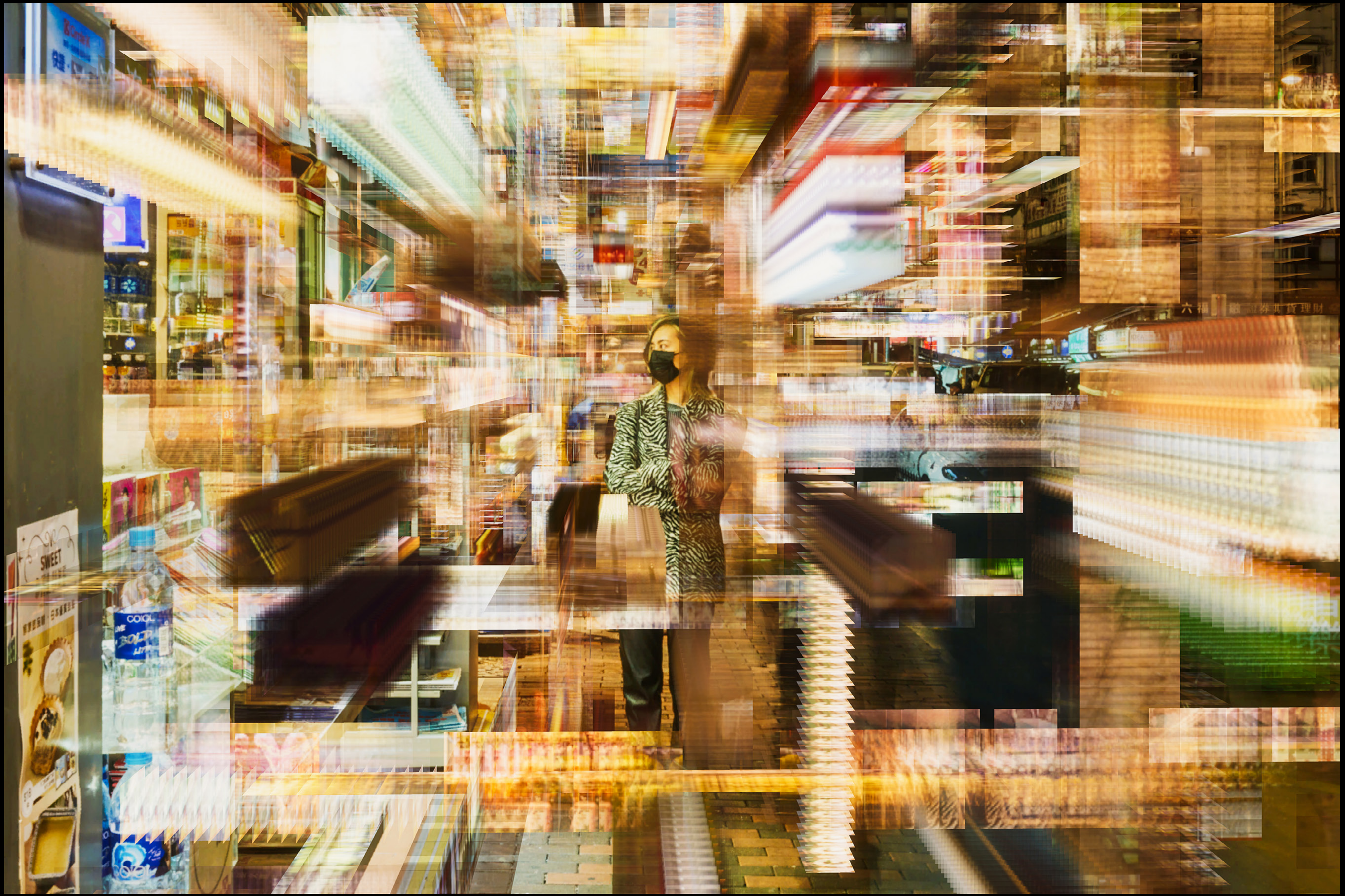
Second, optical flow algorithm will extract the motion of the tracked feature points to 2D vectors indicating both directions and distances (yellow lines).

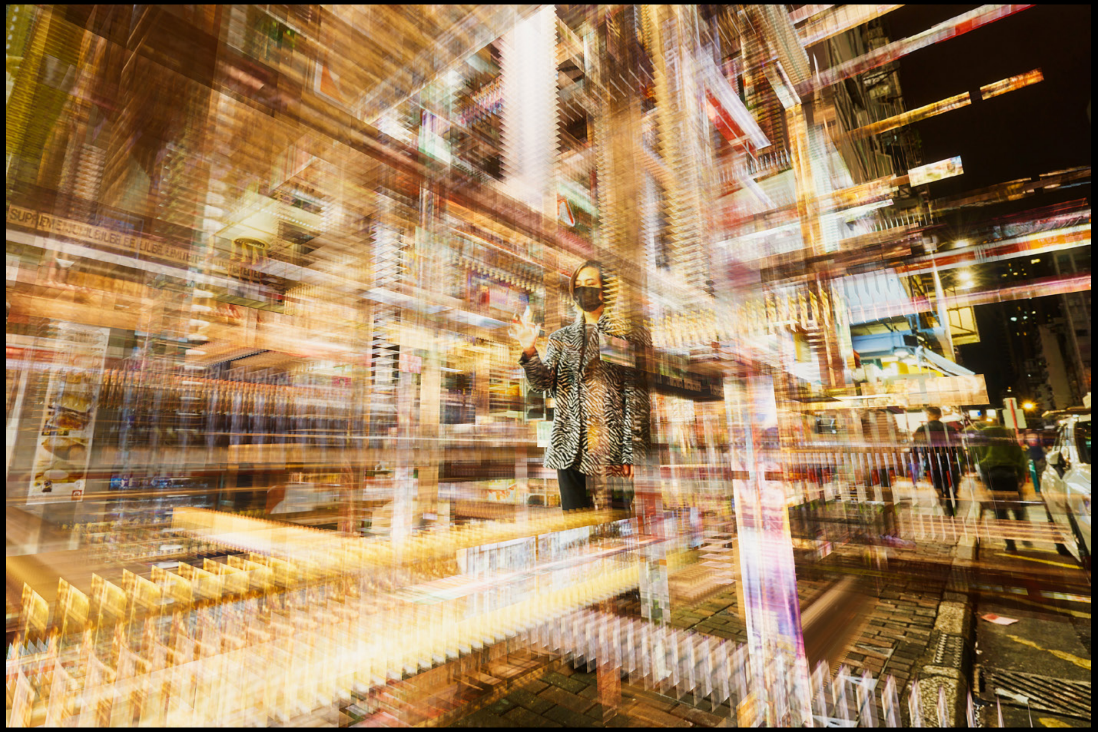
Third, I expand the vectors into flow direction with impact factor following inverse-square law. As a result, The flow directions near moving pedestrian will be highly disturbed, while those at other areas will be smooth.

Lastly, I programmed the pixels to follow the calculated flow directions, to emphasize the motions and disturbances to the scene from the pedestrians.



Last, I generated an installation based on the physical world - at space in front of a store. I tried to convey the order and chaos from the previous experiments by filling the space with sequences of image fragments.
(Model: Larissa Wang)





AngleCAD: Surface-Based 3D Modelling Techniques on Foldable Touchscreens

Can Liu, **Chenyue Dai**, Qingzhou Ma, Brinda Mehra, Alvaro Cassinelli

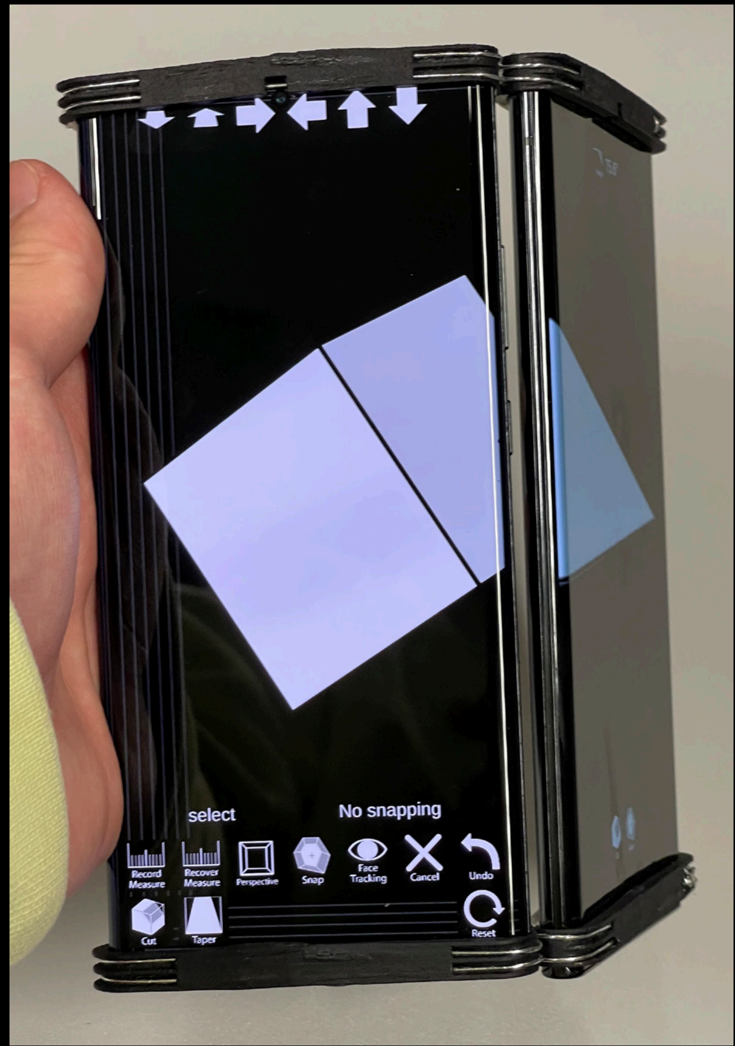
Published on ACM ISS 2022

Personal Contributions: Research assistance, Computational geometry, Gesture interactions, Inter-device communication, Perspective simulation

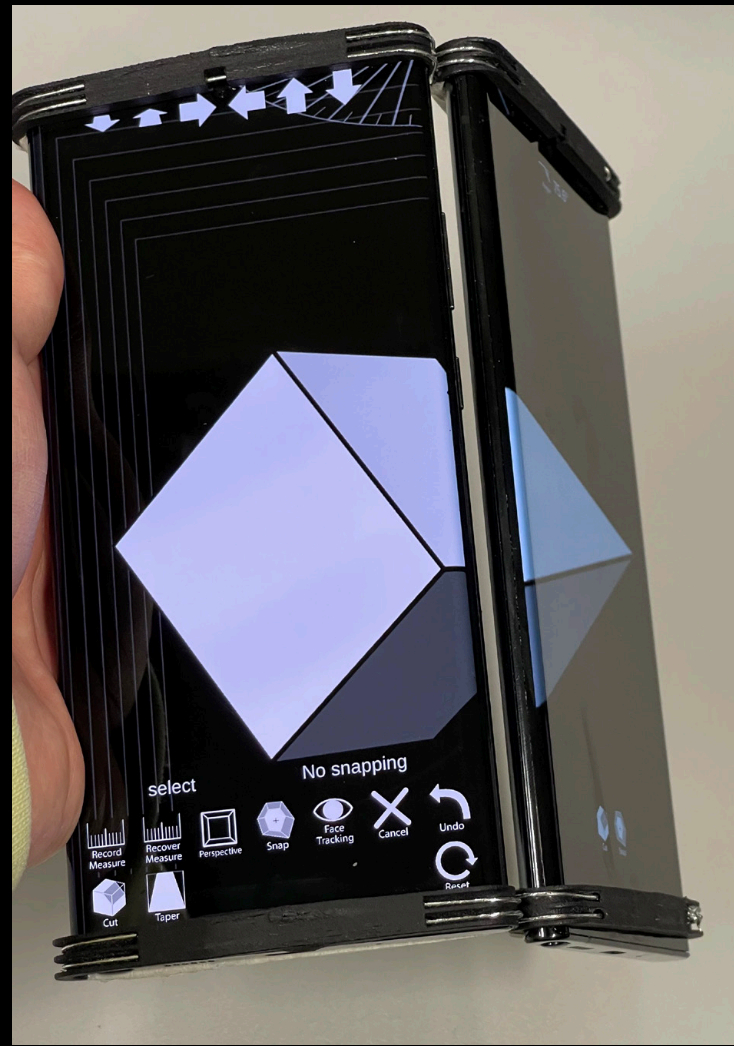
Abstract: 3D modelling and printing are becoming increasingly popular. However, beginners often face high barriers of entry when trying to use existing 3D modelling tools, even for creating simple objects. This is further complicated on mobile devices by the lack of direct manipulation in the Z dimension. In this paper, we explore the possibility of using foldable mobile devices for modelling simple objects by constructing a 2.5D display and interaction space with folded touch screens. We present a set of novel interaction techniques - AngleCAD, which allows users to view and navigate a 3D space through folded screens, and to modify the 3D object using the physical support of touchscreens and folding angles. The design of these techniques was inspired by woodworking practices to support surface-based operations that allow users to cut, snap and taper objects directly with the touch screen, and extrude and drill them according to the physical fold angle. A preliminary study identified the benefits of this approach and the key design factors that affect the user experience.

Real-time perspective simulation supported by face-tracking function:

When the device is tilted, the device can adapt the user's line of sight so that the object also looks "tilted". The separated programs running in two devices are synchronized so that the simulation displays across two screens.



The user observes from directly above.



The user observes from a lower angle, thus can see the bottom of the object.

The user observes from a higher angle, thus can see the top of the object.

Angle detection and clipping:

The application detects and adapts the tilting angle between two screens. When the object intersects with the screen, it will be clipped and the clipping plane will be highlighted in red.

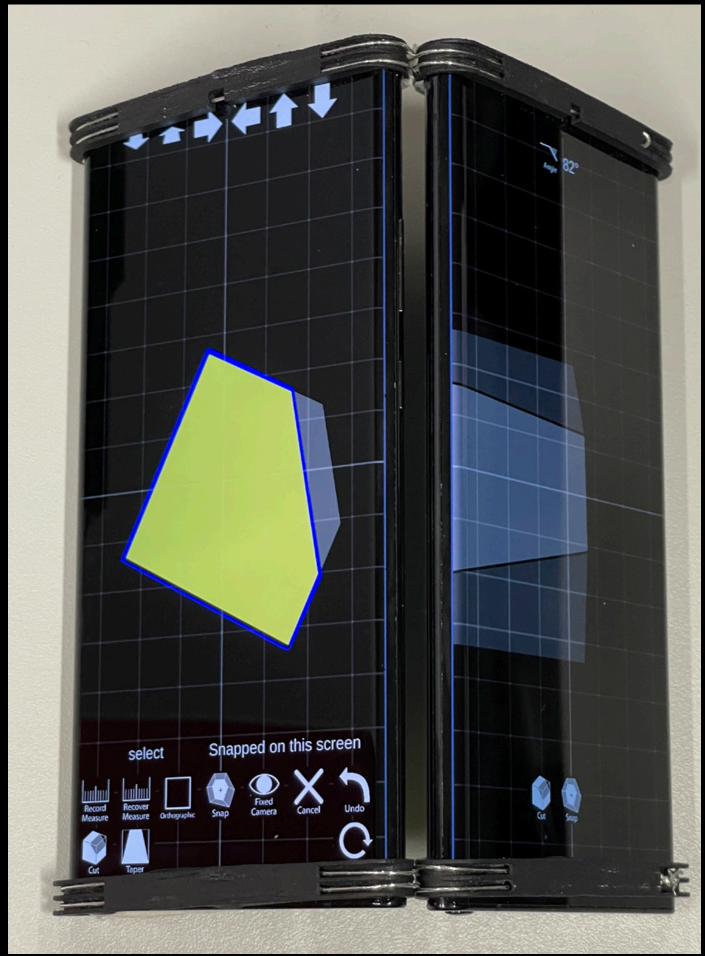
The right screen tilts 13.3° relative to the left screen

62.3°, a corner of the cube is clipped by the

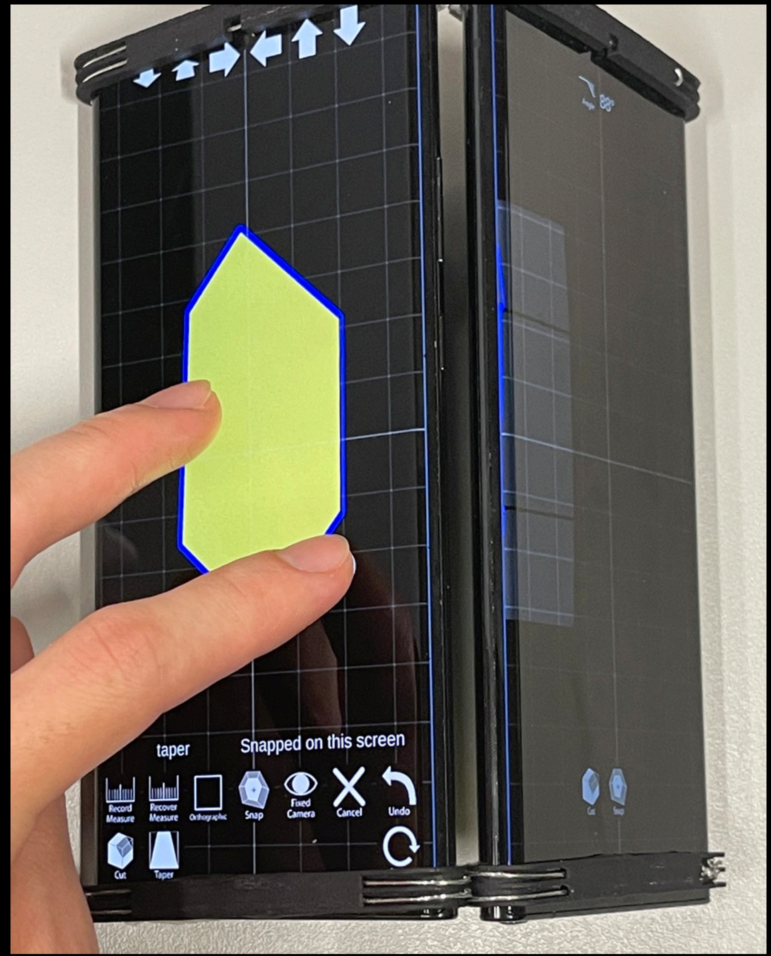
82°, a larger part of the cube is clipped

Function 1: Surface sticking and view mode switching:

Selected surface can be stucked to the screen for direct operations (highlight in yellow).
When stuck, the application will switch to orthographic view.



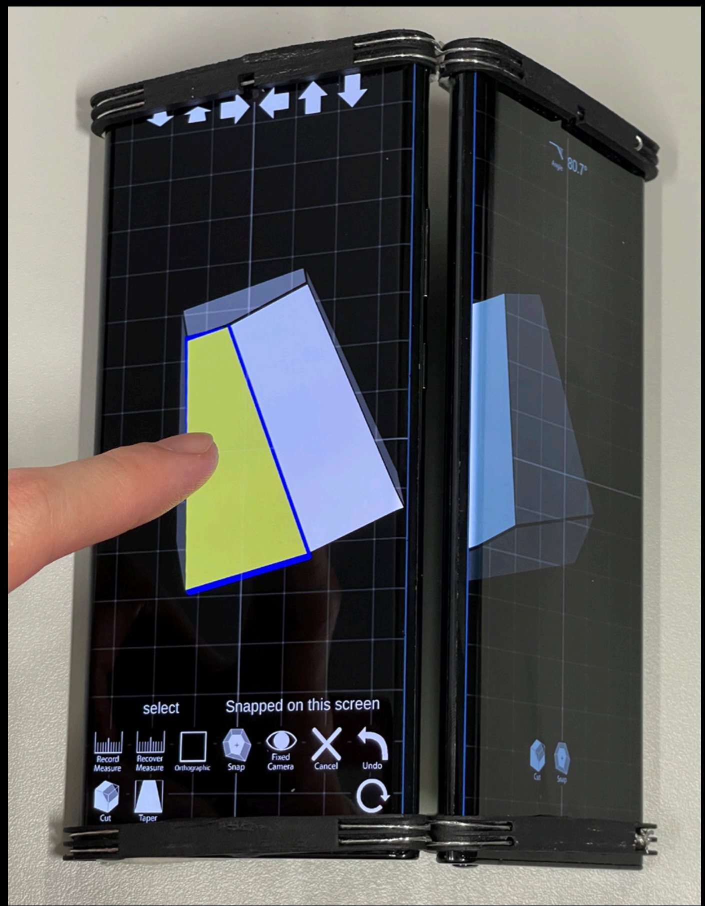
Orthographic view of the object with real scale measuring grid (top view on the left, side view on the right)



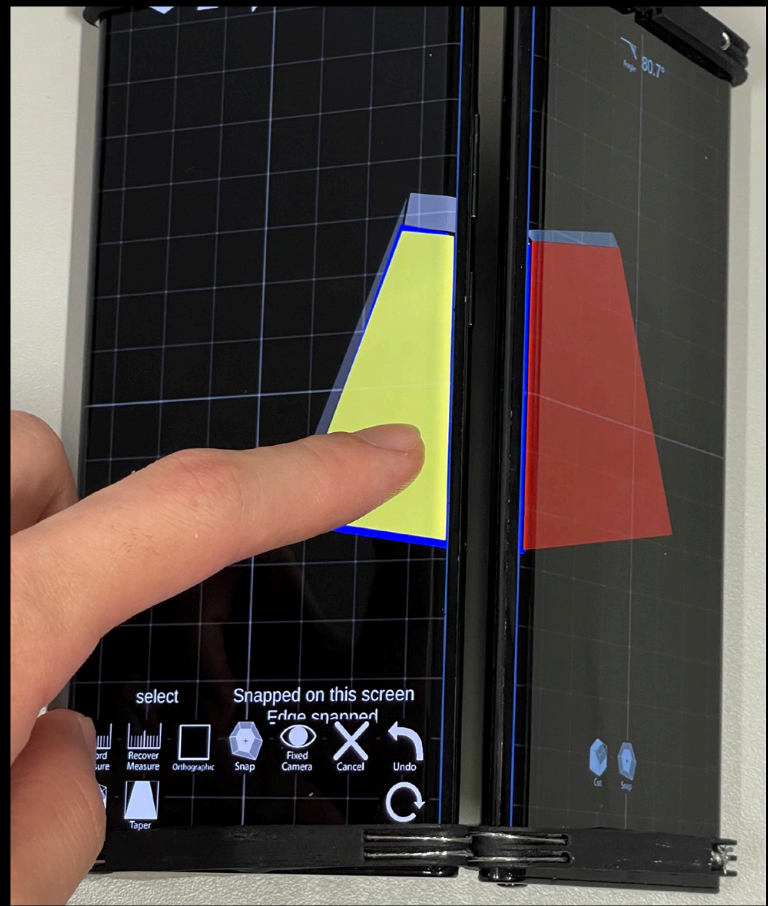
User can measure and resize the object based on the grid (in centimeter)

Function 2: Edge alignment:

When the object is push towards the edge between two screens, it automatically turns to align with the edge, as if the other screen "blocks" its way.



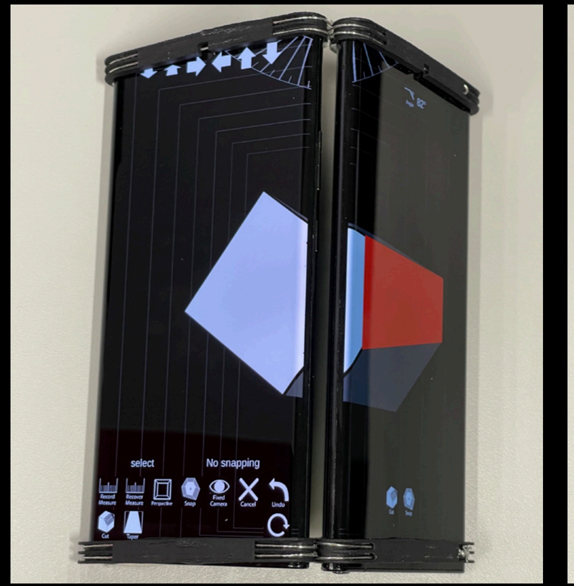
When a surface is stuck, the object can only move in paralled with the screen.



When the object is push towards the edge, it automatically turns to align with the edge.

Function 3: Cut

The screen can act as a cutting plane to cut away the clipped part of the object.



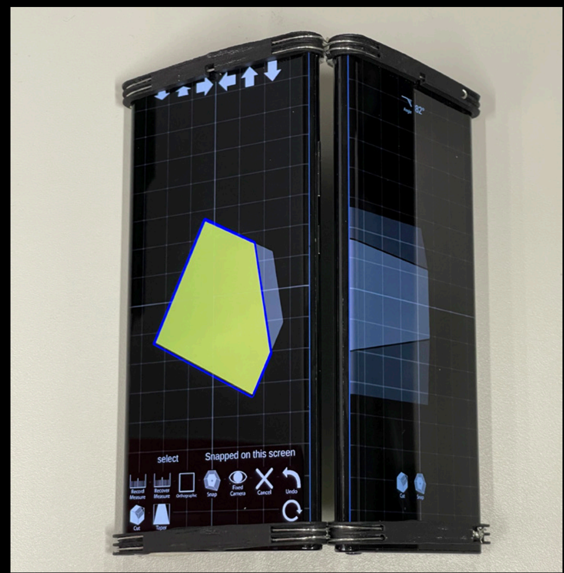
The cube is clipped by the right screen, but not cut yet.

The clipped part is cut away and a new surface is created.

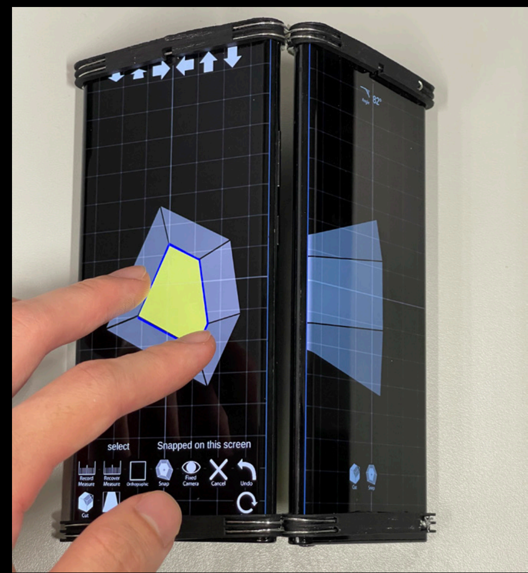
A better view of the remaining object (result in red circle).

Function 4: Taper

When a surface is stuck to the screen, the user can taper (resize) the surface by two fingers pinching.



The object is stuck to the screen



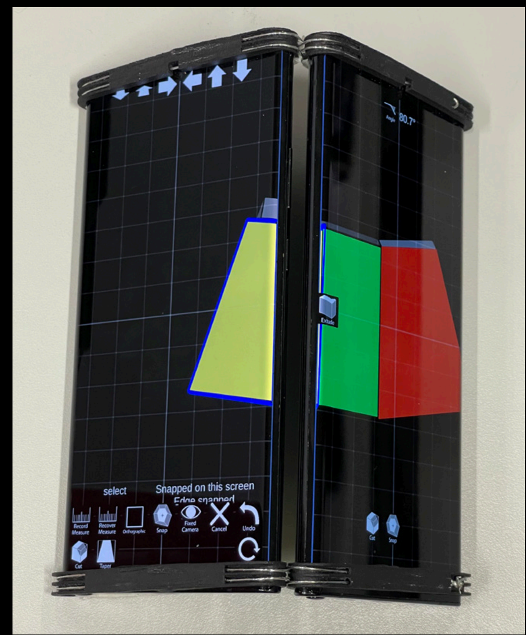
The highlighted surface is resized.

View from another angle (result in red circle).

Function 5: Surface extrusion

When the object is stuck to the screen and align with the edge, the user can drag the button to extrude the selected surface.

Drag to extrude the stuck surface.

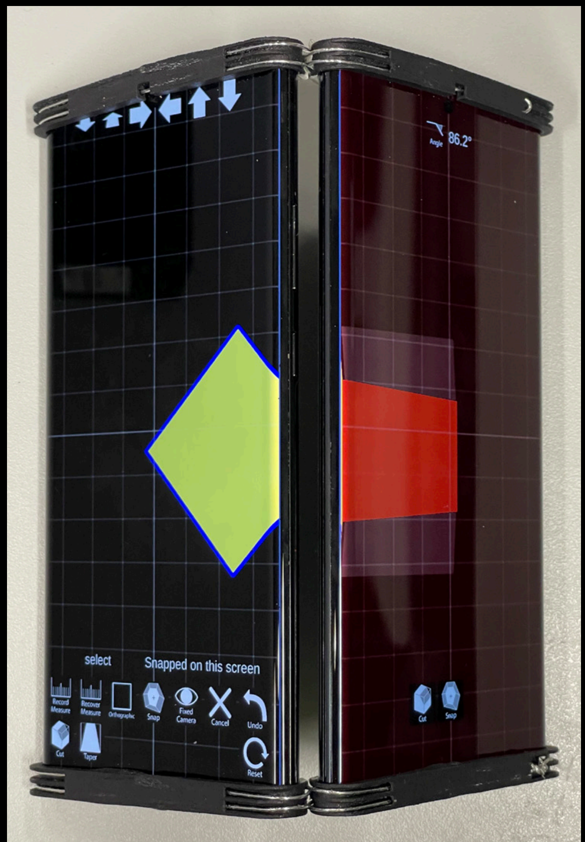


Extrusion result.

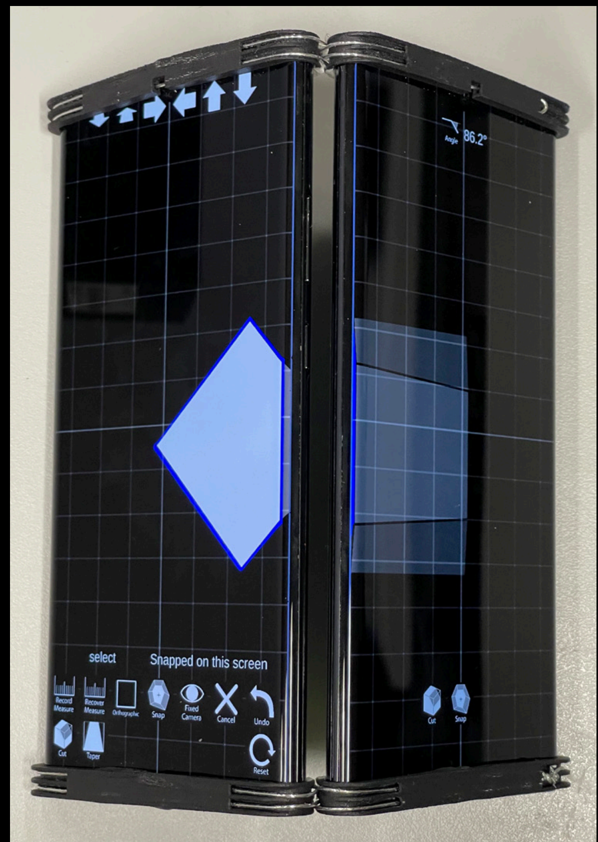
View from another angle (result in red circle).

Example Use Case: Create a “Diamond” from a Cube

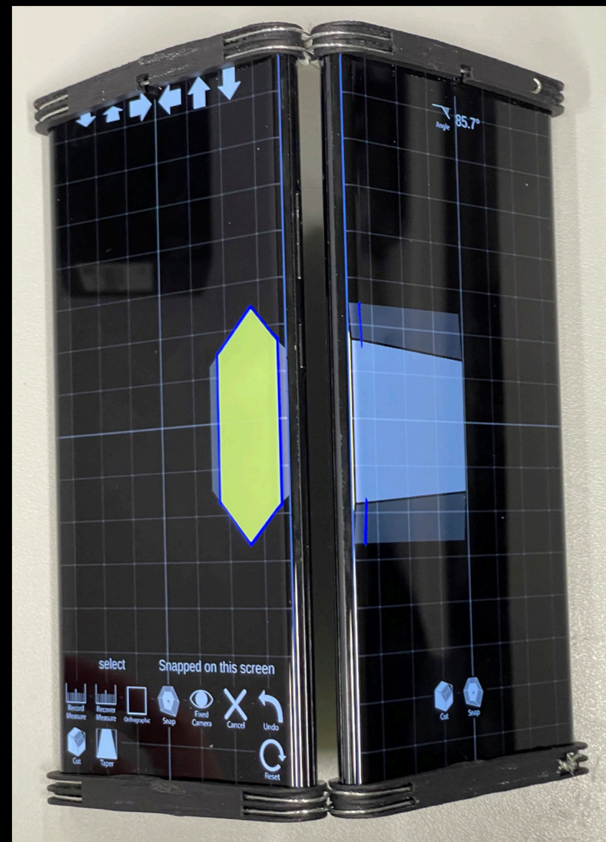
In this designed scenario, I created a diamond-like object from a simple cube to further show the functionality of the application. The photos below demonstrate the detailed steps I used.



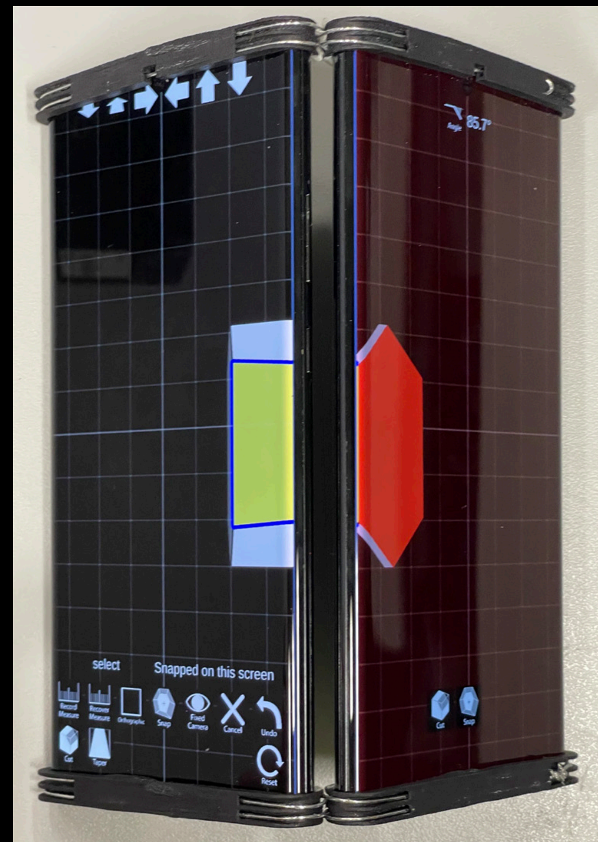
1. I started by cutting the corner of the cube.



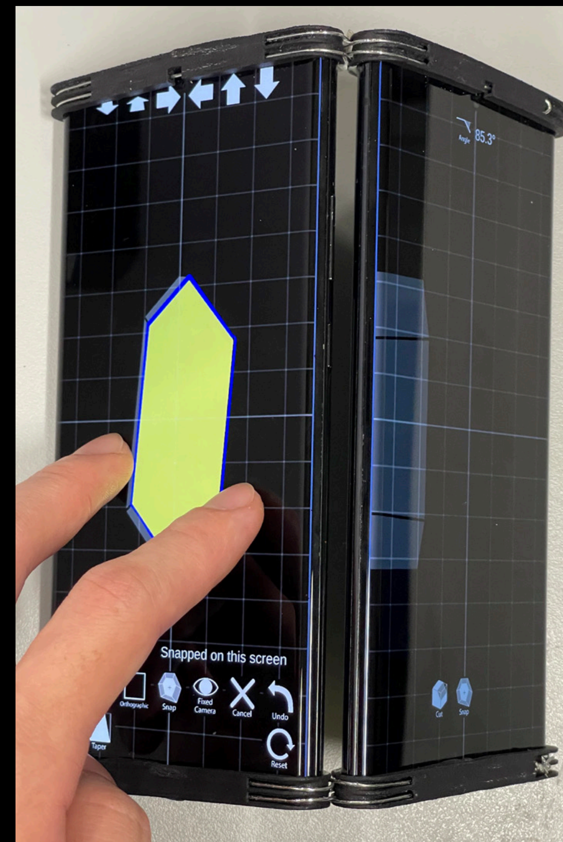
2. The cube was turned into a prism.



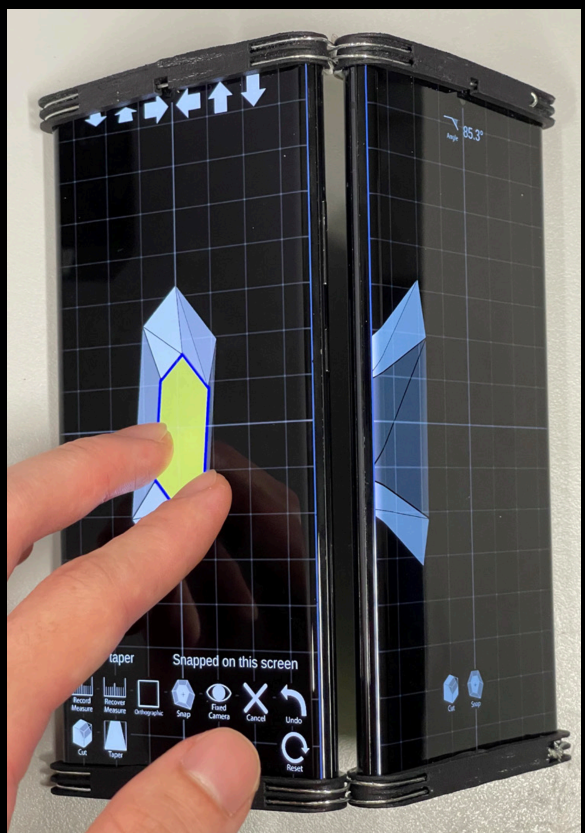
3. I cut another corner and it became hexagonal prism.



4. I cut away half of its height.

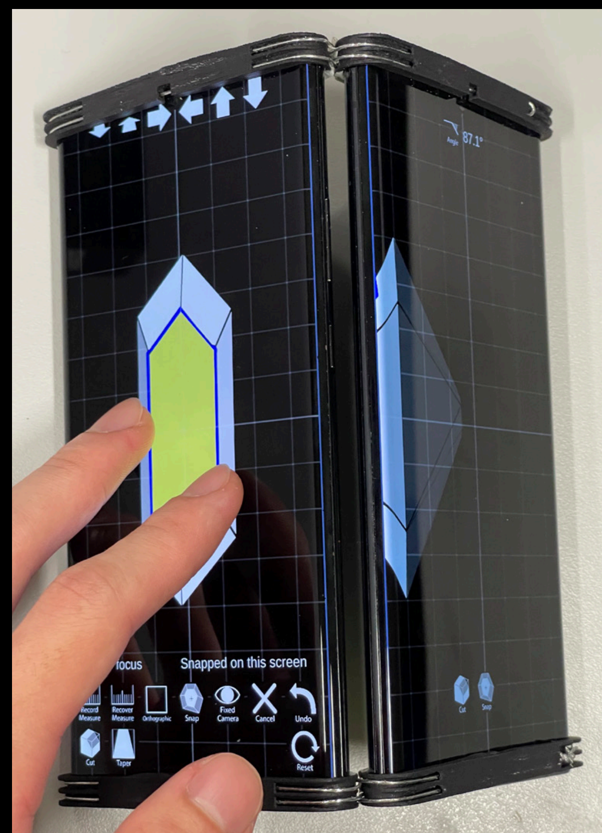


5. I turned the object to operate on its top surface.

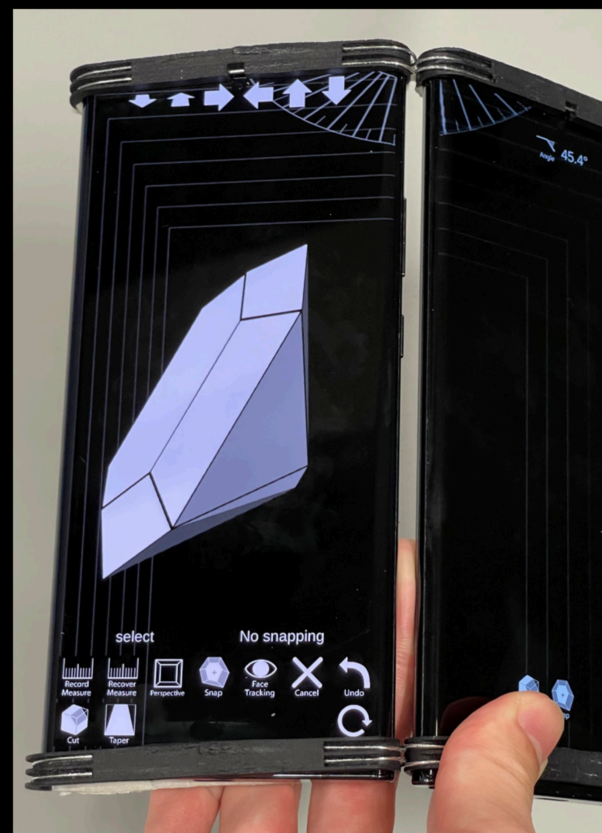


6. I tapered (resized) the top surface to create the tip of the diamond.

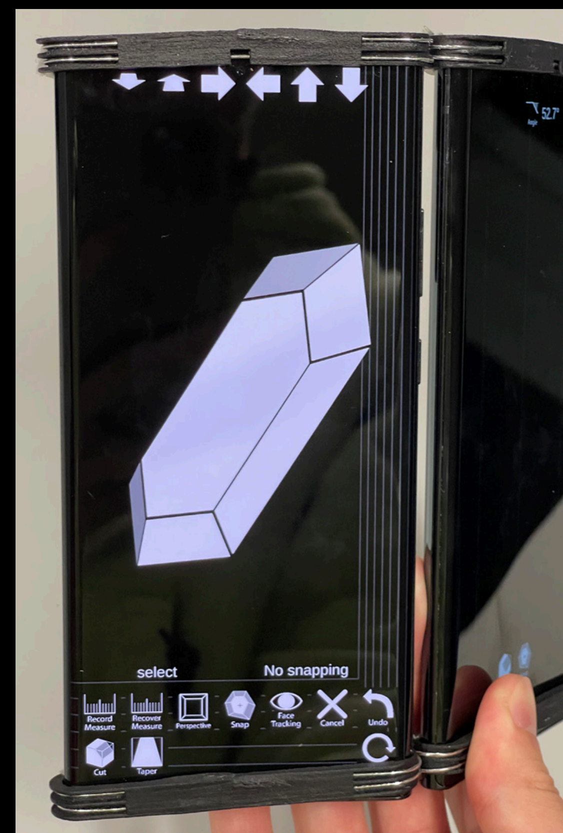
7. I extruded the other top surface to create the canopy part.



8. I tapered (resized) the surface to complete the canopy part.



9. The completed diamond-like object.



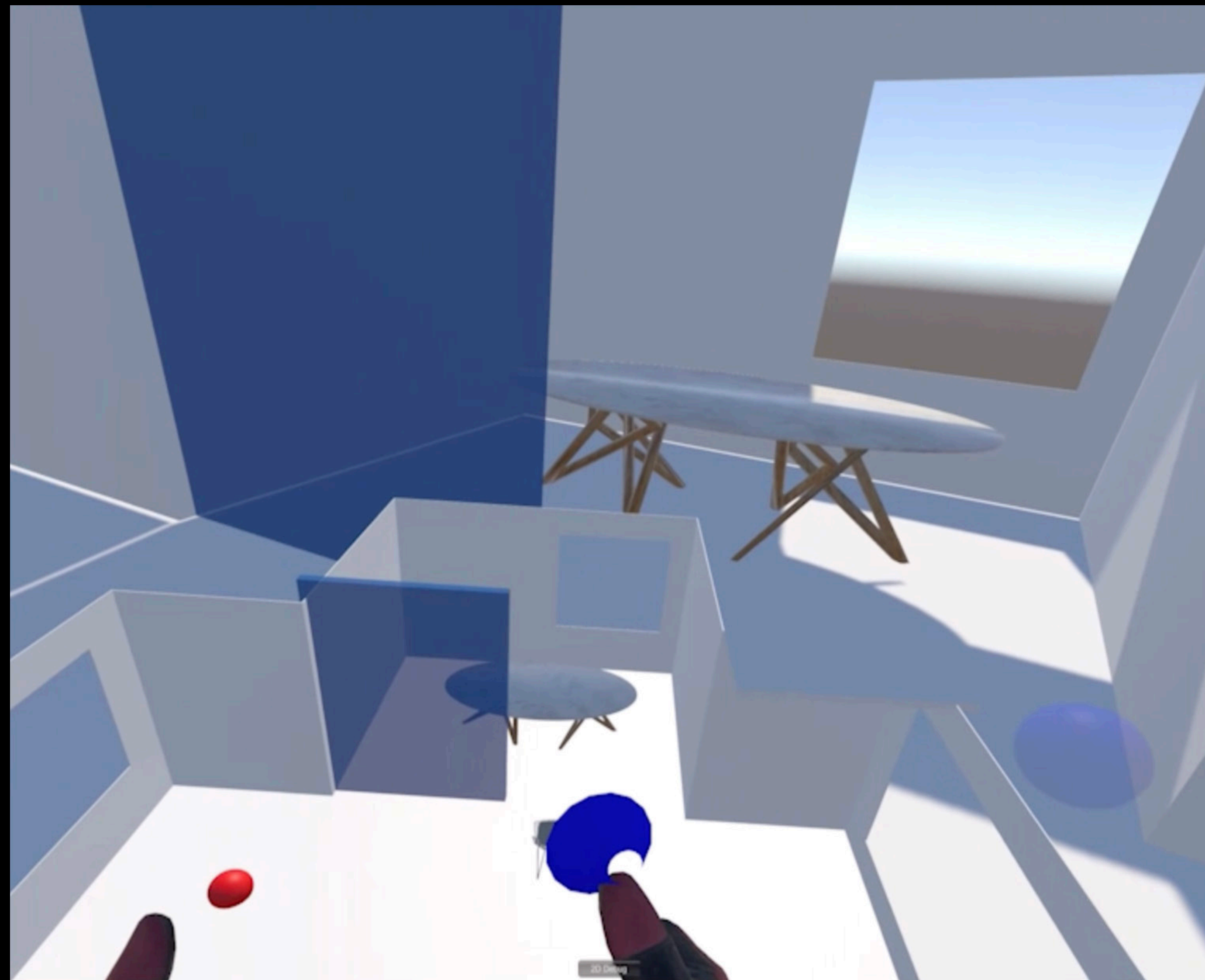
10. The completed diamond from another angle.

Examining the Effects of Geometric Fidelity in a VR Spatial Design Tool

Lan Wei, **Chenyue Dai**, Xuening Peng, Xin Tong, Lan Wei
Pending Result from ACM CHI 2024

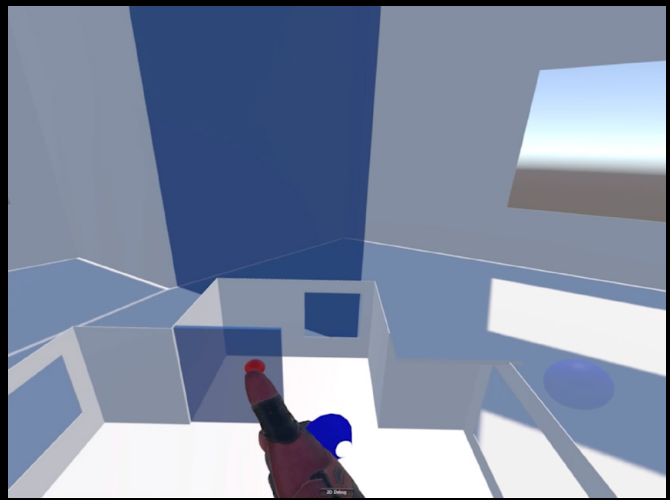
Personal Contributions: Literature Review, Computational geometry, VR interaction Development, Result analysis

Abstract: In spatial design, non-professionals rarely have hands-on opportunities to participate in the design process nor effectively express their needs beyond using words and sketches. While VR can support spatial design, existing research and applications mostly focus on providing High-fidelity objects for users to choose and place around. In this work, we present a user study comparing two versions of a VR tool for spatial design, which provides building blocks in low and high geometric fidelity, respectively. 18 participants were recruited to use both prototypes to complete home designs, and 4 professional designers evaluated their works and interpreted their design intents. We found that the Low-fidelity version allowed participants to think more openly and creatively, leading to a more holistic expression of spatial design. In contrast, while the High-fidelity version promoted users' thinking of everyday scenarios, this fidelity condition limited participants' imagination and shifted their focus to details.



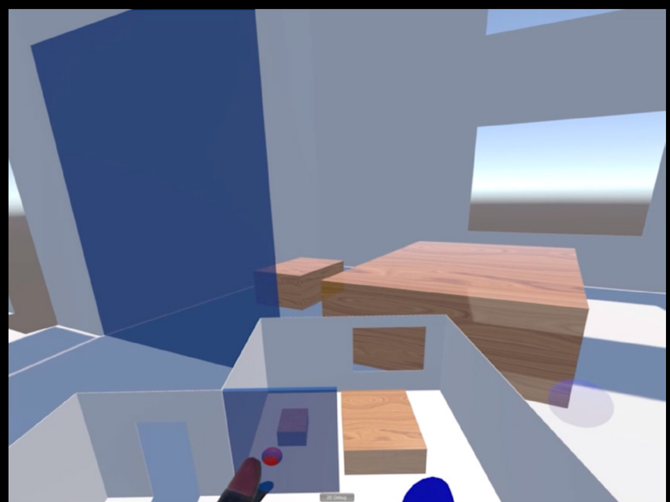
Functions of the Testing System

The system is a VR interactive environment allowing users to prototype their interior design ideas with given assets.

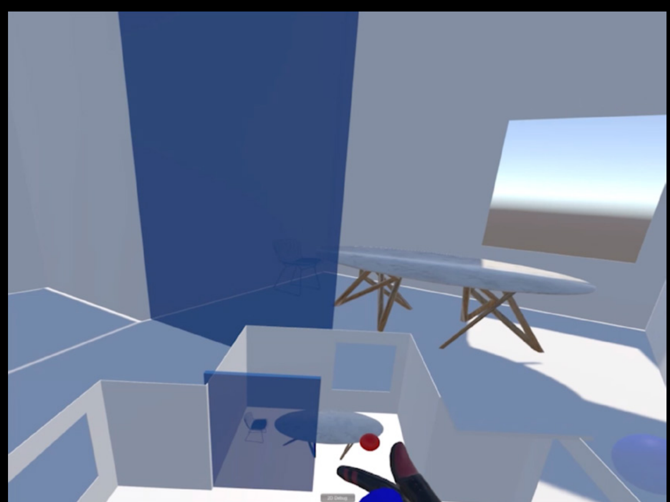


It allows common object manipulation including translating, scaling, rotating, and change of textures.

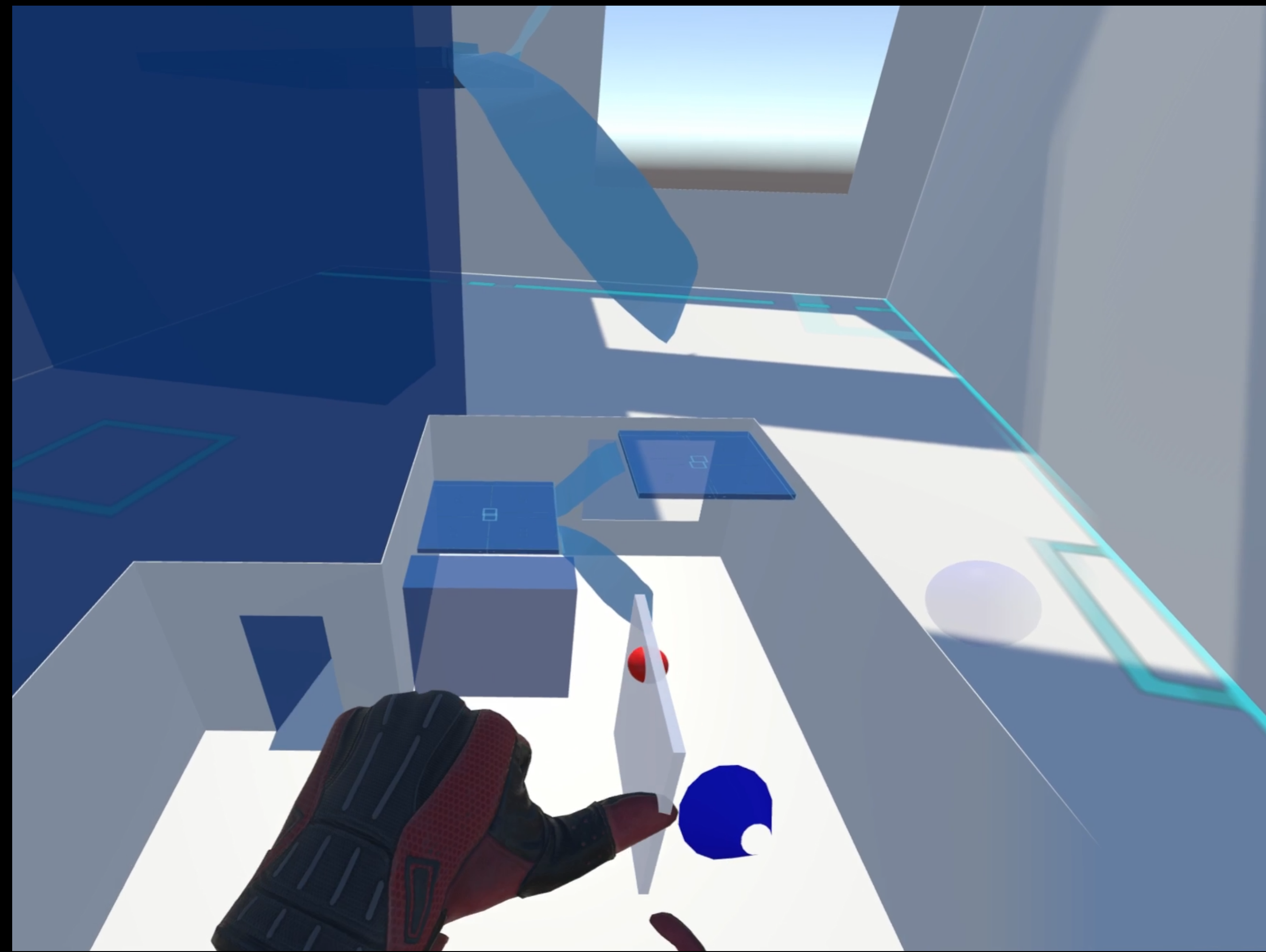
For studying low fidelity, the system provides user with primitive geometries, encouraging them to imagine and signify the space they hope to live in.



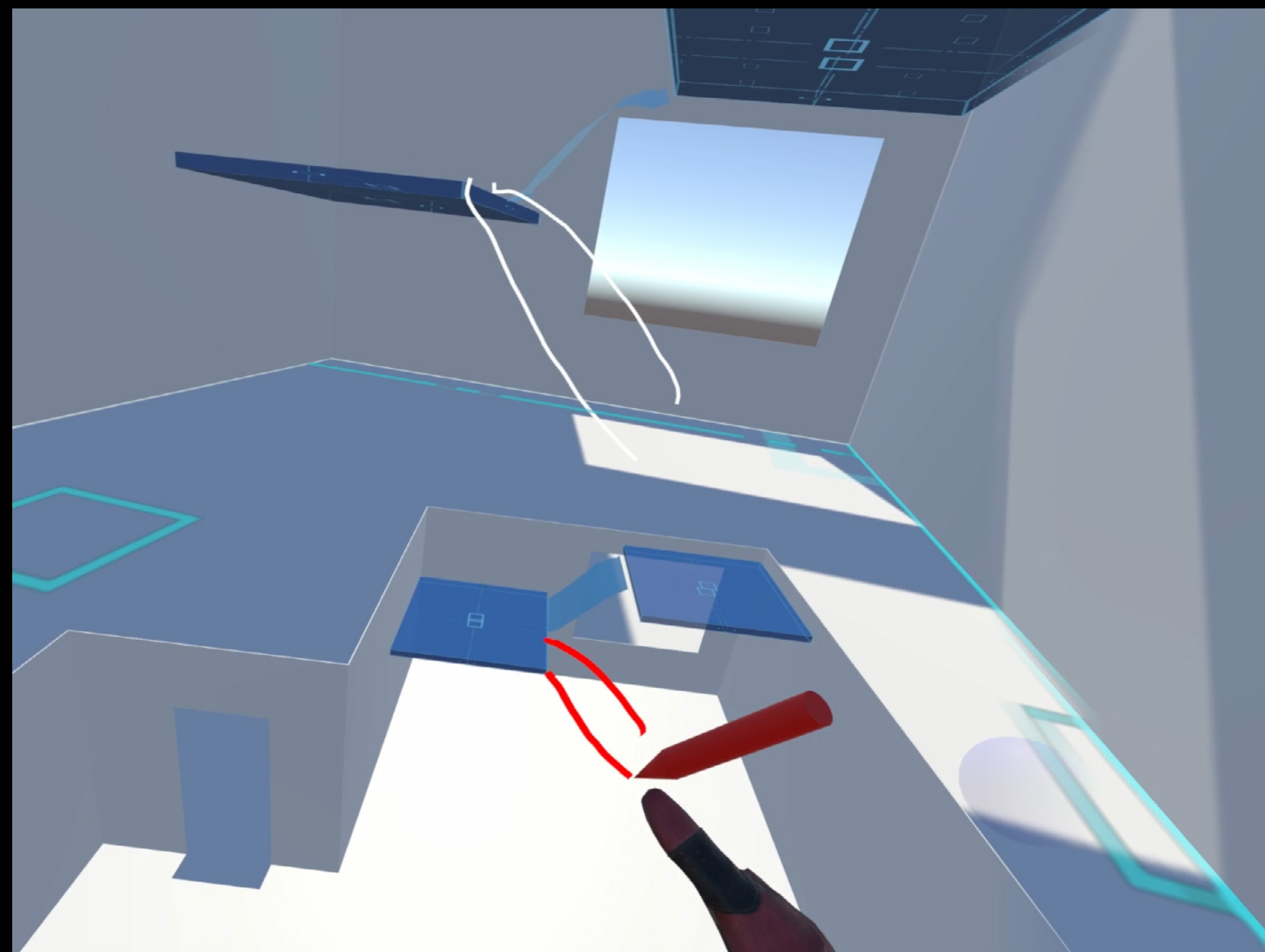
For studying high fidelity, the system provides user with common furniture items



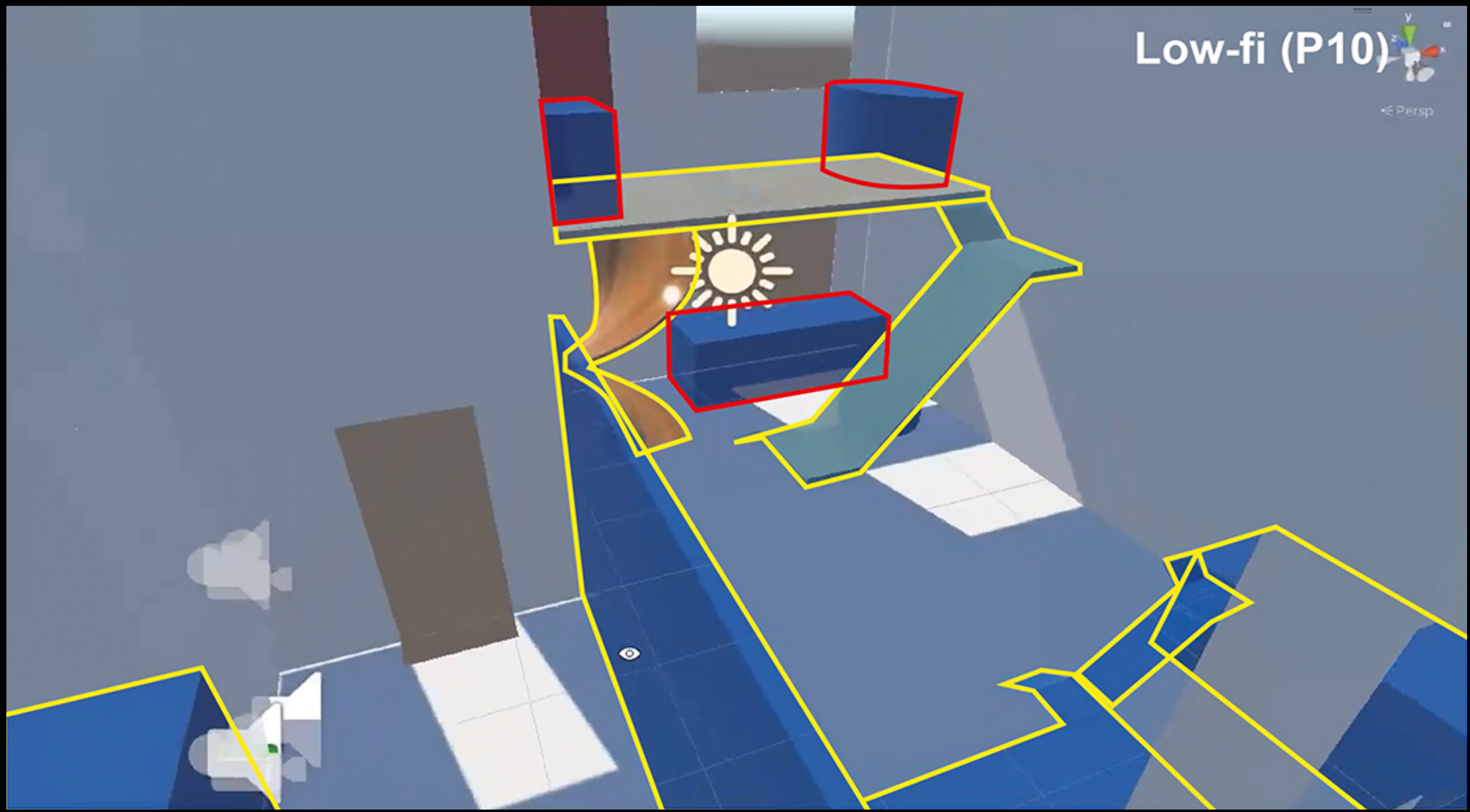
With a rotating handle and a cone showing the user's orientation, the small-model provides a convenient overview of the space similar to traditional 3D modeling software. Users could either move objects in the small-model as a proxy, or directly select and move objects in the large room scene. The changes are synchronized between the small-model and the large room.



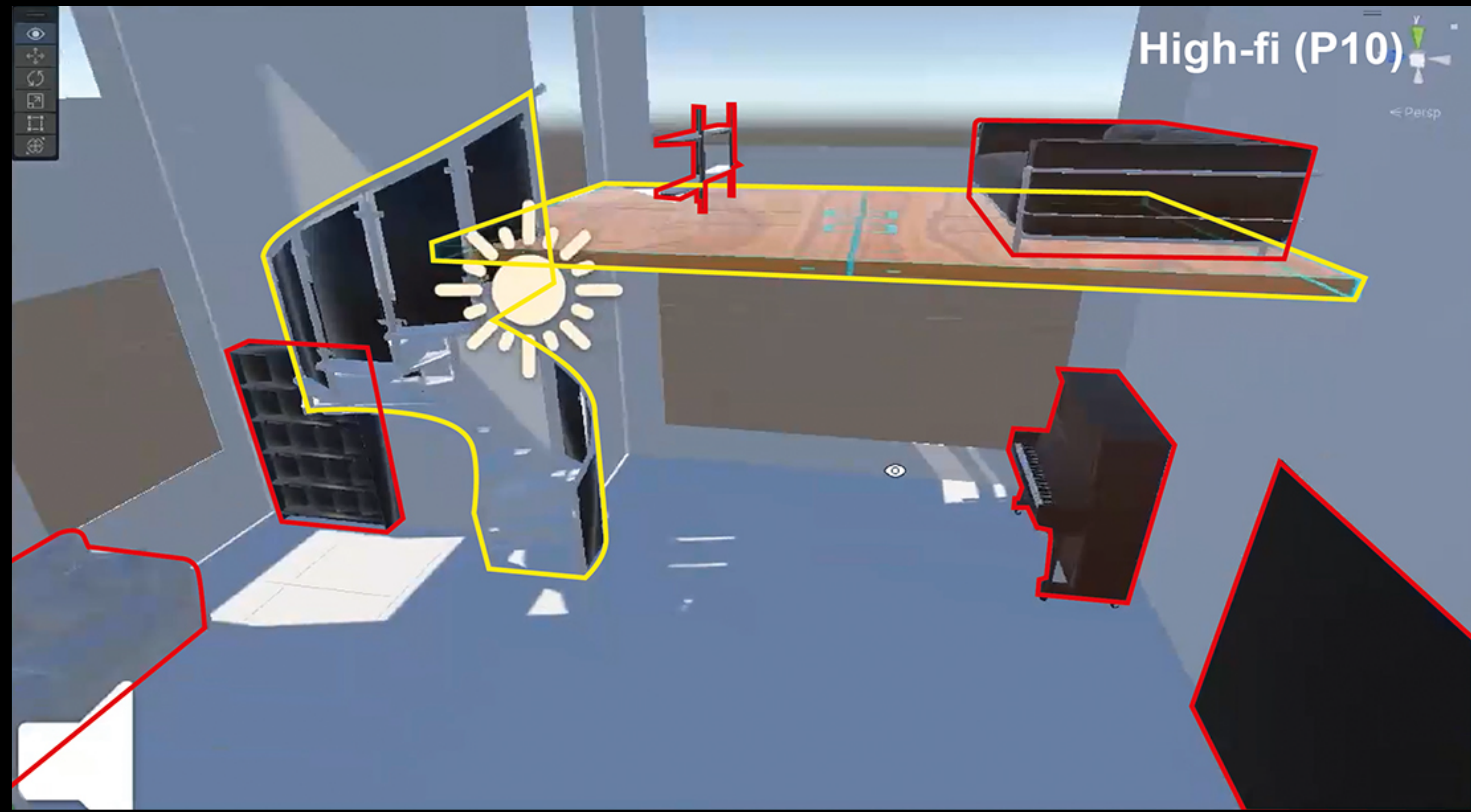
We implemented a free-drawing feature in both Hi-fi and Lo-fi that allowed users to draw 3D surfaces for creating arbitrary surfaces and dividing spaces. Surfaces can be generated from the last two curves added to create irregular Lo-fi objects, such as drawing a slope to represent stairs. After a surface is created, users can navigate to stand on it by using teleport. As a free drawing support, users can use the drawing tool to sketch arbitrary surfaces.



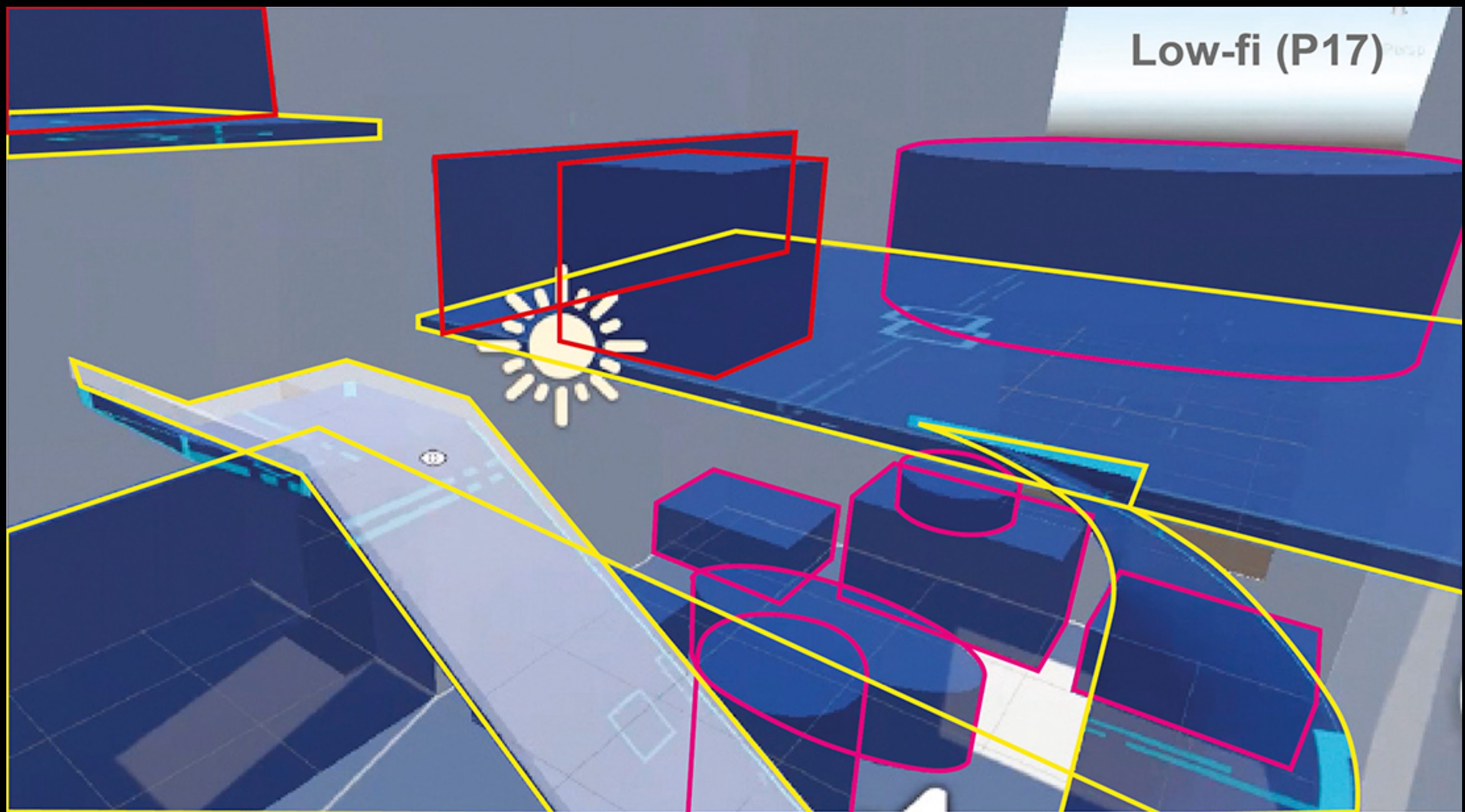
Selected Designs and Responses by Participants



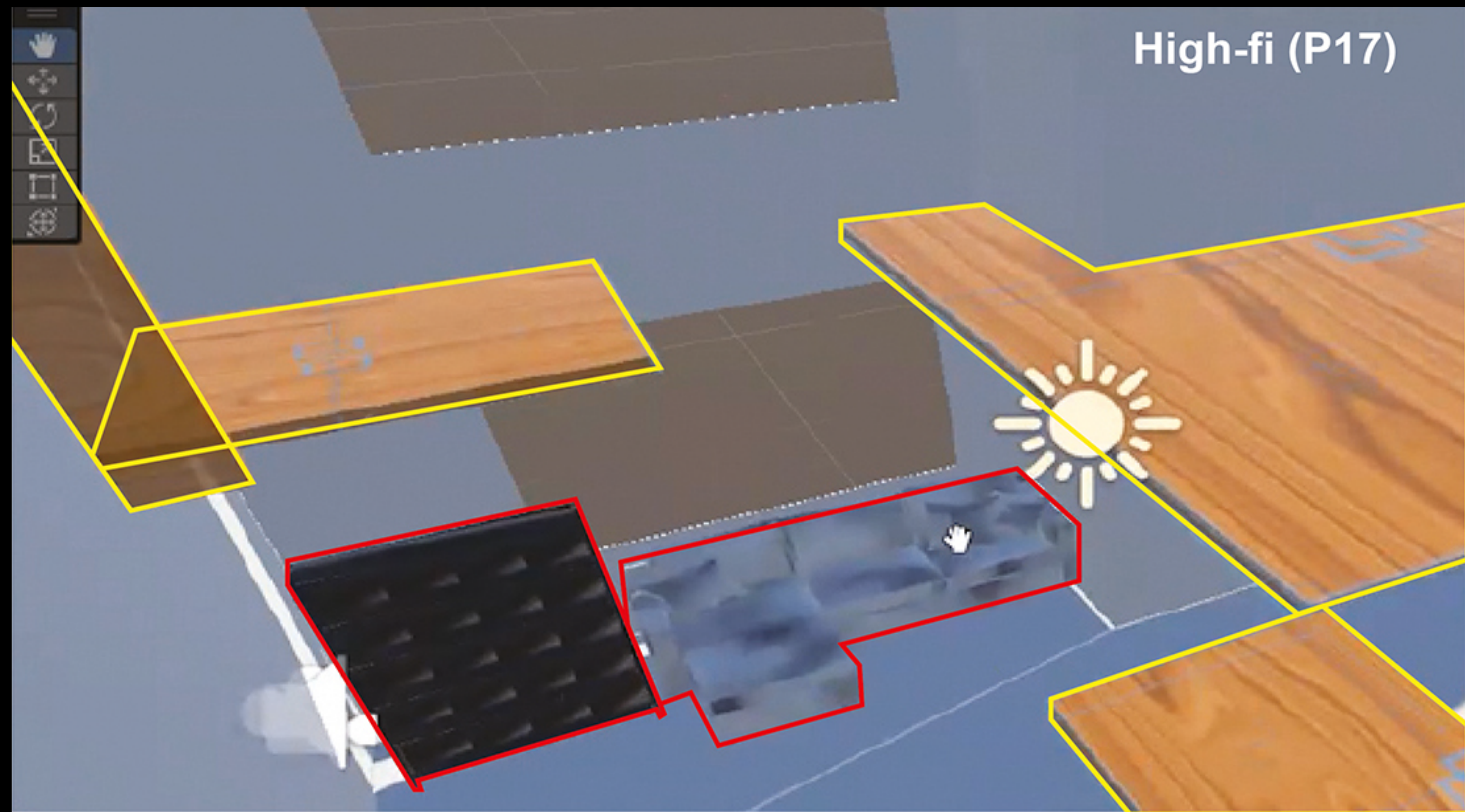
"People will see the kitchen once they enter the house, but I'm not sure how big the kitchen should be."
"Because the space is small, I think wood is suitable to be the main material."
"I need help with spatial utilization."



"People will see a hallway once they enter the house, and there is an exhibition wall in the hallway.'
"Overall style...I want to change the color of the sofa."
"I need help with color matching."



"I want to design an open kitchen."
"The staircase connects these two spaces"
"Here is a studio where I can work in. I might put a piano and desk in it.
"I need help with spatial utilization and lighting design."



"I want to put a big shelf here"
"I want to put a cabinet there with beautiful decorations on it."
"I think the living room is too empty now.