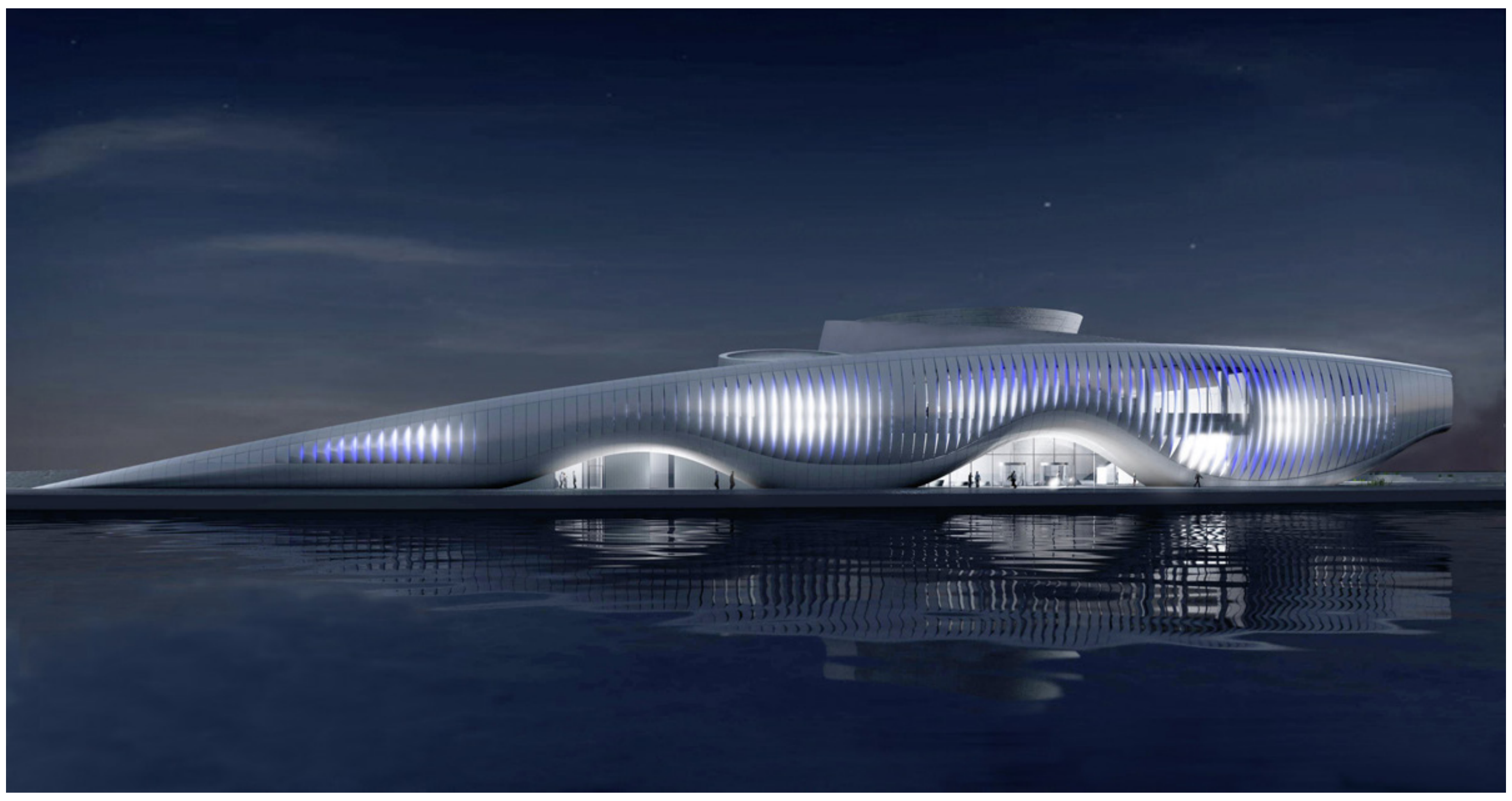
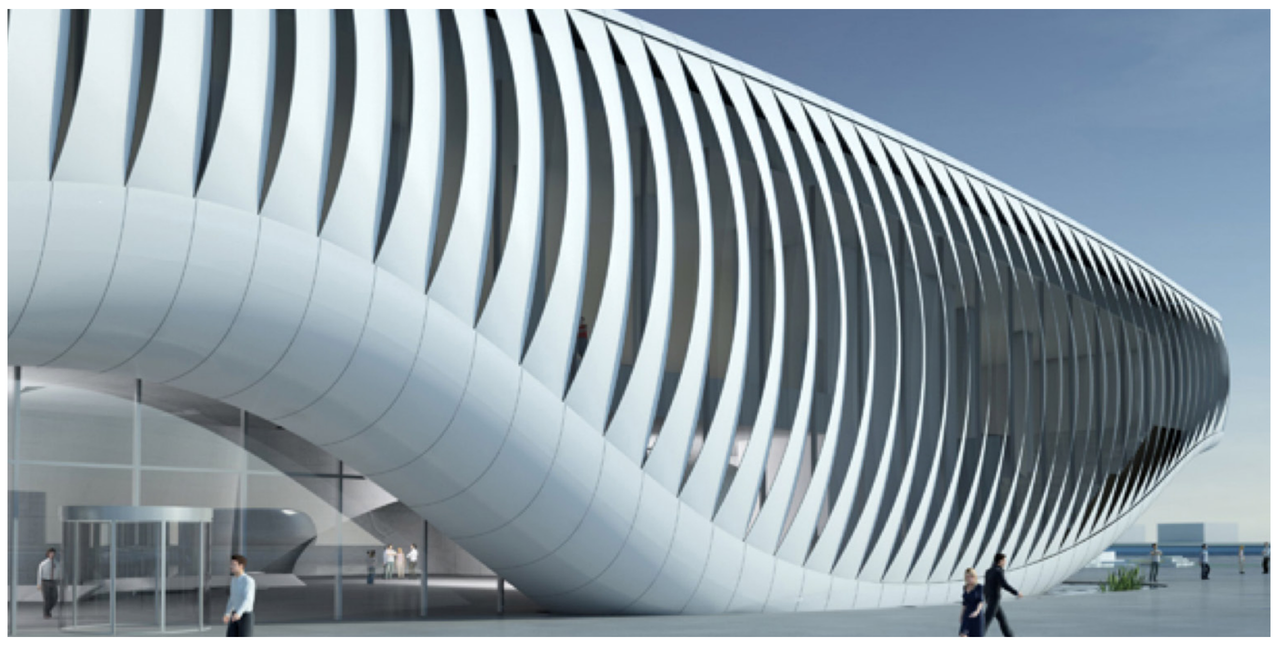
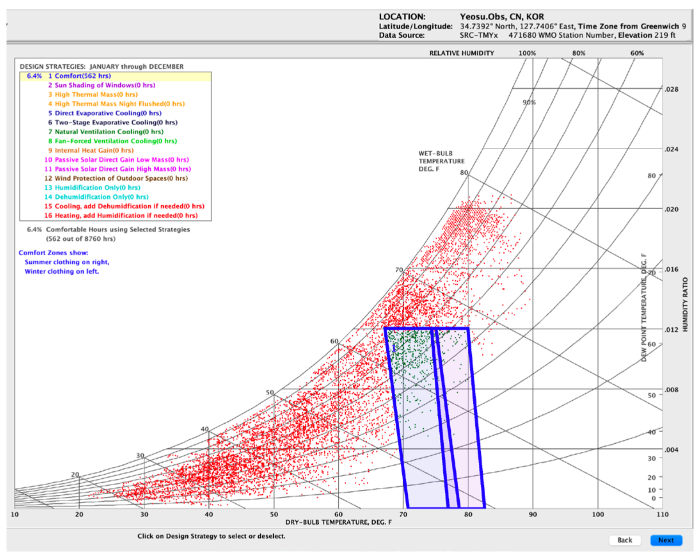
CASE STUDY

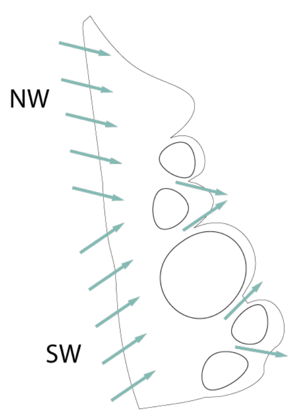
ONE OCEAN PAVILION

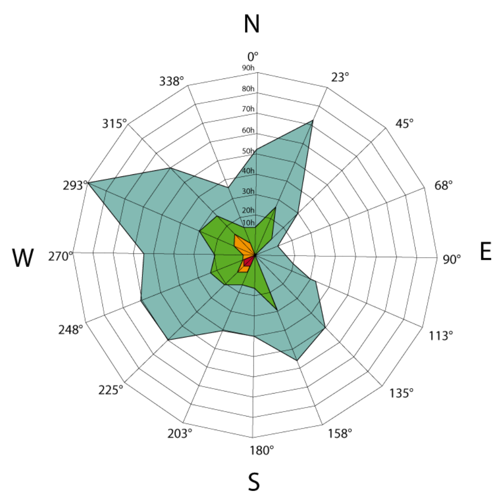


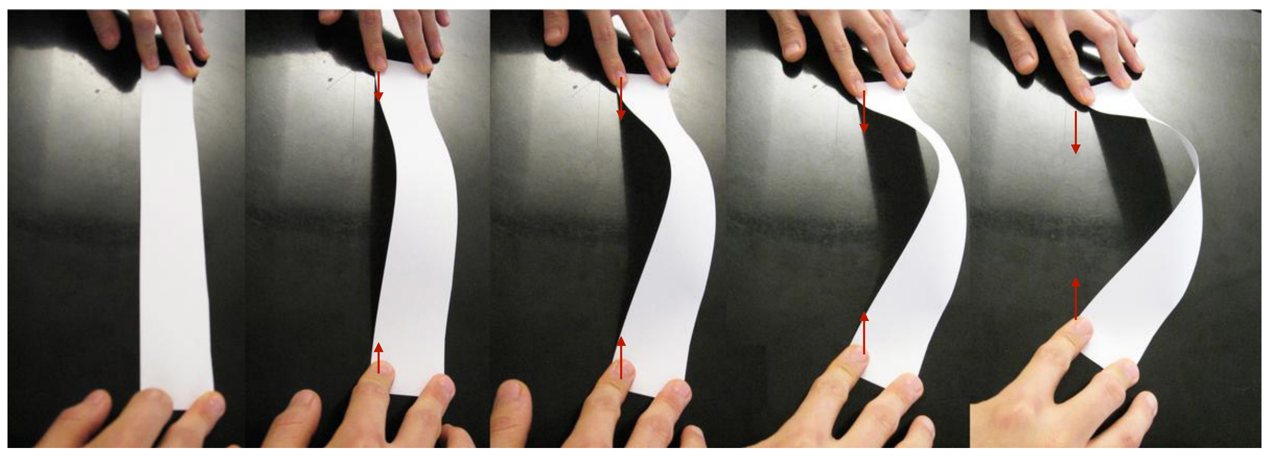


Pavilion ‘One Ocean’ was designed for the World Expo of 2012 in Yeosu.
Client: The Organizing Committee of Expo 2012 Yeosu
Location: Yeosu, South Korea
Area: 6.900 square meter
Construction: 2010 – 2012
Architect: SOMA, Austria
Kinetic facade: Knippers Helbig, Stuttgart





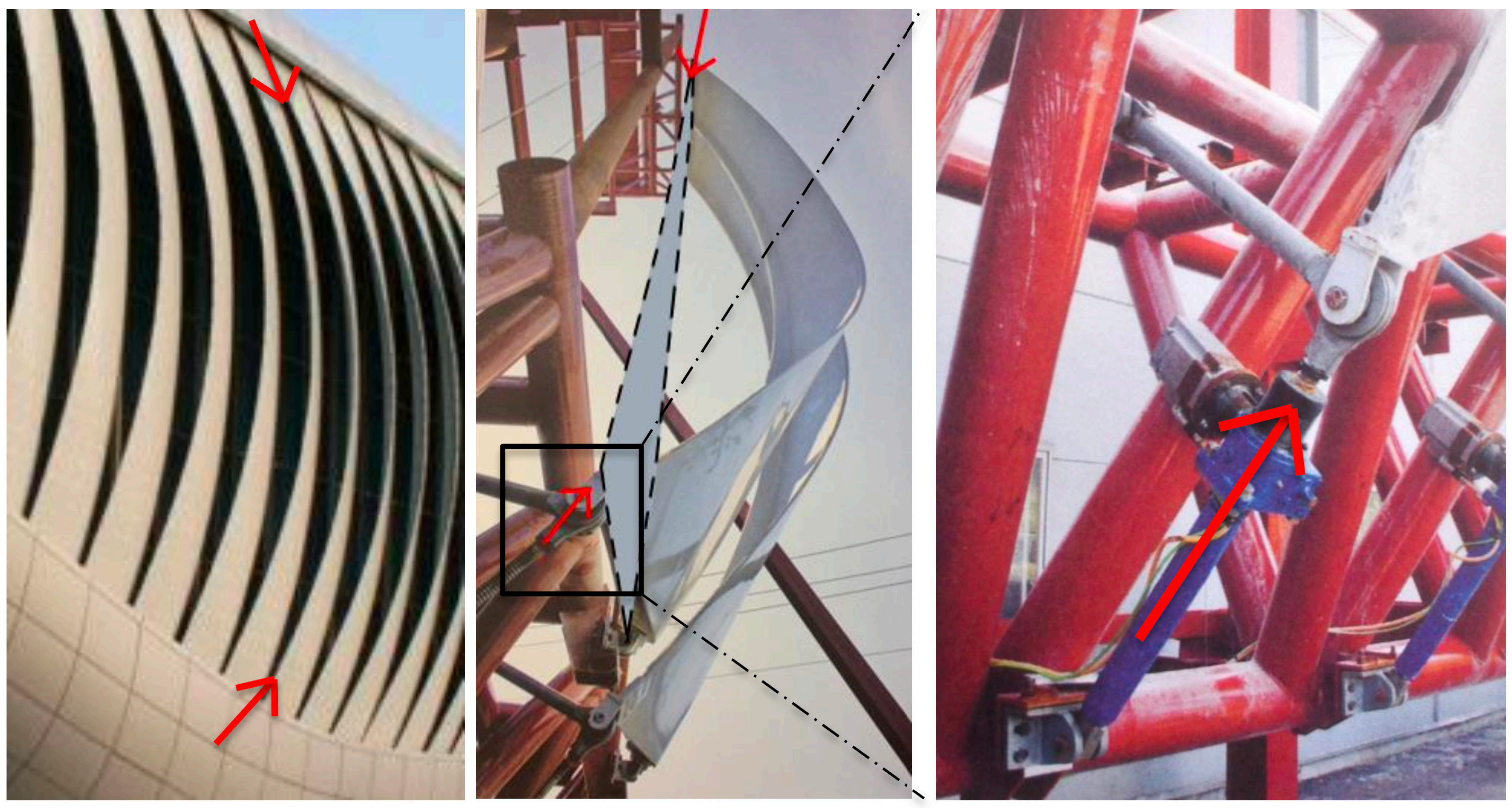




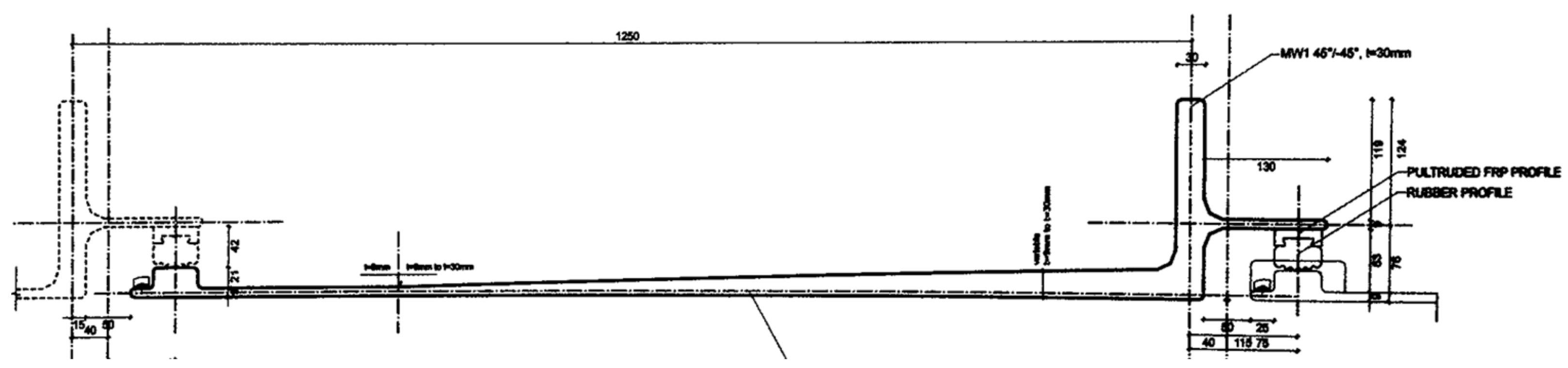
Two points are pivoted for hinging. The other two points are moved linearly towards each other to achieve the required deformation

It is usually cold in Yeosu, with moderate humidity and rainfall.
However, Sun needs to be avoided in the July and August months.
The facade faces West which has significant wind flow.
To prevent damage to the Lamellas, they close when the wind speed exceeds the threshold limit.

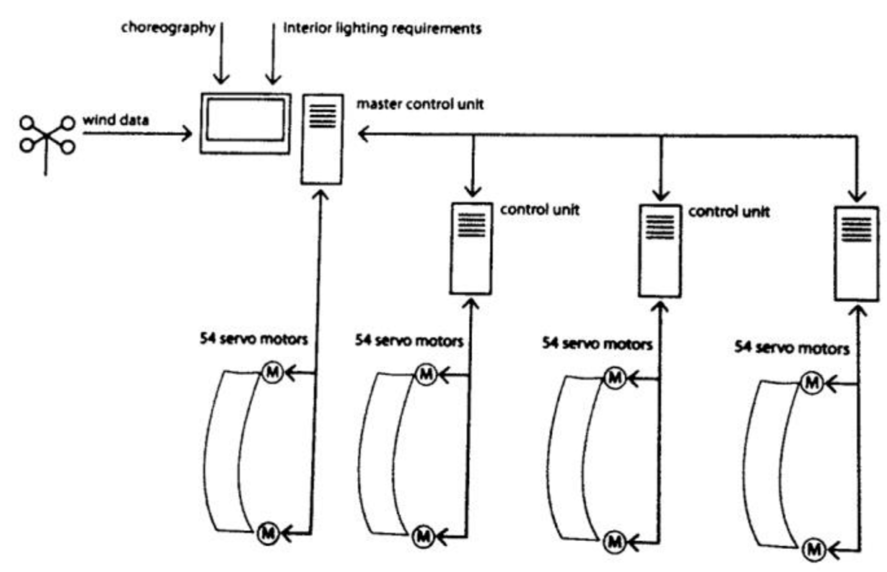
Mock-up tests were done where the lamellas were operated for 35 days consecutively to cross-check the structural behaviour



The linear movement is done by the use of individually actuated motors



There are 108 Lamellas made of glass fibre reinforced polymers (GFRP)
Their height varies from 3 to 13 metres
Their thickness is 200 mm on one side, tapering to 30 mm



The motors are controlled centrally by a master control unit that has the input of wind data and interior lighting requirements

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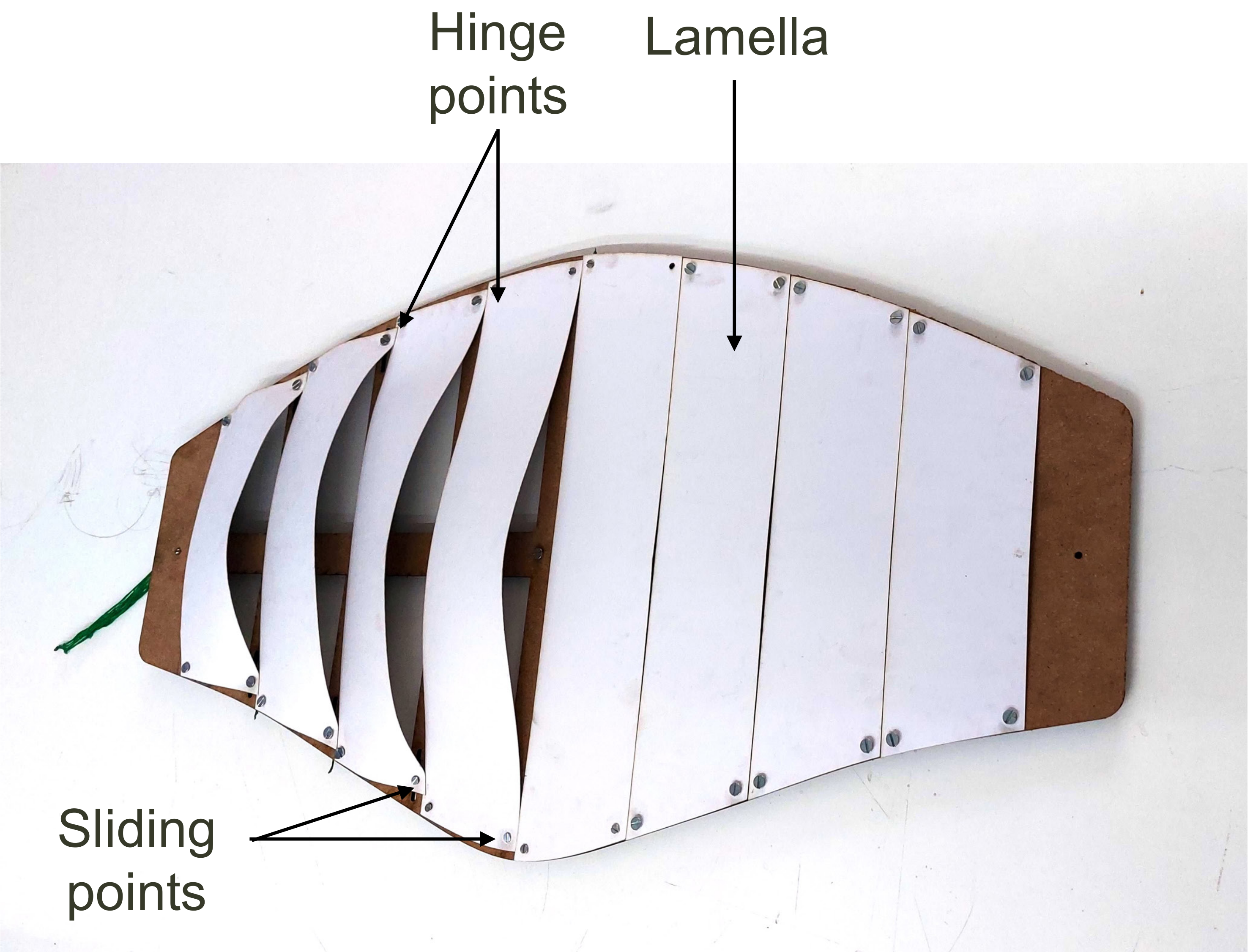
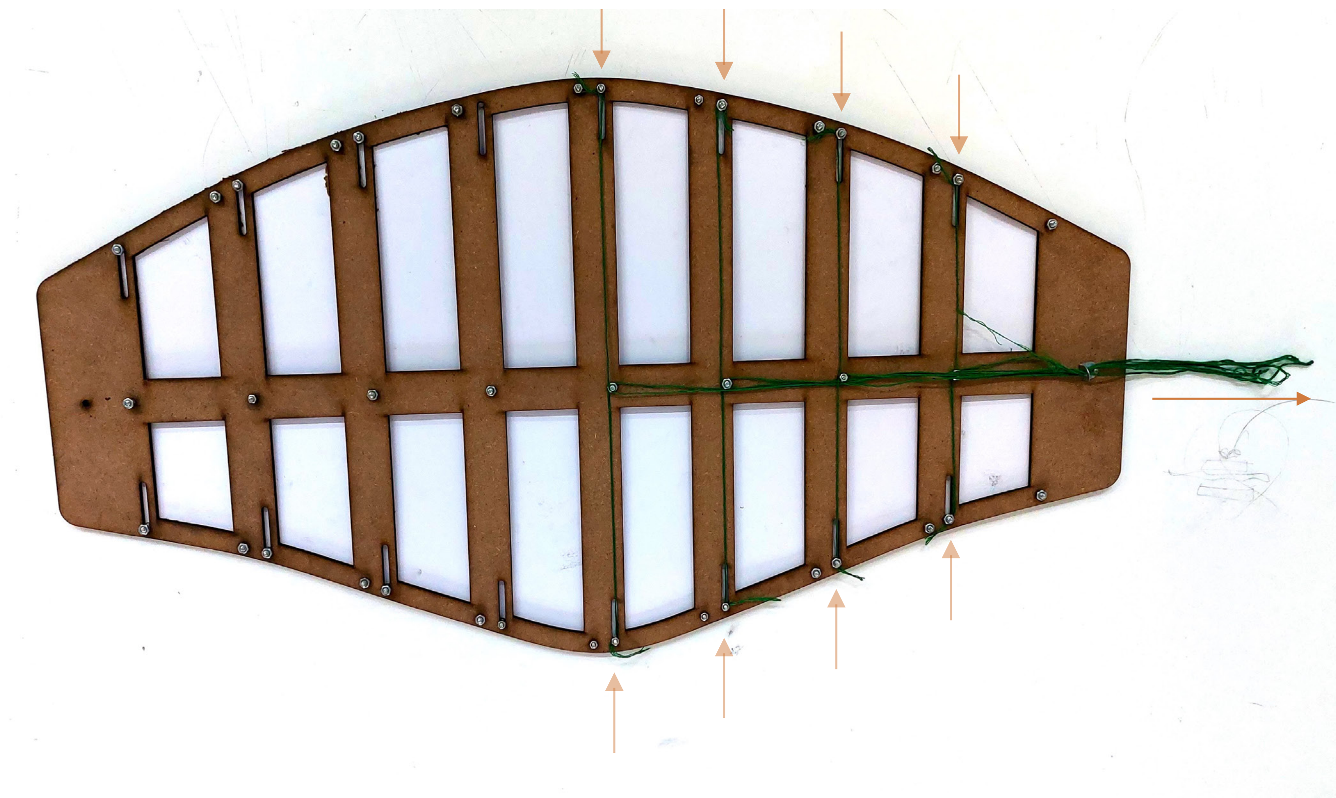
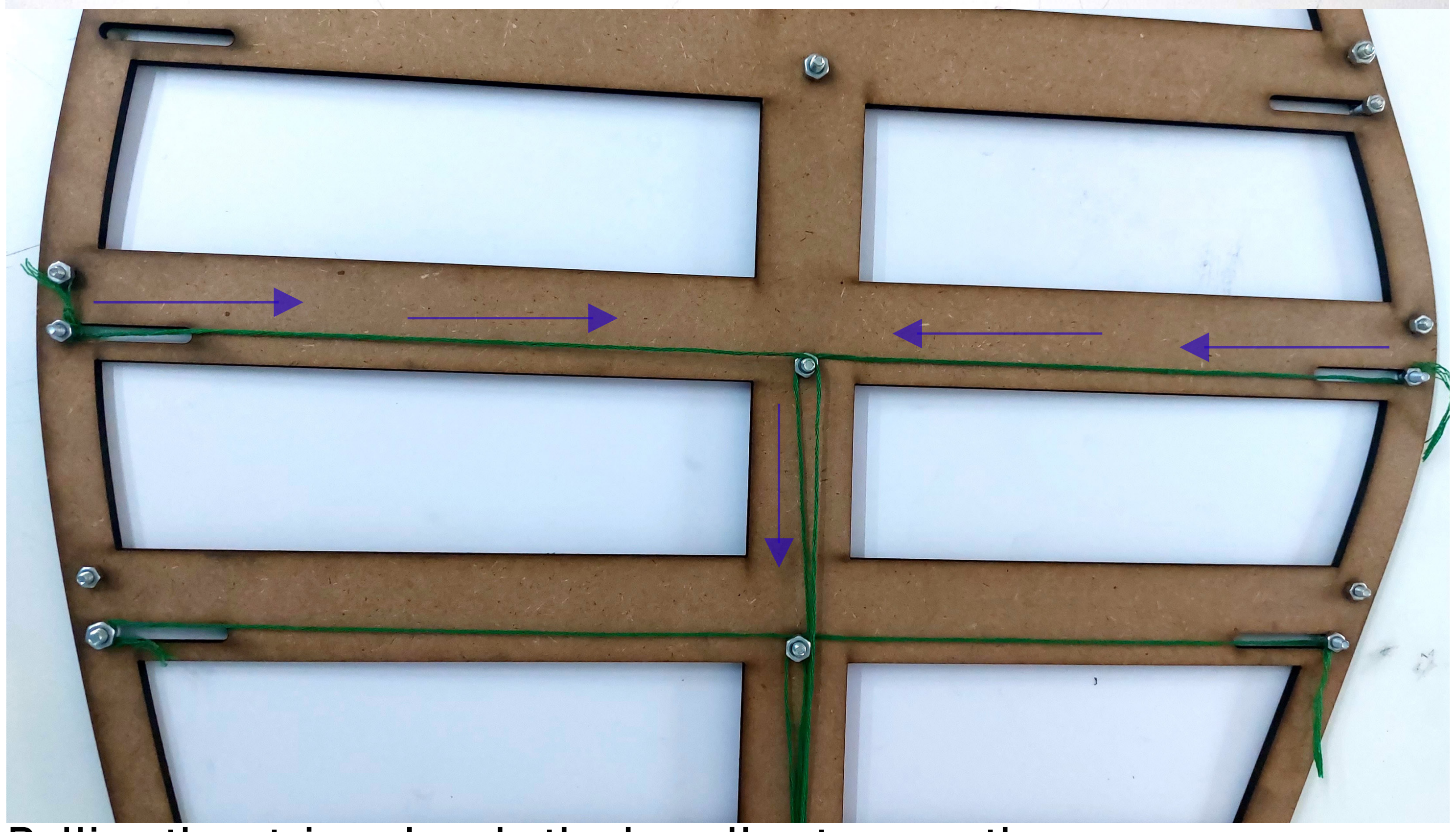
CASE STUDY - MODEL

ONE OCEAN PAVILION, PHYSICAL AND DIGITAL MODEL

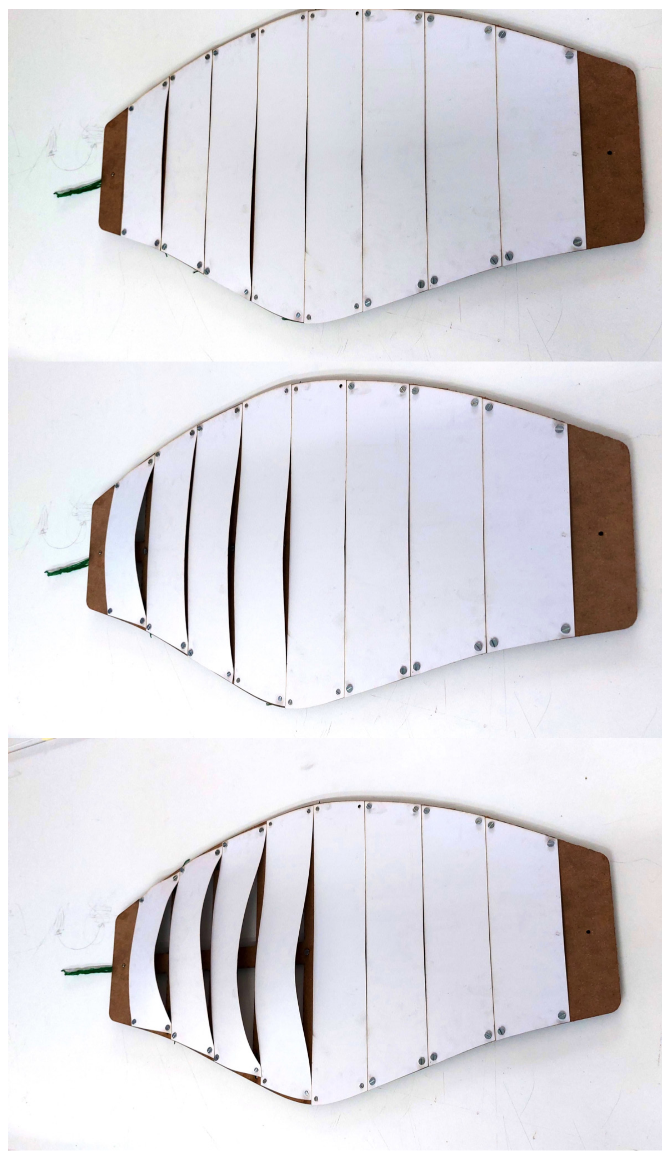


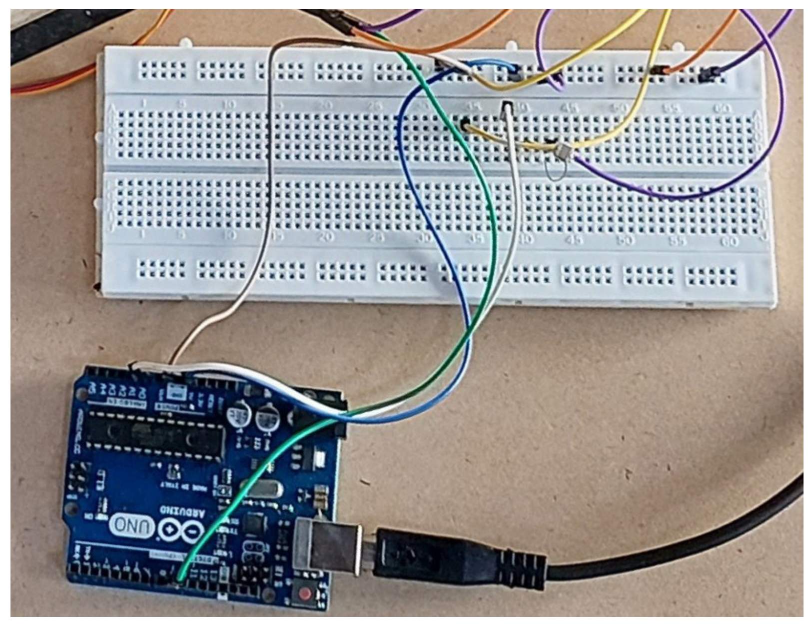


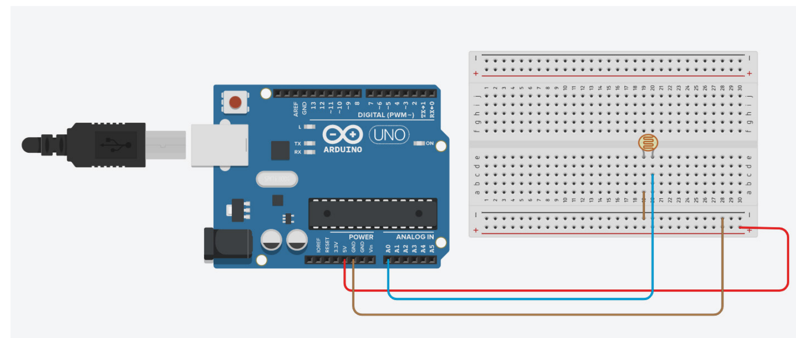
The Skeleton of the model from behind

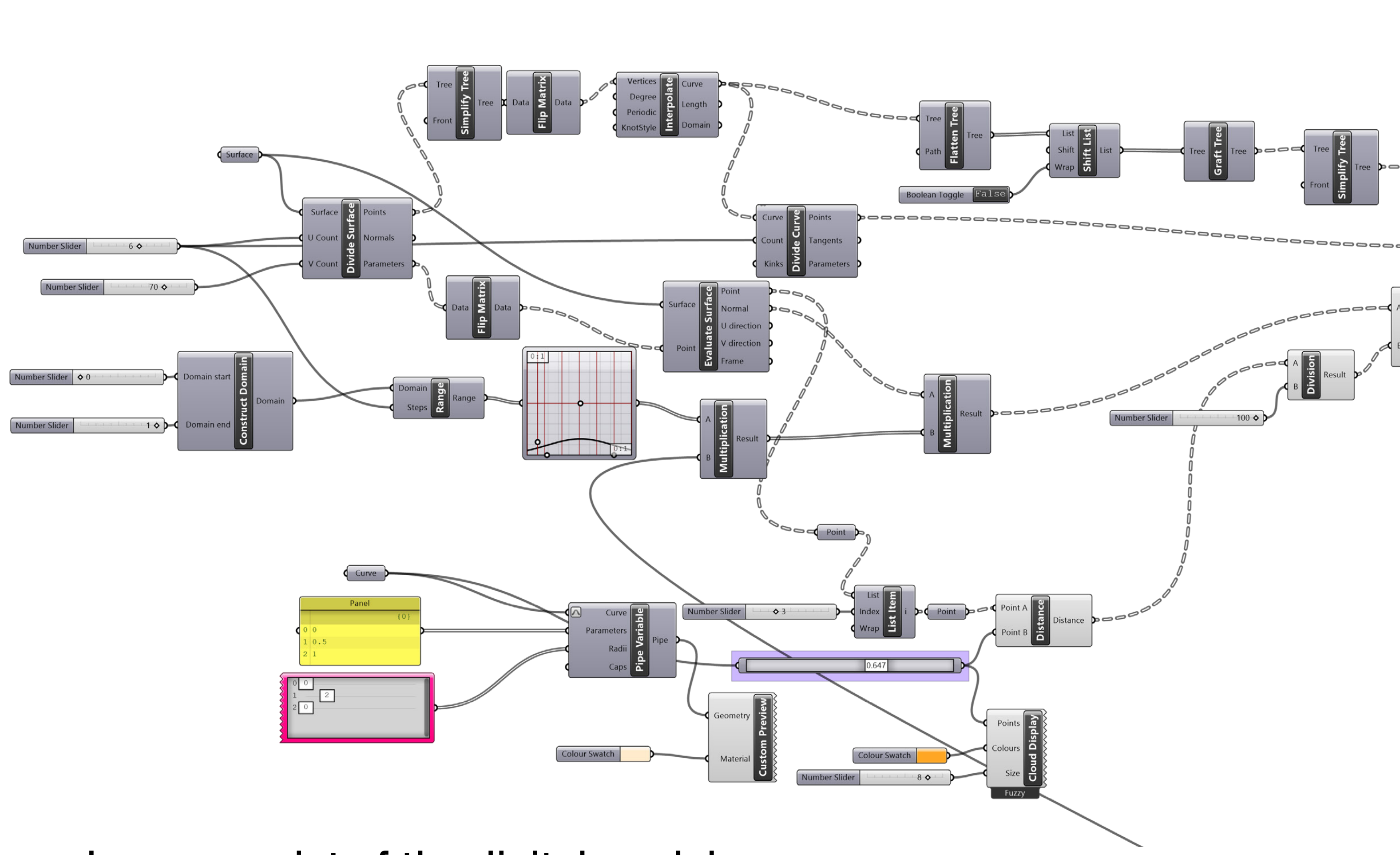


Pulling the strings bends the lamellas to open them

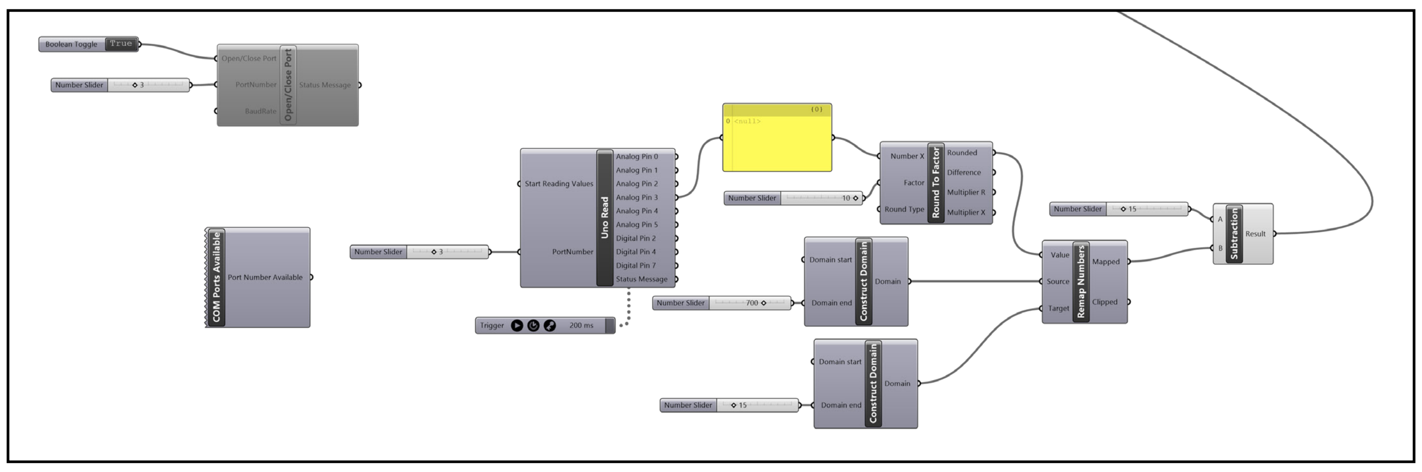




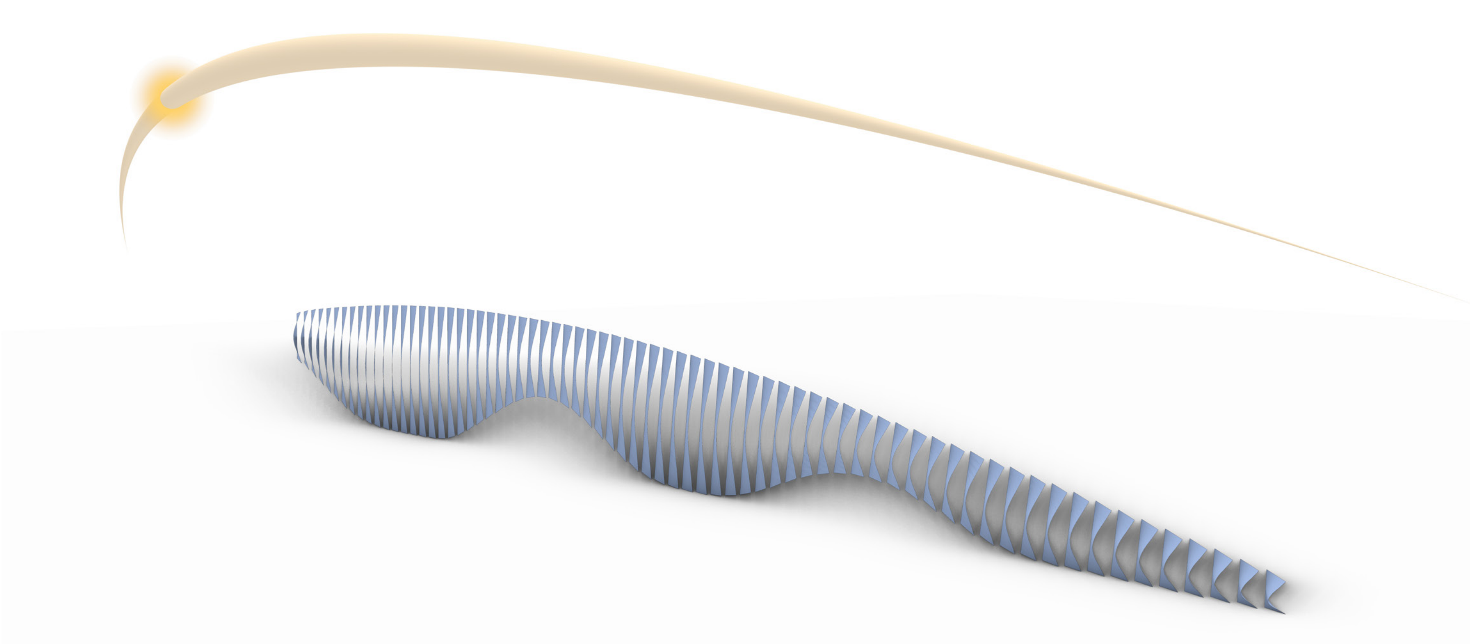


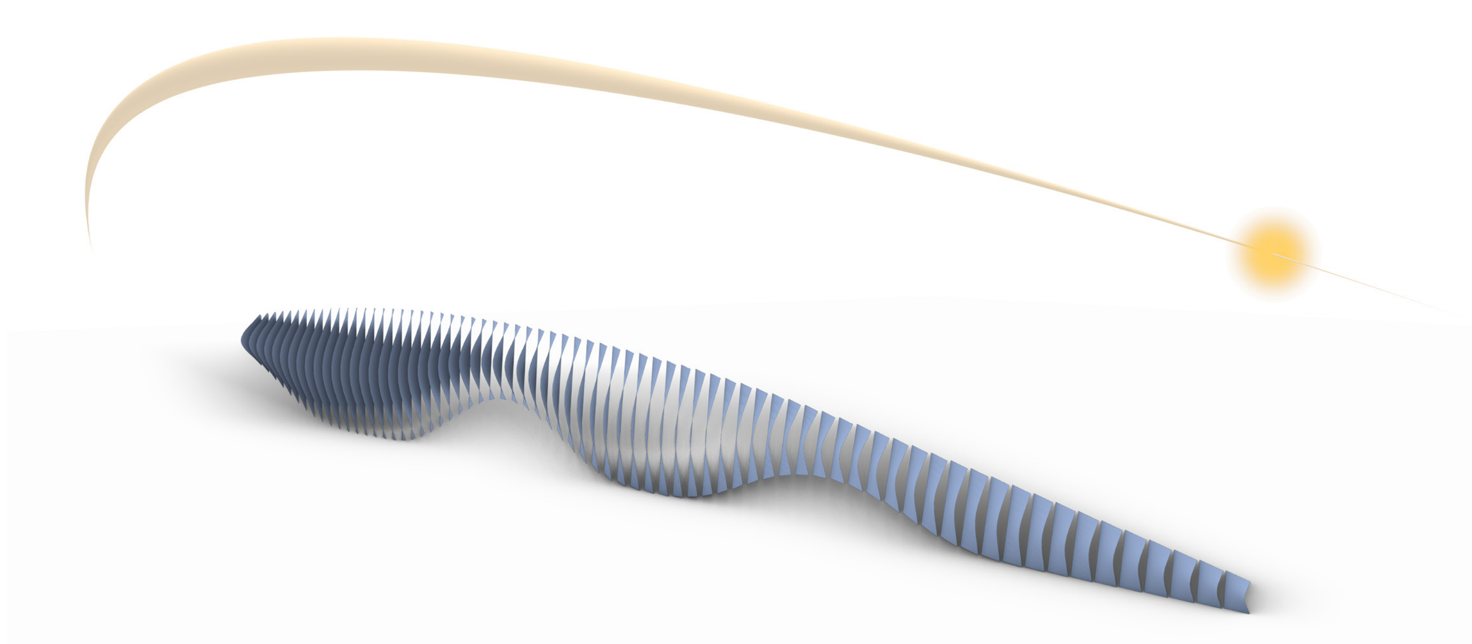


Grasshopper script of the digital model



Script of LDR controlling the digital model's lamellas





The script simulates the opening of lamellas according to the sun path. It also connects the digital model to an LDR (Light Dependent Resistor) through Arduino using the plugin Firefly. The level of opening of the lamellas depend on the sunlight intensity, inversely proportional to it.

SYED MOHAMMAD ASIM | A001

Tutor : IPSITA DATTA

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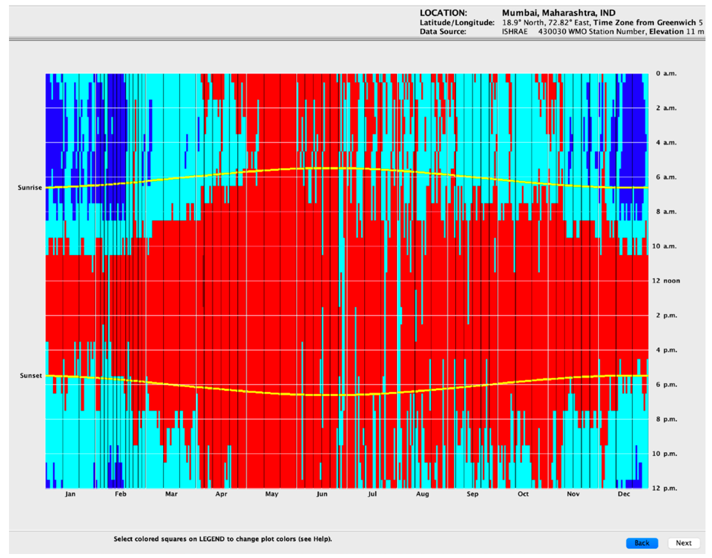
BALWANT SHETH SCHOOL OF ARCHITECTURE

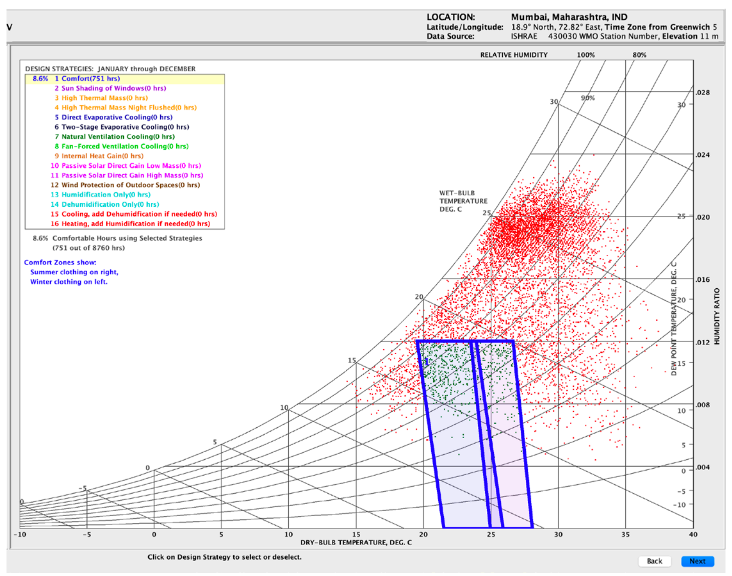
SOLAR RESPONSIVE FACADE

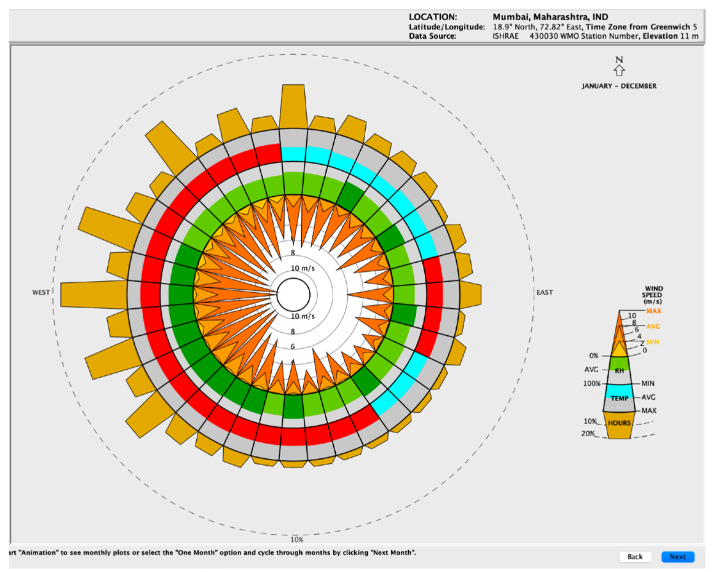
CONTEXT: NMIMS BUILDING, MUMBAI

Research Question:
Can a facade be created that reduces **solar gain** of buildings effectively, based on the **sun path** while also permitting **indirect natural light, ventilation and visibiliy**?

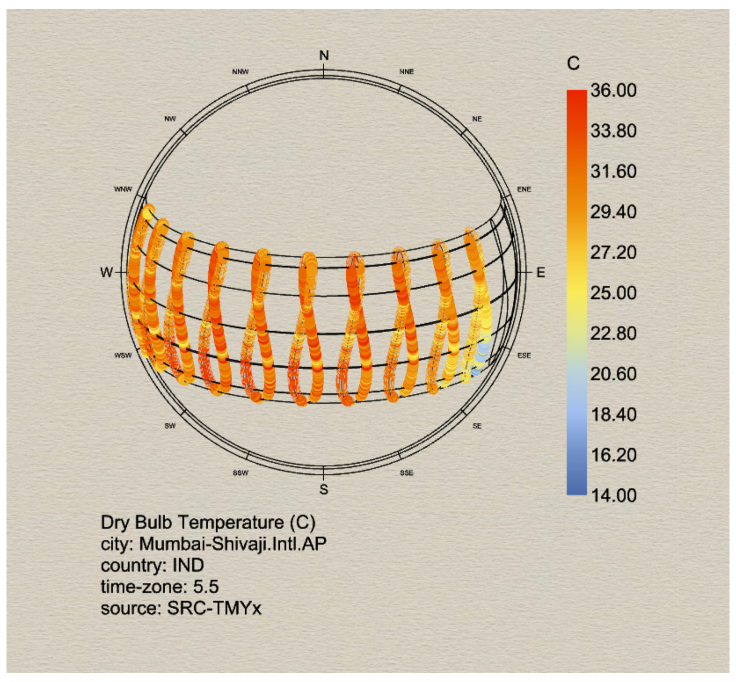
NMIMS building, Mumbai

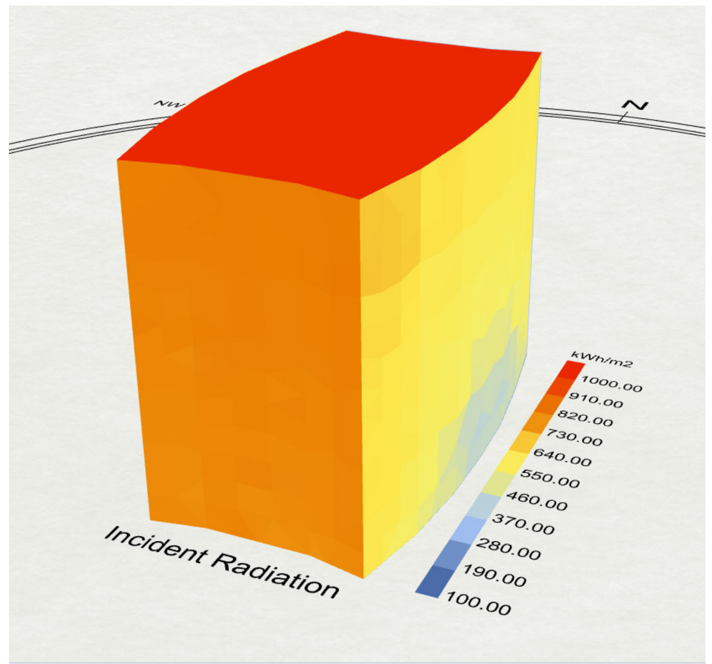




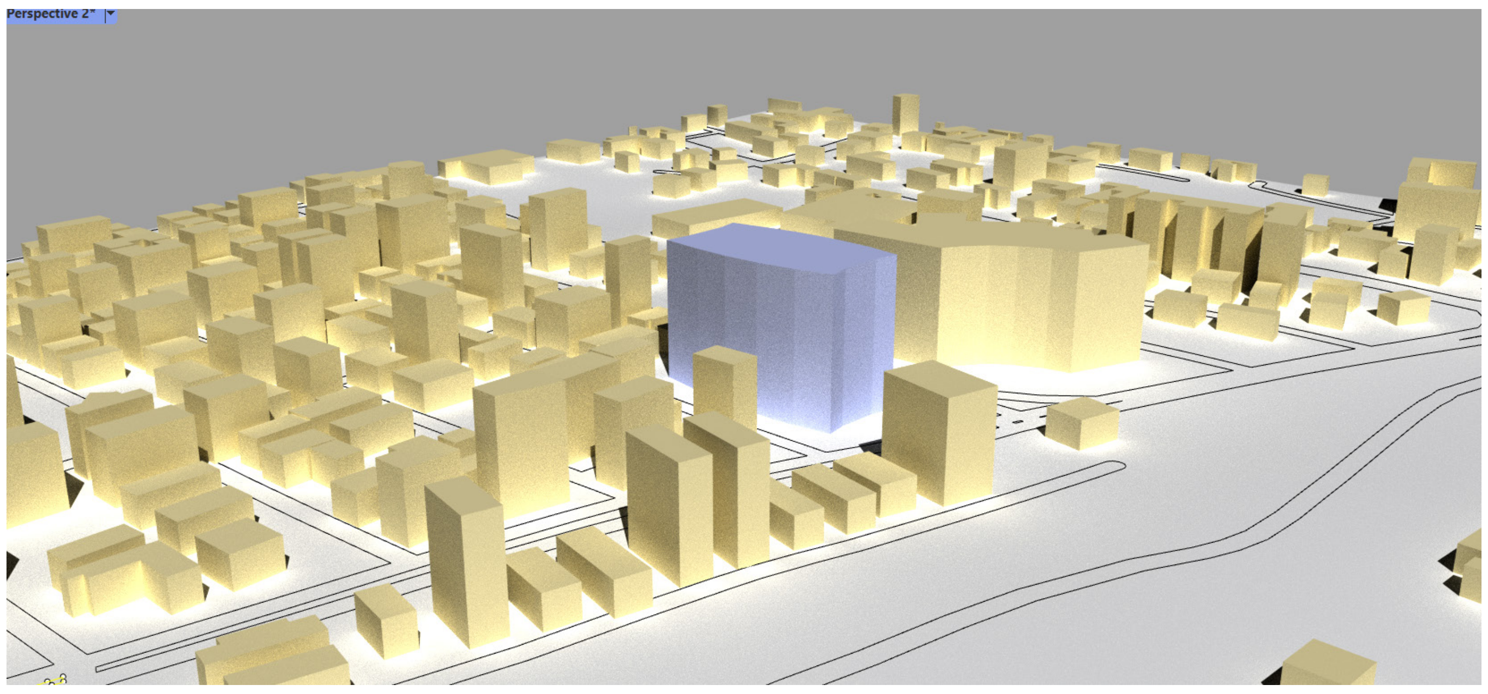


The climate of Mumbai is warm and humid, which requires good ventilation and shade during peak sun hours. The wind is prevelant from the west.

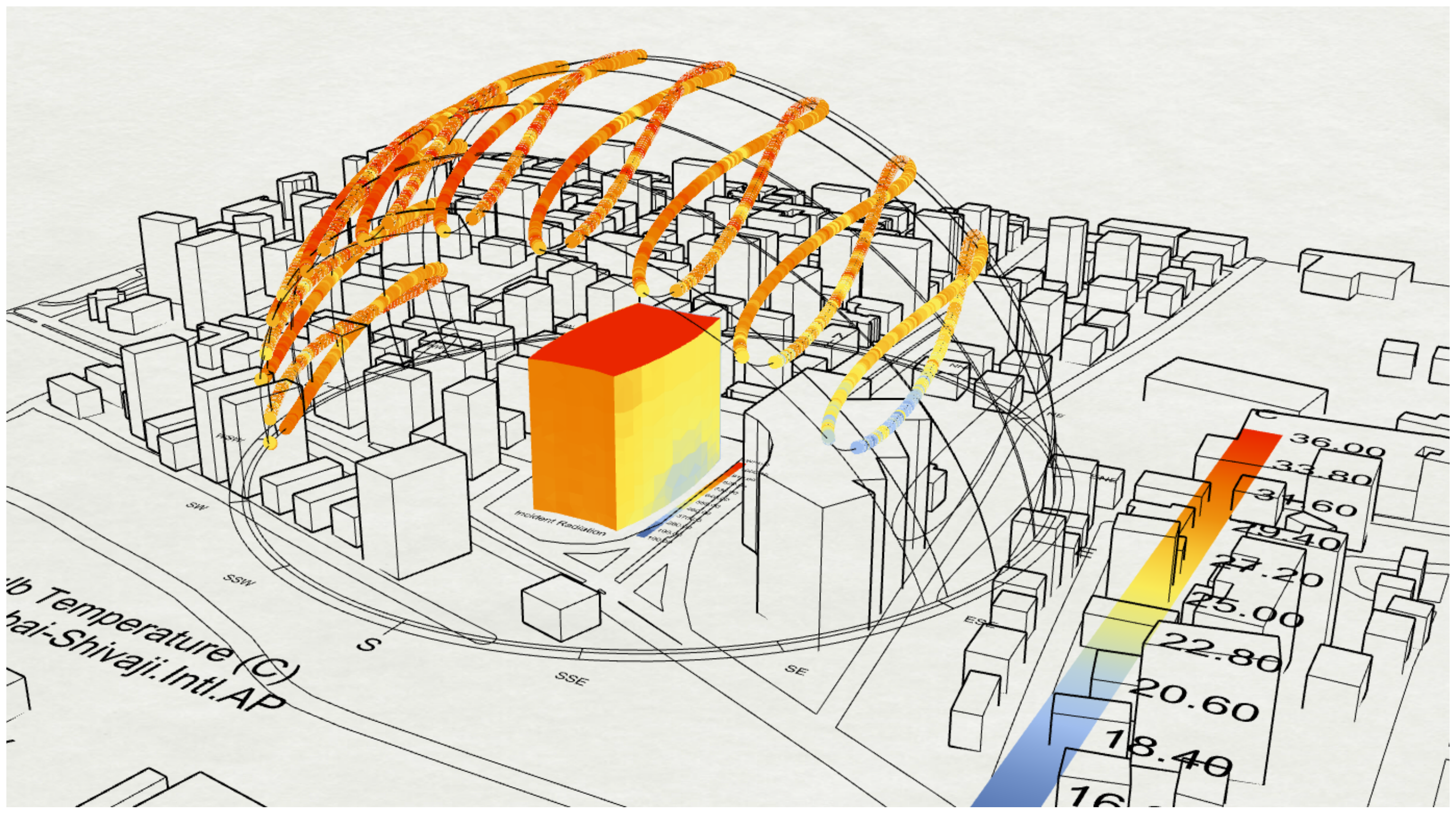


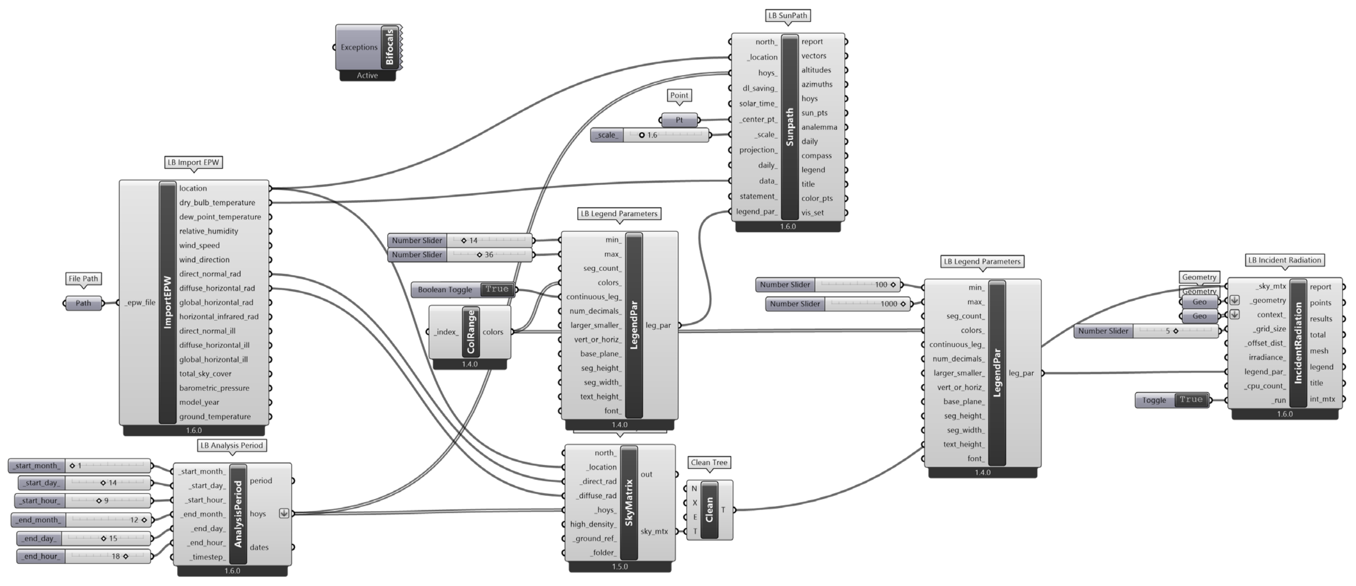


A Grasshopper plugin: Ladybug, is used to identify the incident solar radiation on the building throughout the year

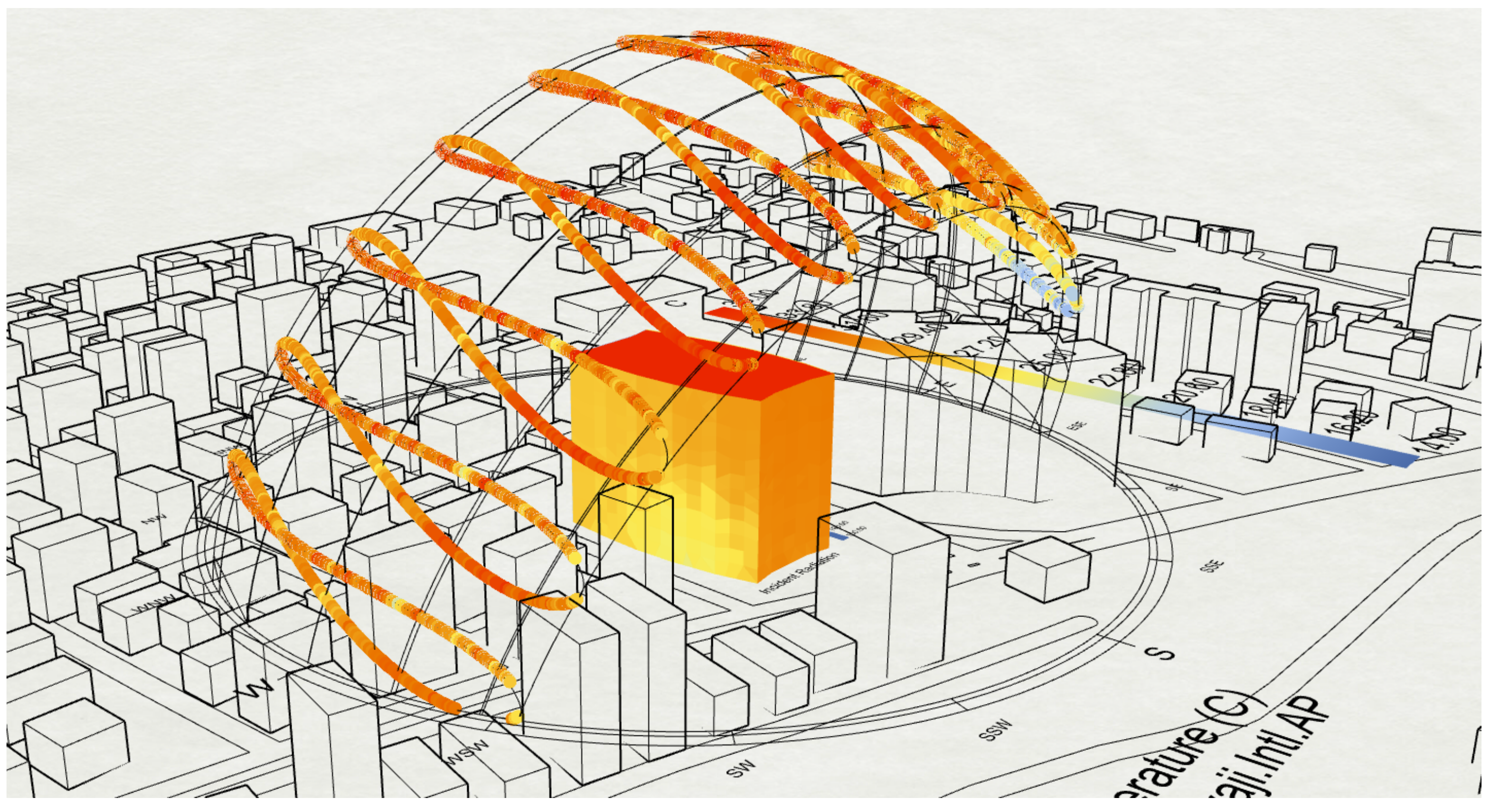


Model retrieved from CadMapper and modified for correct building heights and legibility





The script for radiation and sunpath analysis with the site context



Output of the radiation analysis with the incorporation of context of surrounding buildings

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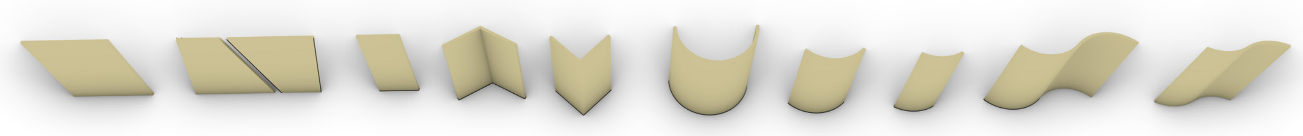
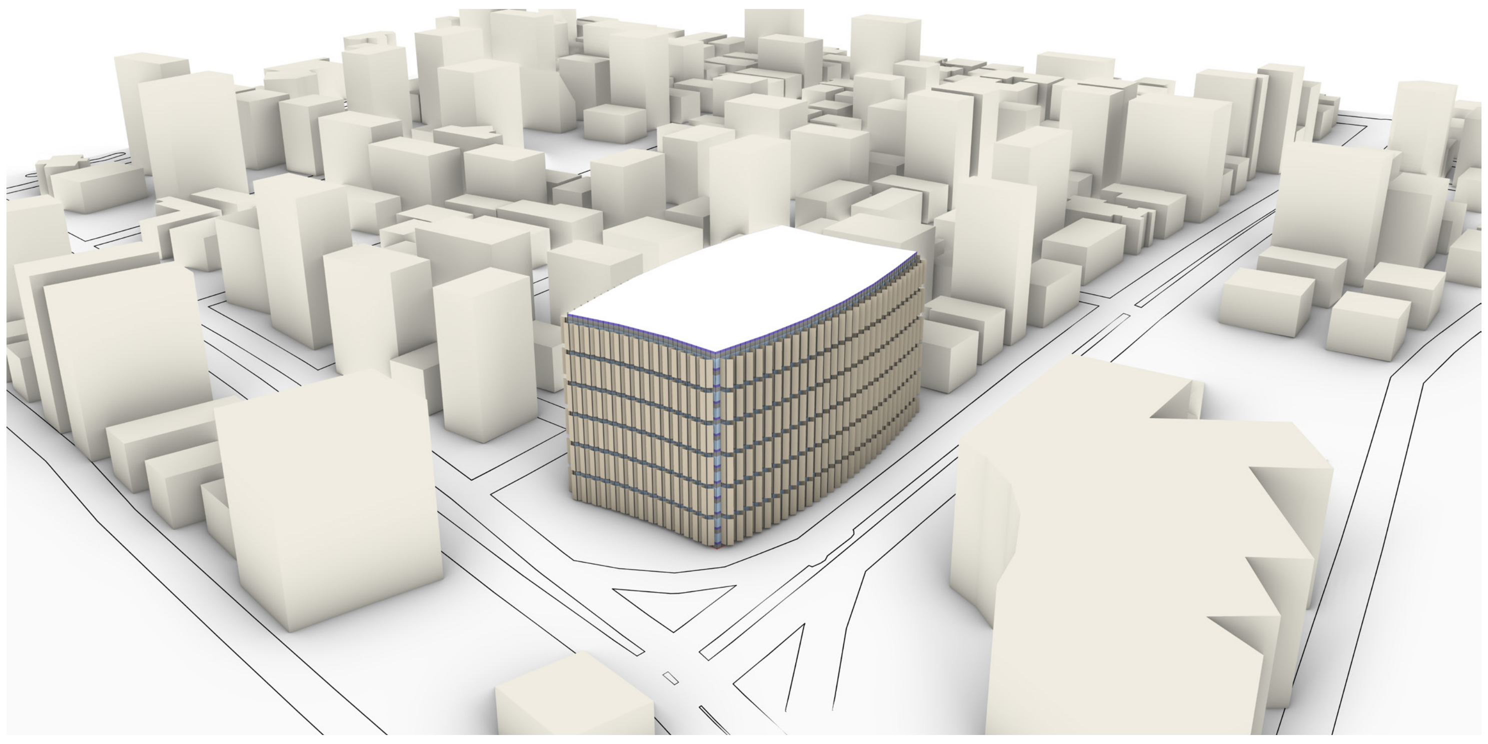
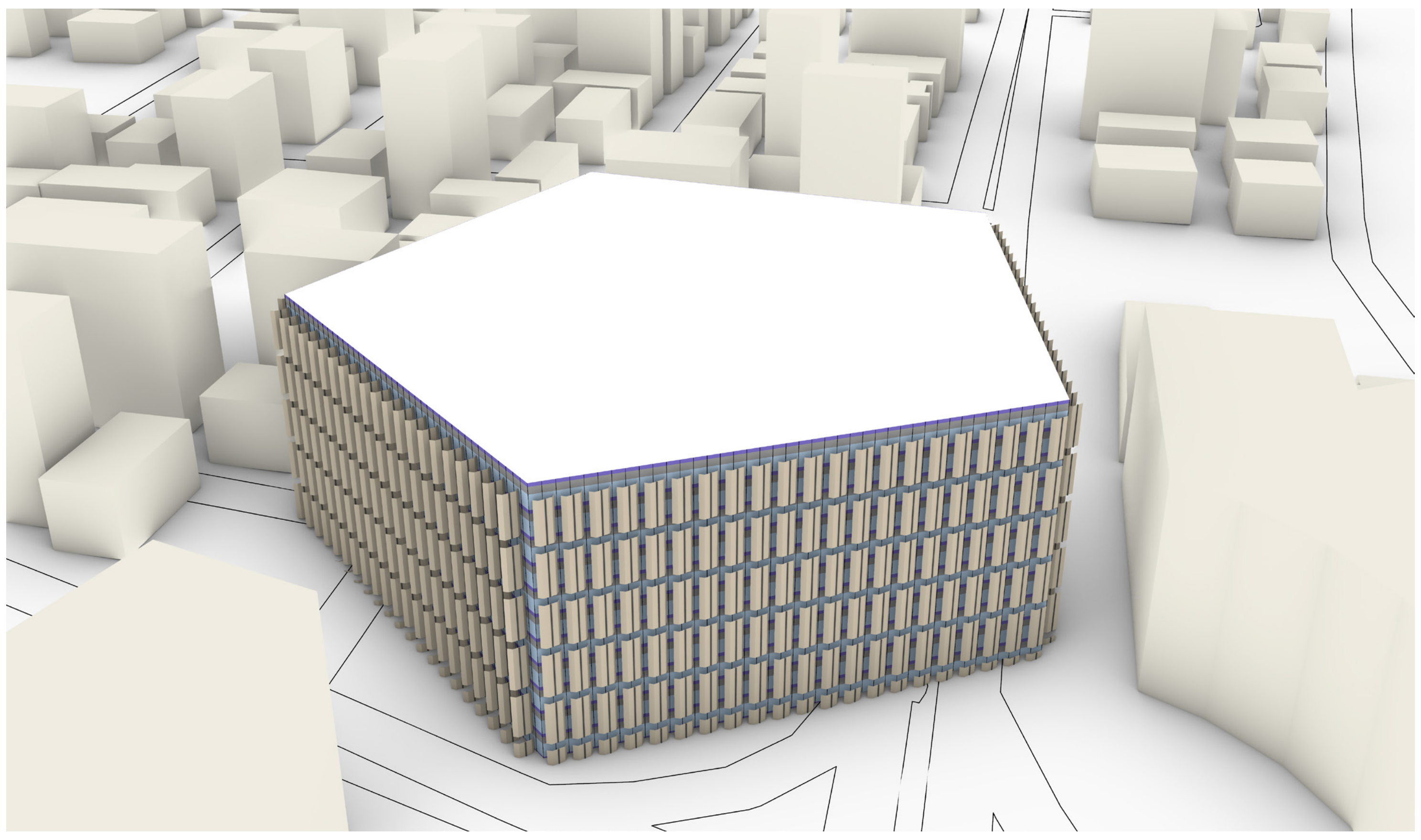
DIGITAL MODEL

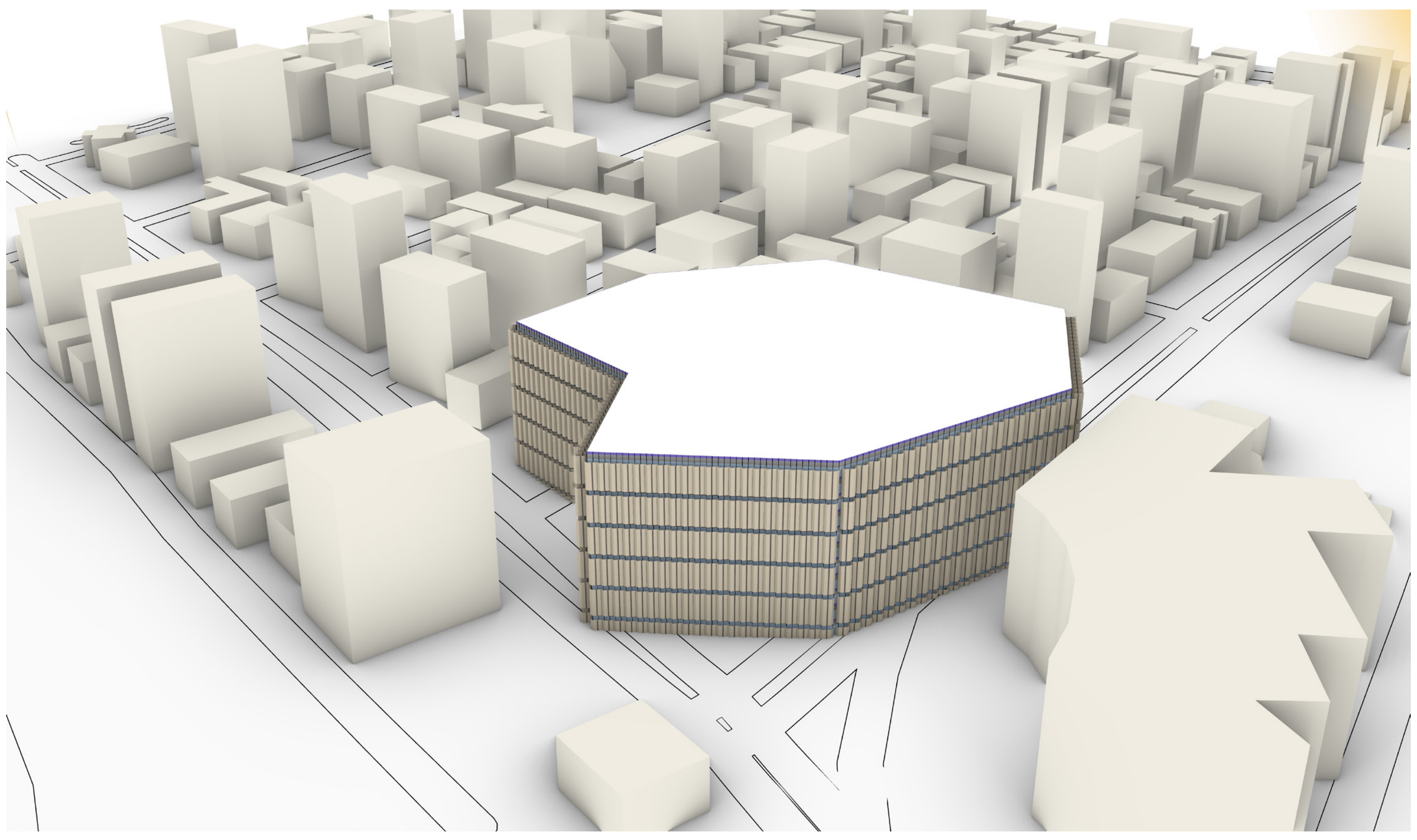
PARAMETRIC MODEL OF BUILDING, FACADE AND THE DIGITAL FRAMEWORK

Research Question:
Can a digital framework be created that allows quicker **iterative testing** of multiple panel forms?

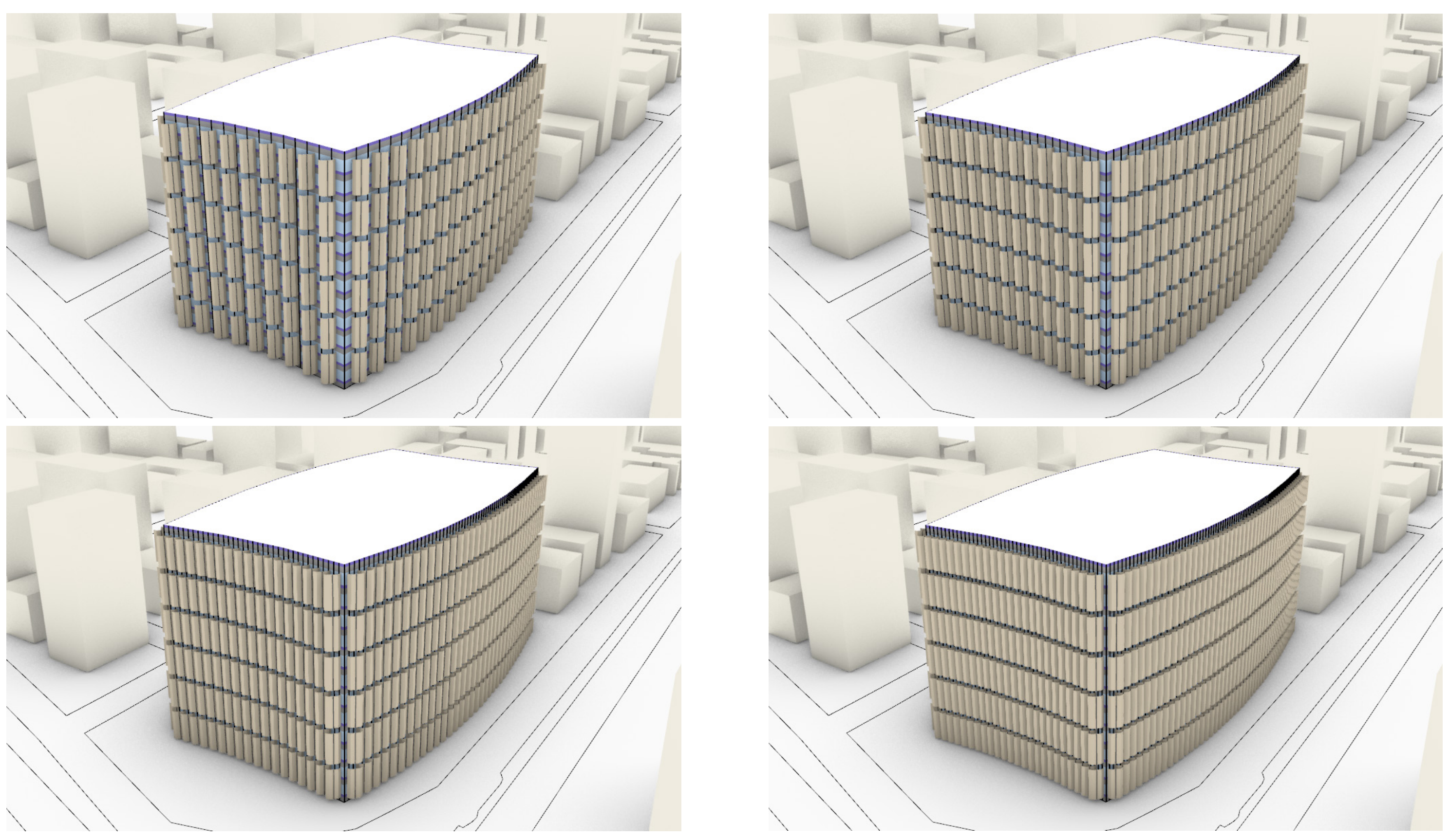




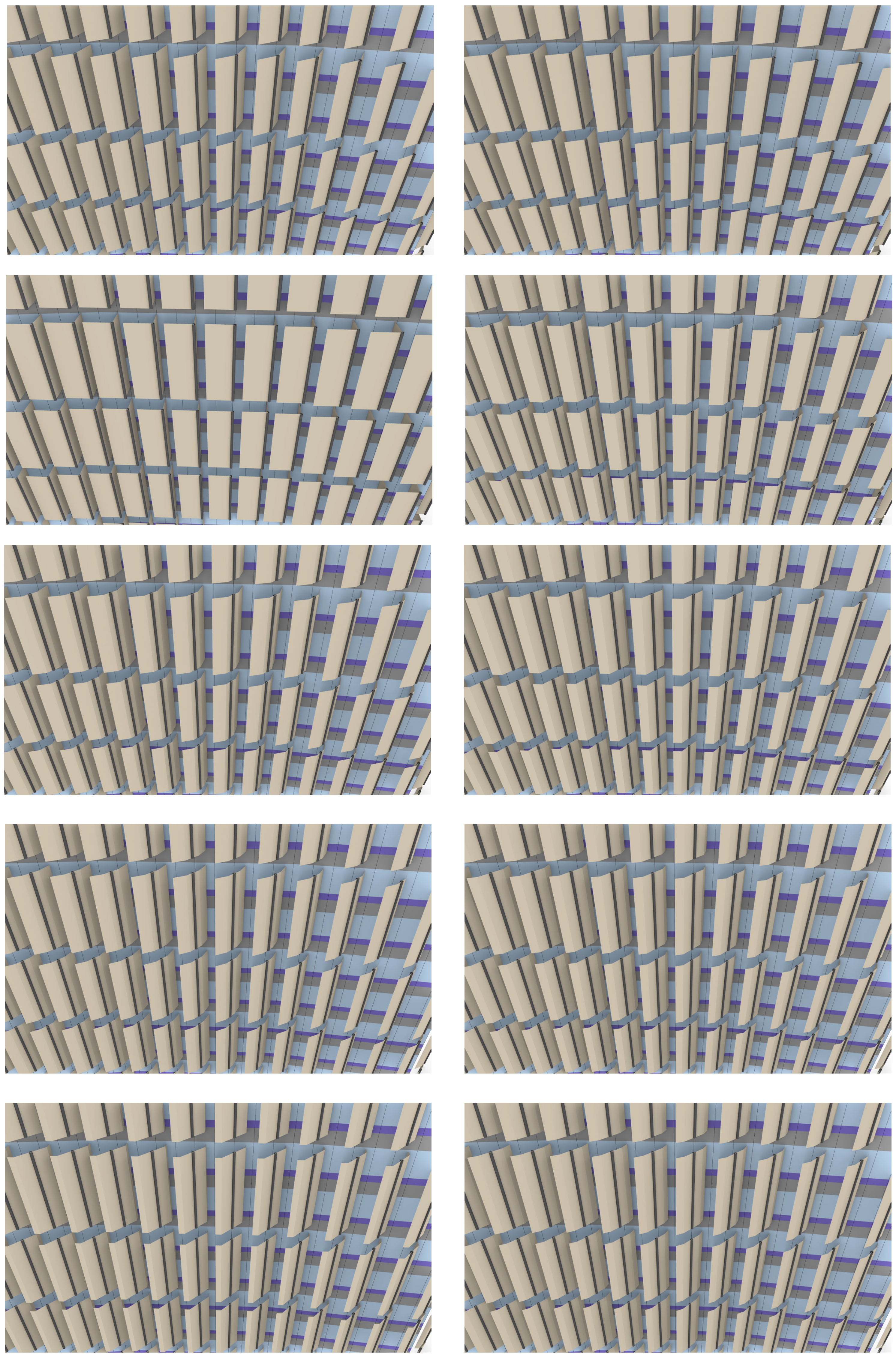




The Script can be applied on any polyline building profile



The panel to windows ratio is adjustable



A script is made that allows quick iteration by selection of different panel selection

	140 DEGREES	120 DEGREES	90 DEGREES
NO OFFSET	2.70 M, 140°	2.70 M, 120°	2.70 M, 90°
0.7 M OFFSET	N/A	N/A	0.70 M, 135°, 1.30 M
0.5 M OFFSET	N/A	0.50 M, 150°, 0.97 M	0.50 M, 135°, 1.70 M
0.3 M OFFSET	0.30 M, 160°, 1.05 M	0.30 M, 1.66 M	0.30 M, 2.10 M
0.2 M OFFSET	0.20 M, 1.60 M	0.20 M, 2.01 M	N/A

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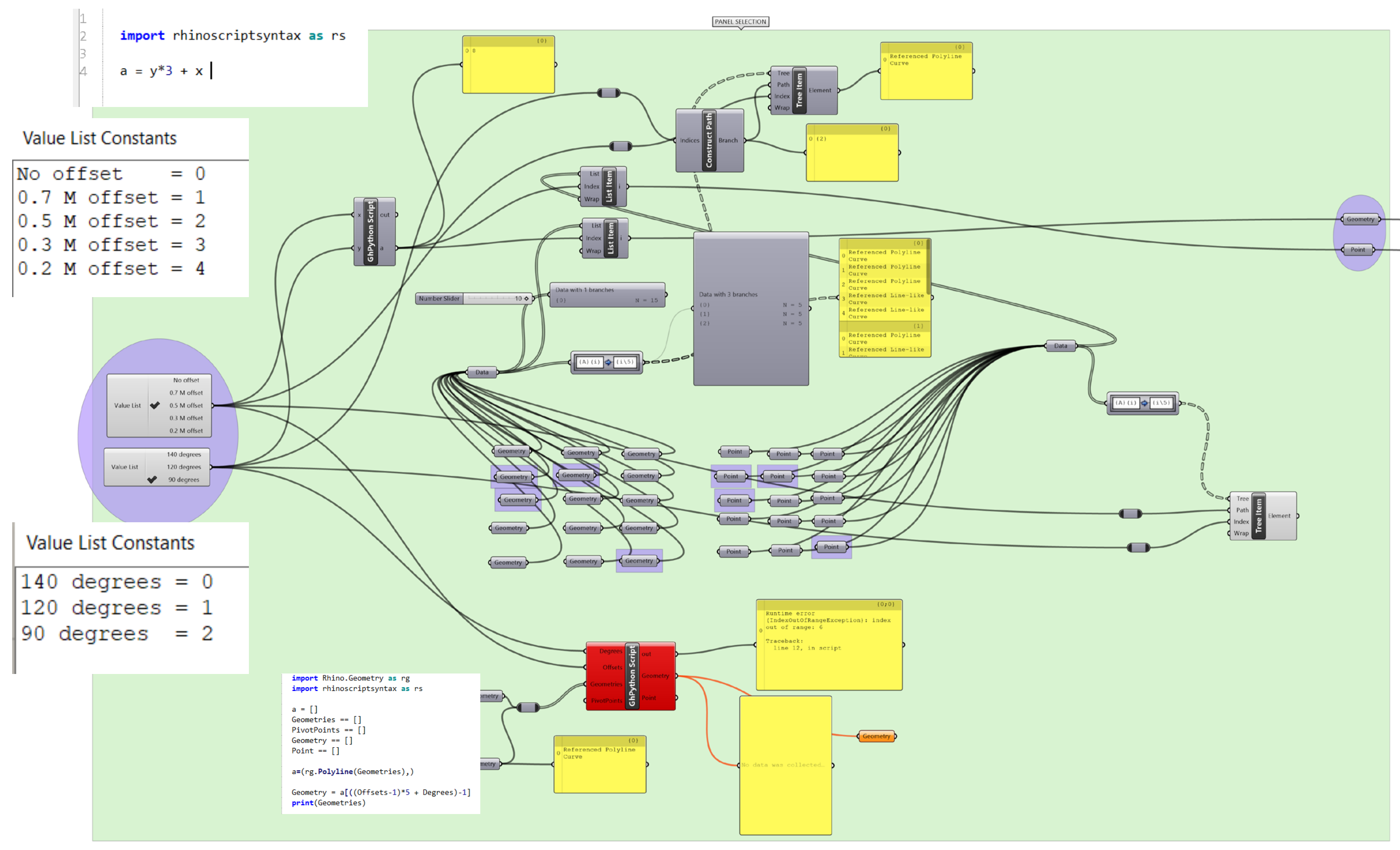
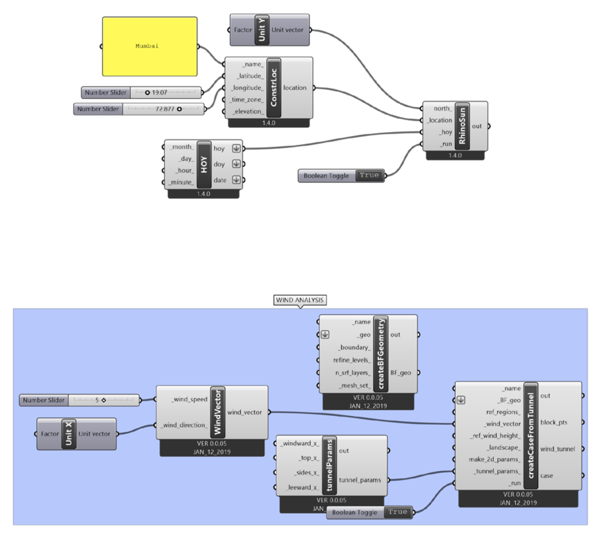
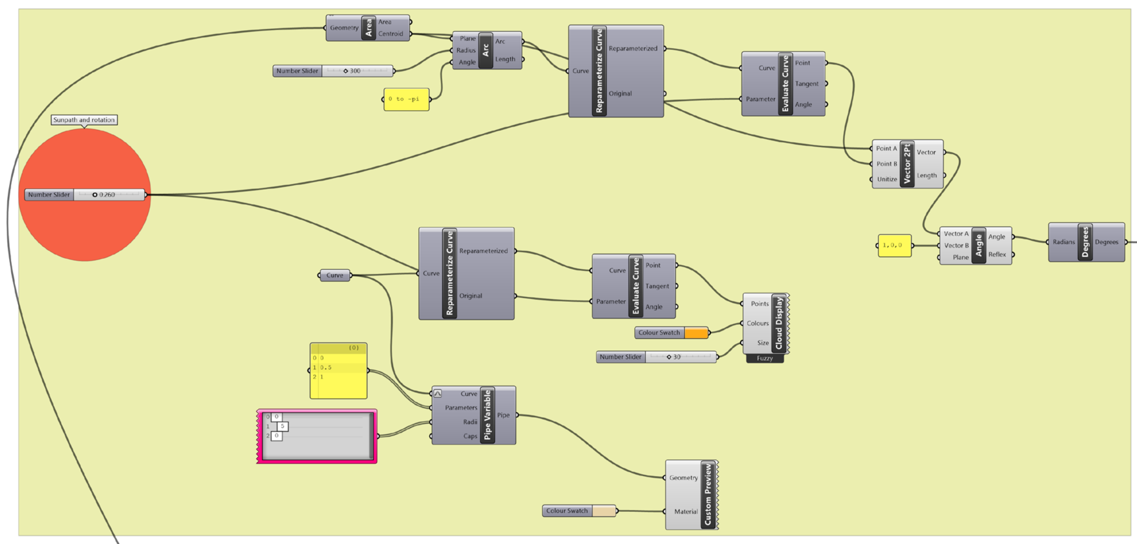
THE SCRIPT OF DIGITAL MODEL



Script of the iterative framework for panel selection

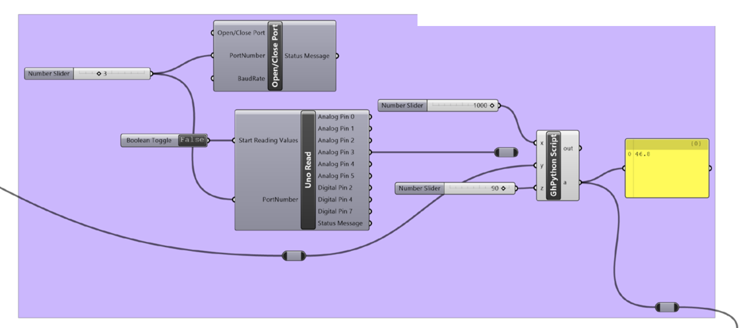


Sun and wind analysis attempt

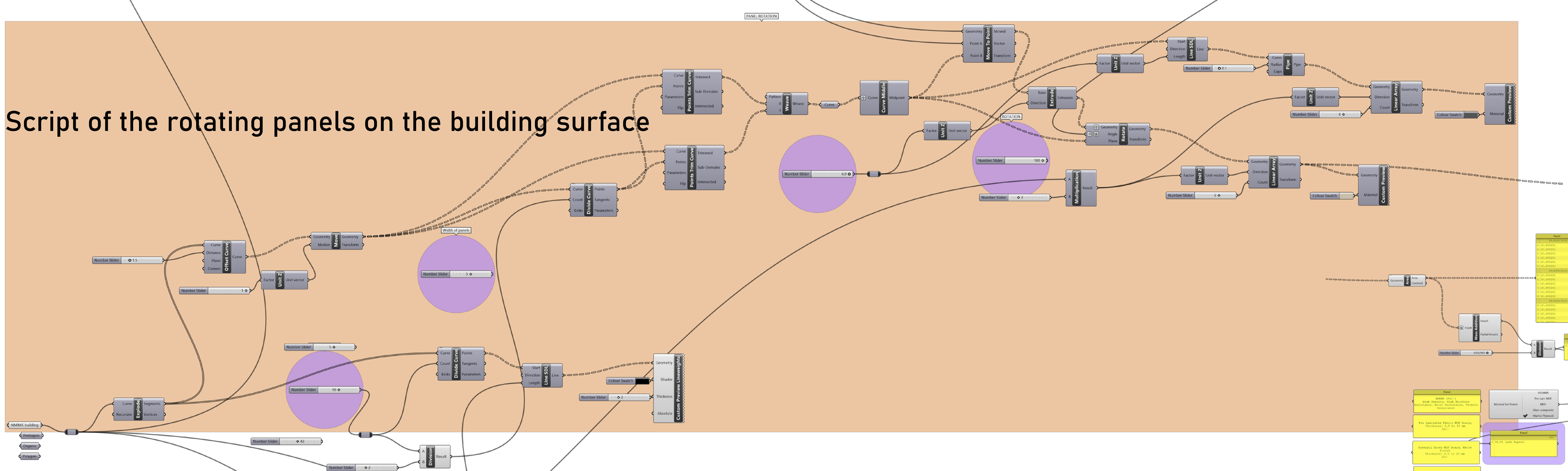


Script of sun path controlled panels

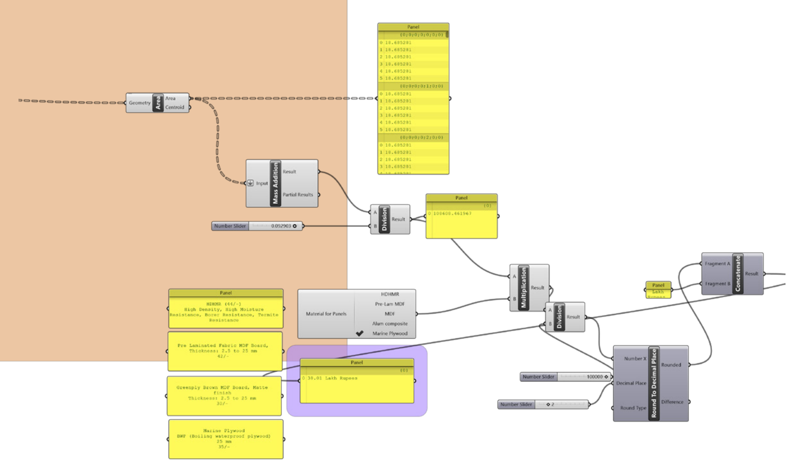
```
import rhinoscriptsyntax as rs

a == []

if x > 700:
    a = y
else:
    a = z
```



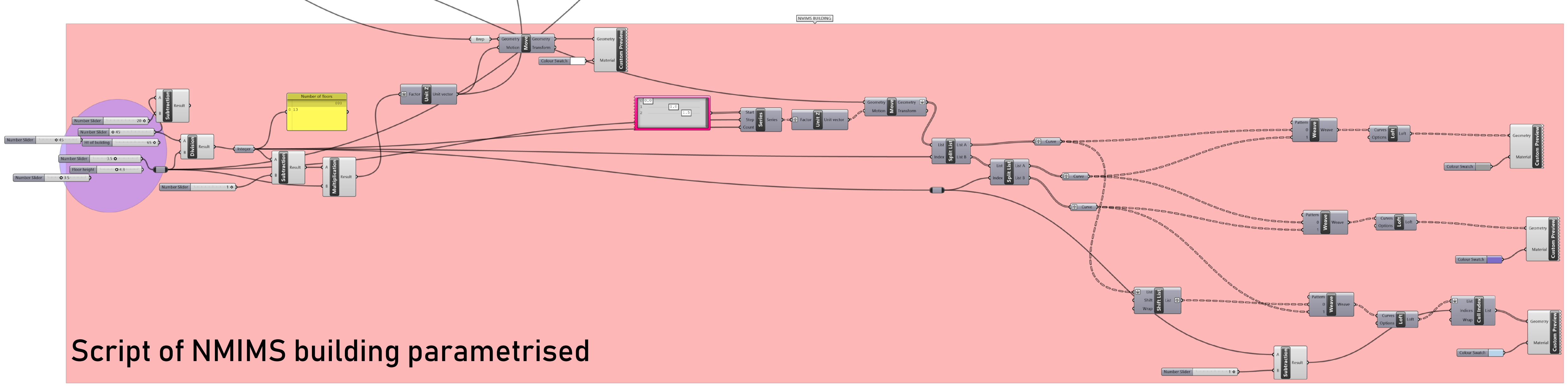
Script for closing panels in shade



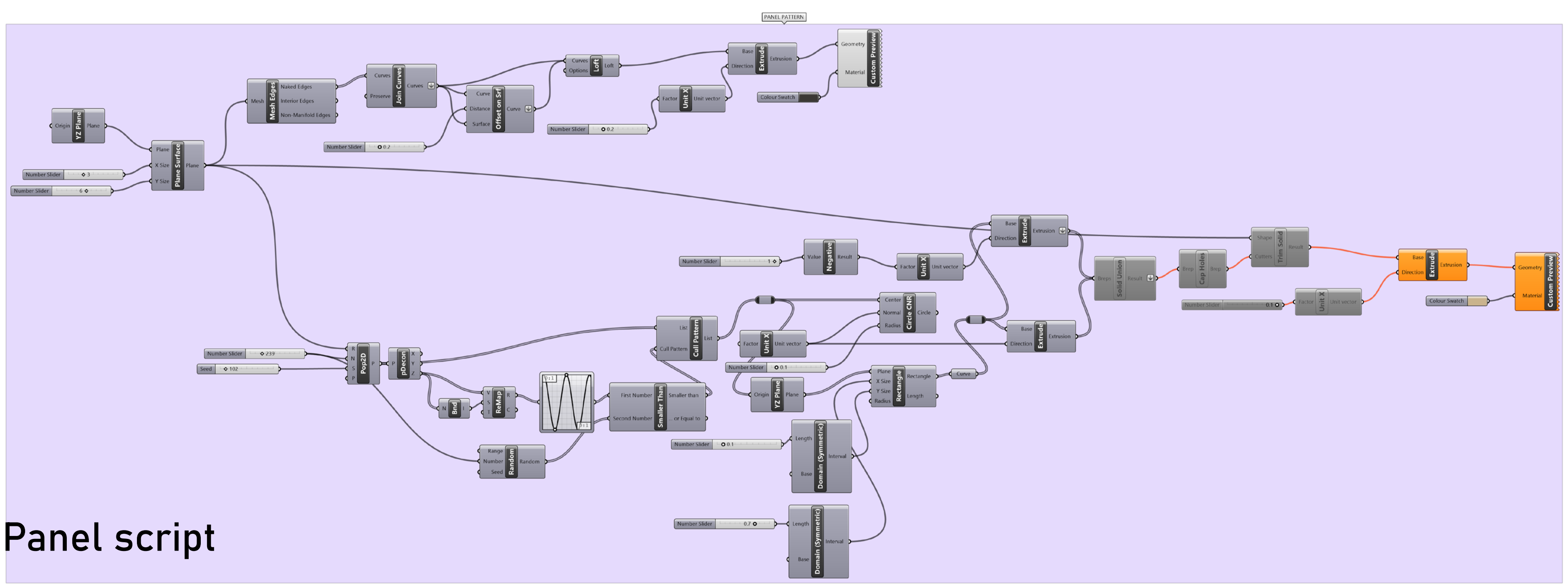
Script of the rotating panels on the building surface



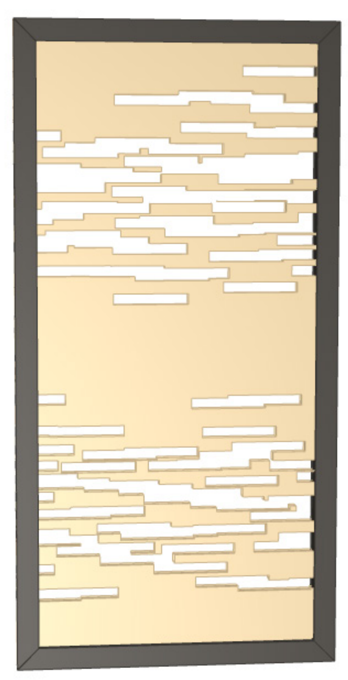
Script for calculating cost



Script of NMIMS building parametrised



Panel script



Panel script outcome (experimental)

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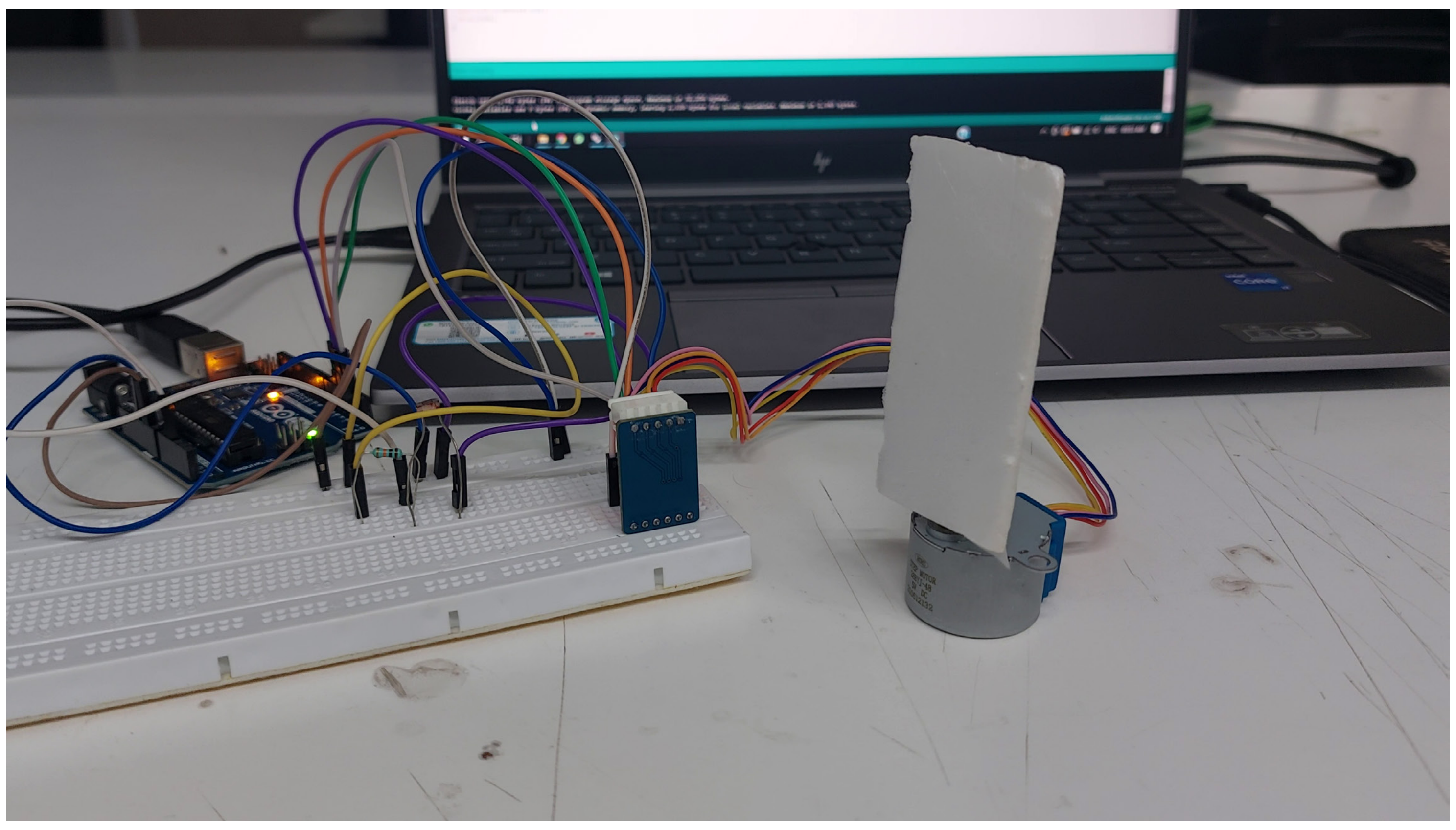
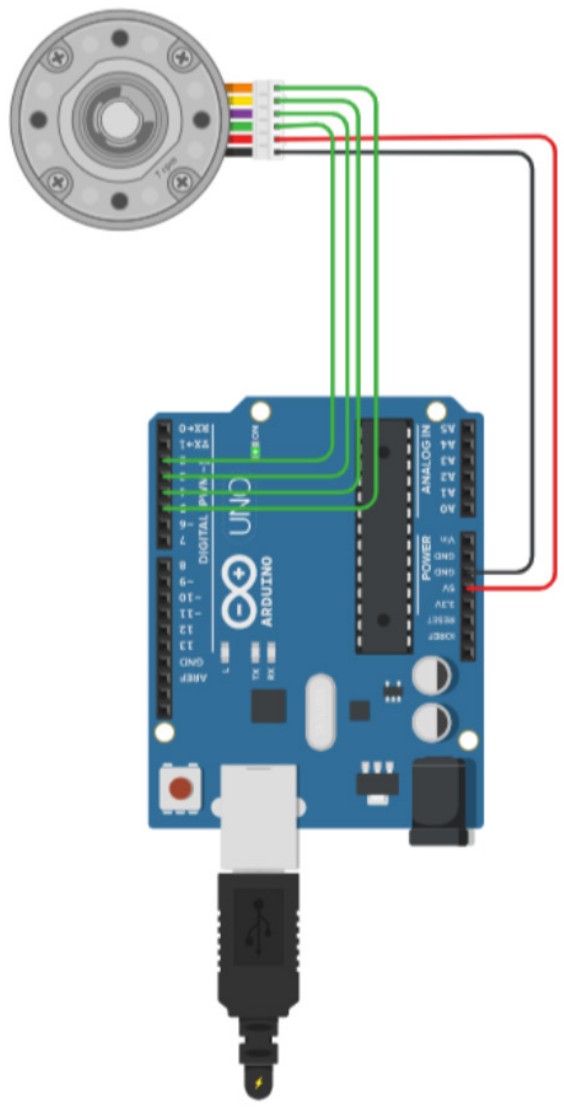
BALWANT SHETH SCHOOL OF ARCHITECTURE

PROTOTYPE USING ARDUINO

DIFFERENT MOTORS ARE CODED AND TESTED OUT

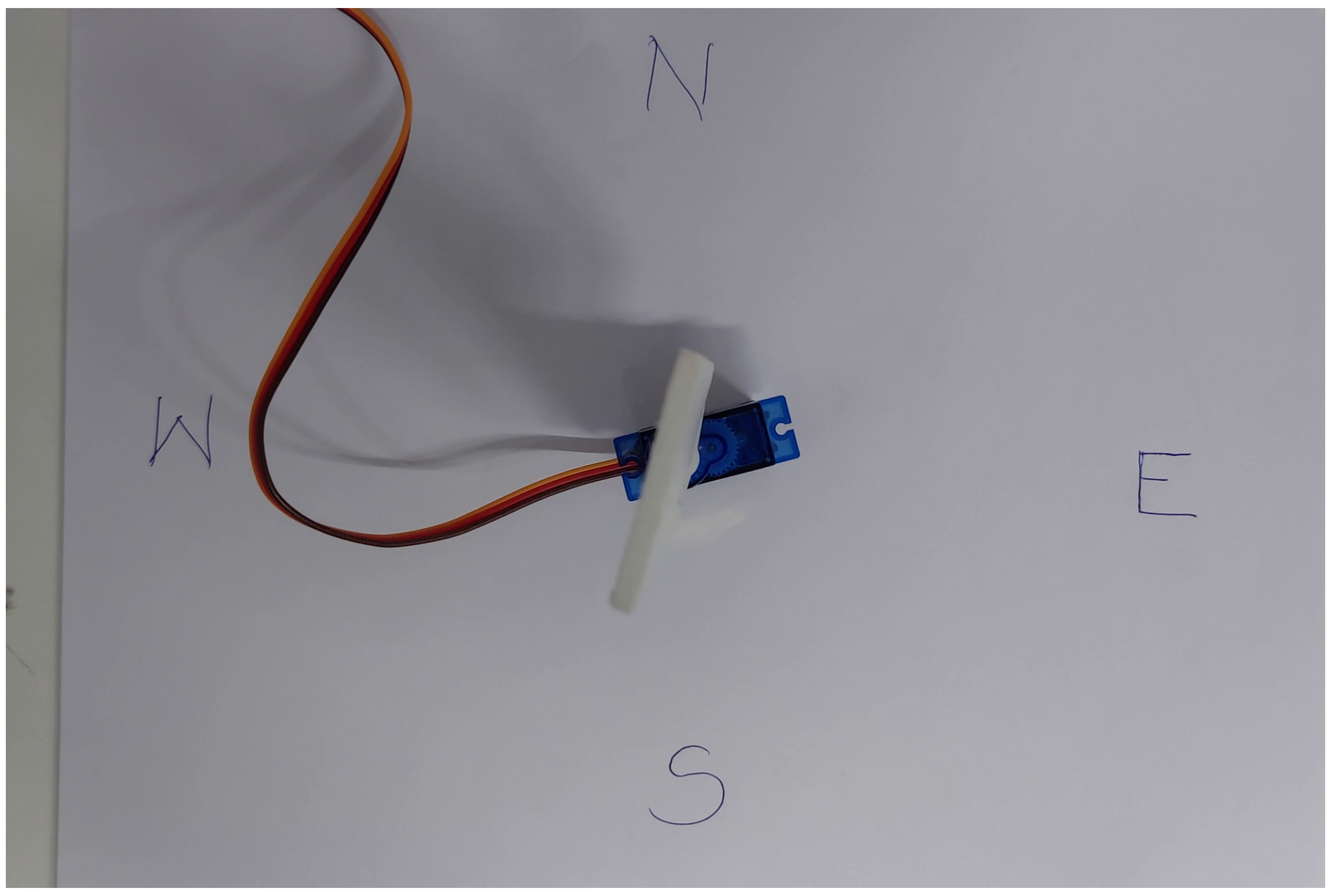
For the automation of the panel rotation according to the sunpath and sunlight levels, 3 types of motors were coded and used out of which the Positional Servo Motor was the most appropriate for the said function.



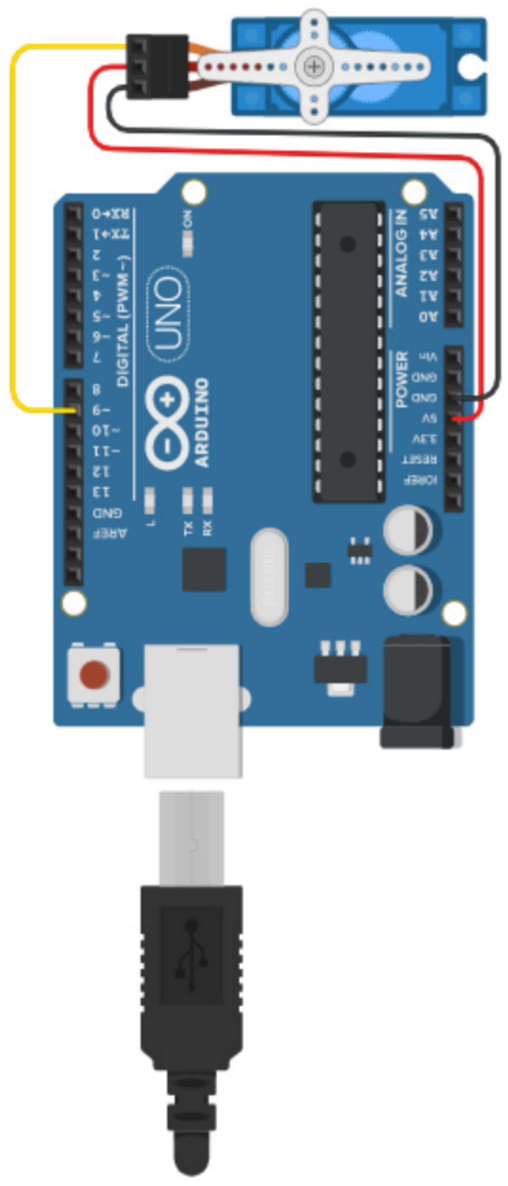


```
int motor1=2;
int motor2=3;
int motor3=4;
int motor4=5;
void setup()
{
  pinMode(motor1,OUTPUT);
  pinMode(motor2,OUTPUT);
  pinMode(motor3,OUTPUT);
  pinMode(motor4,OUTPUT);
}

void loop()
{
  digitalWrite(motor1,HIGH);
  delay(1000);
  digitalWrite(motor1,LOW);
  delay(100);
  digitalWrite(motor2,HIGH);
  delay(100);
  digitalWrite(motor2,LOW);
  delay(100);
  digitalWrite(motor3,HIGH);
  delay(100);
  digitalWrite(motor3,LOW);
  delay(100);
  digitalWrite(motor4,HIGH);
  delay(100);
  digitalWrite(motor4,LOW);
  delay(100);
}
```

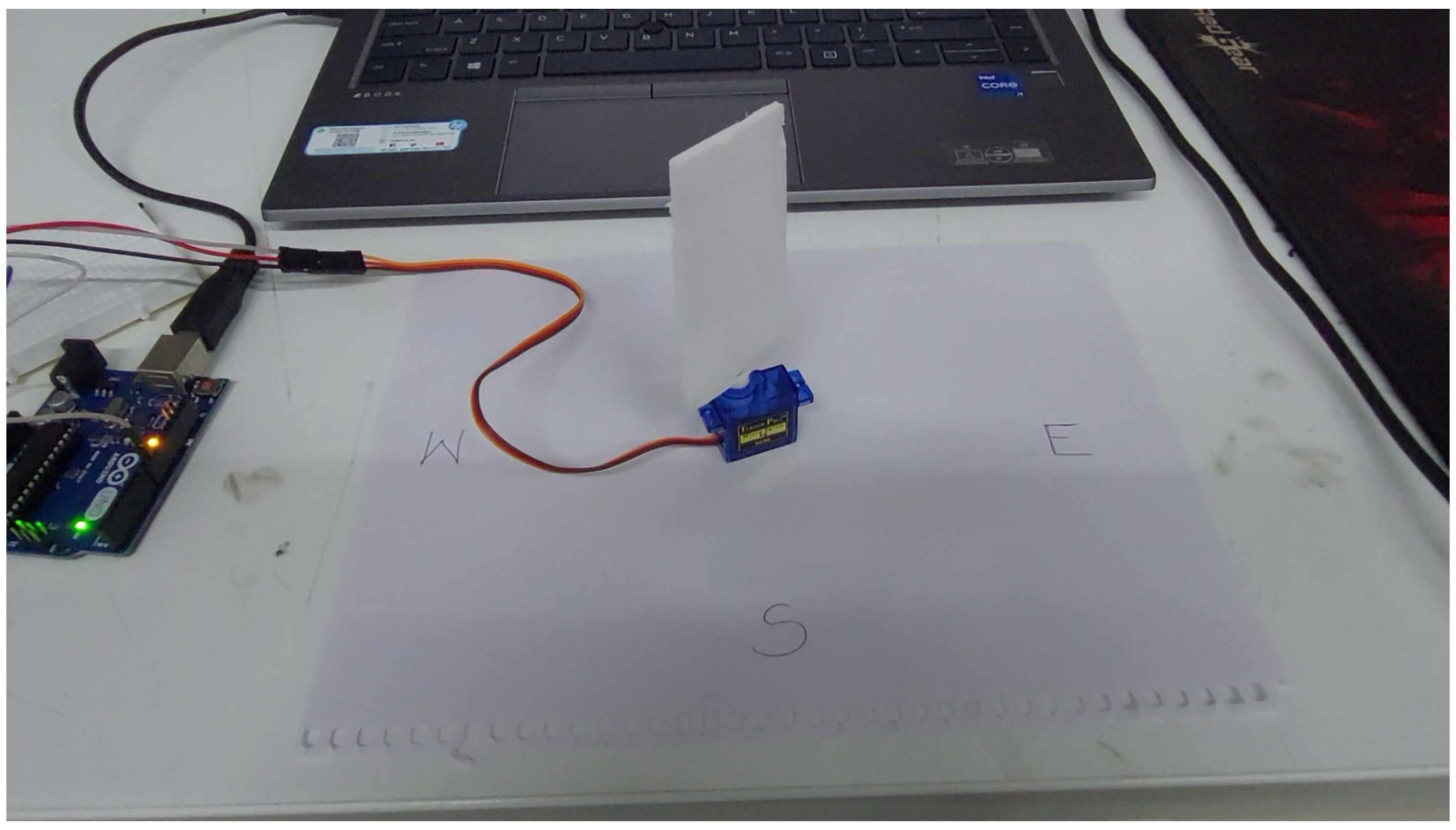
Stepper Motor



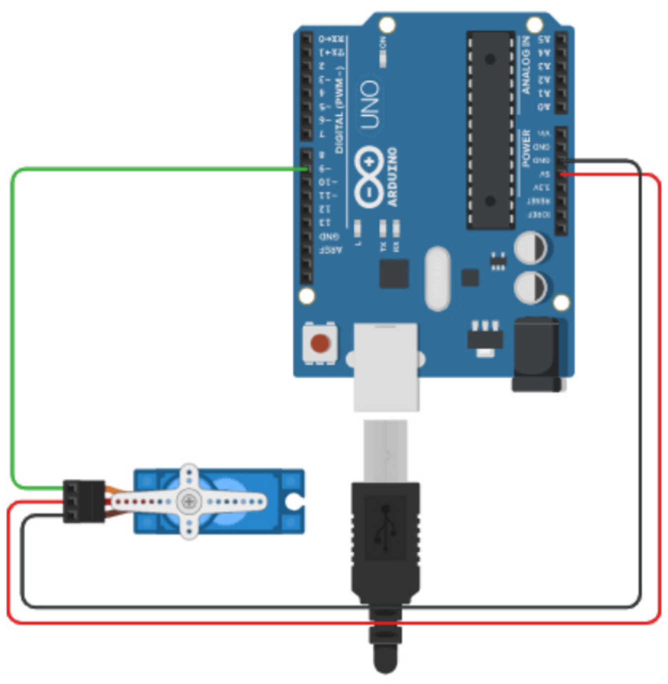
Continuous Servo Motor



```
#include <Servo.h>

Servo servo_9;
int x = 0;
void setup()
{
  servo_9.attach(9, 500, 2500);
}

void loop()
{
if (x < 7){
  x = x+1;
  servo_9.write(80);
  delay(200);
  servo_9.write(90);
  delay(1000);
 }
else{
  x = 0;
  servo_9.write(100);
  delay(650);
  servo_9.write(90);
  delay(2000);
}}
```



Positional Servo Motor

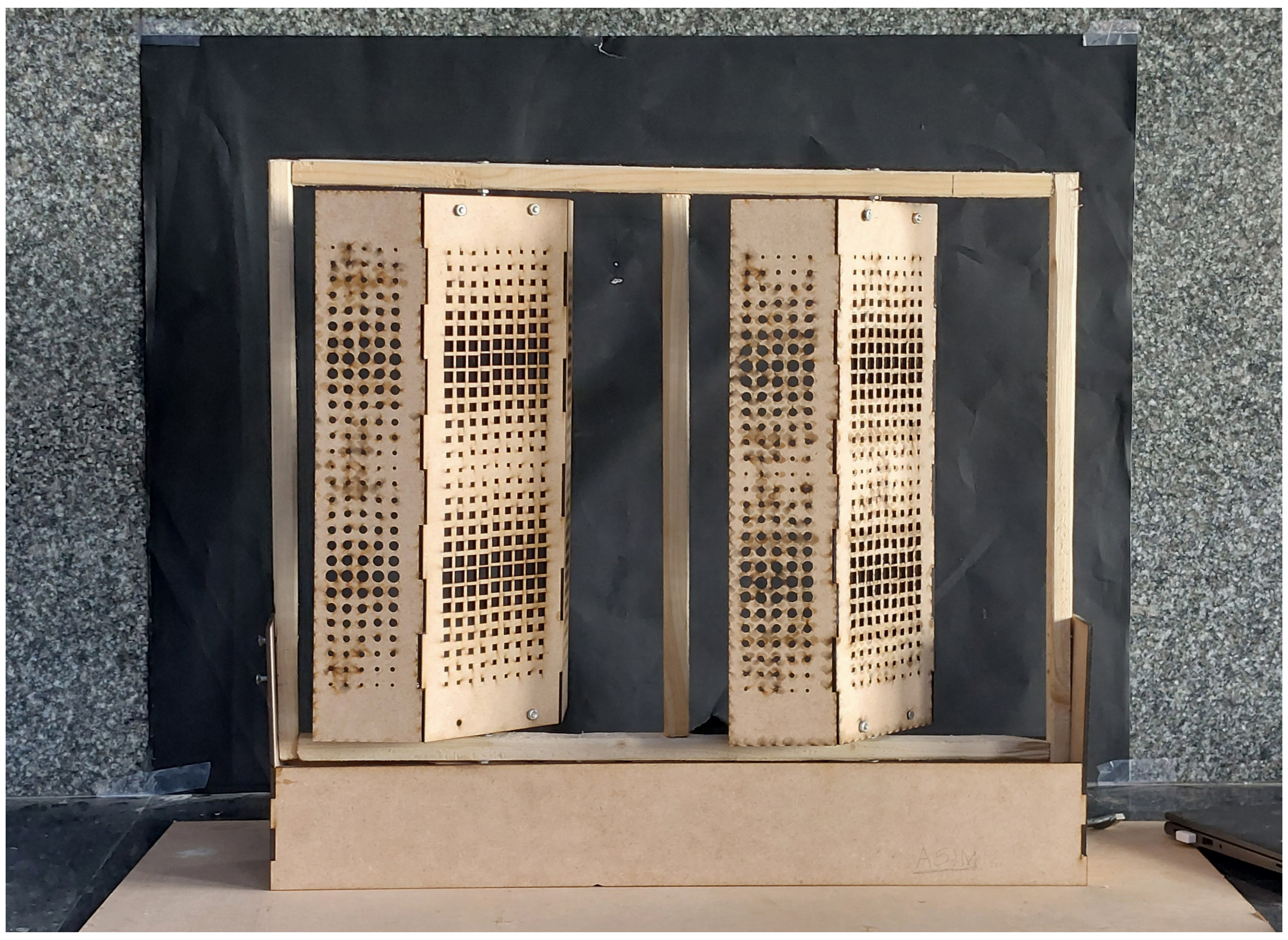


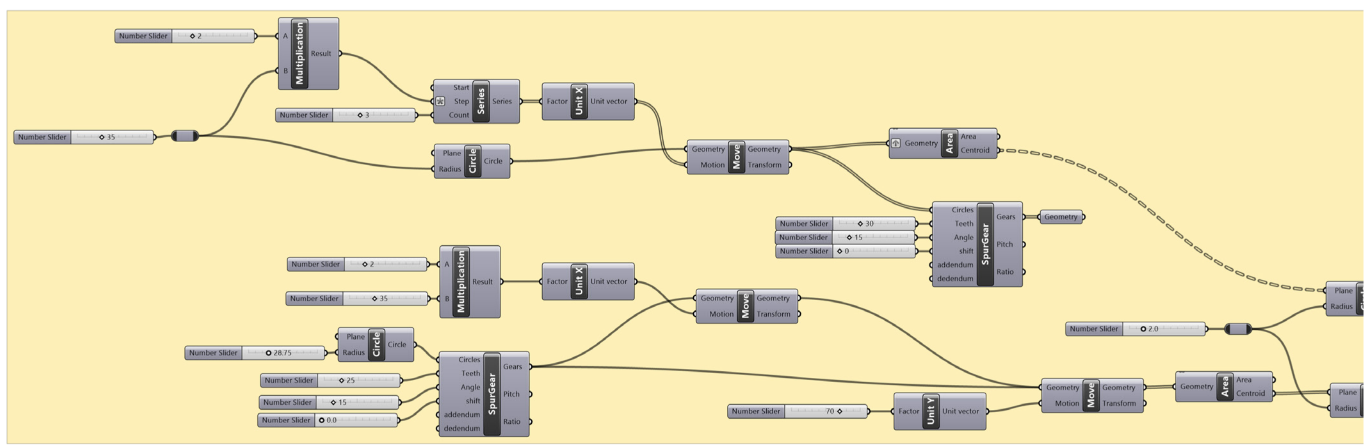
```
#include <Servo.h>

Servo myservo;

int y = 5; //the angle per movement
int x = 180/y;

void setup()
{
  Serial.begin(9600);
  myservo.attach(9);
}

void loop()
{
if (x > -1){

   myservo.write(y*x);
   delay(1000);
   x = x-1;
}
else {
  x = 180/y;
}
}
```

PHYSICAL MODEL

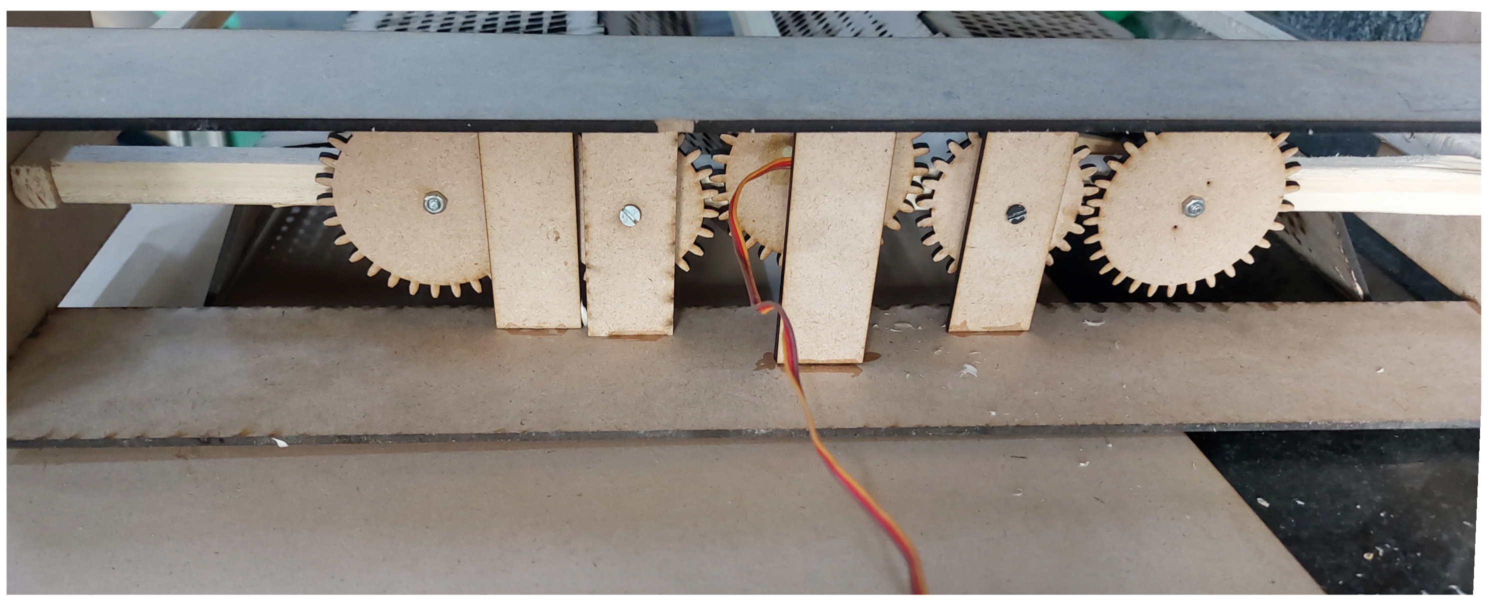
PANELS AND ARDUINO AUTOMATION

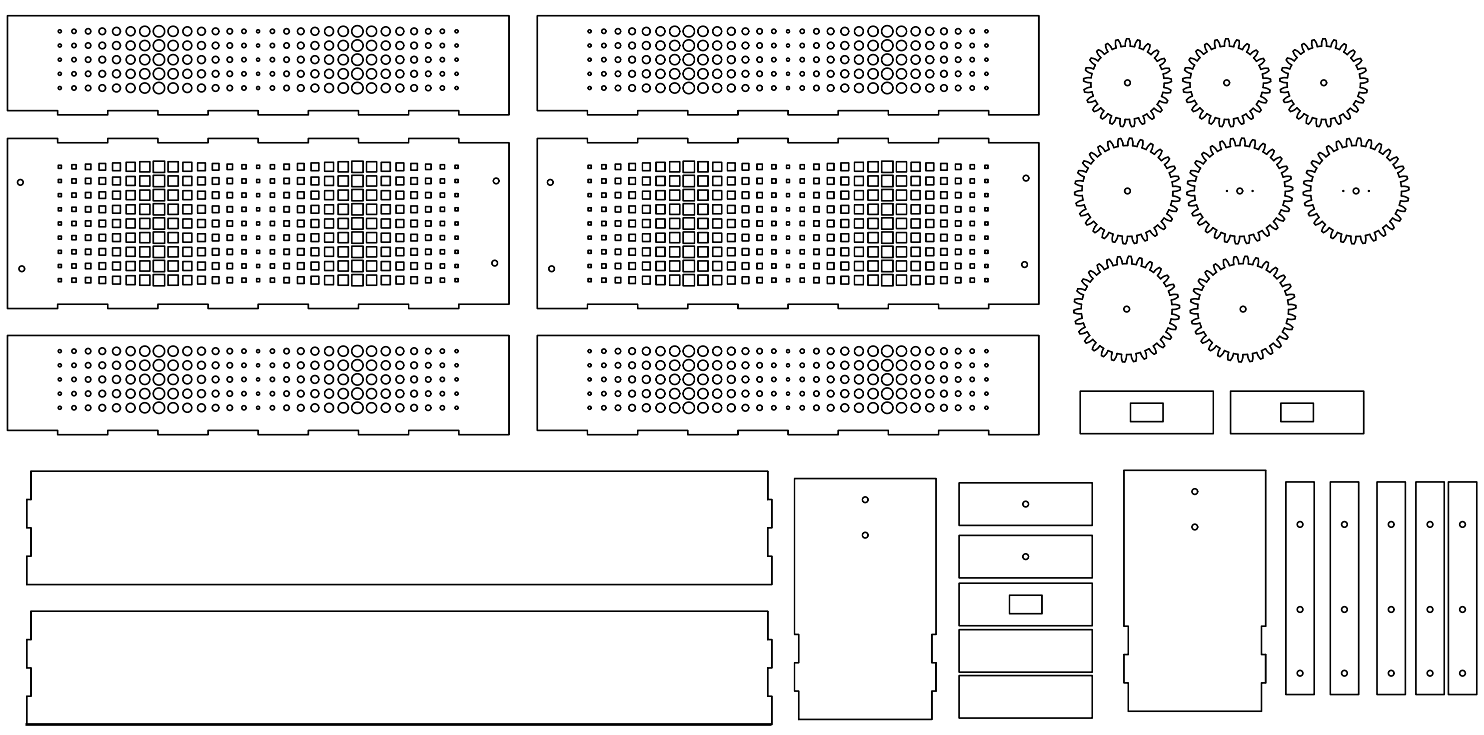
Each panel covers two floors vertically and two windows horizontally, effectively catering to 4 windows. They are perforated such that they **shade the sun at higher azimuth angles while allowing when it is lower**. This is achieved by a gradual decrease in aperture size as we move away from the centre of the windows. Moreover, the larger aperture size allow **natural indirect light, visibility and ventilation** for the inhabitants.



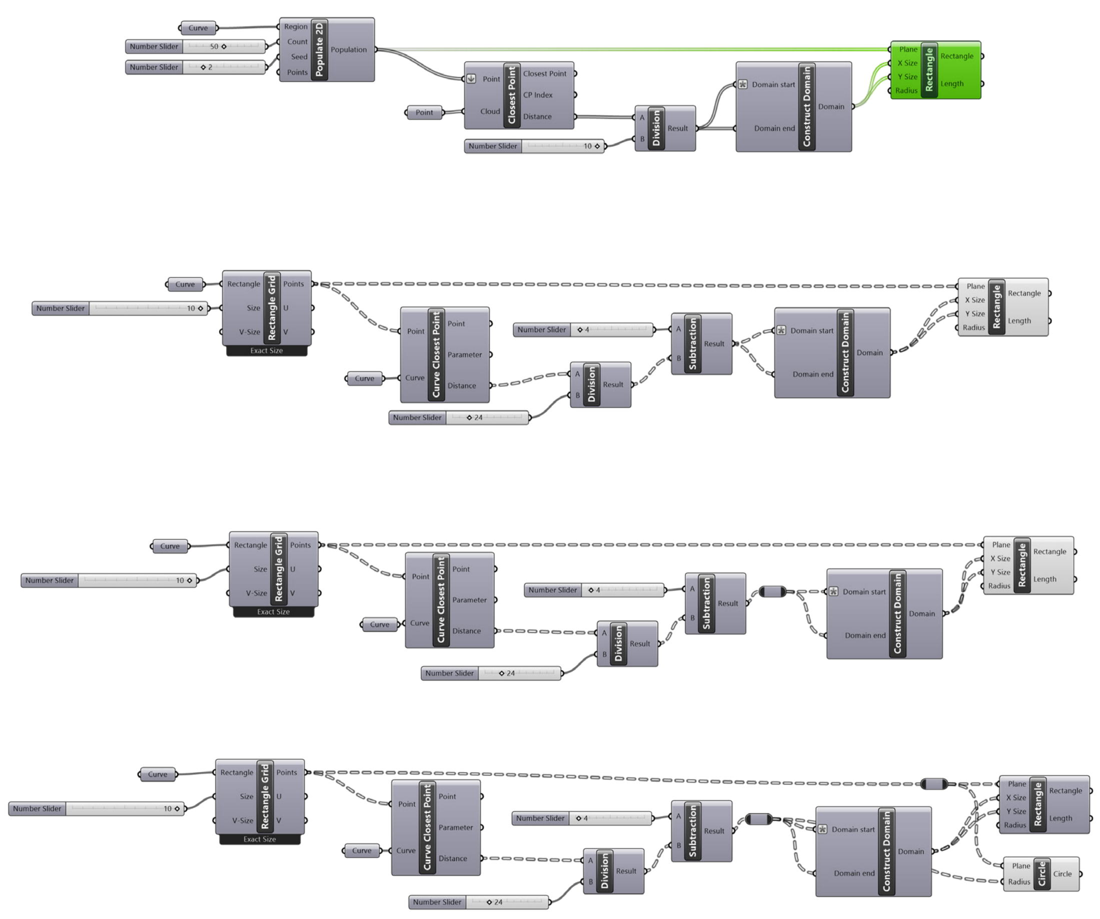


Angle = 15 degrees, Teeth = 25 and 30, Pitch = 5.37 and 5.44 mm respectively





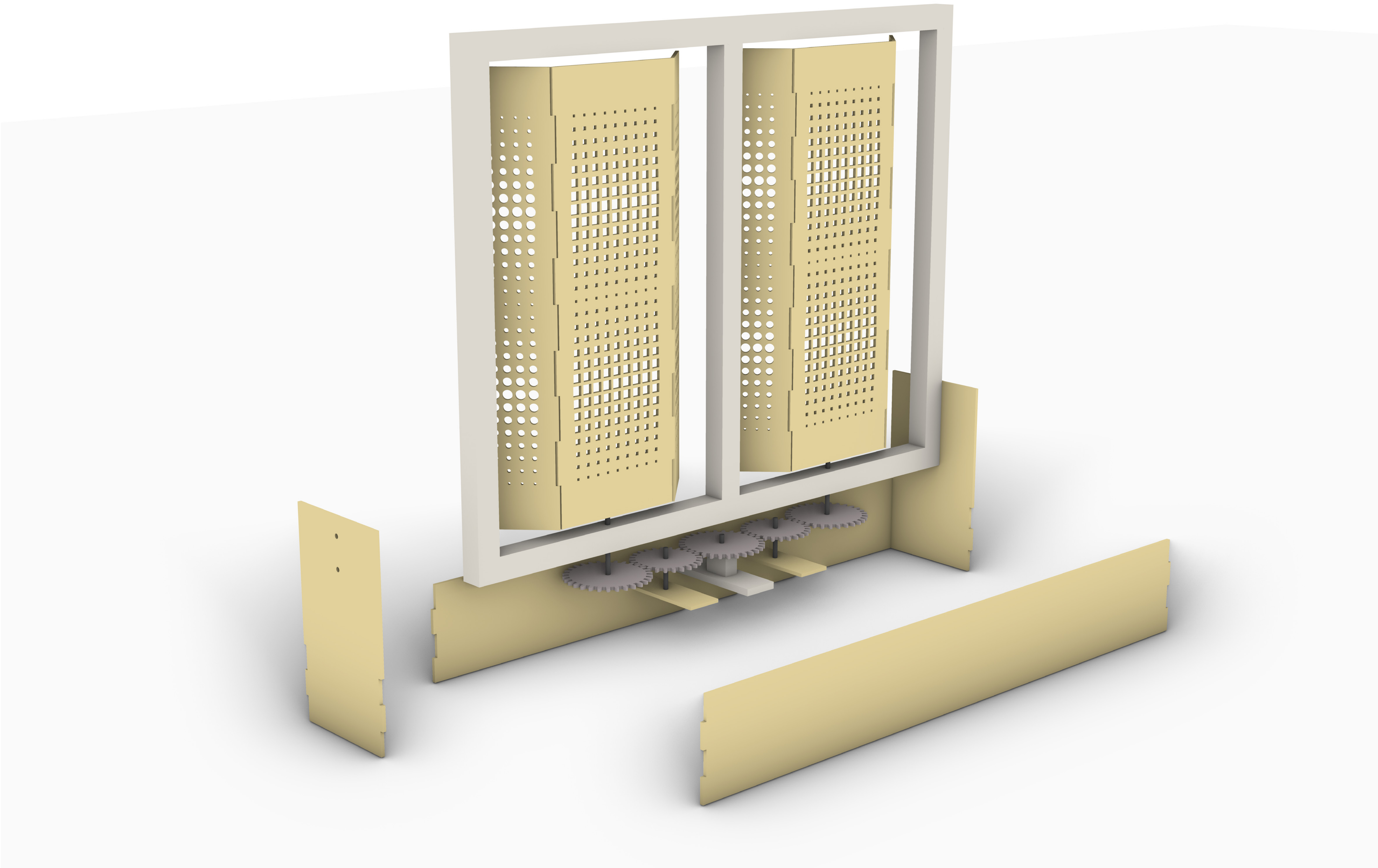
Laser cutting dwg file

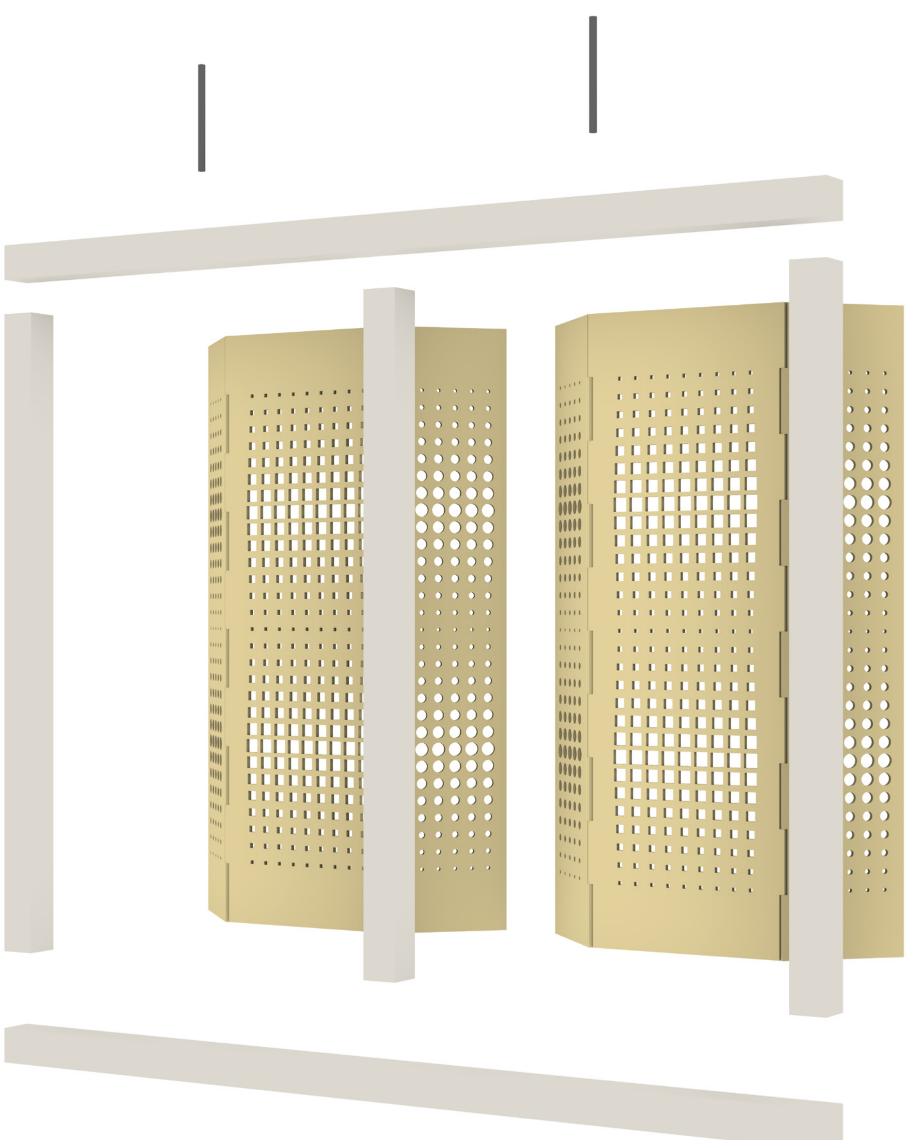


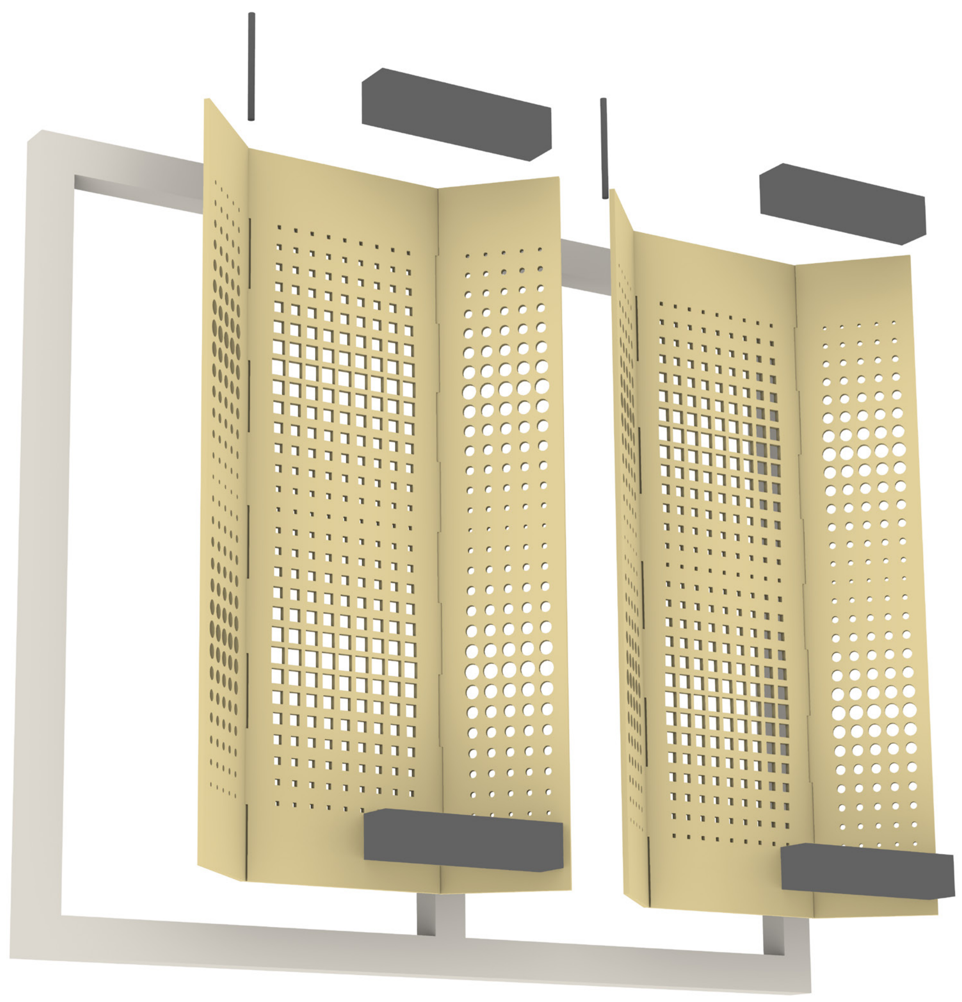
Script for the gears and pattern on the pannels based on attractor curves.

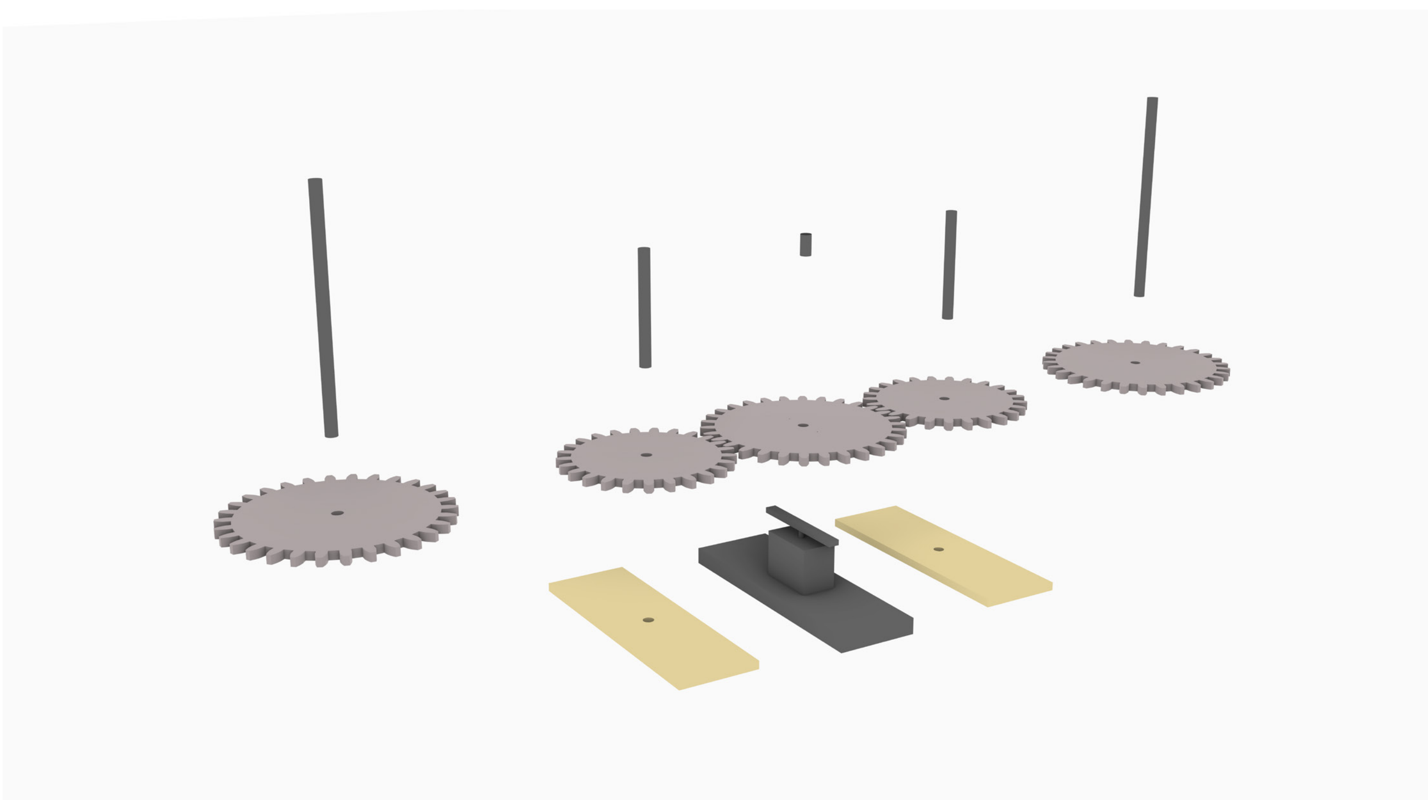
WORKSHOP MODEL

DIGITAL MODEL OF THE WORKSHOP MODEL



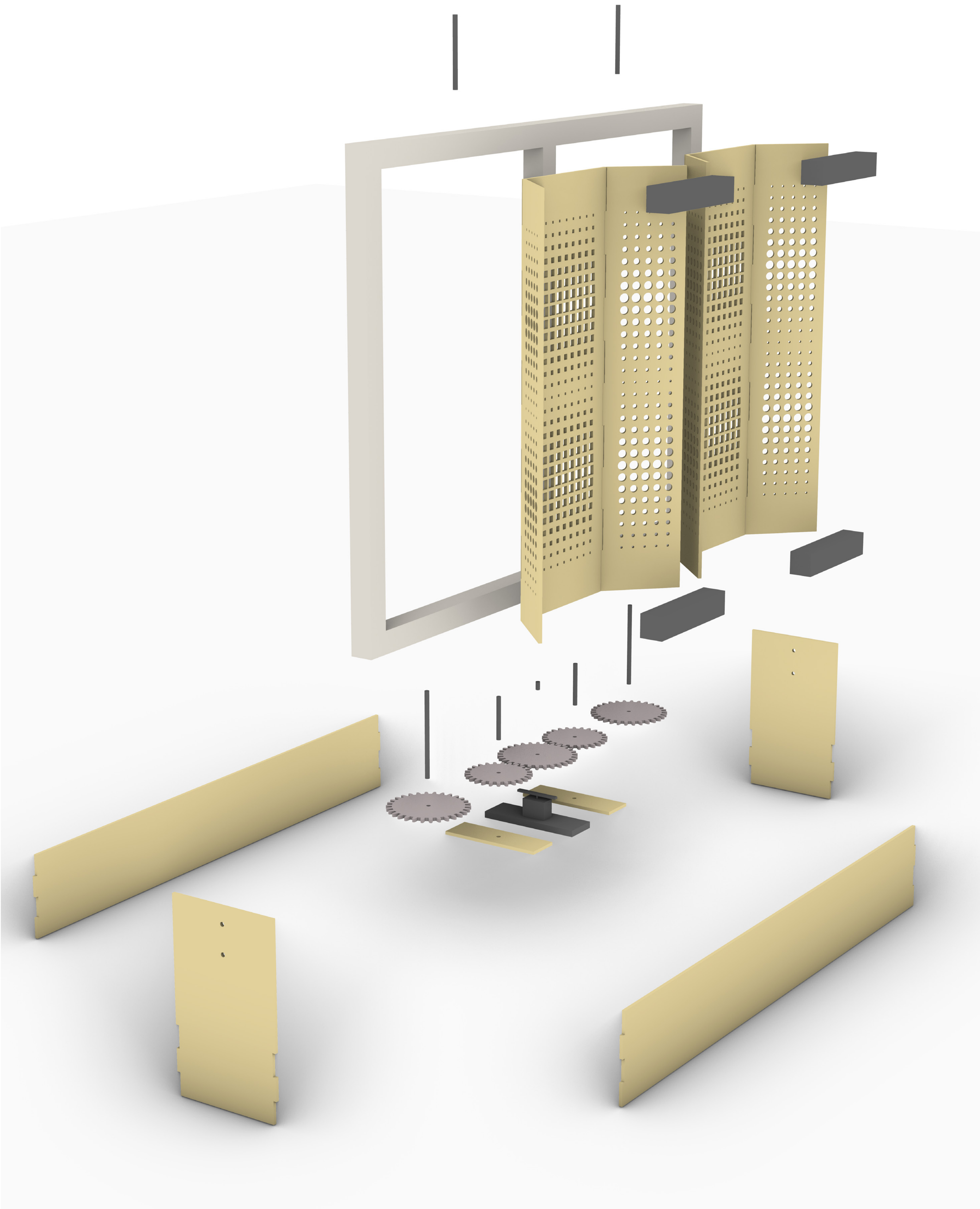




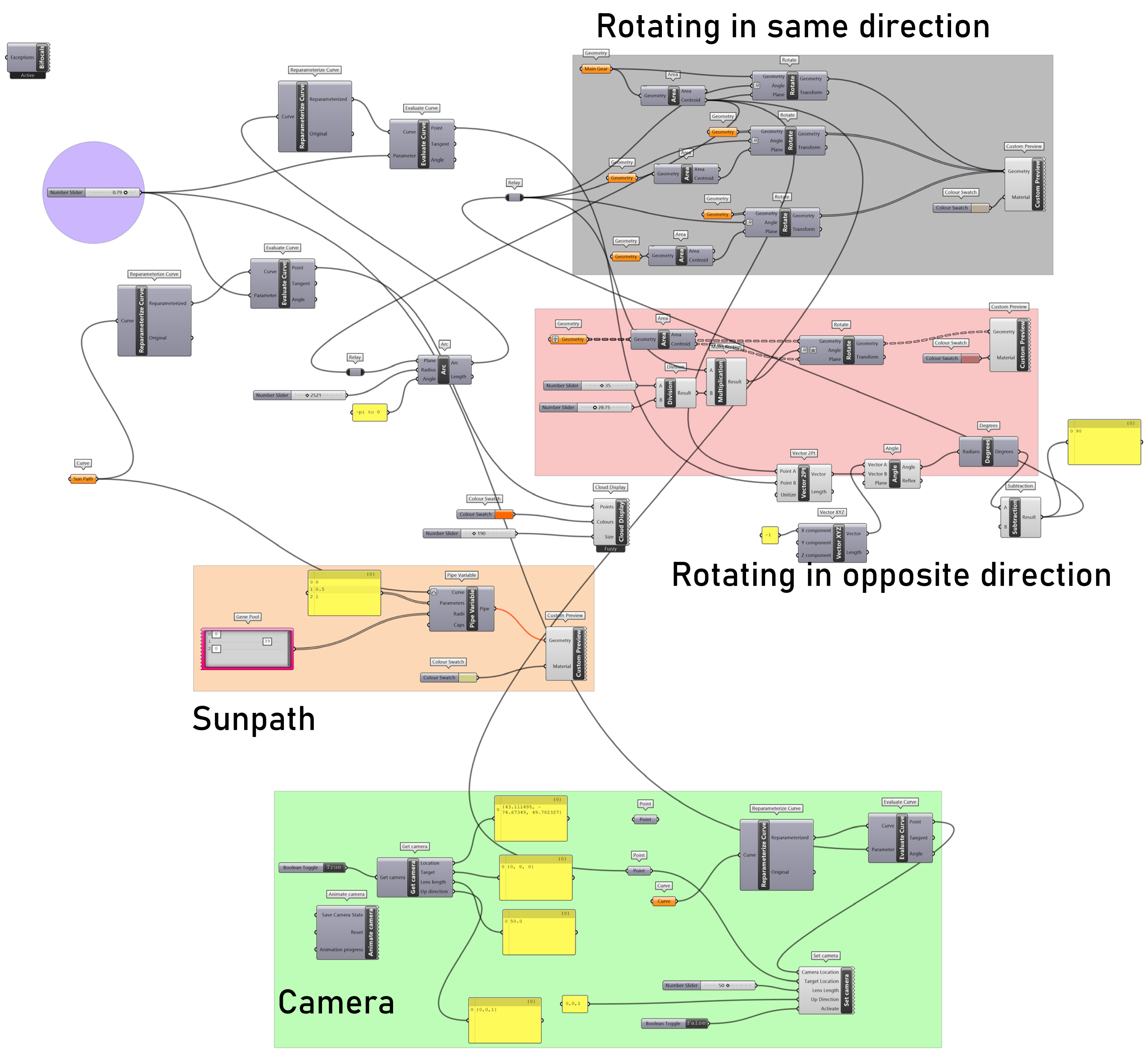


The model is made of Medium Density Fibreboard 3 mm thick. The parts are all lasercut. Pivots are created by screws. The board and the gears are fixed to the screw for the transfer of torque by the servo motor through the idler gears. The idler gears fill the space between the main gears and also rotate in the opposite direction which makes all the main gears rotate in the same direction.

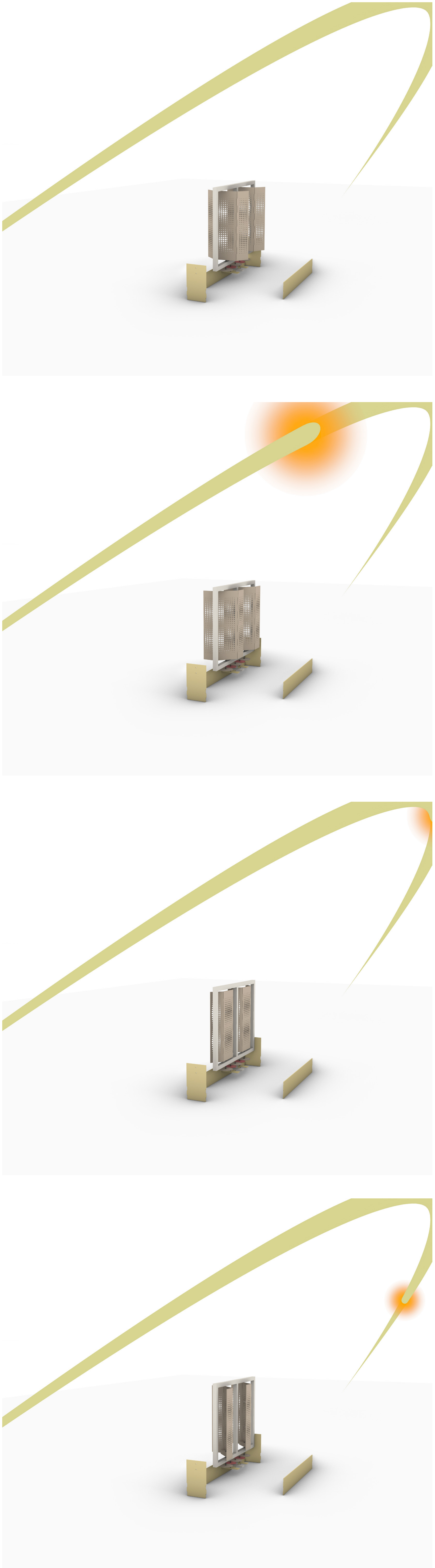
WORKSHOP MODEL



Exploded view of the workshop model



The script for controlling the panels and gears using sun path



Model responds to sun

SYED MOHAMMAD ASIM | A001

PERFORMATIVE BUILDING SKINS | SEMESTER 4 | M.ARCH

Tutor : IPSITA DATTA

BALWANT SHETH SCHOOL OF ARCHITECTURE