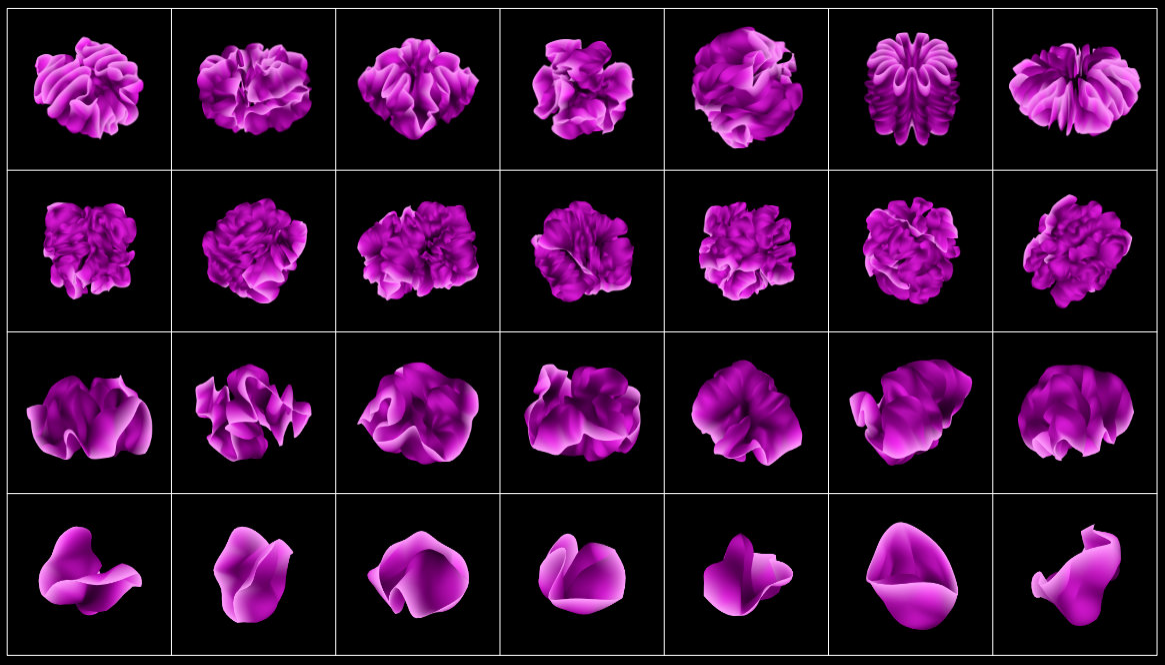
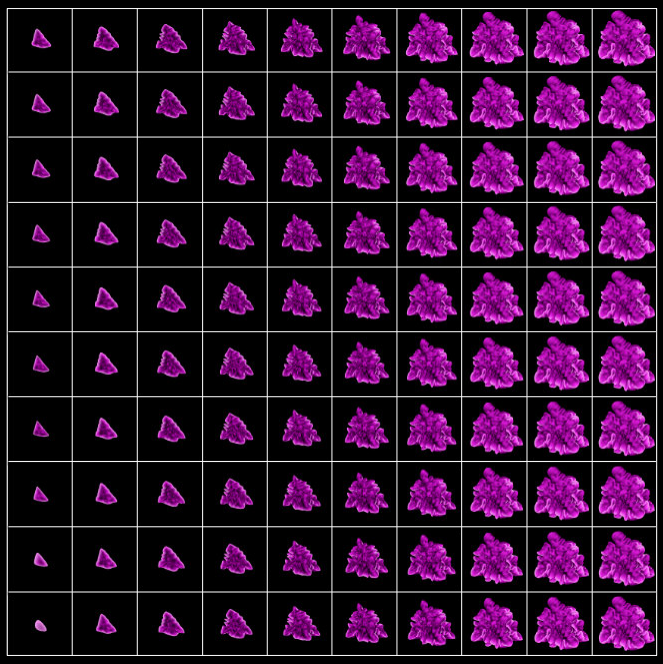
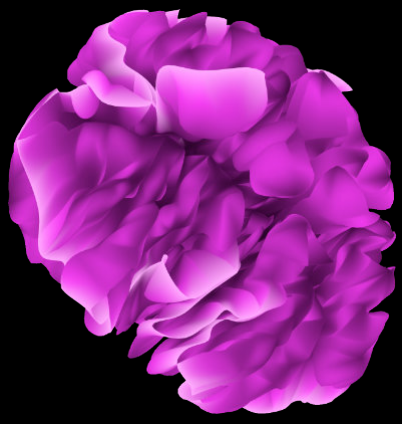
SUMMARY





GROWTH EVOLUTION



Boundary edge
New vertex
Old vertex

Mesh Simulation for
5000 vertices

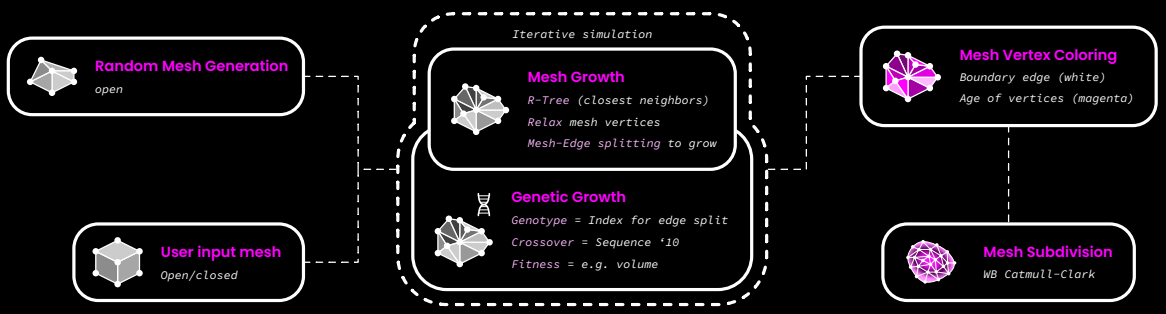
MESH GROWTH

The project aims to create a design pipeline for users to form-find organic shapes through growing simulations. It should enable to form-find custom input geometries and should give the user visual feedback through real-time simulations and geometry colorings.
It is developed with C# for Grasshopper.

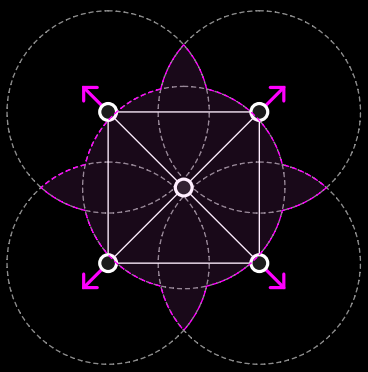
The MeshGrowSystem class is the core of the simulation and encapsulates the two main methods to grow a given input mesh - RelaxRTree() and Mgrow(). Through a finite loop of these two methods the mesh vertices system gets continually relaxed and extended, by splitting mesh edges that become too long. To optimize computation time i implemented a R-Tree to find closest neighbours faster within the mesh vertices cloud.

GOAL

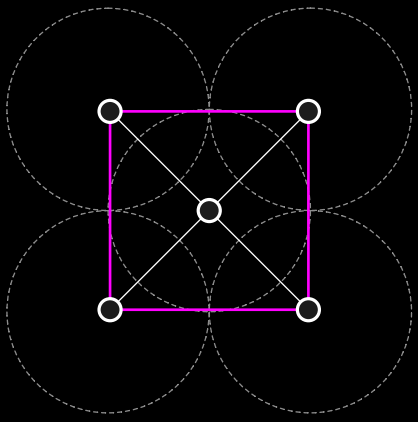
PIPELINE



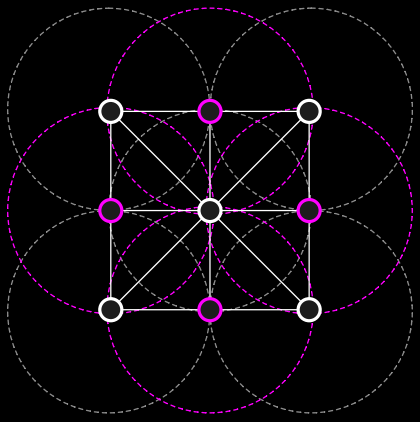
GEOMETRY GROWTH



#1 -COLLISION
If two cells are too close, they will both move away from each other - reaction detection.



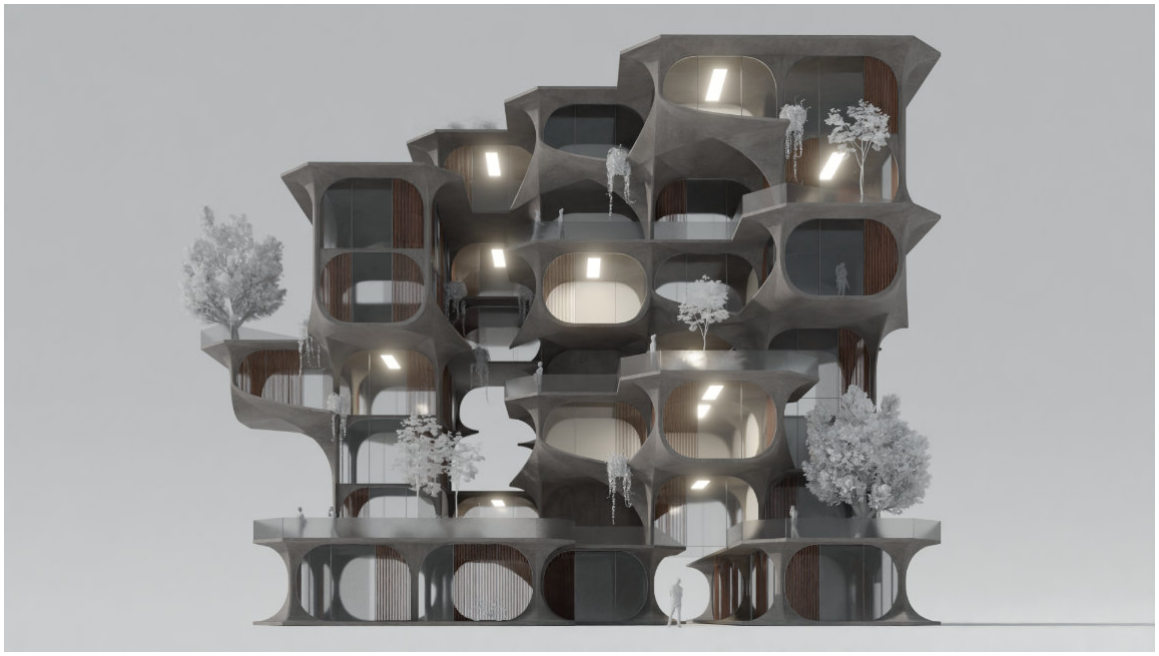
#2 - RELAX
If the system of cells is enough distanced, the system is relaxed and stops moving.



#3 - GROW
If two cells are too close, they will both move away from each other.

PSEUDO CODE

```
public class MeshGrowSystem{
   //PROPERTIES
   private R-Tree rTree; //R-Tree with current vertices, to find closest in vertex cloud
   private List<Point3d> rPoints; //For callback event of R-Tree search in range

   //CONSTRUCTOR
   public MeshGrowSystem(Mesh m){
      //Duplicate start-mesh(m) and store in class
   }

   //RELAXATION OF MESH VERTICES WITH R-TREE
   public void RelaxRTree(double relaxDis){
      //Update R-Tree with transformed mesh vertices
      //Create List<Vector3d> to store movement of mesh vertices before transforming
      for (//All verices){
         //Use R-Tree to get vertices that are too close and in relaxDis
         for (//All vertices in relaxDis){
            //Calculate push-Vector3d to move out of relaxDis for each in-range vertex neighbor
         }
         //Average Sum of all push-Vector3d for each vertex
         //Add to movement List<Vector3d> for mesh vertices
      }
      for (//All verices){
         //Transform each vertex with movement List<Vector3d>
      }
   }

   //CALLBACK EVENT FOR R-TREE SEARCH
   private void RTreeEventHandler(object sender, RTreeEventArgs args){
      //Add found vertex within relaxDis to rPoints
   }

   //MESH GROWTH THROUGH MESH-EDGE SPLITTING
   public void MGrow(double relaxDis){
      if (//Current count of verticies < //Maximum amount of vertices){
         //Create lookup list for edges to split List<VertexPair>
         for (//All mesh edges){
            if (//Mesh edge length > relaxDis){
               //Store vertex pair for edge to split in lookup list
         }
         }
         for (//All vertex pairs of edges to split){
            //Get correct index of edge with vertex pair
            //Split edge with received index
         }
      }
   }
}
```

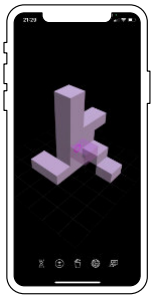


HOUSING APP

Reimagine Housing.

This is the latest coding group project that we developed with a group of four students. Our goal was to speed up the client-architect design process, by developing an interactive AR App. The architect would pre-design a set of architectural components and the client would be able to manually adjust and aggregate those in a virtual space, which could be accessed with any given iOS device.
Our team investigated different domains to automate specific design operations to make the interaction for the user as easy and playful as possible.
I implemented the front- and backend of the app and merged the results of my team members. We used C# in Unity combined with multiple AR packages to access the ARKit framework of apple devices.

FRONTEND FLOW

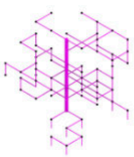


User Seed

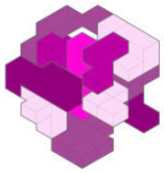
Augmented Reality

Aggregation

Cellular Automata
Genetic Algorithm



Graph



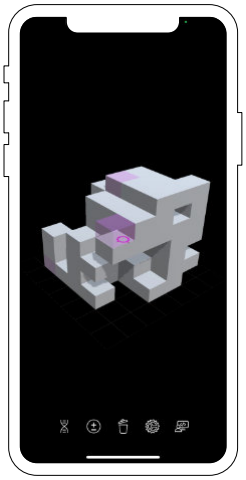
Clustering

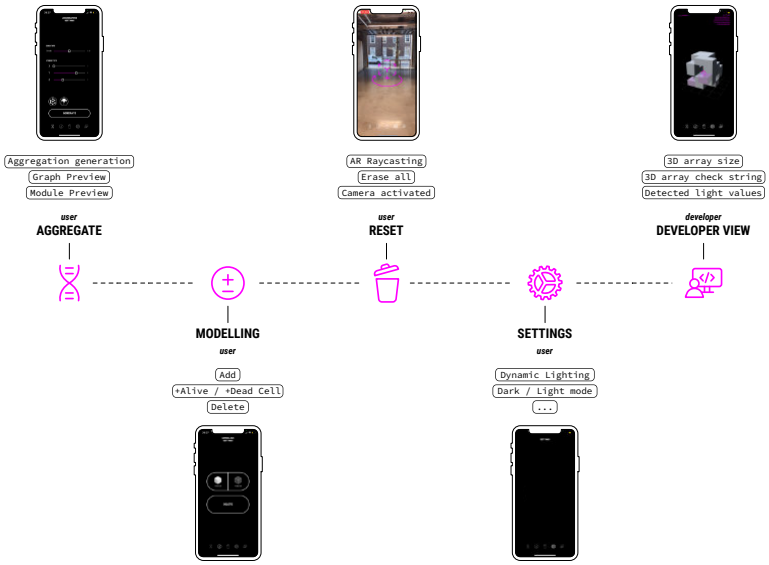
K-Means Clustering

Modules

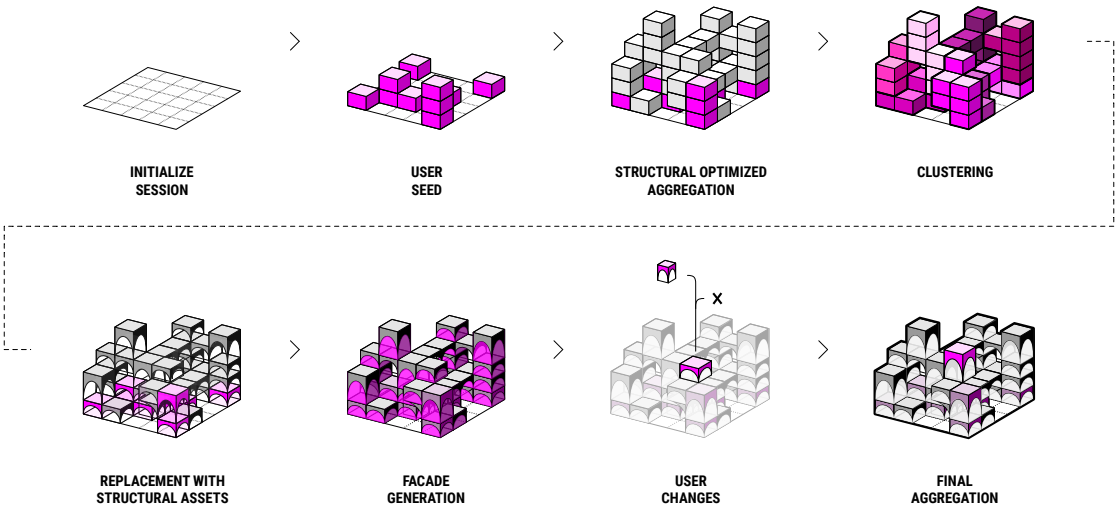
3D Graphic Statics

USER INTERFACE

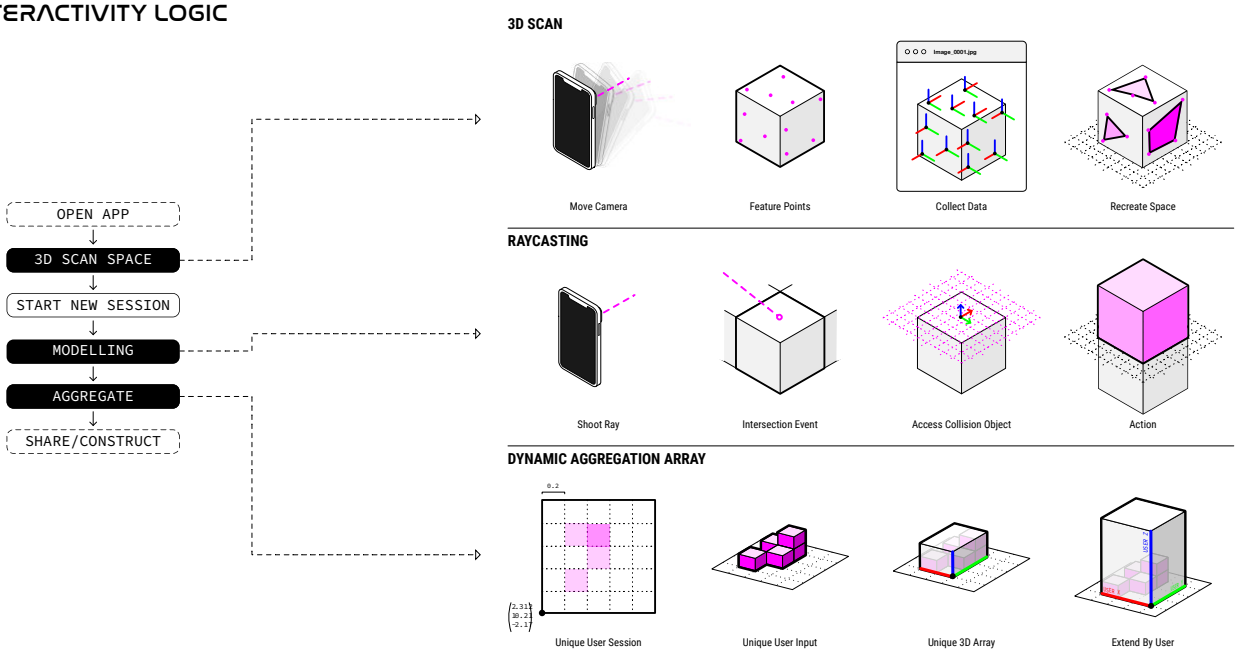


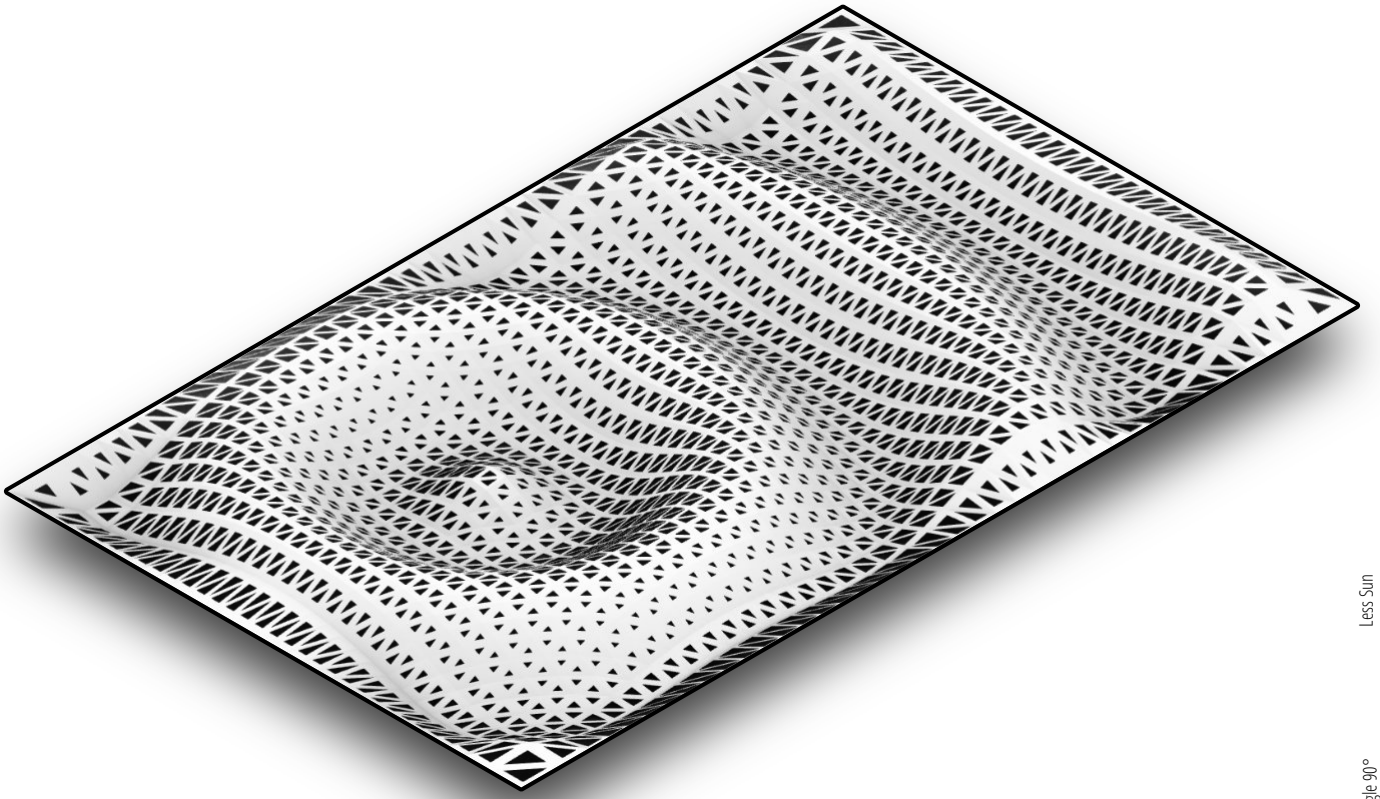


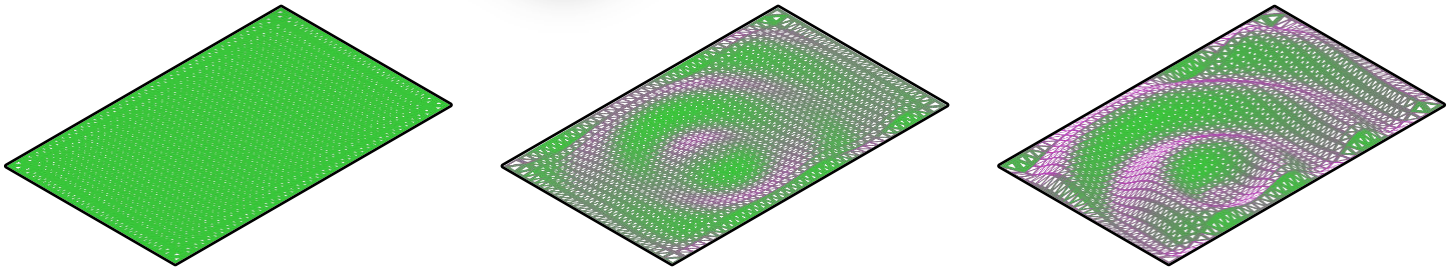
BACKEND



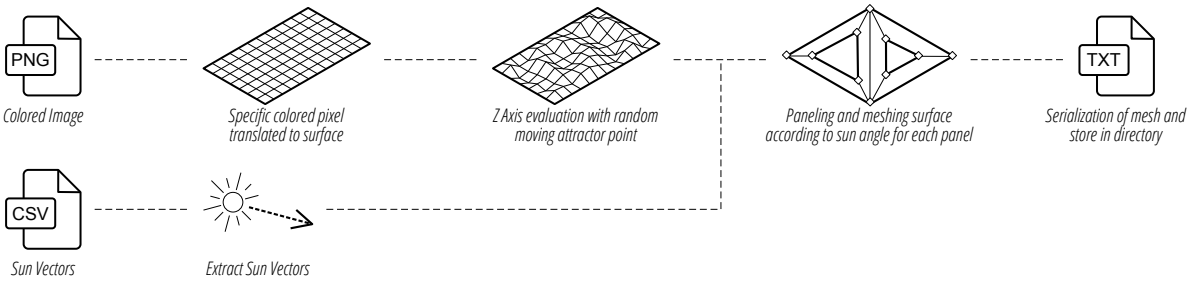
AR INTERACTIVITY LOGIC







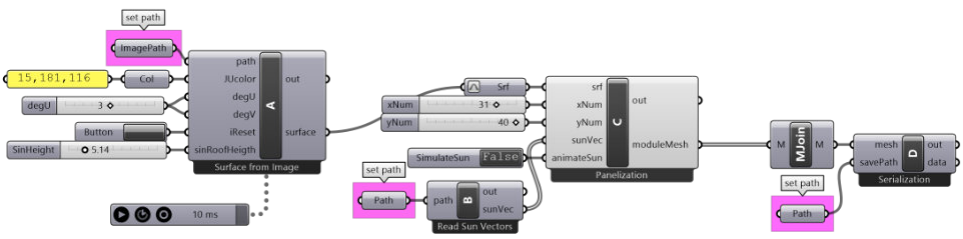
C# WORKFLOW



PARAMETRIC ROOF

This C# script is the latest and one of the most advanced coding projects I have done so far. It was the final project in my first term during my M.Sc. in Architectural Computation. The Grasshopper script consists of almost 100% out of custom-written components which use the Rhino API and some additional libraries to create a parametric animated roof out of panels.

As visualized in the diagram above, I generated a basic surface from an image using a specific target color to calculate it from the colored pixel. I also extract the sun vectors for London in June from a CSV file to integrate these vectors into the parametric system. Together with a random walker, I evaluated the basic 2D surface into 3D and meshed and colored each panel according to its relation to the sun.



PANELIZATION - C# extract
Component C in Grasshopper Script

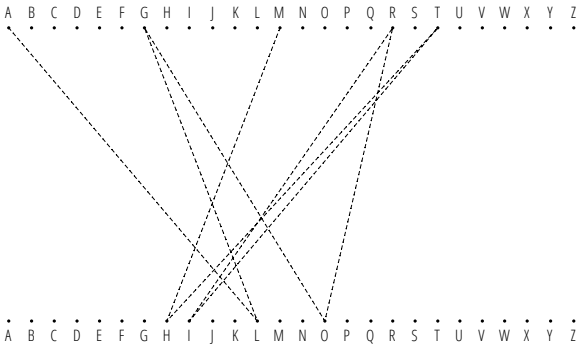
RunScript

```
//Component Message
Component.Message = "Panelization";
//Create Roof Class
assignmentRoof = new Roof(srf, xNum, yNum);
//Call roof division function
assignmentRoof.DivideSurfaceIntoPointGrid();
//Create Triangular Mesh from surface
assignmentRoof.TriangularMeshRoof();
//Extract Triangular Face edges
assignmentRoof.DrawTriFaceEdges();
//Calculate Triangular Face Planes
assignmentRoof.CalculateTriFacePlanes();
//Animate sun
if (animateSun){
 //Select Sun vector (Select new sun vector if animated)
 sunVectorSelector = sunVectorSelector + 1;
}
 //If not animated stick to first static sun Vector
else{
 sunVectorSelector = 0;
}
//Select new Sun Vector
currentSunVector = sunVec[sunVectorSelector];
//Create Parametric Modules with sunVector angle
assignmentRoof.ParametricModule(currentSunVector);

//OUTPUT
moduleMesh = assignmentRoof.moduleMeshs;
```

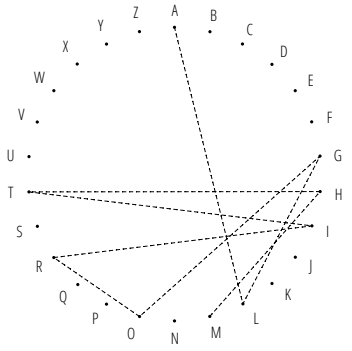
Additional Code

```
//ANIMATION VARIABLE - ONLY ONCE
Vector3d currentSunVector;
int sunVectorSelector = 0;
//DISPLAY REASONS
Roof assignmentRoof;


//<<<< MODULE CLASS >>>>
public class Module{

 //++++ PROPERTIES ++++
 //module Number
 int moduleNumber;
 //Module Plane
 Plane plane;
 //List of Vertices
 List<Point3d> faceVertices;
 //Module Edge PolylineCurve
 PolylineCurve faceEdge;
 Polyline faceEdgePolyline;
 //Centerpoint of face
 Point3d centerPoint;
 //Module opening vertices movement lines
 List<Line> openingVerticesMovementLines;
 //Triangle Offset
 //points
 List<Point3d> offsetPoints;
 //Polyline
 Polyline offsetLine;
 //Mesh vertices List
 List<Point3d> meshVertices;
 //Final Mesh
 public Mesh moduleMesh;
 //Current Sun Vector London
 Vector3d sunVector;
 //Angle how Sun hits the module
 //0=90degree hit, the greater the less sunlight
 public double sunAngle;
 //Color for mesh (depending on sun angle)
 public Rhino.Display.DisplayMaterial panelMaterial;


 //++++ CONSTRUCTOR ++++
 //Store data in object and calculate sun angle hit of module
 public Module(Plane _plane, List<Point3d> _faceVertices,
  int _moduleNumber, PolylineCurve _faceEdge,
  Vector3d _sunVector){
  //Store important module data in object
  plane = _plane;
  faceVertices = _faceVertices;
  moduleNumber = _moduleNumber;
  faceEdge = _faceEdge;
  sunVector = _sunVector;

  //Sun Vector relation to module normal
  //Invert panel normal
  Vector3d invertedNormal = plane.Normal * -1;
  //Angle in Degrees (0==90 degrees hit of the panel, if larger
    number less and less direct sun, more than 90 == no sun at all)
  sunAngle = RhinoMath.ToDegrees(Vector3d.Vector
  Angle(invertedNormal, sunVector));
 }

 //++++ METHODS ++++
 //#1 Custom offset edge for module opening (depending on panel triangle
      shape)
 public void OffsetModule(double remapHighBound){
  //Centerpoint
  //Create basic face edge polyline instead of polyline curve (inital idea was
    to use the offset method of the polylinecurve class)
  List<Point3d> closedPolylineVerticesList = new List<Point3d>(face
  Vertices);
  closedPolylineVerticesList.Add(faceVertices[0]);
  faceEdgePolyline = new Polyline(closedPolylineVerticesList);
  //Calculate center of face
  centerPoint = faceEdgePolyline.CenterPoint();
  offsetPoints = new List<Point3d>();
  //Move Vertices
  //Instanciate List for corner center lines(opening vertices
    movement lines)
  openingVerticesMovementLines = new List<Line>();
  //Instanciate List for offsetted points

  //Create movement lines for opening vertices of module
  for(int i = 0; i < faceVertices.Count;i++){
   //Create movement line for checking/display purposes
   openingVerticesMovementLines.Add(new Line(centerPoint,
   faceVertices[i]));
   //measure length of each line
   double lineLength = openingVerticesMovementLines[i].Length;
   //remap value in length unit
   double remapedValue = (sunAngle - 0) * (lineLength - 0) /
   (remapHighBound - 0);
   //Get Unit vector
   Vector3d vertexMoveVector = new Vector3d(centerPoint -
   faceVertices[i]);
   vertexMoveVector.Unitize();
   //Create movement vector with remaped value
   Vector3d finalVertexMove = vertexMoveVector * remapedValue;
   offsetPoints.Add(faceVertices[i] + finalVertexMove);
  }

  //Prepare list for closed polyline generation
  List<Point3d> closedPolylinePoints = new List<Point3d>(offsetPoints);
  closedPolylinePoints.Add(offsetPoints[0]);
  //create polyline from new vertices
  offsetLine = new Polyline(closedPolylinePoints);
 }

 //#2 Mesh parametric modules with opening
 public void CreateMesh(double remapHighBound){
  //Instanciate Mesh
  moduleMesh = new Mesh();
  //Create one List with all vertices
  meshVertices = new List<Point3d>(faceVertices);
  meshVertices.AddRange(offsetPoints);
  //Store Vertices in mesh
  moduleMesh.Vertices.AddVertices(meshVertices);
  //Loop through vertices to create faces for each module
  for(int i = 0; i < faceVertices.Count;i++){
   //Calculate Index pattern for face generation
   if(i < faceVertices.Count - 1){
    int a = i;
    int b = i + faceVertices.Count;
    int c = i + faceVertices.Count + 1;
    int d = i + 1;
    //Create face
    moduleMesh.Faces.AddFace(a, b, c, d);
   }
    //Last face needs to be generated differently cause of the vertices
      order in the list
   else{
    int a = i;
    int b = i + faceVertices.Count;
    int c = faceVertices.Count;
    int d = 0;
    //Create face
    moduleMesh.Faces.AddFace(a, b, c, d);
   }
  }
  //Compute Normals and Compact
  moduleMesh.Normals.ComputeNormals();
  moduleMesh.Compact();

  //Calculate Color for mesh
  //Remap angle to RGB color value
  double colorValue = (sunAngle - 0) * (255 - 0) /
  (remapHighBound - 0);
  //RGB value formula for material creation
  int rValue = Convert.ToInt32(255 - colorValue);
  int gValue = Convert.ToInt32(colorValue);
  int bValue = Convert.ToInt32(255 - colorValue);
  //Instanciate Display Material
  panelMaterial = new Rhino.Display.DisplayMaterial(System.
  Drawing.Color.FromArgb(rValue, gValue, bValue));
 }
}

//<<<< ROOF CLASS >>>>
public class Roof{
 //++++ PROPERTIES ++++
 //Base Surface
 Surface roofBaseSurface;
 //Panel points on surface
 List<Point3d> roofPanelGrid;
 //Basic Roof mesh
 Mesh basicRoofMesh;
 //Amount of rectangular grid cells in XY (will be divided into 2
   triangular faces)
 double xNum;
 double yNum;
 //Amount of Points in XY
 int xNumPoints;
 int yNumPoints;
 //List of Lists for all face vertices grouped
 List<List<Point3d>> groupedFaceVertices;
 //Polylines for wireframe of faces
 List<PolylineCurve> triangularFaceEdges;
 //Triangular face planes
 List<Plane> triangularFacePlanes;
 //Parametric Module List
 List<Module> modules;
 //List of all extracted Module meshs for visualization purposes
 public List<Mesh> moduleMeshs;
 //List of all extracted Module mesh COLORS
 public List<Rhino.Display.DisplayMaterial> moduleColors;
 //Largest angle
 double largestSunAngle;

 //++++ CONSTRUCTOR ++++
 public Roof(Surface _srf, int _xNum, int _yNum){
  //store base surface into class
  this.roofBaseSurface = _srf;
  //Instanciate basic mesh
  basicRoofMesh = new Mesh();
  //Store amount of panels & Points for XY inside class
  xNum = _xNum;
  yNum = _yNum;
  xNumPoints = _xNum + 1;
  yNumPoints = _yNum + 1;
 }

 //++++ METHODS ++++
 //#1 Divide Base surface into Point Grid to panelize it
 public void DivideSurfaceIntoPointGrid(){
  //Instanciate Point grid
  roofPanelGrid = new List<Point3d>();
  //Calculate  parameter steps according to amount of panels
  // X
  double xParameterStep = 1 / xNum;
  // Y
  double yParameterStep = 1 / yNum;
  //Generate points with correct paramter steps size
  for(int i = 0; i < xNumPoints;i++){
   for(int j = 0; j < yNumPoints;j++){
    //Generate and store points
    roofPanelGrid.Add(new Point3d(roofBaseSurface.
    PointAt(xParameterStep * i, yParameterStep * j)));
   }
  }
 }

 //#2 Mesh triangulate surface
 public void TriangularMeshRoof(){
  //Apply UV points from surface to mesh vertices
  basicRoofMesh.Vertices.AddVertices(roofPanelGrid);
  //Instanciate List of Lists for grouped Face Vertices
  groupedFaceVertices = new List<List<Point3d>>();
  //Create Faces while looping through vertices
  for(int i = 0; i < xNumPoints - 1;i++){
   for(int j = 0; j < yNumPoints - 1; j++){
    //Calculate vertex indices
    int a = i * yNumPoints + j;
    int b = i * yNumPoints + (j + 1);
    int c = (i + 1) * yNumPoints + (j + 1);
    int d = (i + 1) * yNumPoints + j;
    //Create Faces
    basicRoofMesh.Faces.AddFace(a, b, c);
    basicRoofMesh.Faces.AddFace(a, c, d);
    //Store Face points in List of List
    groupedFaceVertices.Add(new List<Point3d> {roofPanelGrid[a],
    roofPanelGrid[b],roofPanelGrid[c]});
    groupedFaceVertices.Add(new List<Point3d> {roofPanelGrid[a],
    roofPanelGrid[c],roofPanelGrid[d]});
   }
  }
  //Compute Normals and Compact
  basicRoofMesh.Normals.ComputeNormals();
  basicRoofMesh.Compact();
 }
```

(...) 73 more lines for this Component



"Algorithm"

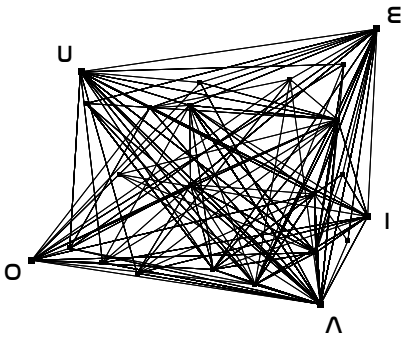


"Algorithm"

YŪ Words Become Jewellery

The U.E.D. algorithm was originally written in Processing.js to transform books into large scaled megastructures.

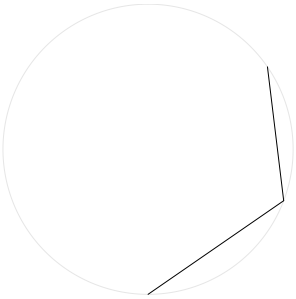
The algorithm's principle is extraordinarily simple and therefor easy to understand. Everything starts with an entered word, sentence or paragraph in latin characters. The whole input is going to get split up into individual letters. You get an unique and deterministic sequence which will be used to draw its related pattern. The algorithm drafts a continous line following the inputs sequence. Result is a specific web, capturing the word's letter connections.



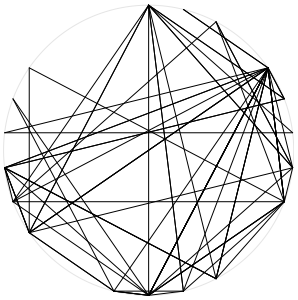
' Ein namenhafter Wissenschaftler [...] hielt einmal einen öffentlichen Vortrag über Astronomie. Er schilderte, wie die Erde um die Sonne und die Sonne ihrerseits um den Mittelpunkt einer riesigen Ansammlung von Sternen kreist, die wir unsere Galaxis nennen. Als der Vortrag beendet war, stand hinten im Saal eine kleine alte Dame auf und erklärte: "Was Sie uns da erzählt haben, stimmt alles nicht. In Wirklichkeit ist die Welt eine flache Scheibe, die von einer Riesenschildkröte auf dem Rücken getragen wird." Mit einem überlegenen Lächeln hielt der Wissenschaftler ihr entgegen: "Und worauf steht die Schildkröte?" - "Sehr schlau, junger Mann", pariert die alte Dame. "Ich werd's Ihnen sagen: Da stehen lauter Schildkröten aufeinander."[...] '

Extract - Translated with U.E.D. below
A Brief History of Time (German),
Stephen Hawking

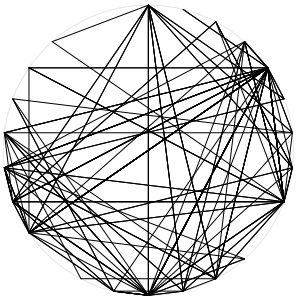
1 Word



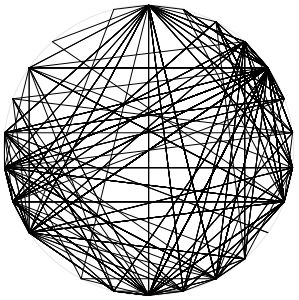
1 Sentence

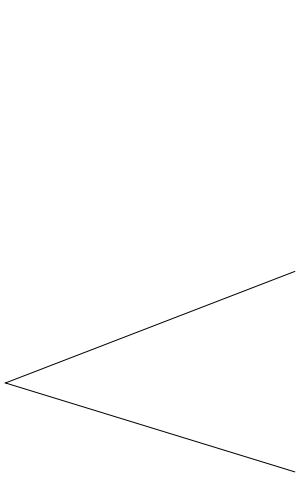


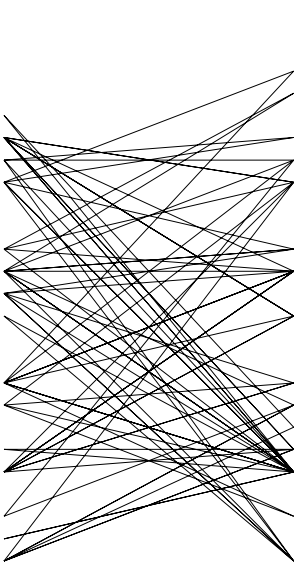
2 Sentences

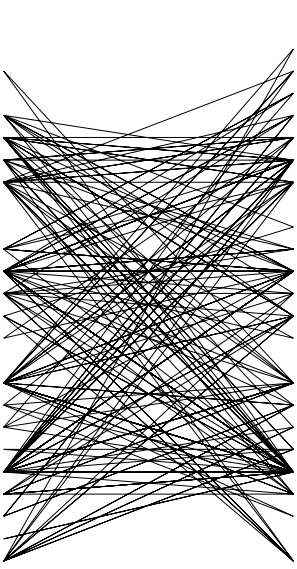


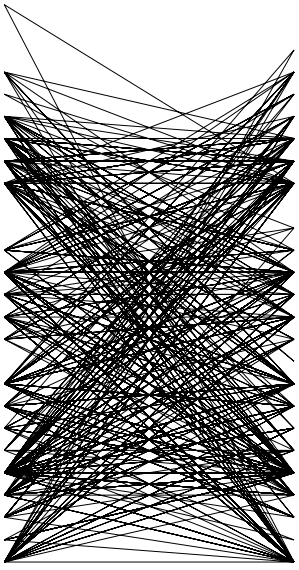
1 Paragraph

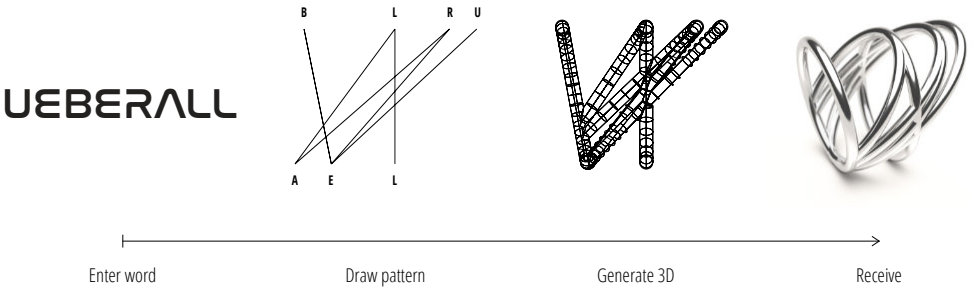












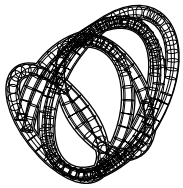
The idea to create jewellery and to reprogram the U.E.D. algorithm, evolved on the night before christmas in 2018.

In May 2019 I founded the start-up YŪ with my dean's research assistant to focus on developing a high-tech and unprecedented brand that enables customers to individulize and shape the whole product in the friendliest way possible.
I reprogramed and extended the algorithm in Grasshopper and Python to make it accessable for a web plug-in. We designed a website and integrated the algorithm into our web system.

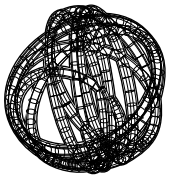
Today we are on the edge to go public with our entire work and to make a first real life test. Have a look at our website to see the latest progress.

www.yubyyou.com

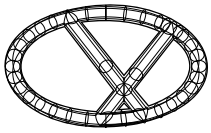
RING



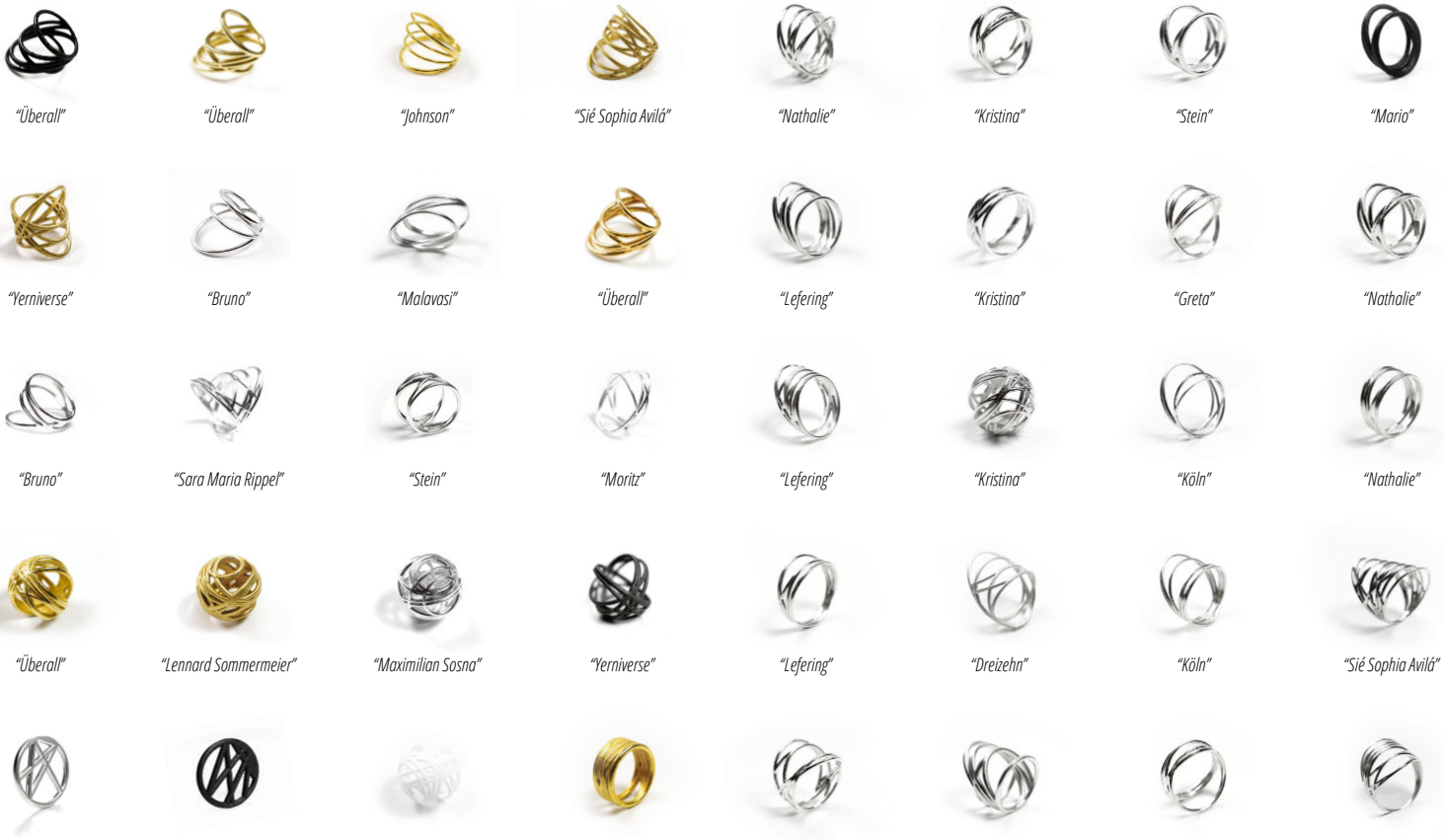
CHARM



AMULET



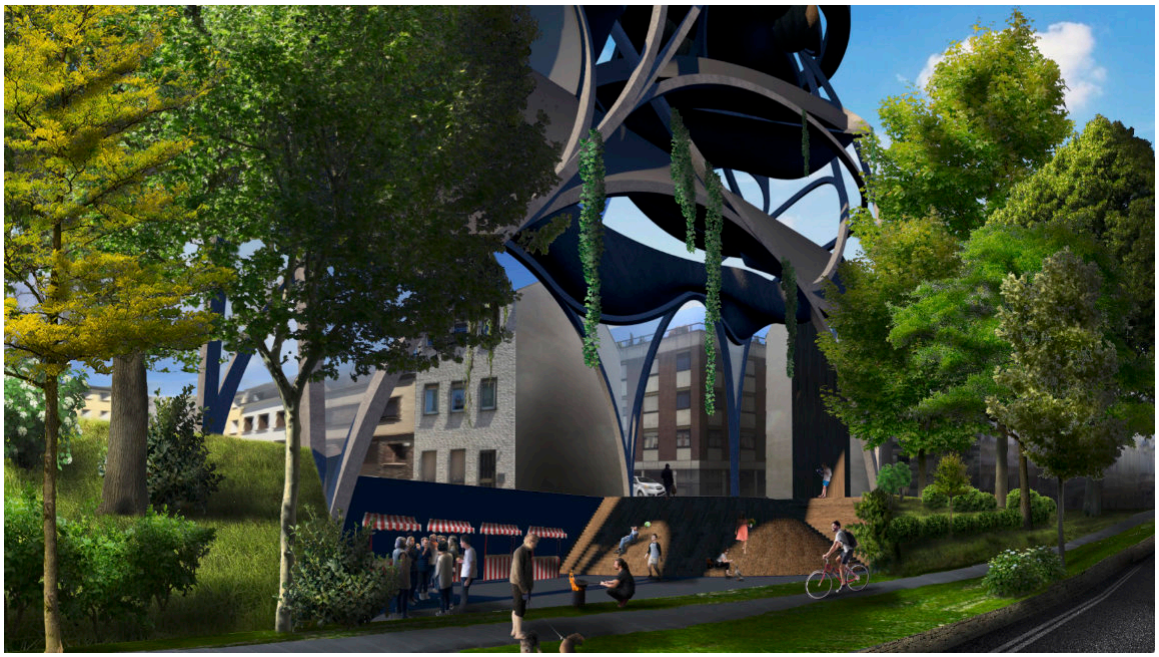
Down below you can see the 40 first jewellery pieces we made for customers in 2019. All of them have a unique and personal meaning at its core.



MÖ

Humans always had a deep connection to the natural environment.

In the 21st century climate change and other ecology related topics made mankind realize the importance of this extraordinary environment. Rather than making cities grey and dead, humans tried to integrate nature again into the big city life.
Some concrete structured buildings grew like big trees in the heart of the cities. They achieved a direct coexistence between humans and nature. People were able to enjoy the sunset next to a couple of trees and flowers, 60m above the ground. A peaceful and calm place next to the fast and chaotic - a home to a few ecological pioneers.

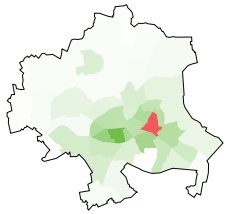


Parks

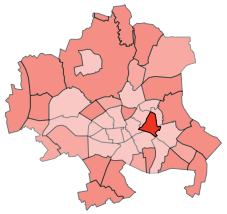
Street grid

Property

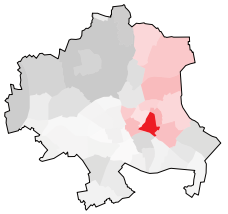
Building height



Population density

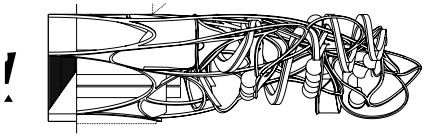


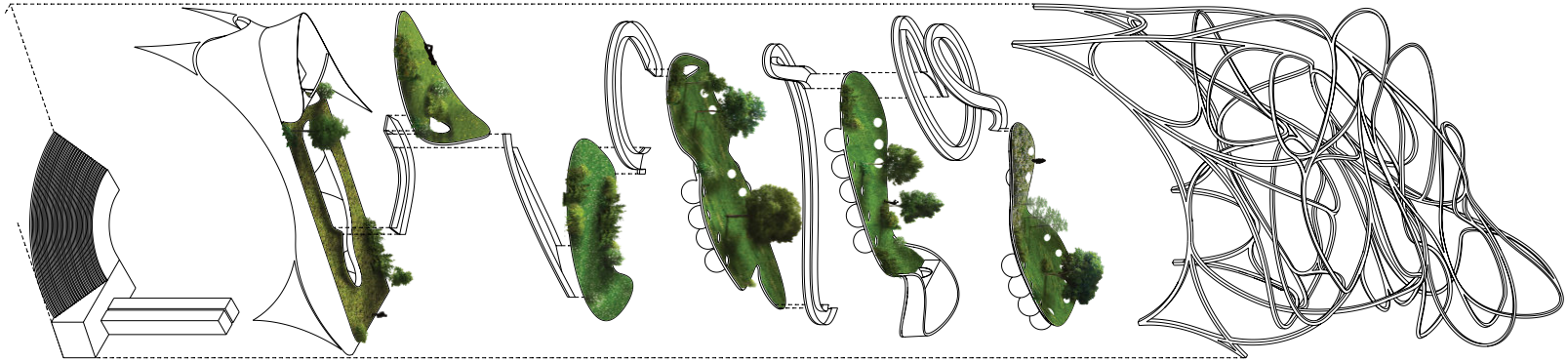
Demography

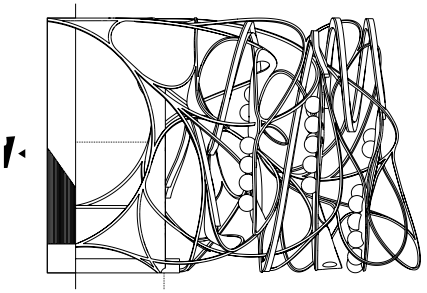


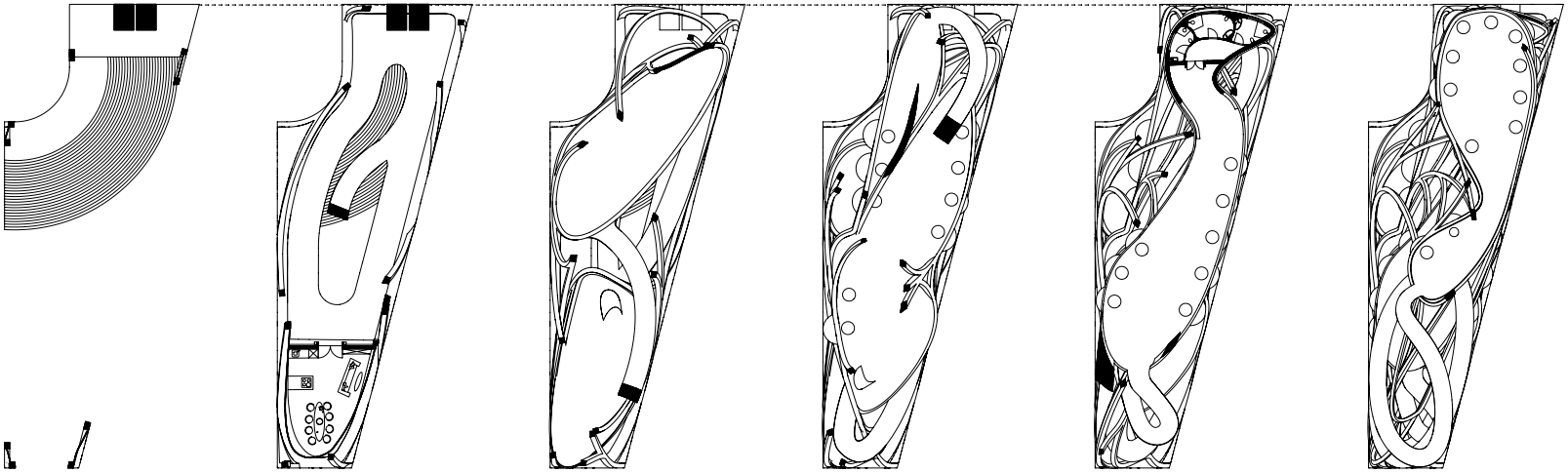
Districts

Mönchengladbach, DE









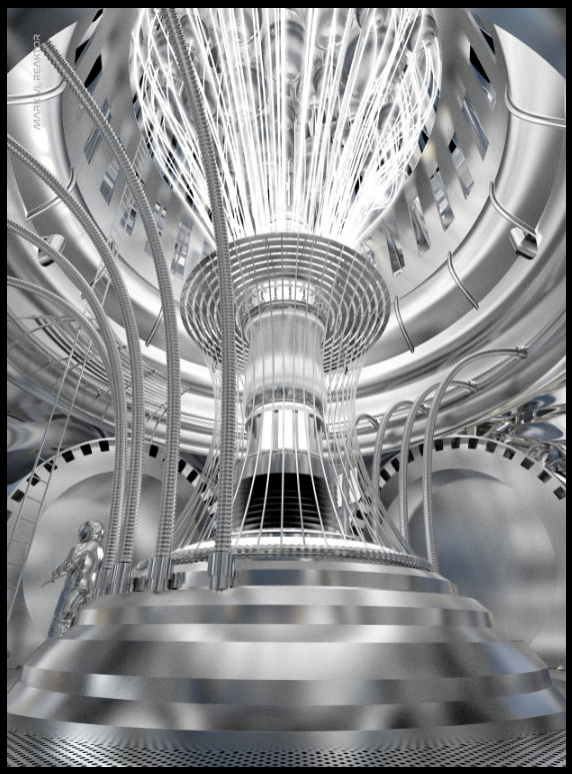
HABITAT B

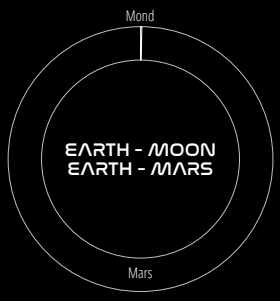
This is a studio project that I intitiated myself to work on for half a year with my professor.

Main prupose of this extraordinary field of study was to explore architecture beyond earth. After a lot of research i focused on our moon - earth's closest neighbour. I discovered the R.O.X.Y. reactor from Airbus, which can turn moondust into a variety of ressources without a lot of energy. I designed two robots for two different phases on the moon. A small one to replicate itself and to grow manufactruing time. And a big one, as you can see on the right, to produce enough ressources for space colonilization.

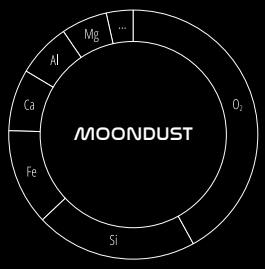
With the following link you can enter my VR art exhibition related to the space architecture project.

https://hub.link/P4mDdt2

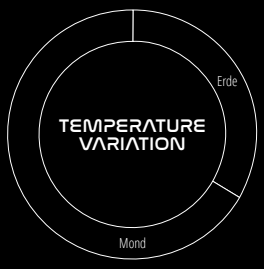




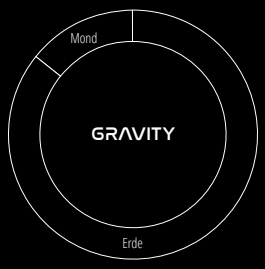
Earth - Moon, *384'400 km*
Earth - Mars, *185'130'000 km*



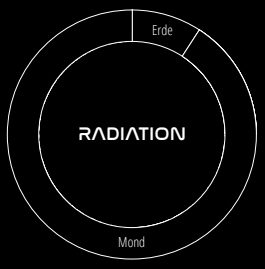
O2, *Oxygen, 42%*
Si, *Silicon, 21%*
Fe, *Irone, 12,5%*
Ca, *Calcium, 8%*
Al, *Aluminum, 7%*
Mg, *Magnesium, 6%*
..., *Other components 3,5%*



Earth, *-89.2°C to 56.7°C*
Moon, *-160°C to 130°C*

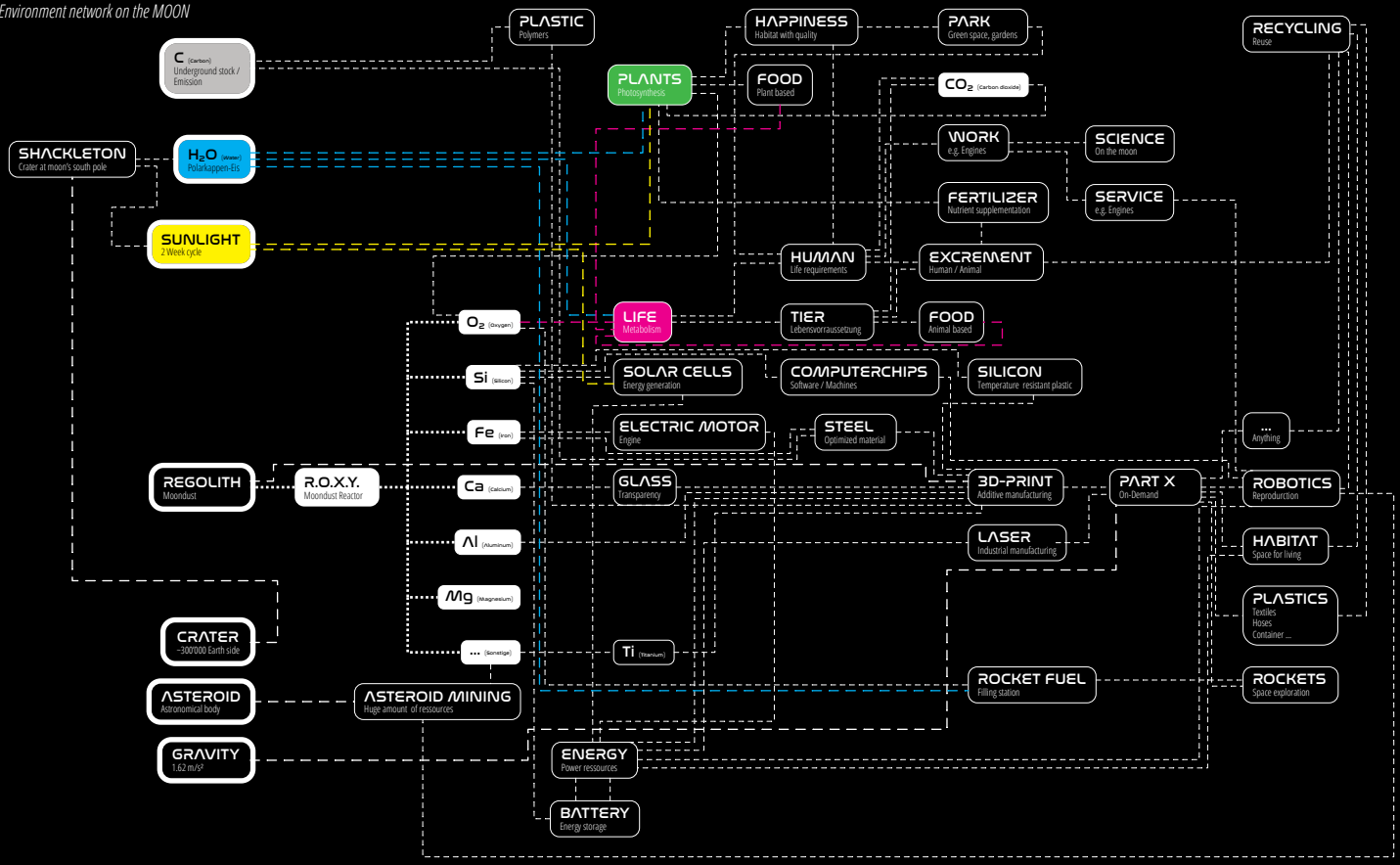


Earth, *9.807 m/s²*
Moon, *1.62 m/s²*

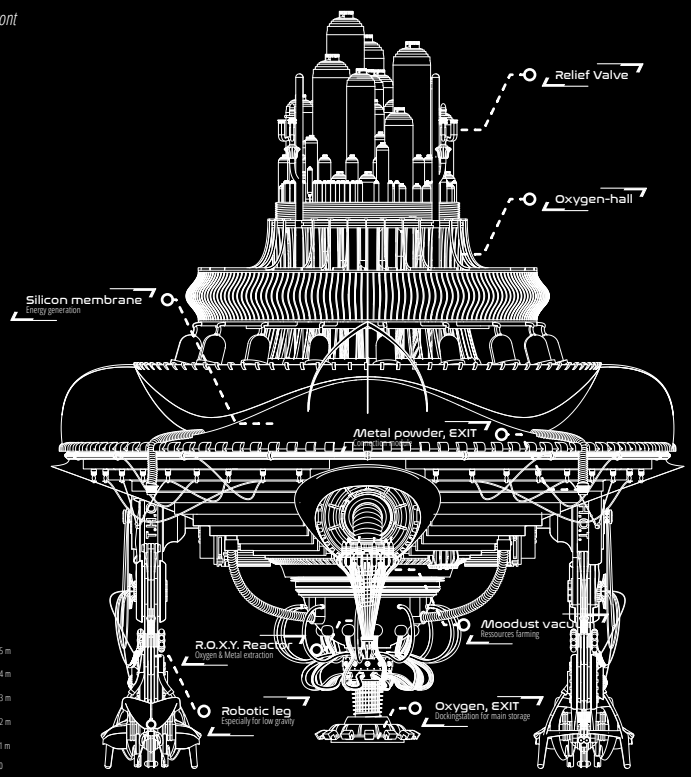


Earth, *6 mSv, Transatlantic flight*
Moon, *60 mSv*

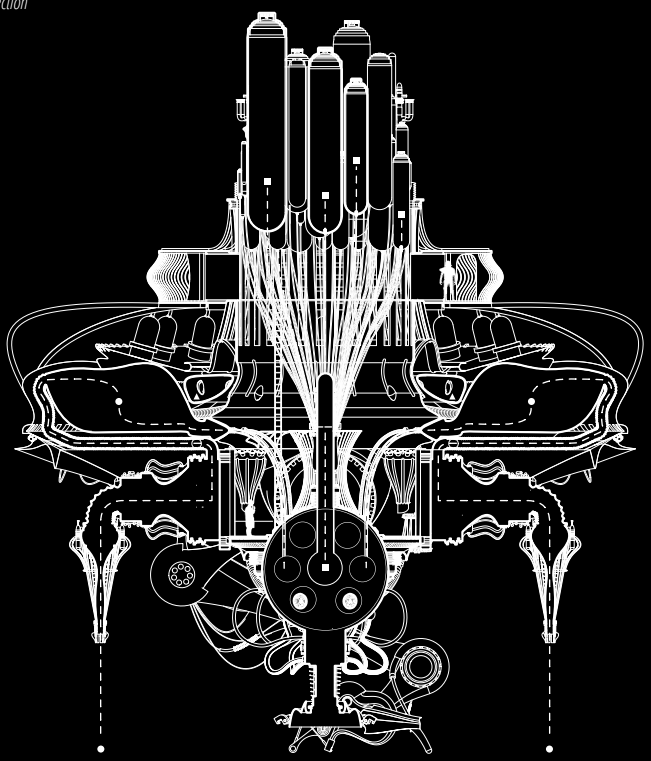
Environment network on the MOON



Front



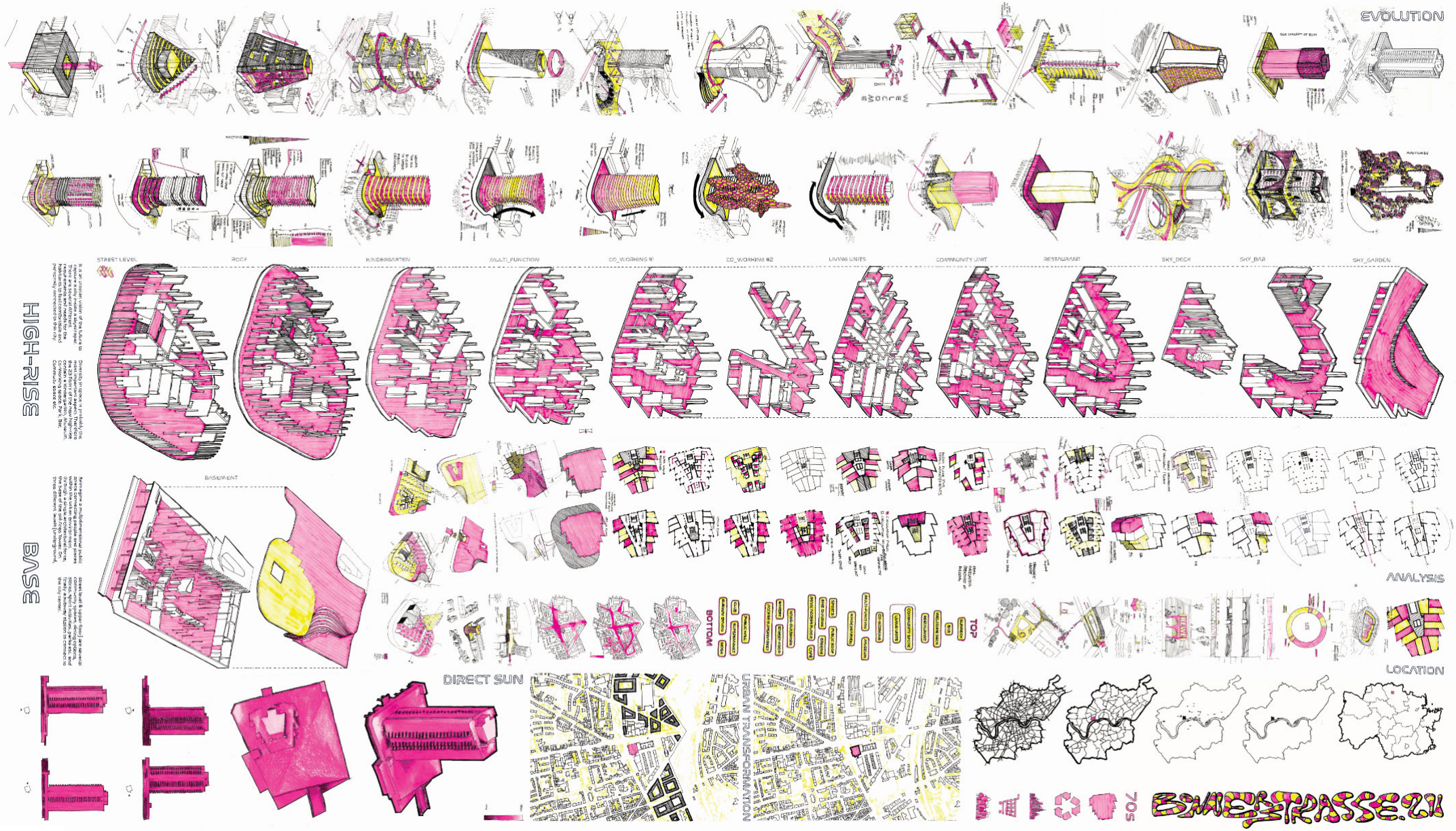
Section

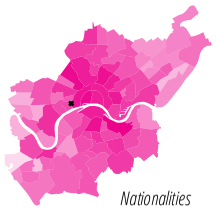


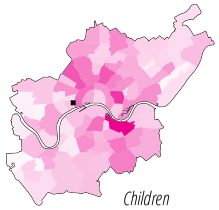
B211

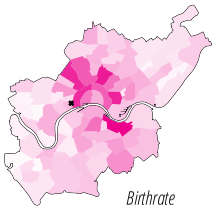
The vertical city, a transgenerational utopia full of fantasy and harmony. A place characterized by freedom and versatility that would not be possible for an average apartment block. Light and dark, quiet and loud, green and gray. A space that metamorphoses through its high density and contrasts into a colorful place shaped by its inhabitants. From a basement with subway station, club and grocery, to a sky garden with sundeck and café. The vertical city as an architectural manifesto for a social future full of diversity and acceptance. A place of community and togetherness.

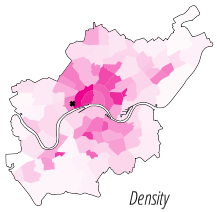
This Bachleor Thesis project marked the ending of my undergraduate degree in architecture and interior design in Düsseldorf, Germany in 2021.

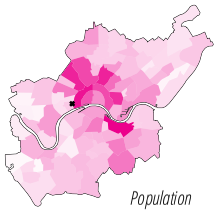

EVOLUTION
HIGH-RISE
STREET LEVEL
ROOF
KINDERGARTEN
MULTI_FUNCTION
CO_WORKING #1
CO_WORKING #2
LIVING UNITS
COMMUNITY UNIT
RESTAURANT
SKY_DECK
SKY_BAR
SKY_GARDEN
BASE
BASEMENT
ANALYSIS
BOTTOM
TOP
LOCATION
DIRECT SUN
URBAN TRANSFORMATION

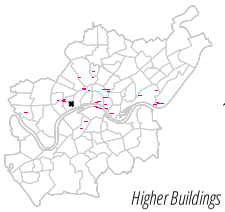

Nationalities


Children

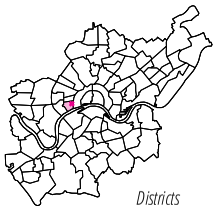

Birthrate

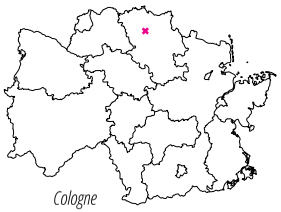

Density

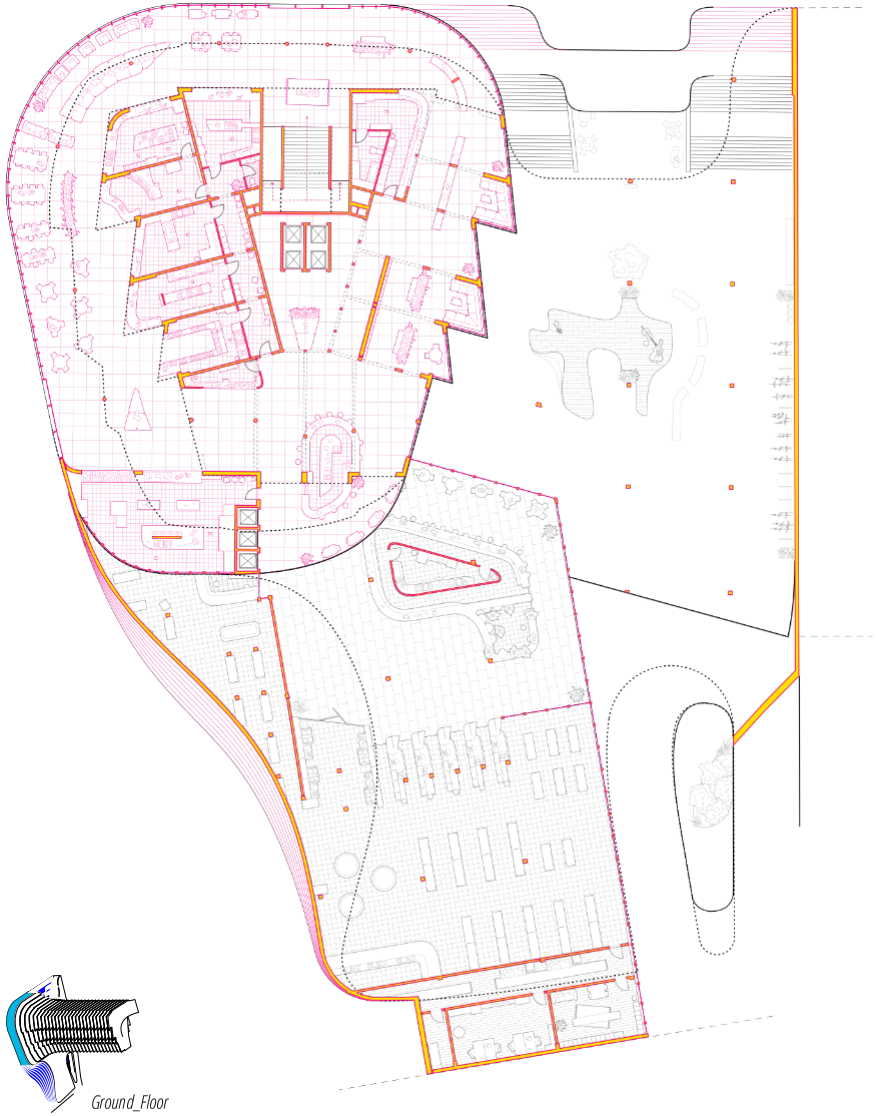

Population


Higher Buildings

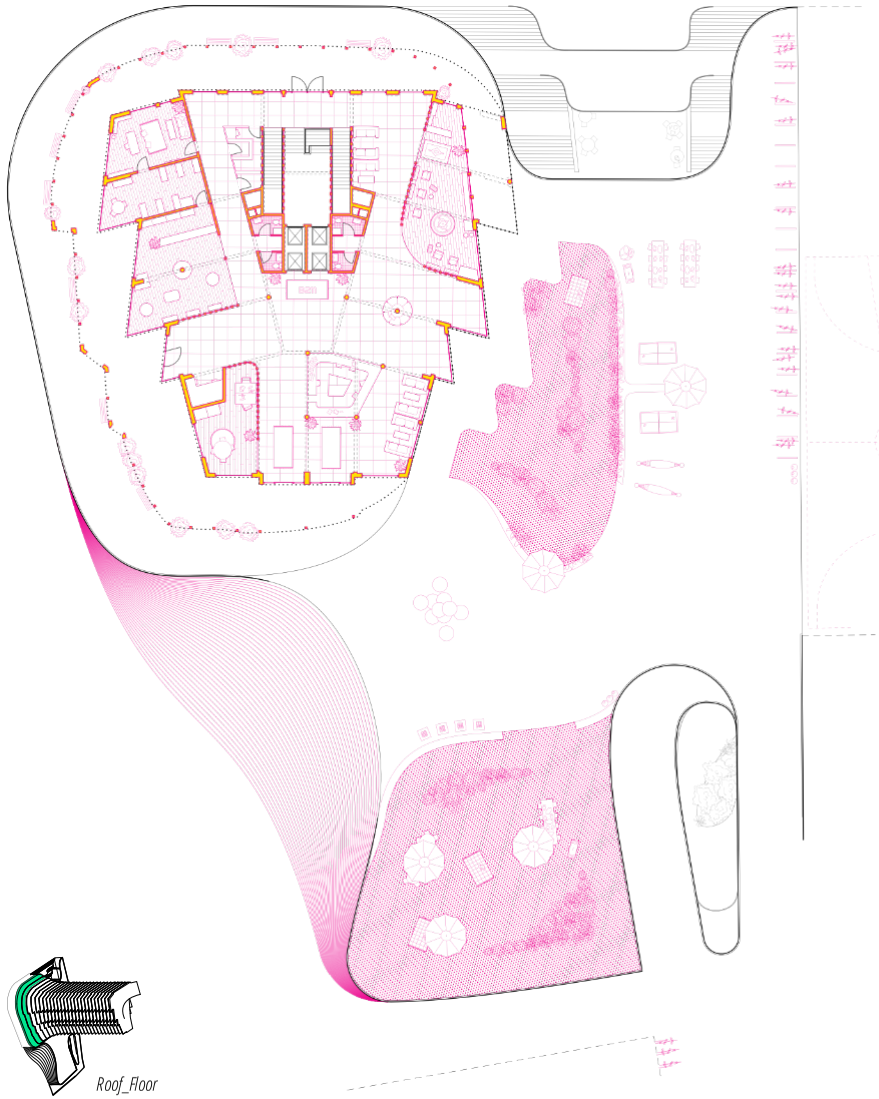

Road Network


Districts

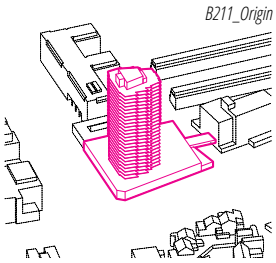

Cologne

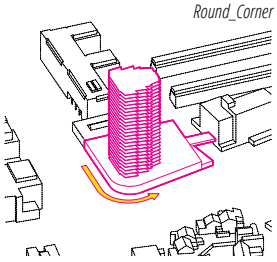


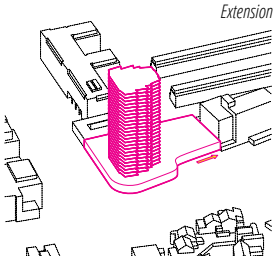
Ground_Floor

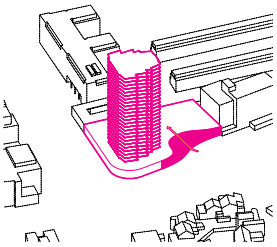


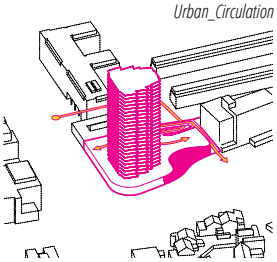
Roof_Floor

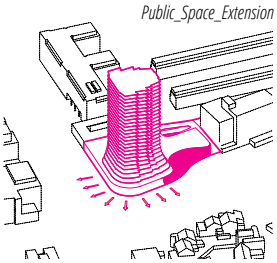

B211_Origin

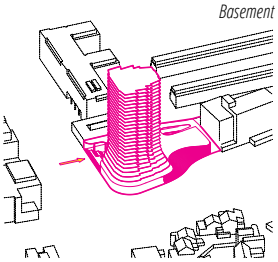

Round_Corner

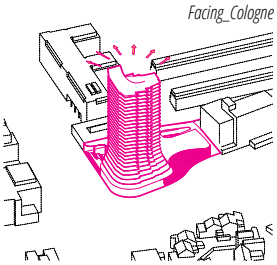

Extension

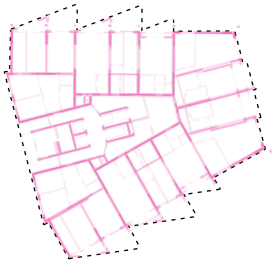



Urban_Circulation

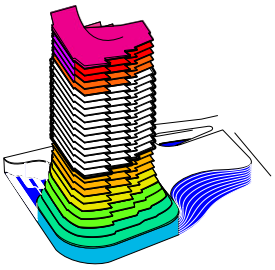

Public_Space_Extension


Basement

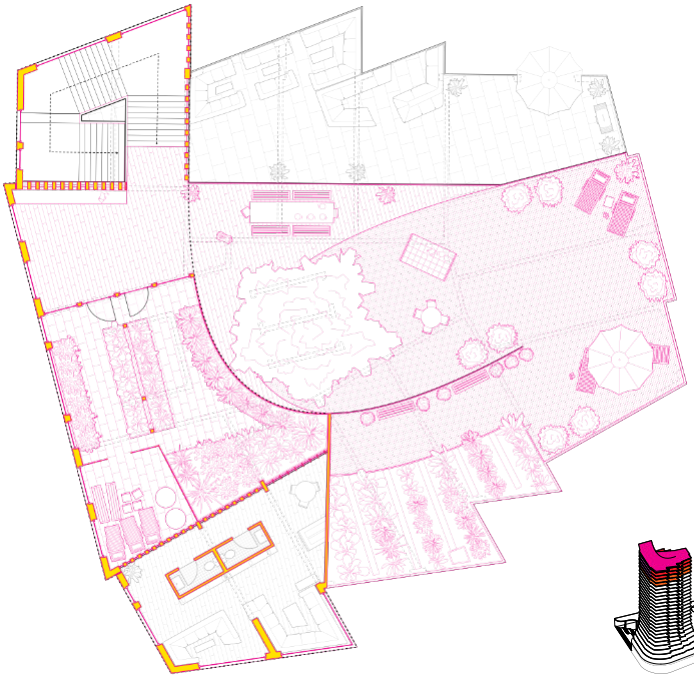

Facing_Cologne



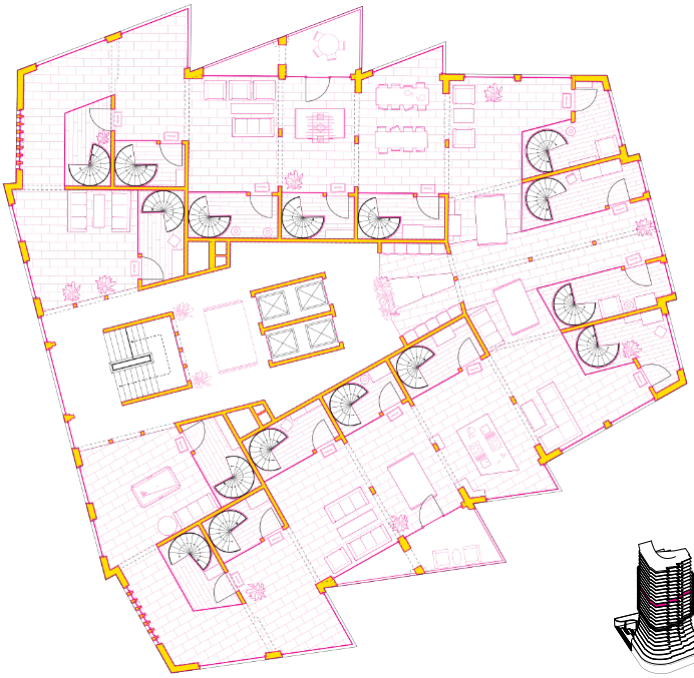
Continuous Old Structure — Nothing



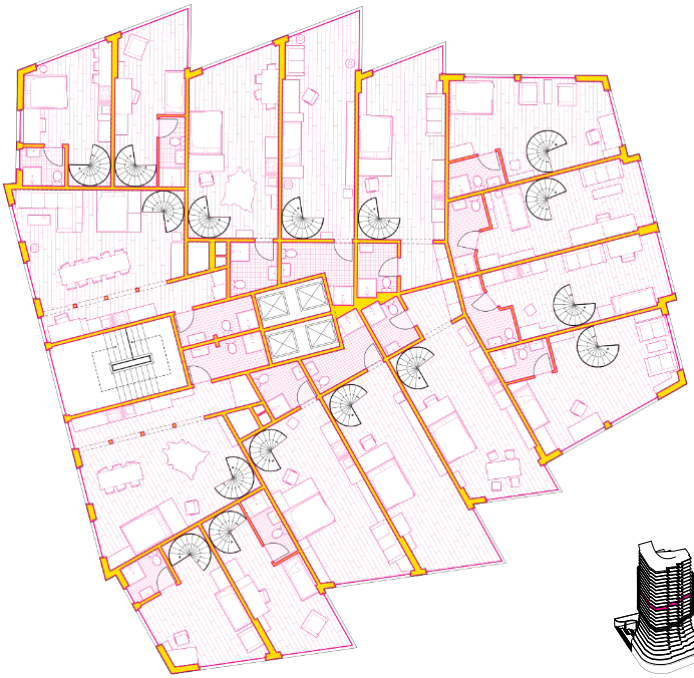
- SKY_Garden
- SKY Welcome Deck
- Bar
- Restaurant
- Living_UNITs
- Co-Working
- Multi-Functional Space_Museum
- Kindergarten
- Lobby_Doctor_Pharmacy_Bank _Hairdresser
- Bike Sharing_Sports_Public Space _SUNROOF
- Public Space_Temporary Shop Space _Street Food_Meet_Relax
- Basement_Supermarket_Club _Train Station_Kiosk



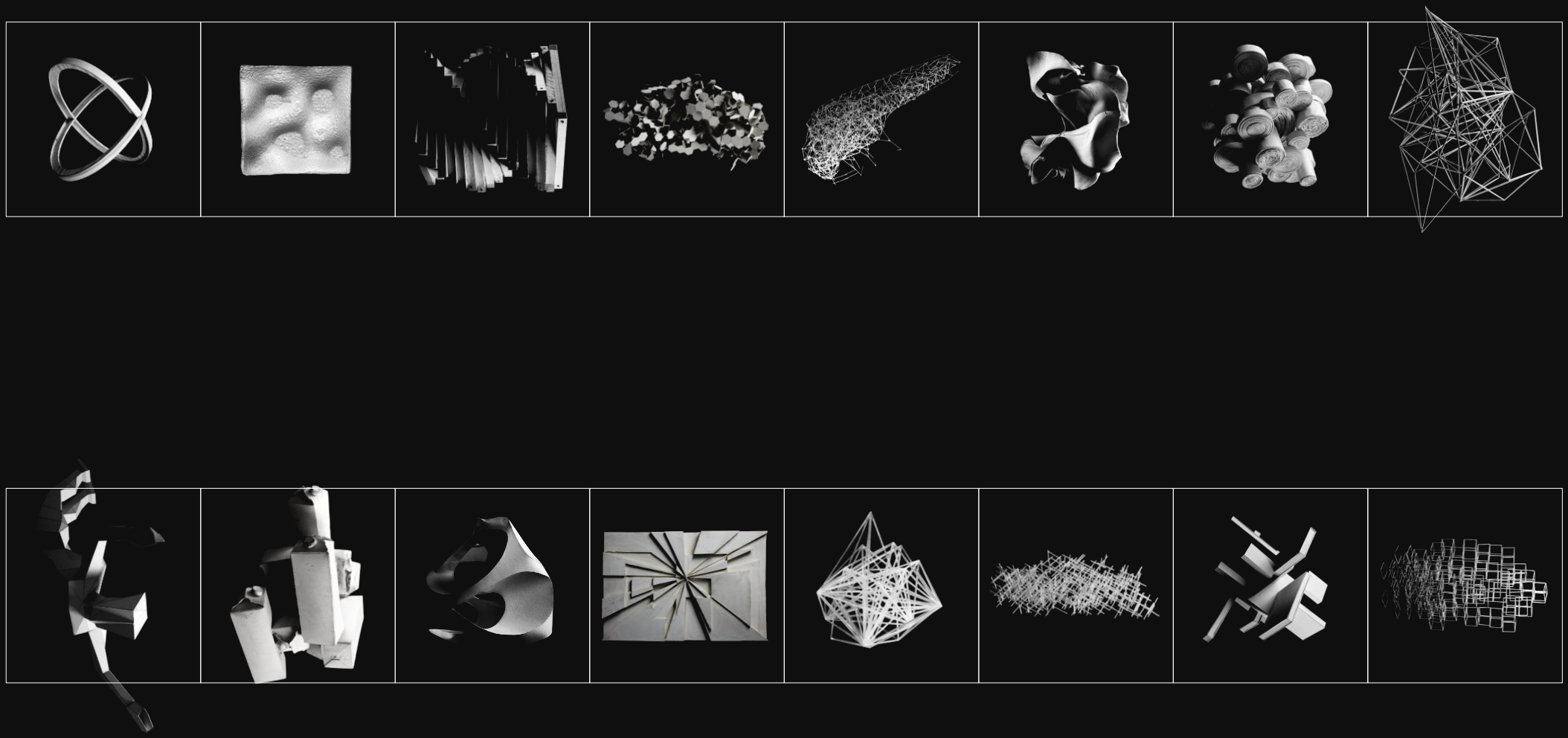
SKY_Floor

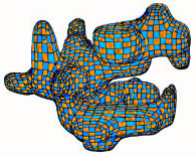


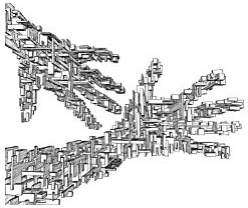
Community_Floor

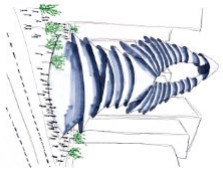
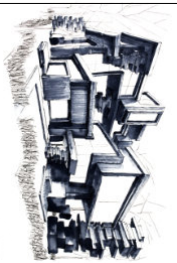


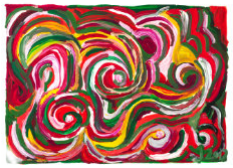
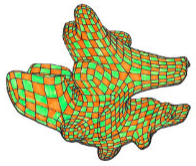
Living_Units

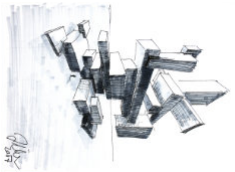
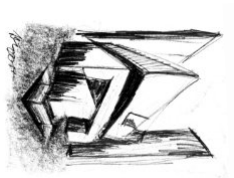
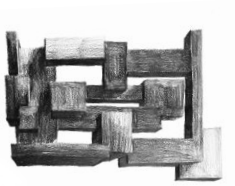
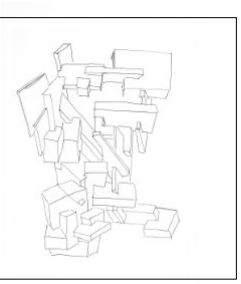


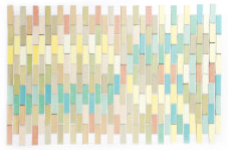
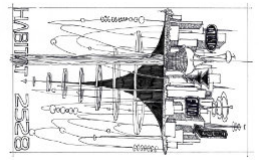



DREAM
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