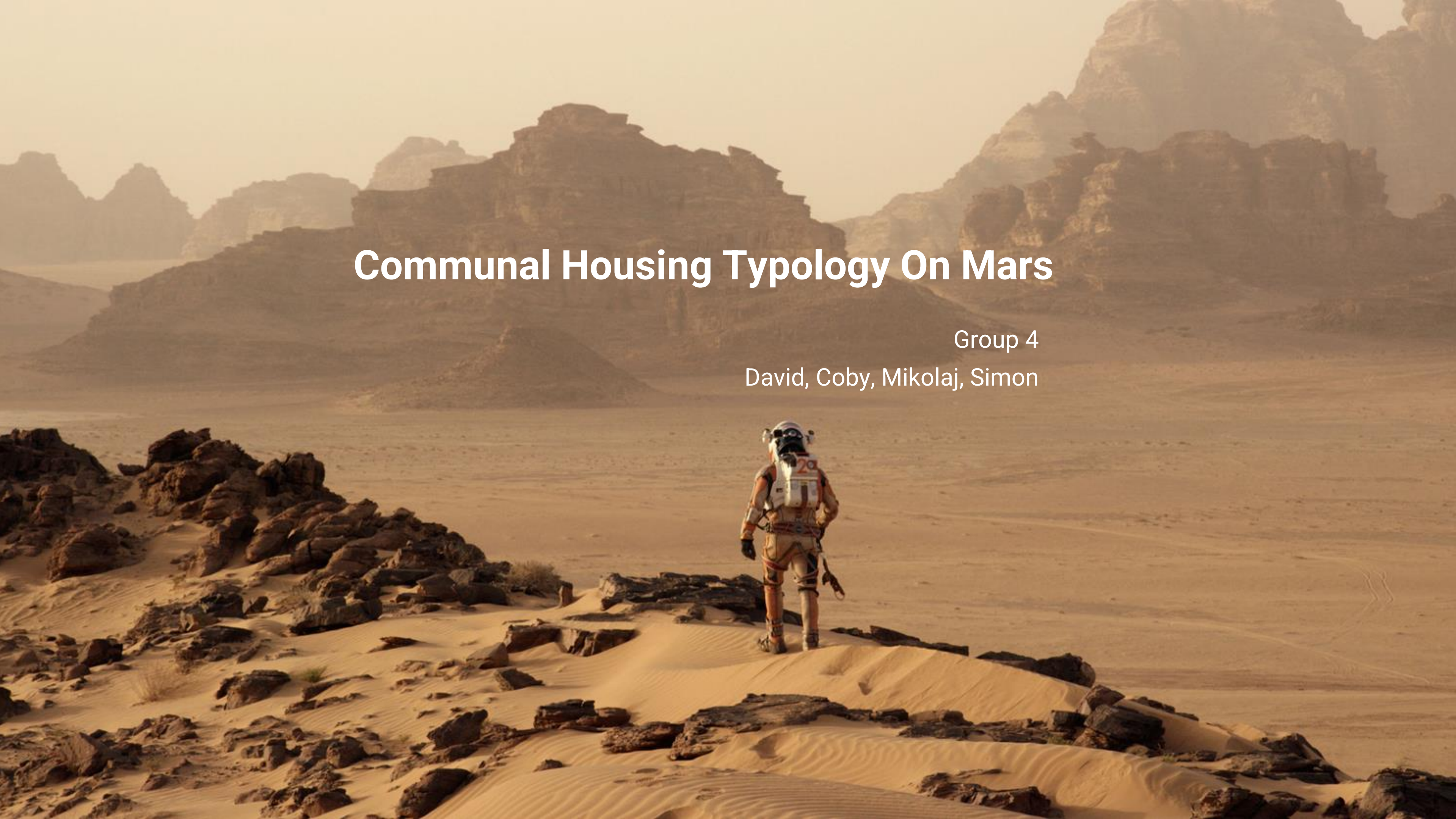
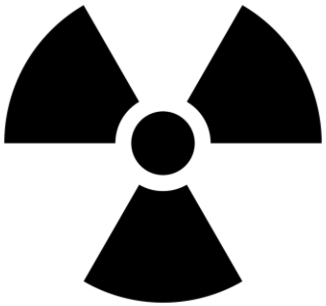


Communal Housing Typology On Mars

Group 4

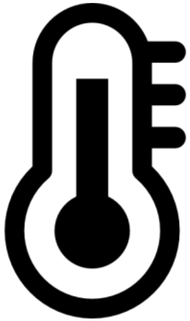
David, Coby, Mikolaj, Simon

Challenges on Martian habitat



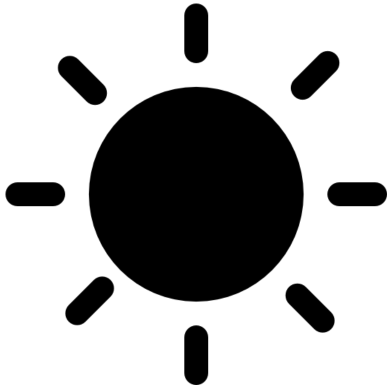
Radiation

Average radiation level in Mars is 40-50 times that of the Earth



Temperature

Swings from 22° Celsius in daytime and -99° Celsius in nighttime

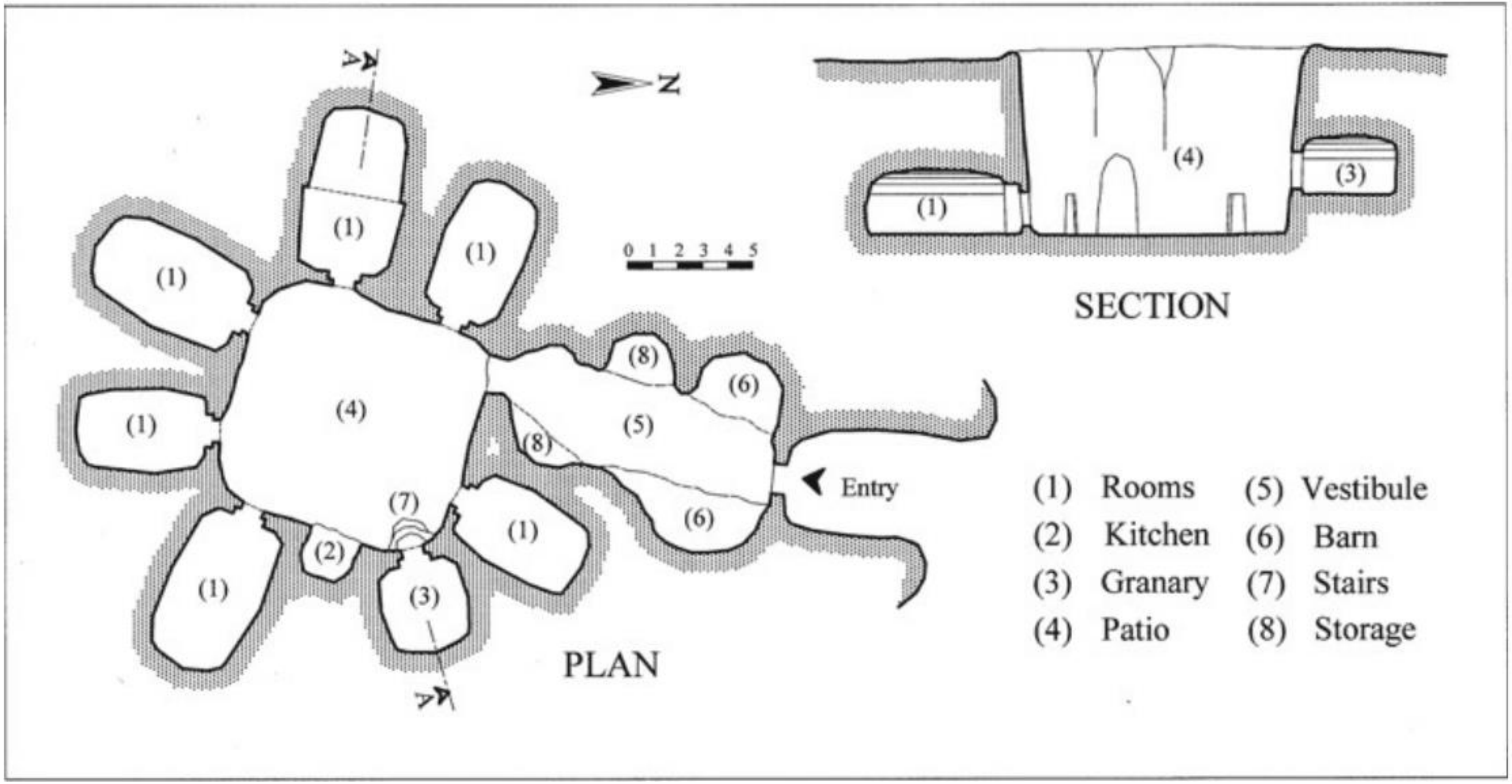


Light

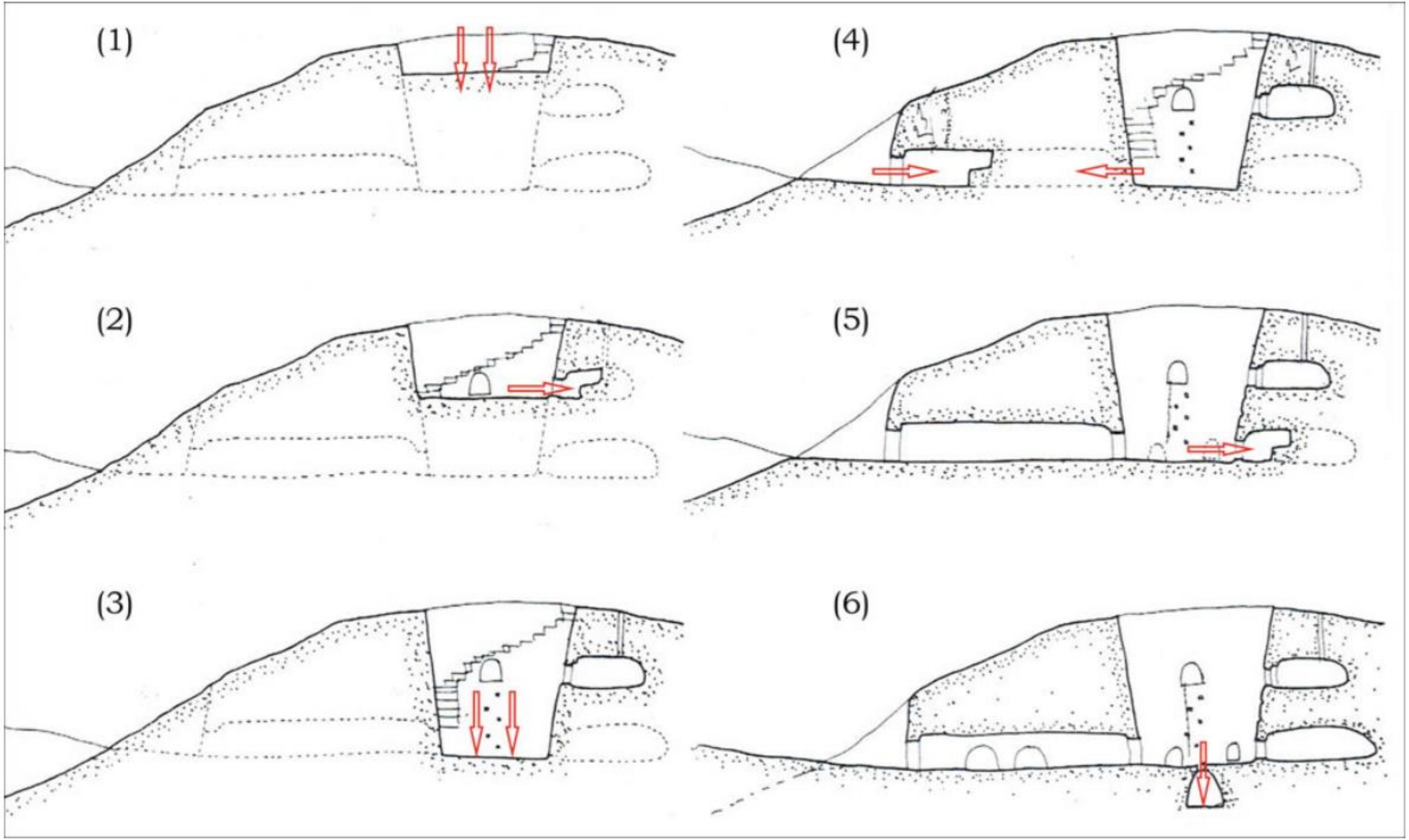
Low-lighting condition as Mars is more far away from the sun

Case study

Case study - underground courtyard design

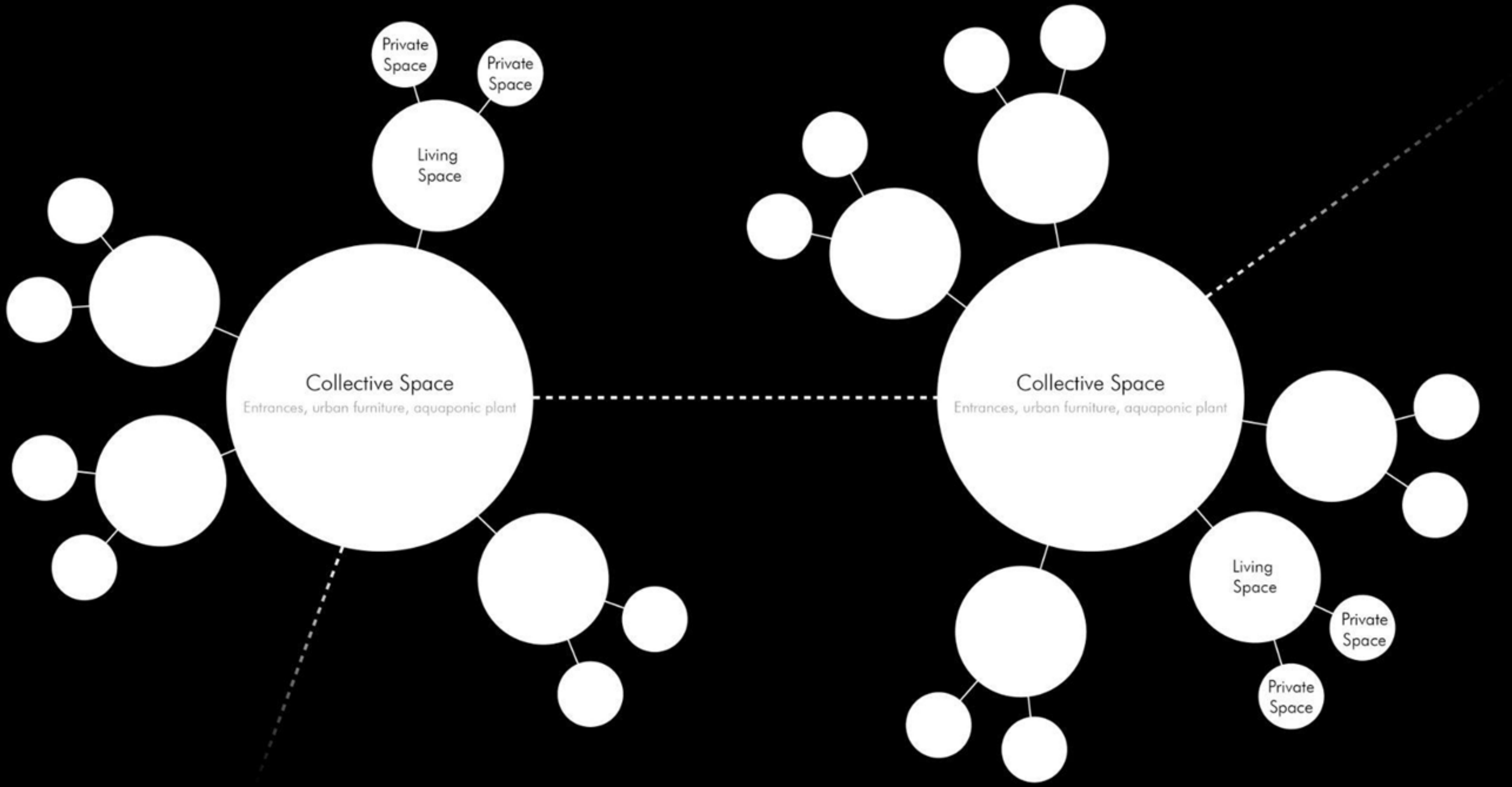


N
0 1 2 3 4 5
A-A
(1)
(2)
(3)
(4)
(5)
(6)
(7)
(8)
Entry
PLAN
SECTION
(1) Rooms
(2) Kitchen
(3) Granary
(4) Patio
(5) Vestibule
(6) Barn
(7) Stairs
(8) Storage


(1)
(2)
(3)
(4)
(5)
(6)

Overall design

Courtyard organization concept



components: courtyard + housings + canopy

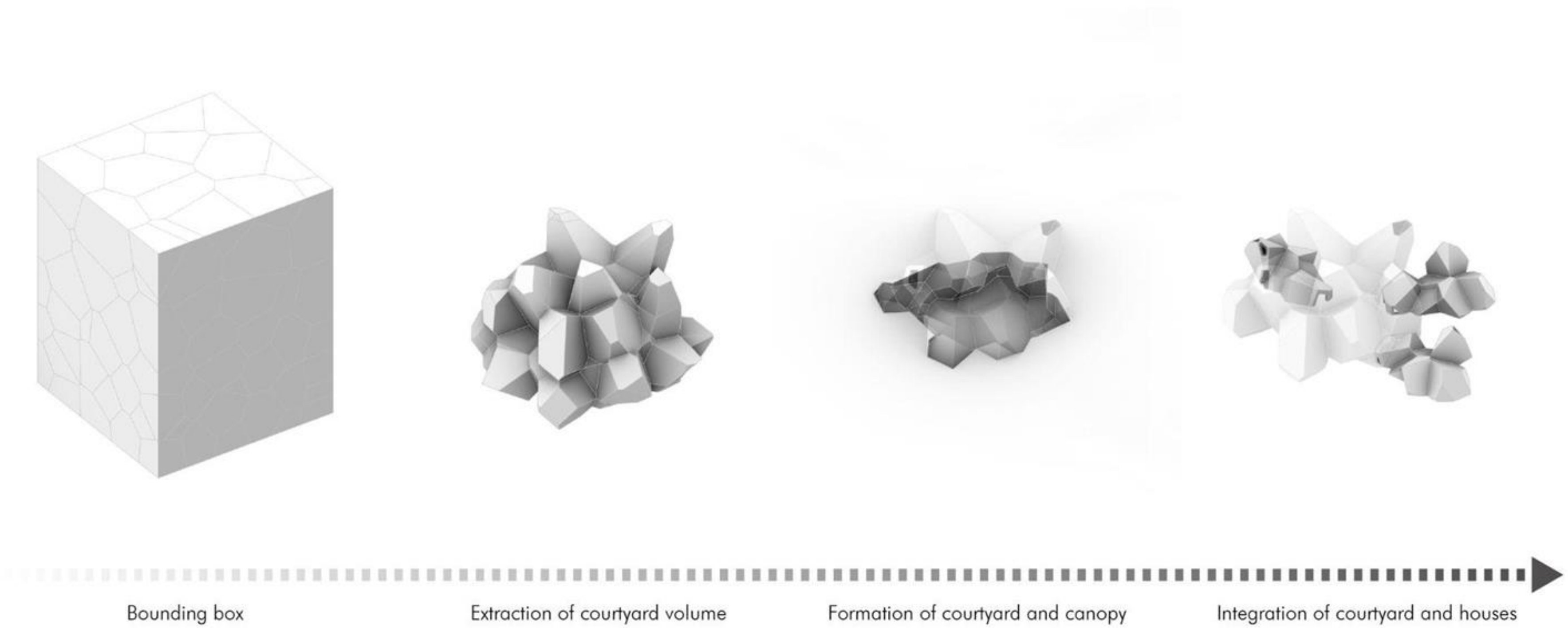
courtyard excavation

housing unit

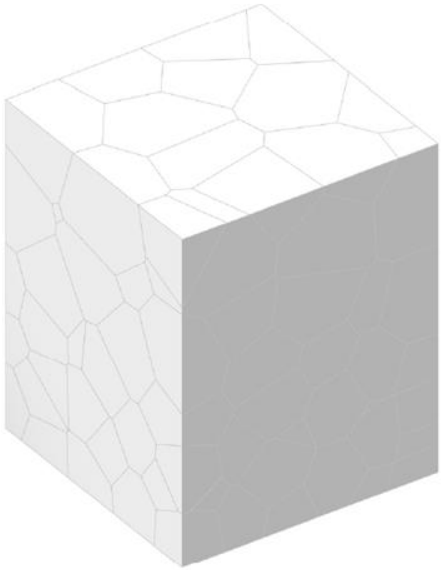
radiation shielding canopy

Overall design process

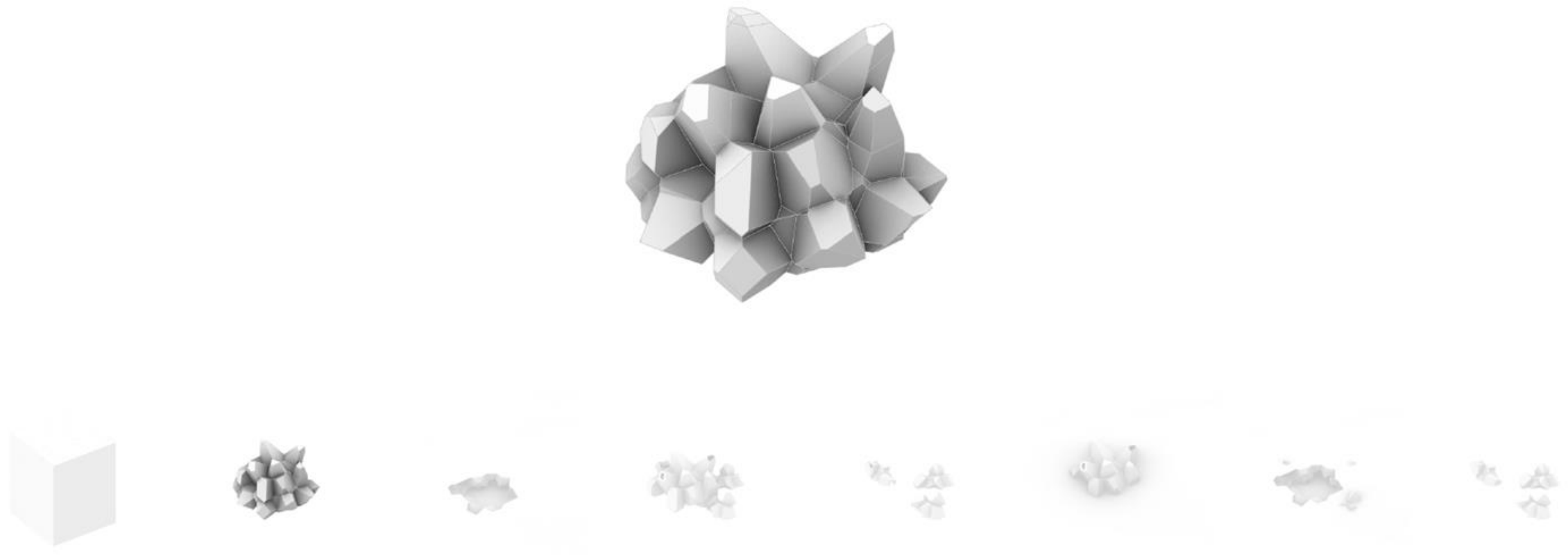
Overall voronoi design



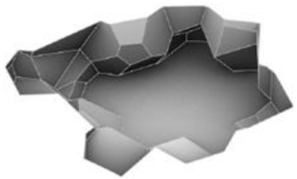
Box to Voronoi



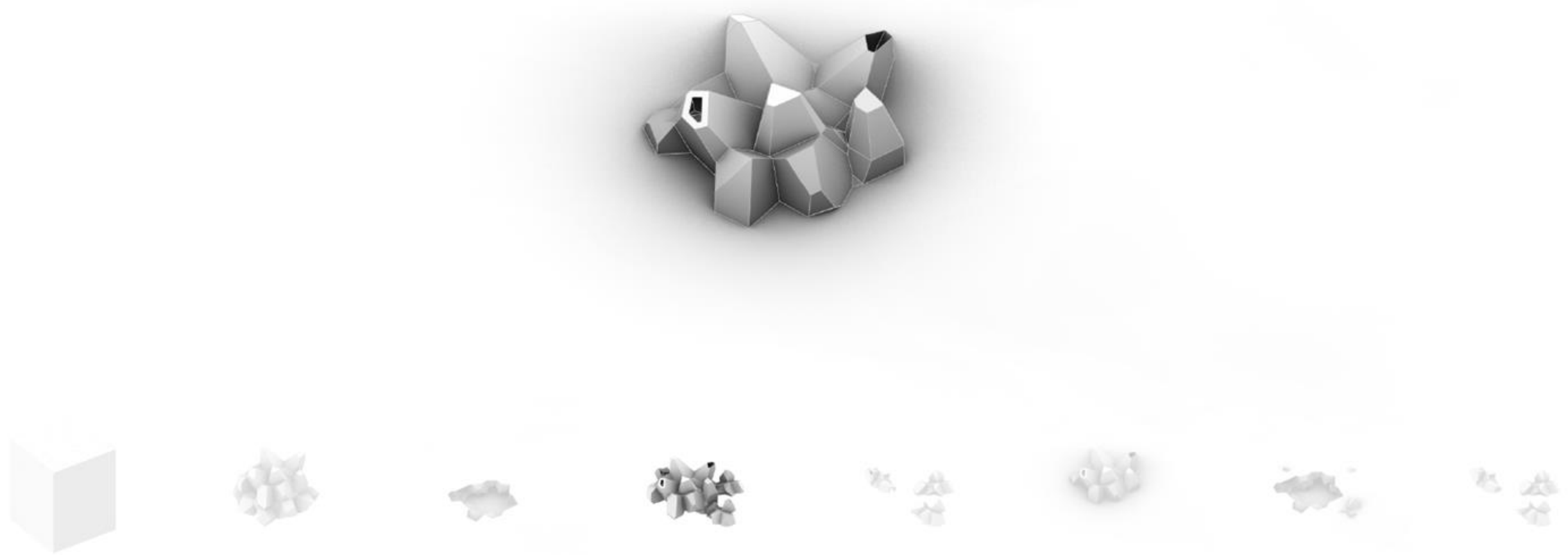
Voronoi selection



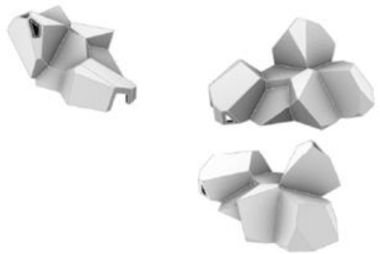
Creating courtyard



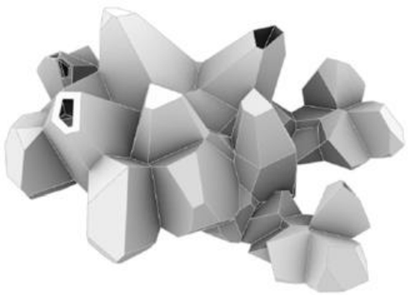
Creating canopy



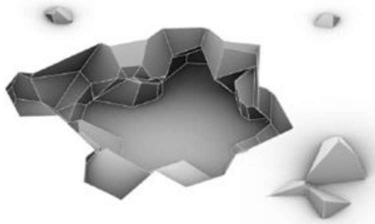
Creating housing units

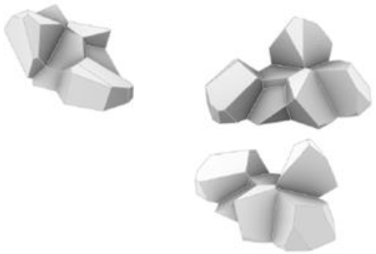


Attaching the housing units



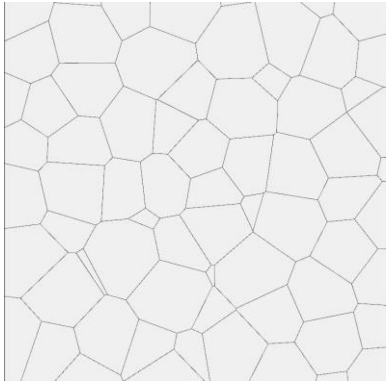
Overall design



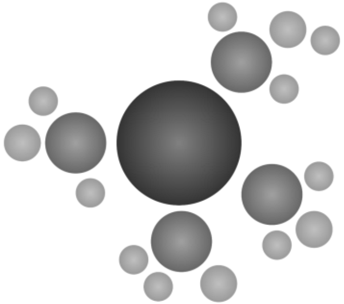


Courtyard design

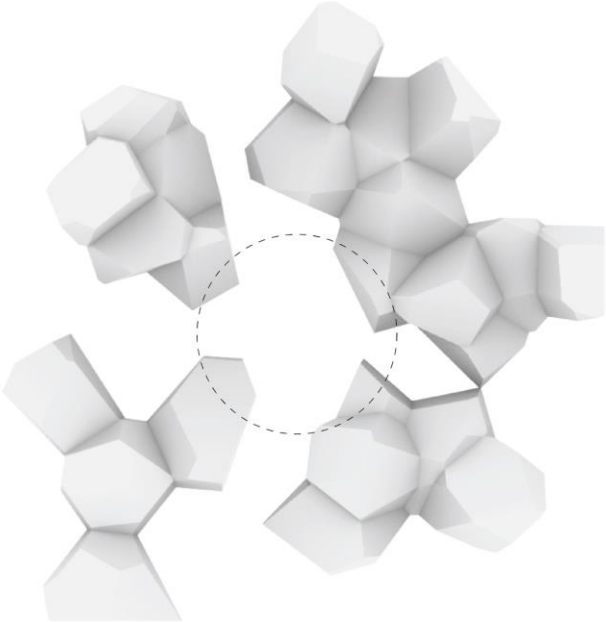
Voronoi housings to community



Voronoi cell construction

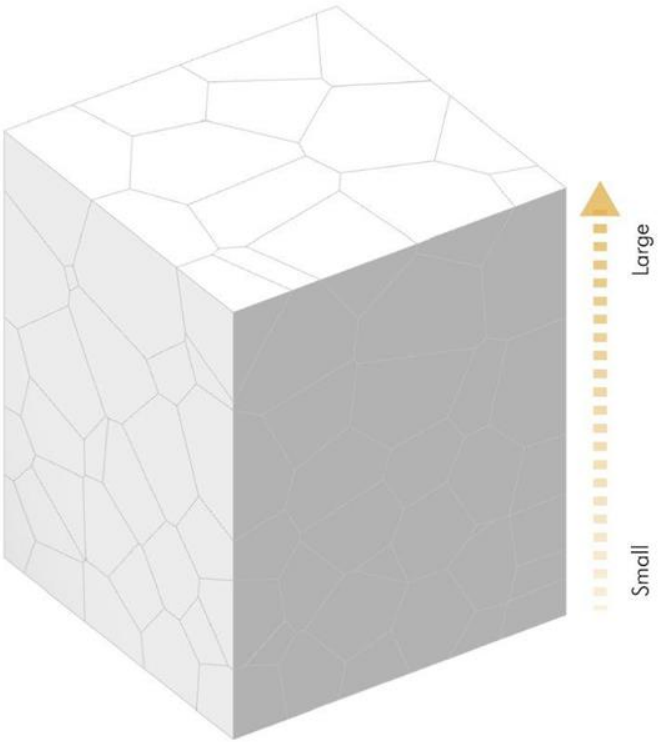


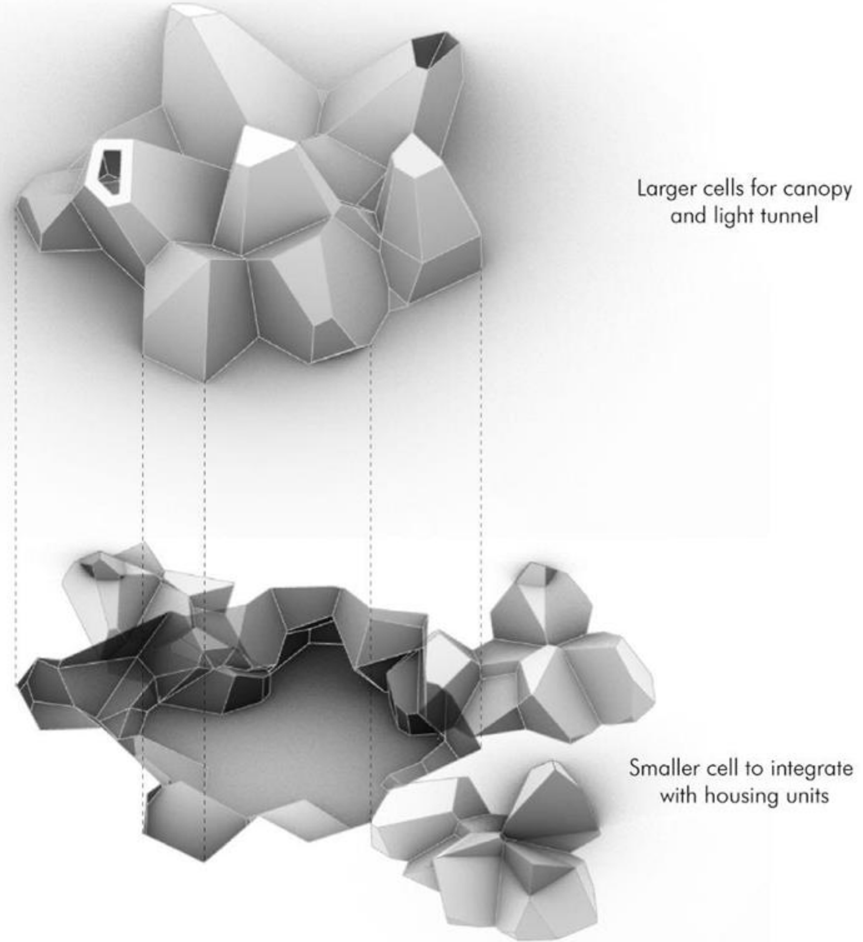
Programme organization



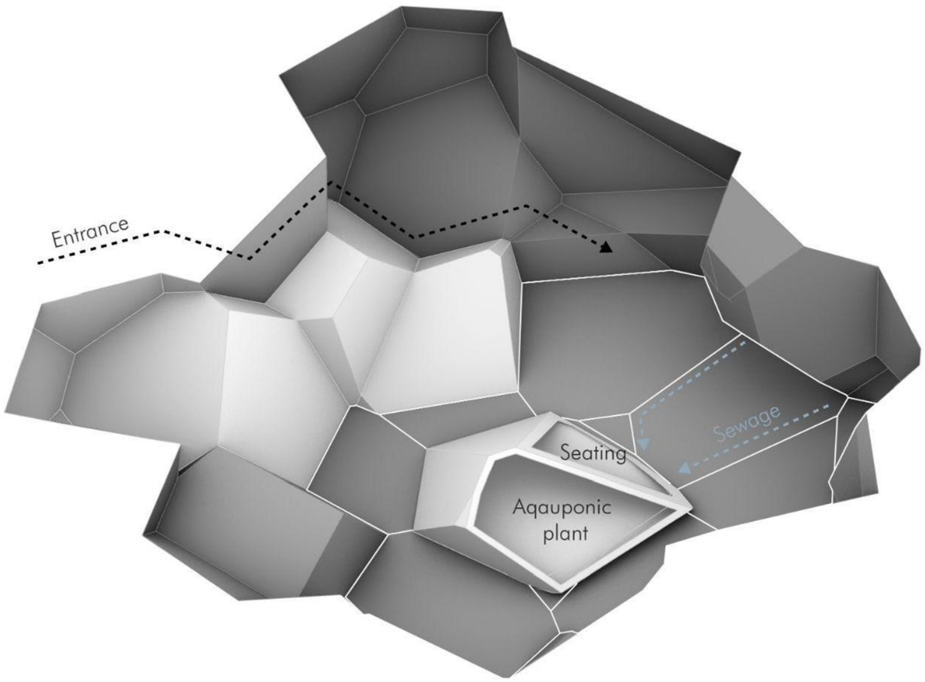
Voronoi cell organization

Courtyard voronoi design



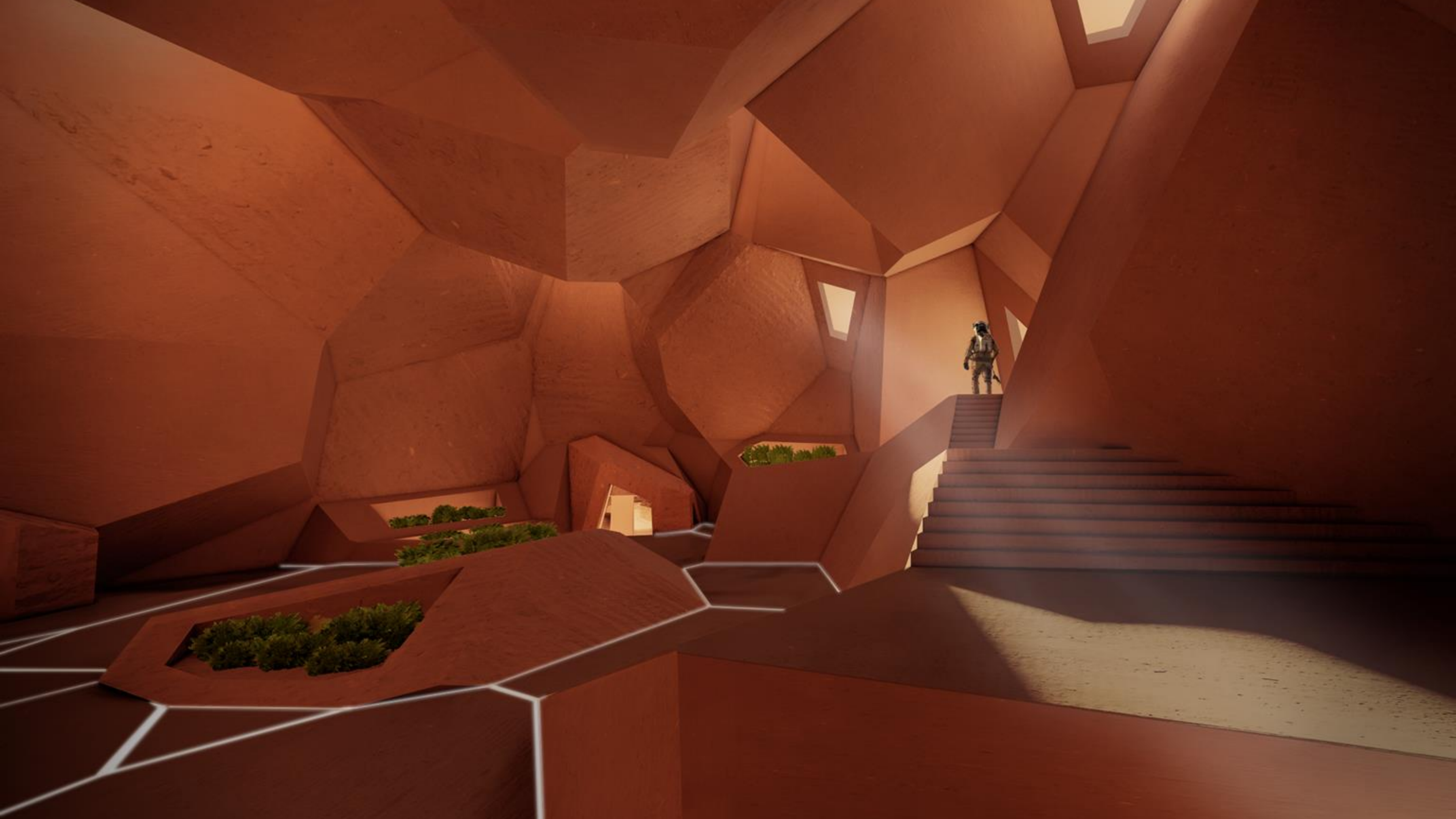


Courtyard urban furniture design



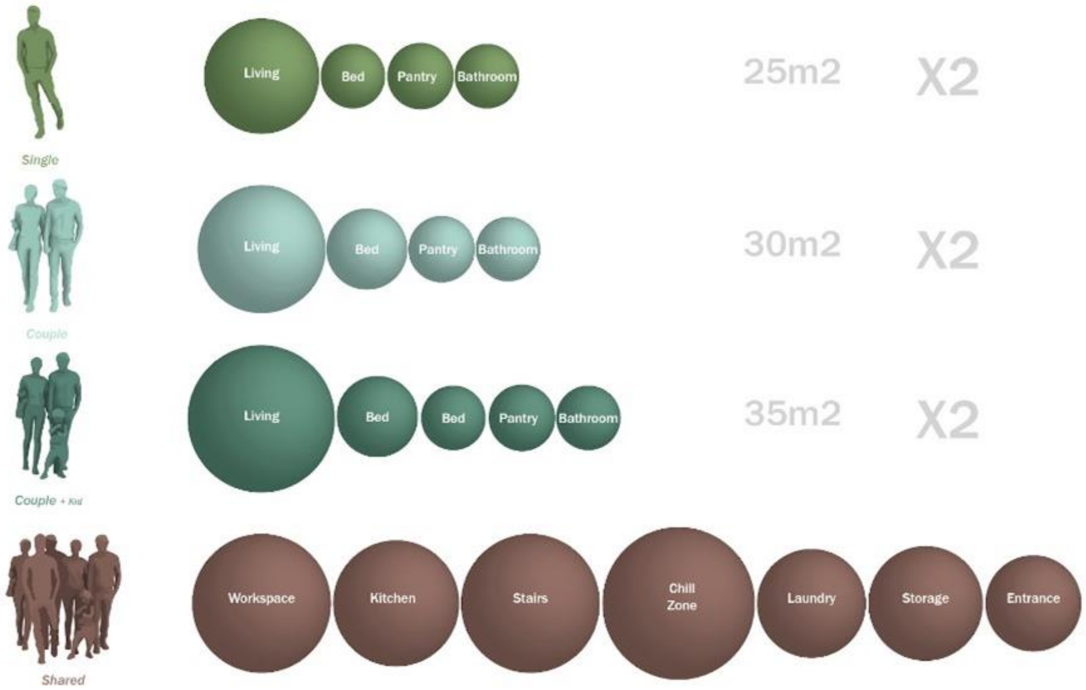
Cell stair design

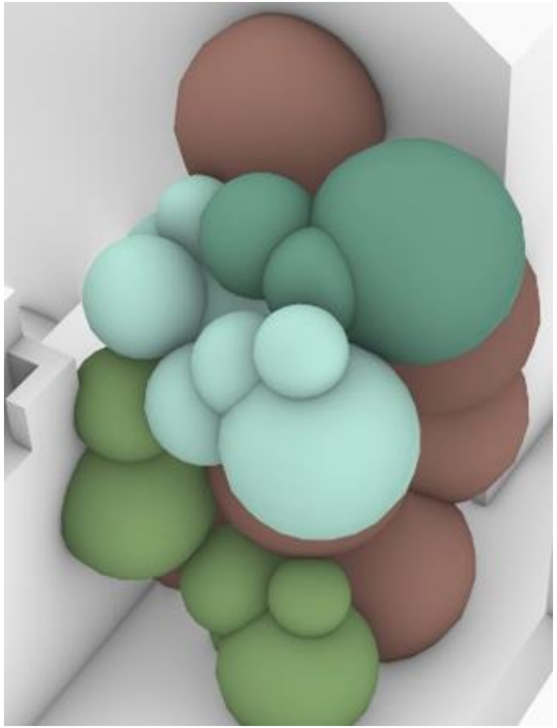
Aquaponic plant



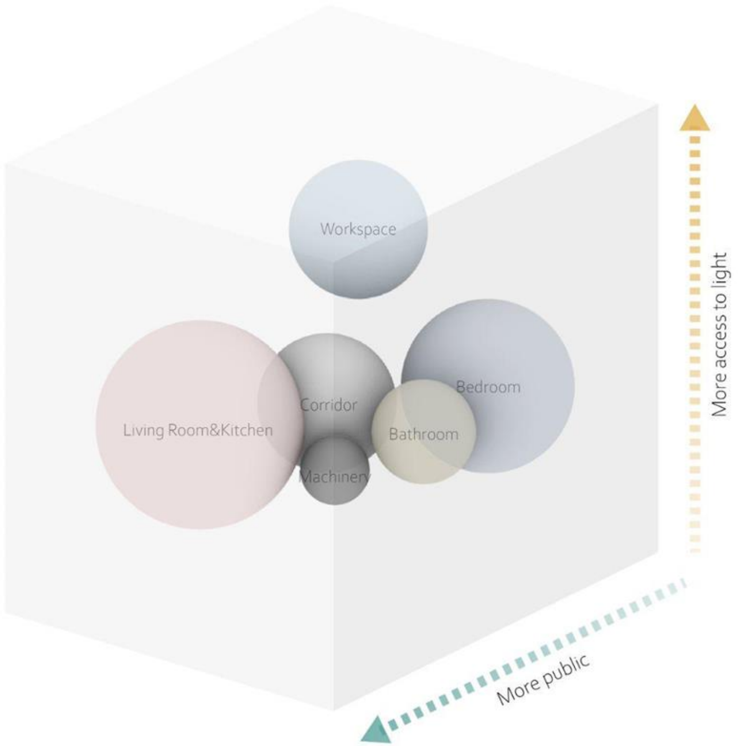
Housing design

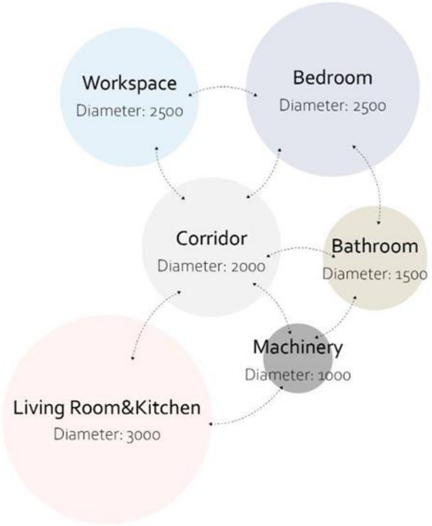
Case study - customization of spaces



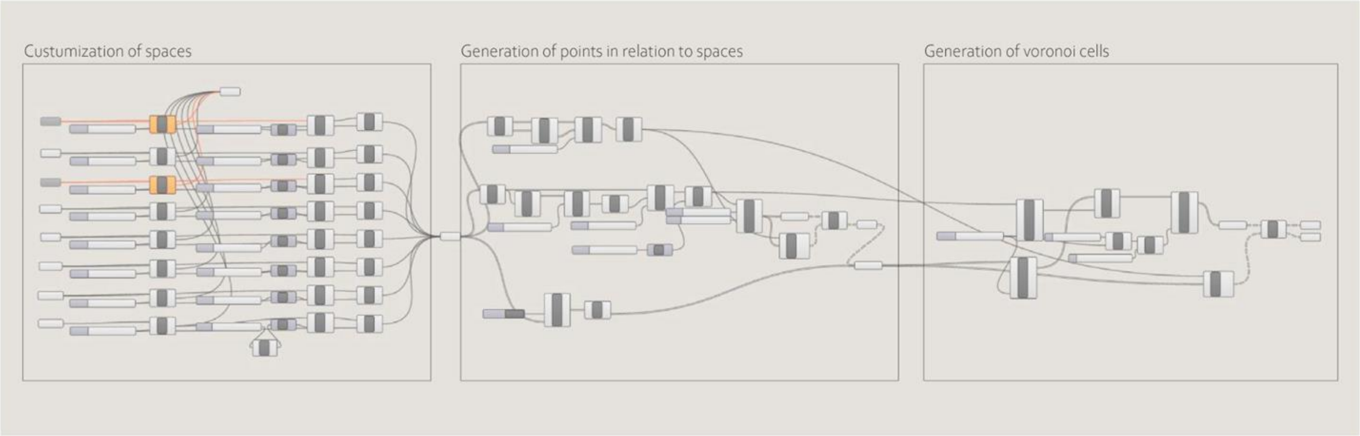


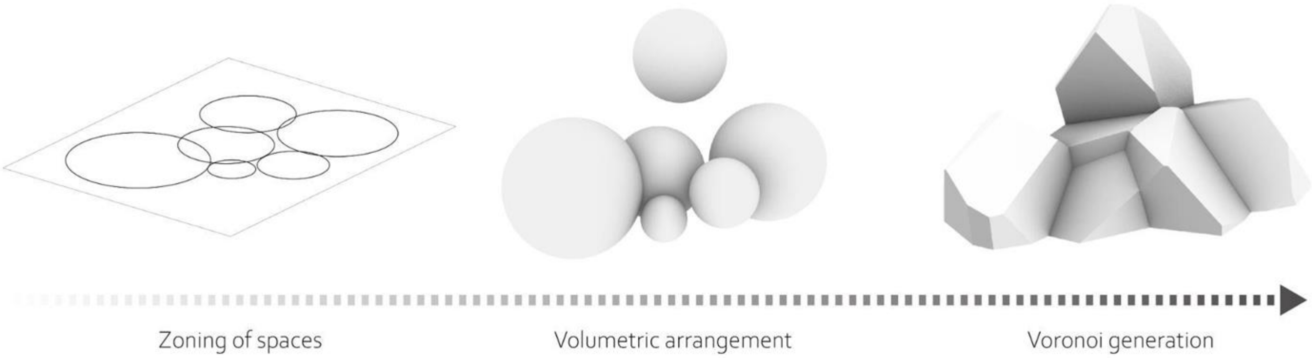
Design strategy - customization of volume



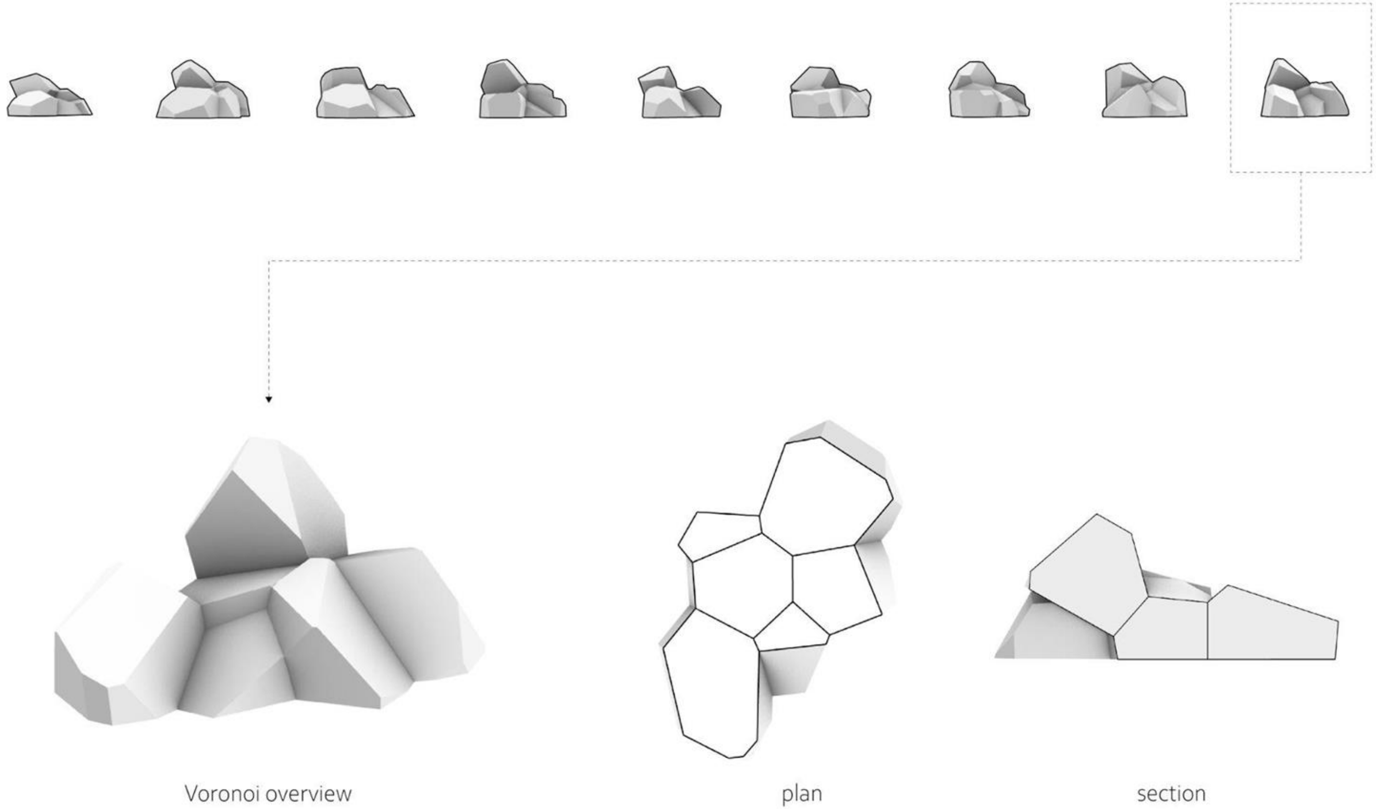


Translation of volume to voronoi

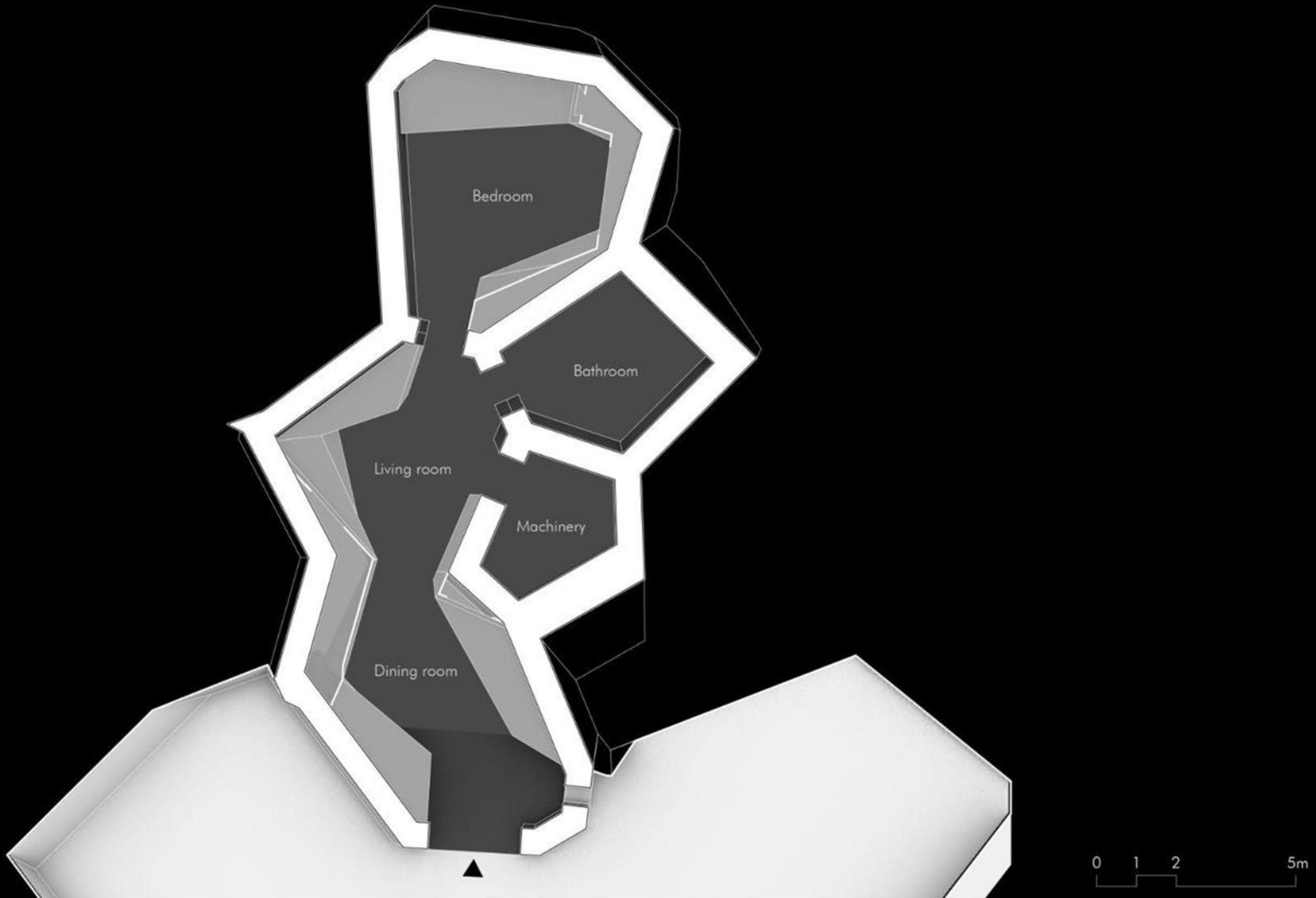




Selection of better options

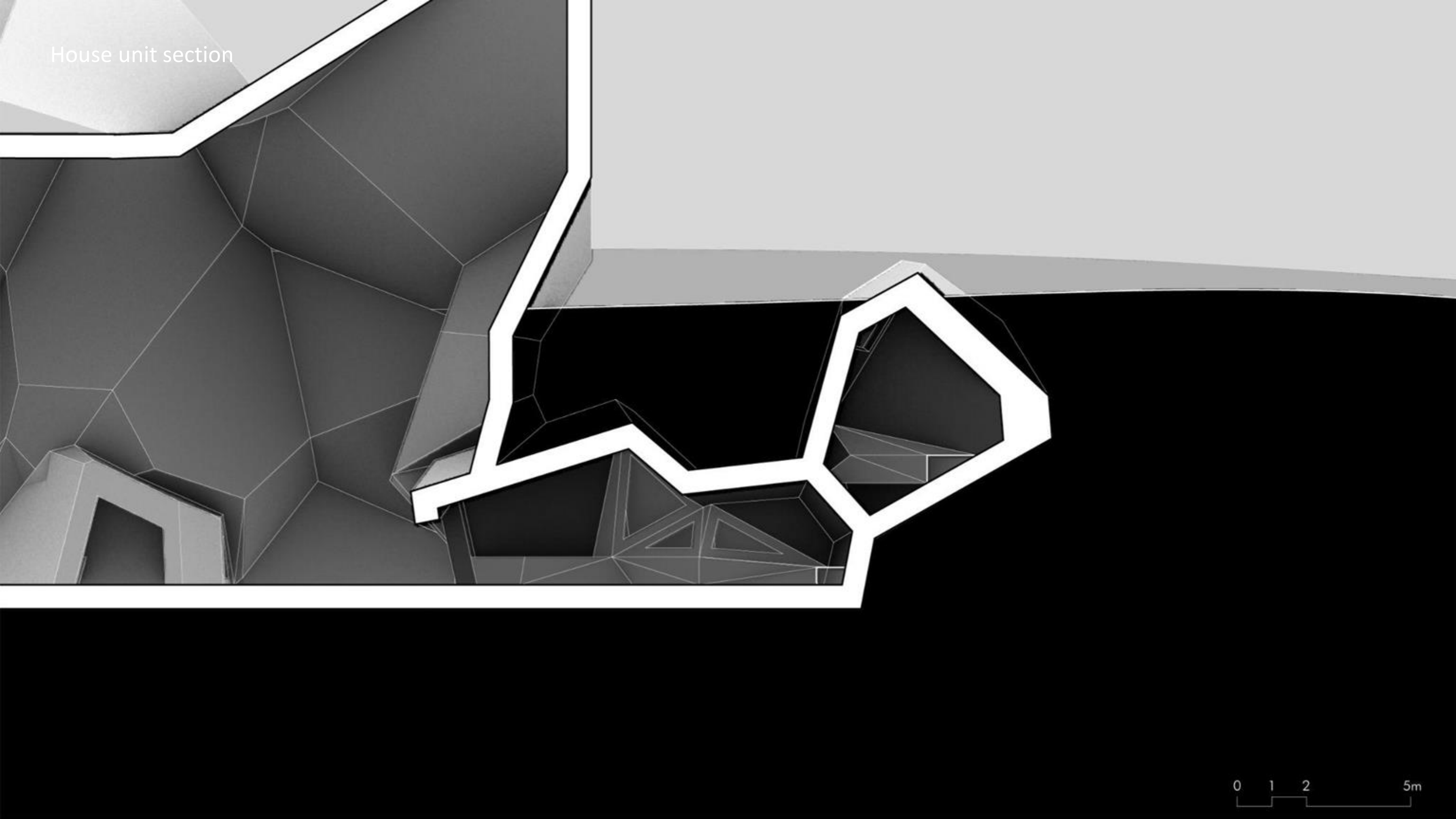


House unit plan

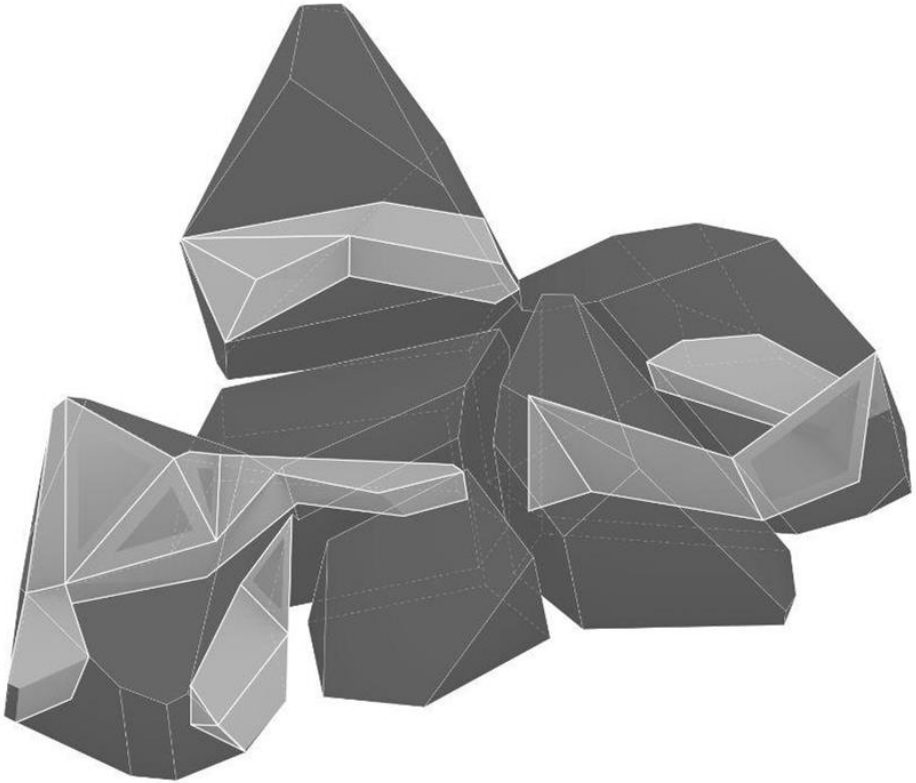


Courtyard section

House unit section

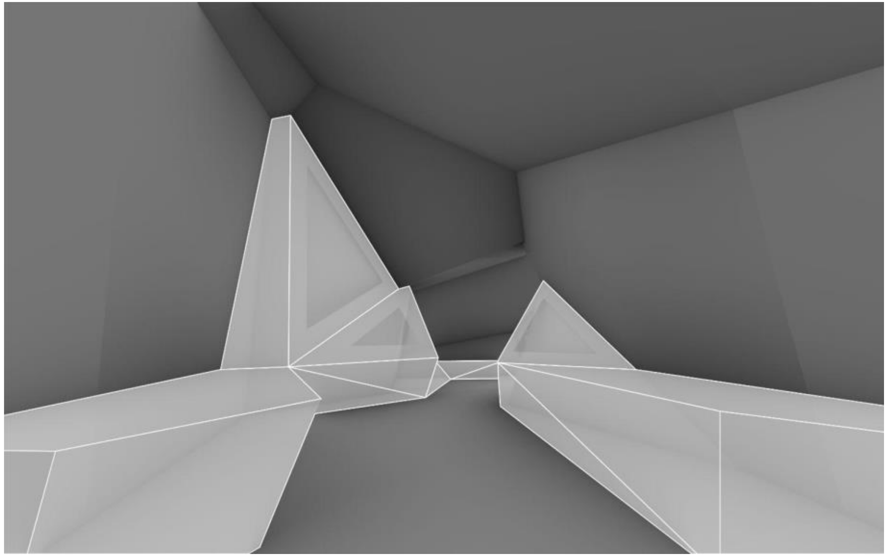


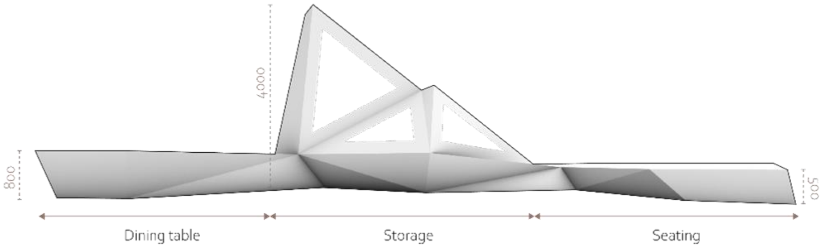
Furniture design

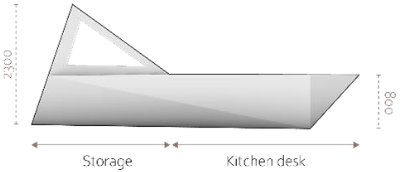


-extended from the wall
-continuous triangulated plane
-variations in form for different usage

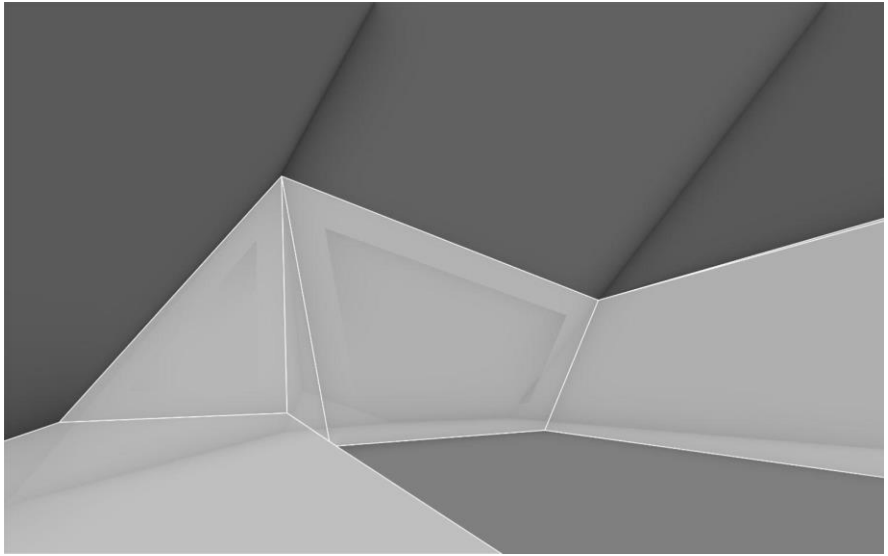
Furniture design - dining room

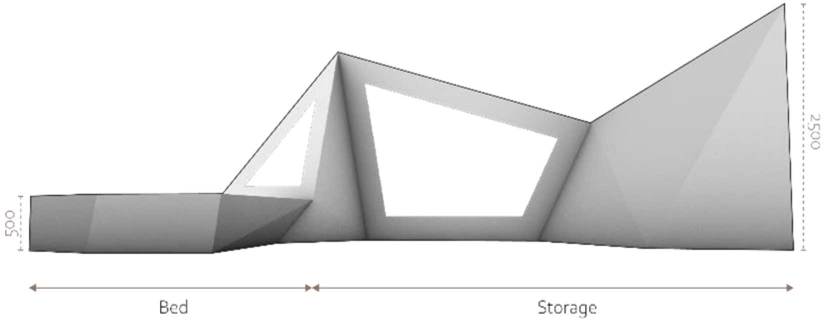




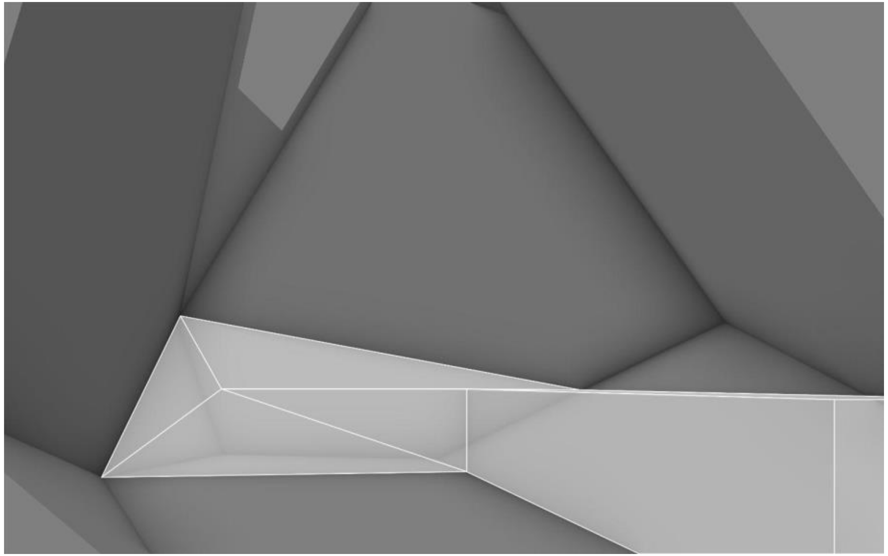


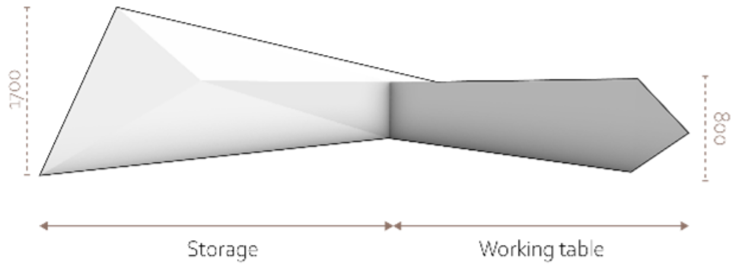
Furniture design - bedroom





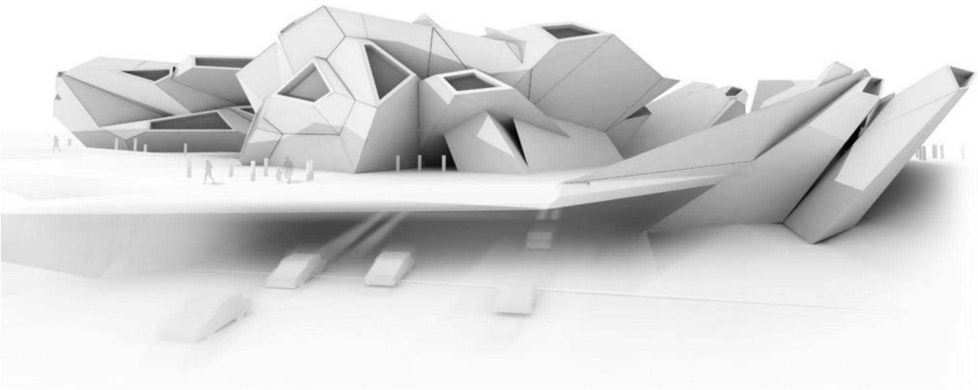
Furniture design - studio



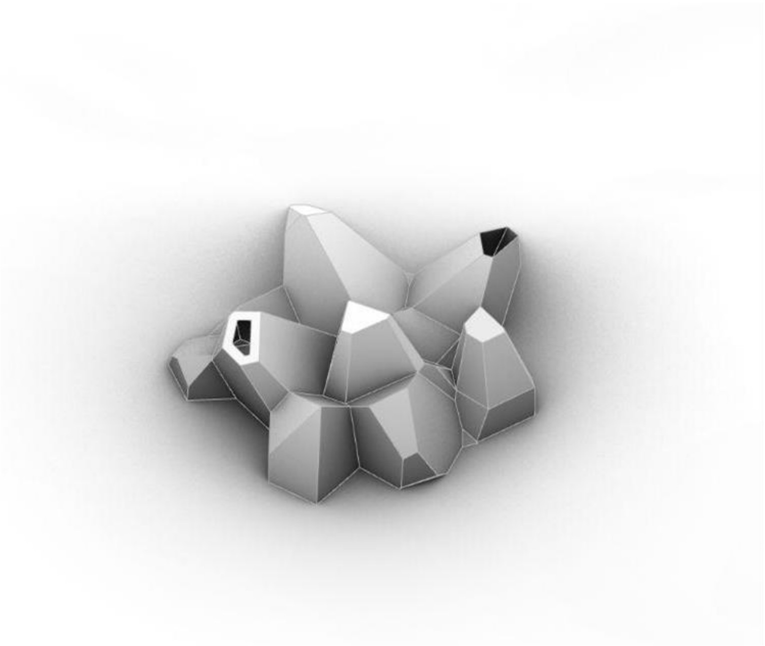


Canopy design

Inspiration



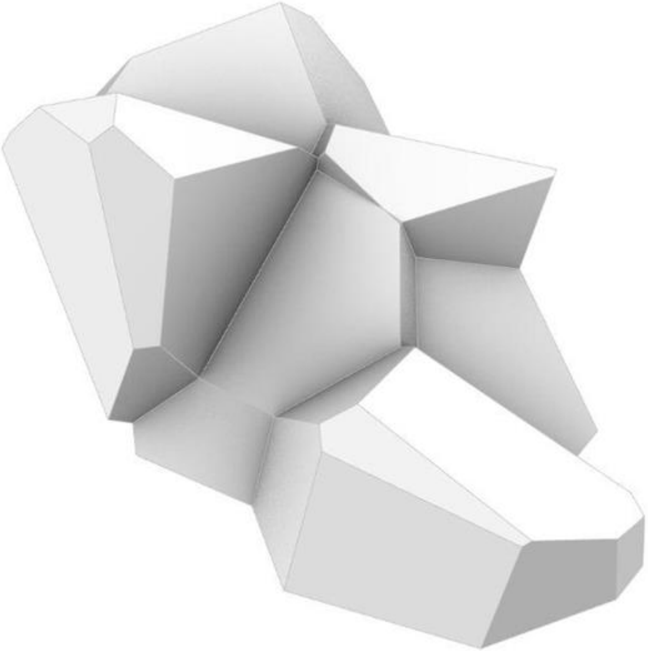
Student example

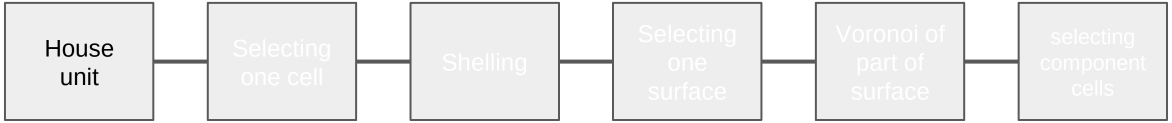


Voronoi dome generation

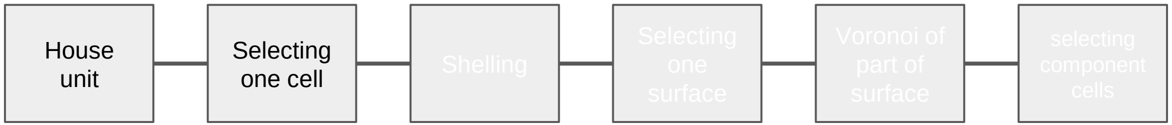
Production and assembly

House unit as base model

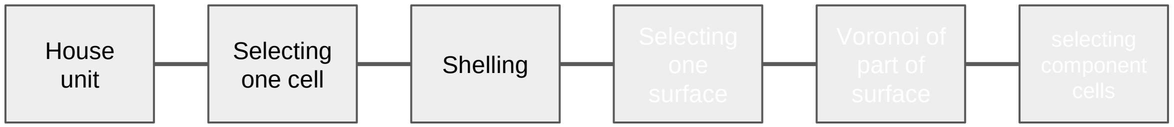




Selection of one of cell



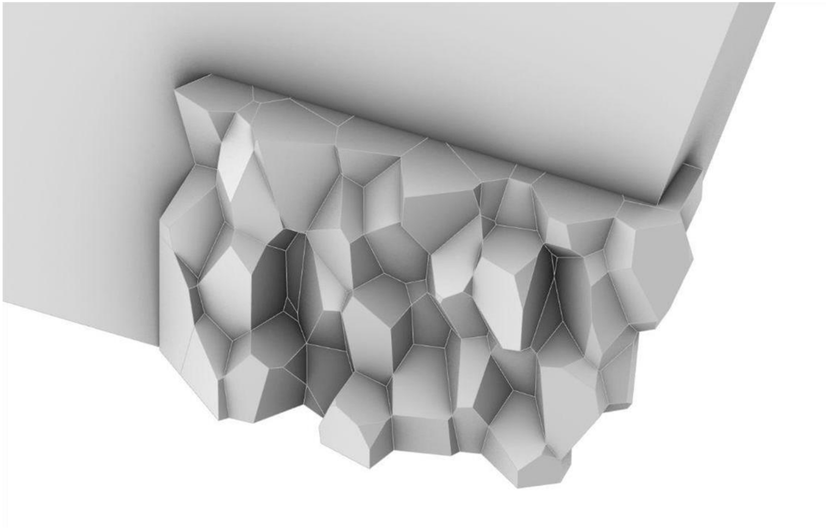
Adding wall thickness of cell



Selection of wall

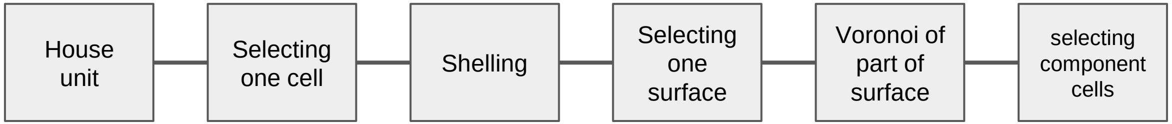
House unit — Selecting one cell — Shelling — Selecting one surface — Voronoi of part of surface — selecting component cells

Voronoi in wall fragment

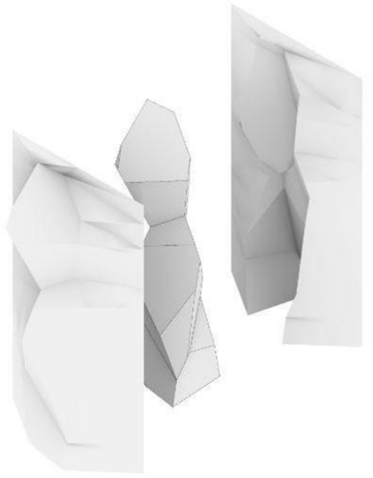


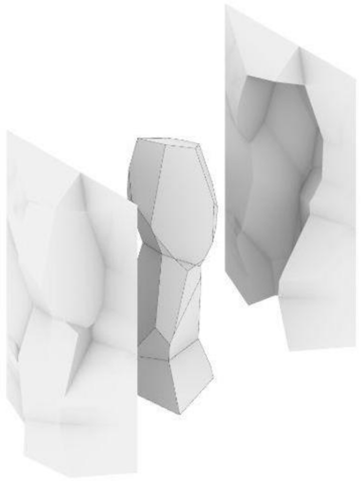
House unit — Selecting one cell — Shelling — Selecting one surface — Voronoi of part of surface — selecting component cells

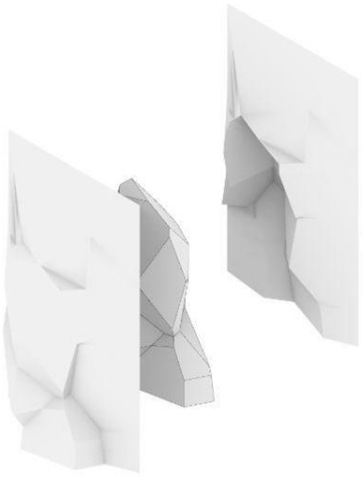
Selection of component



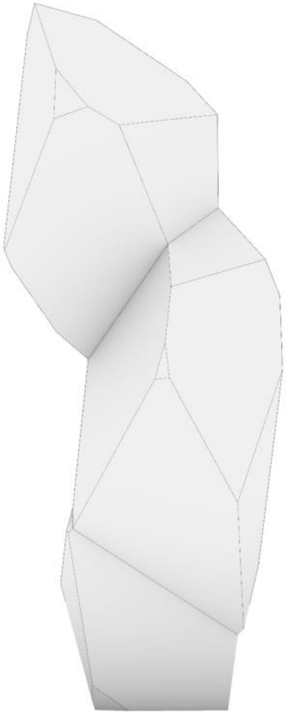
Preparing the components for initial material removal tool path creation



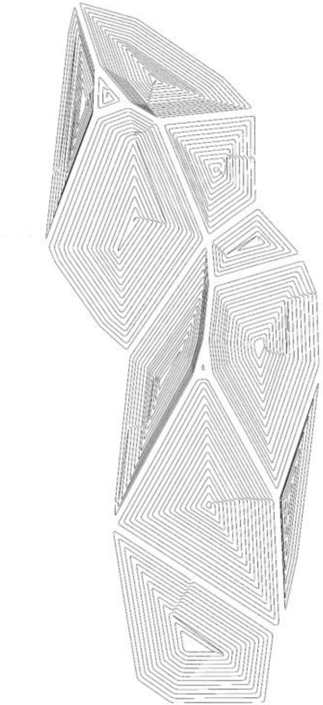




Face selection, face texturization and hole selection



Isolate naked faces



Create tool paths for the faces

Texturized faces and holes

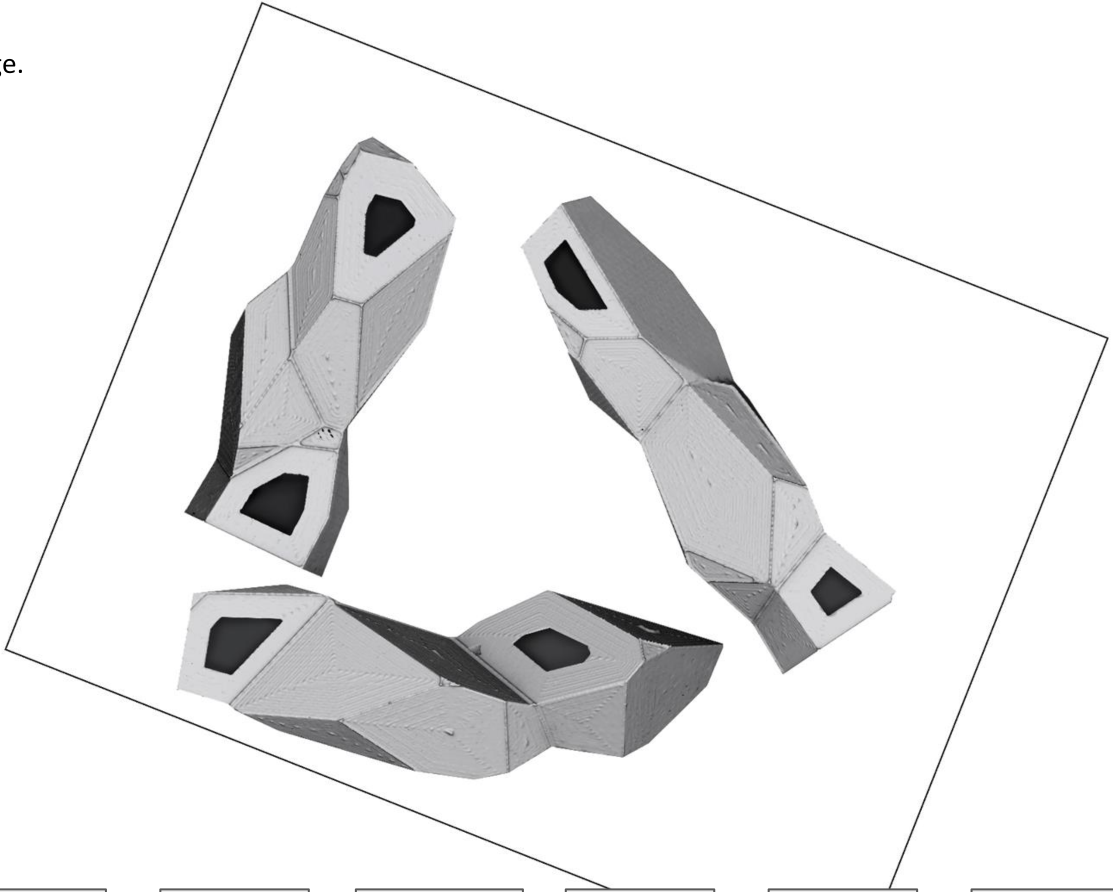

KUKA

ComputerVision

Preparing components onto platform (frame)

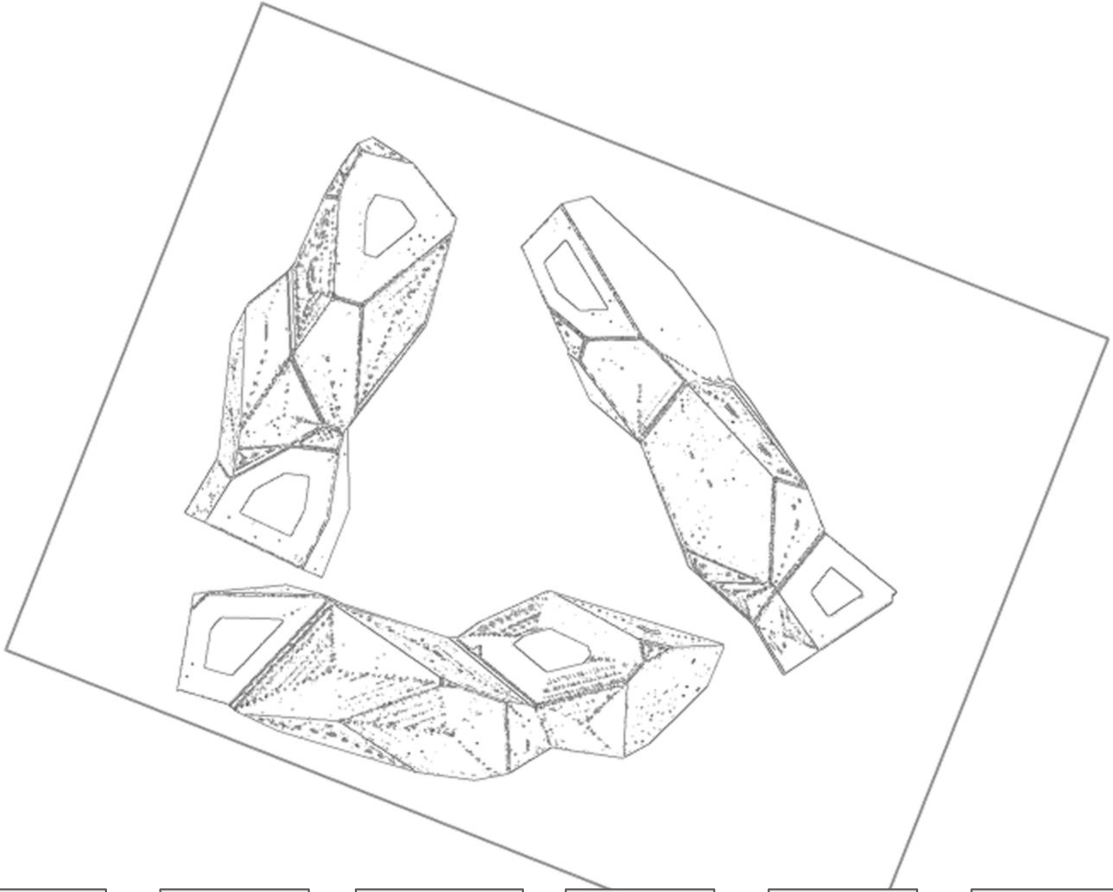
Add image here of the components being placed on the frame, it would be nice to have an animated gif of that happening.

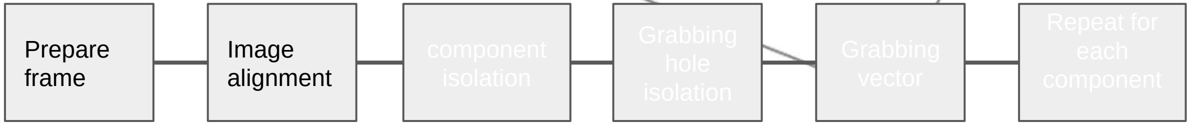
We set up a camera of the components on a frame,
This frame should be identifiable and complete in the image.



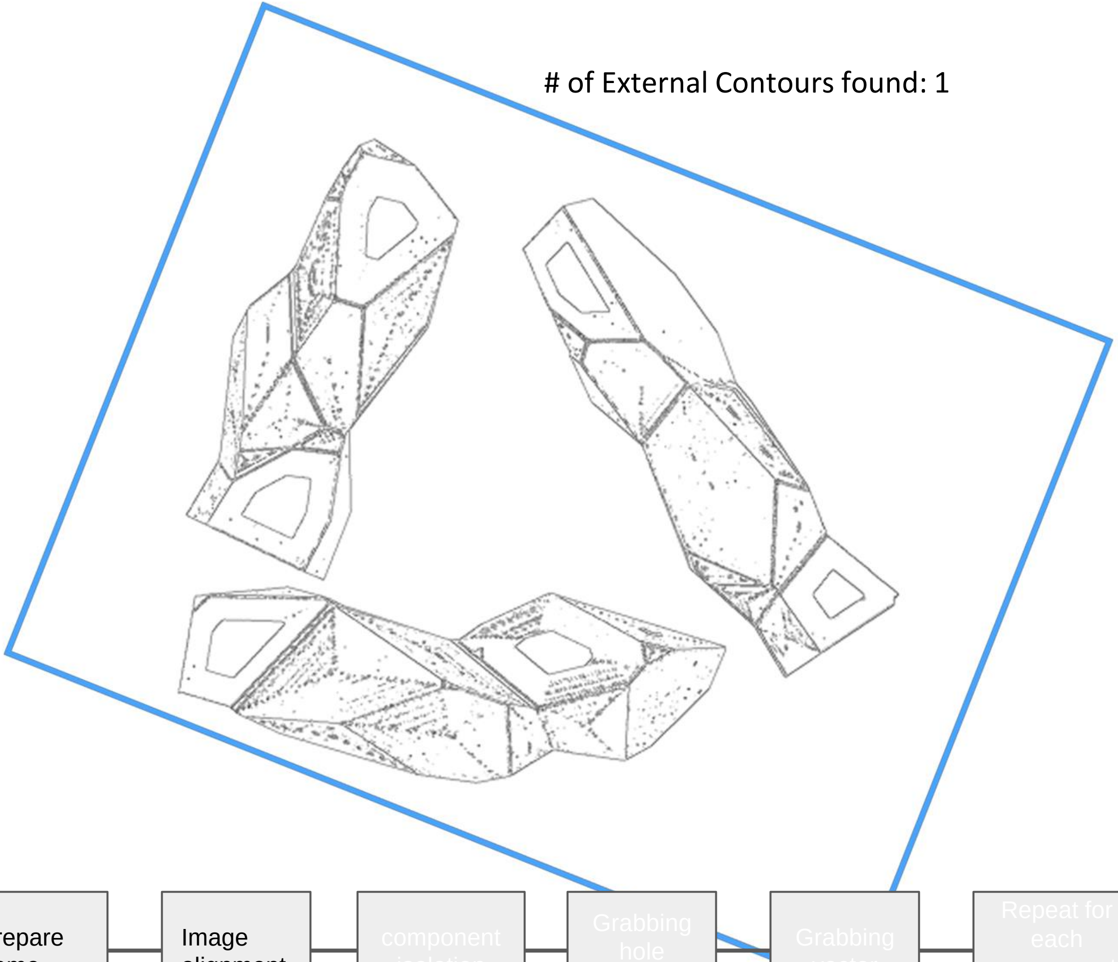
Prepare frame → Image alignment → component isolation → Grabbing hole isolation → Grabbing vector → Repeat for each component

An edge contour algorithm is run on the image. In this case it is the Canny edge detector algorithm. Here a gradient of contrast is used to determine an edge. The difference in gradient is a parameter that can be fine tunes to match the image.



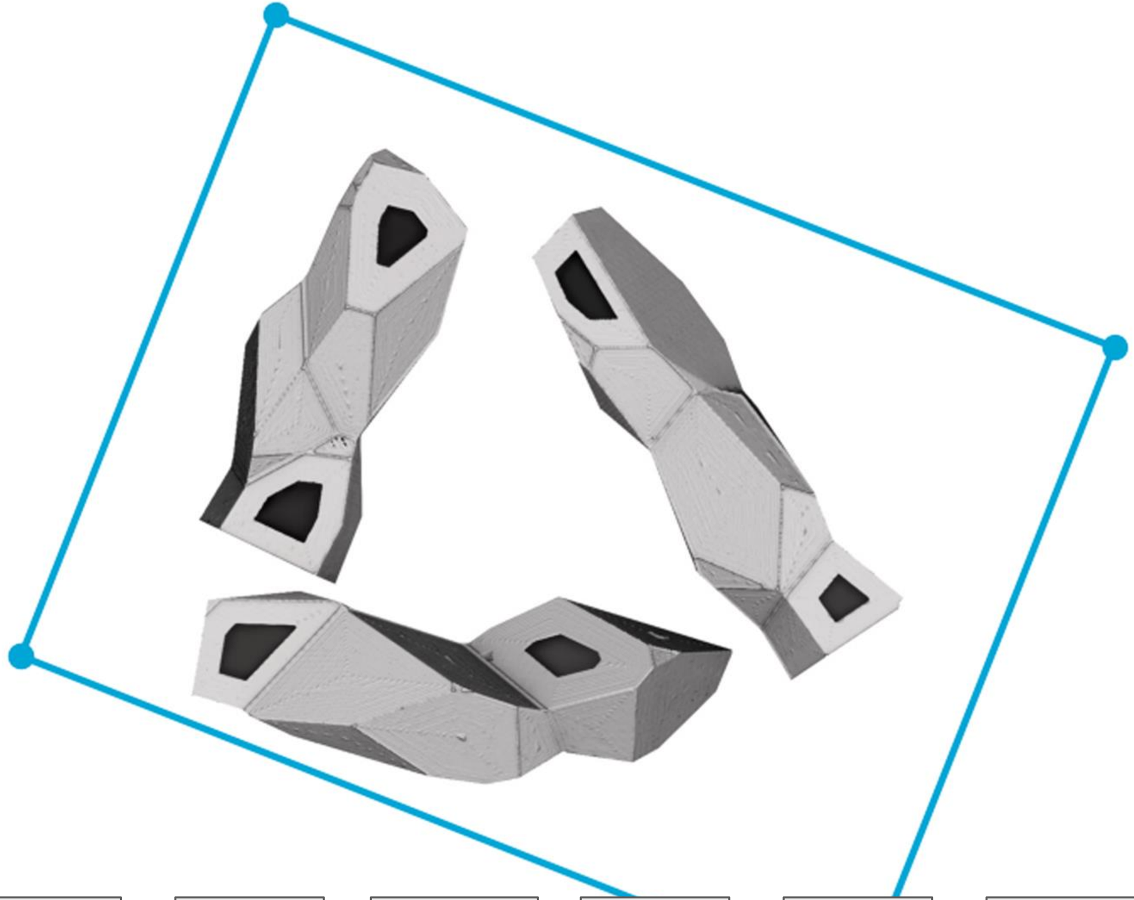


On the edges we run a contour finding algorithm called findContours and we set it to find only the most external contours. This is to identify the edge of the frame.



Prepare frame → Image alignment → component isolation → Grabbing hole isolation → Grabbing vector → Repeat for each component

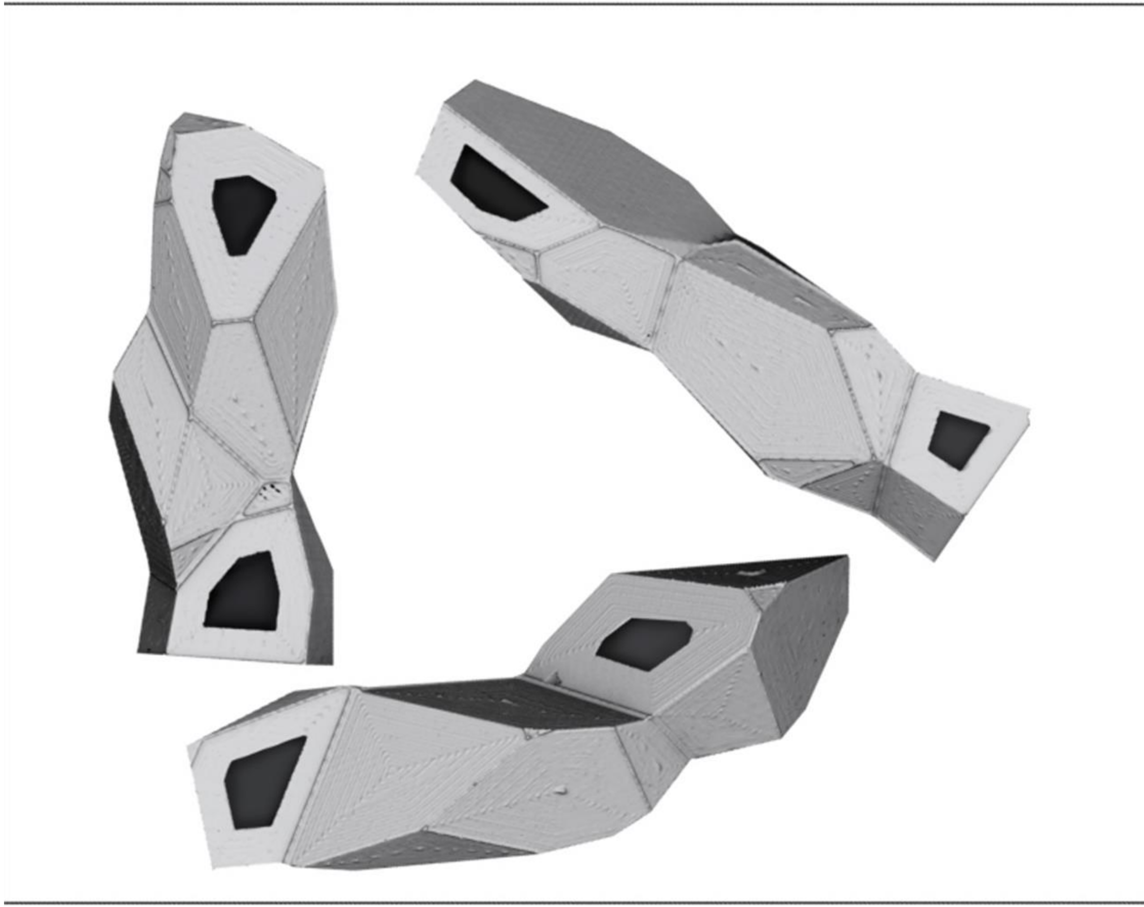
The contour is matched to a box polygon

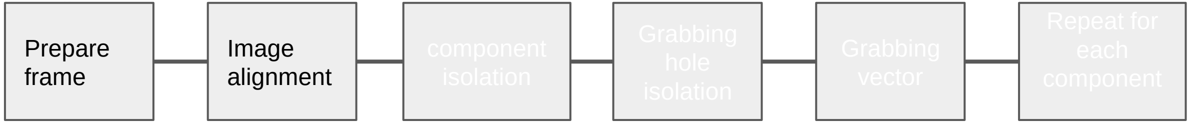


Prepare frame — Image alignment — component isolation — Grabbing hole isolation — Grabbing vector — Repeat for each component

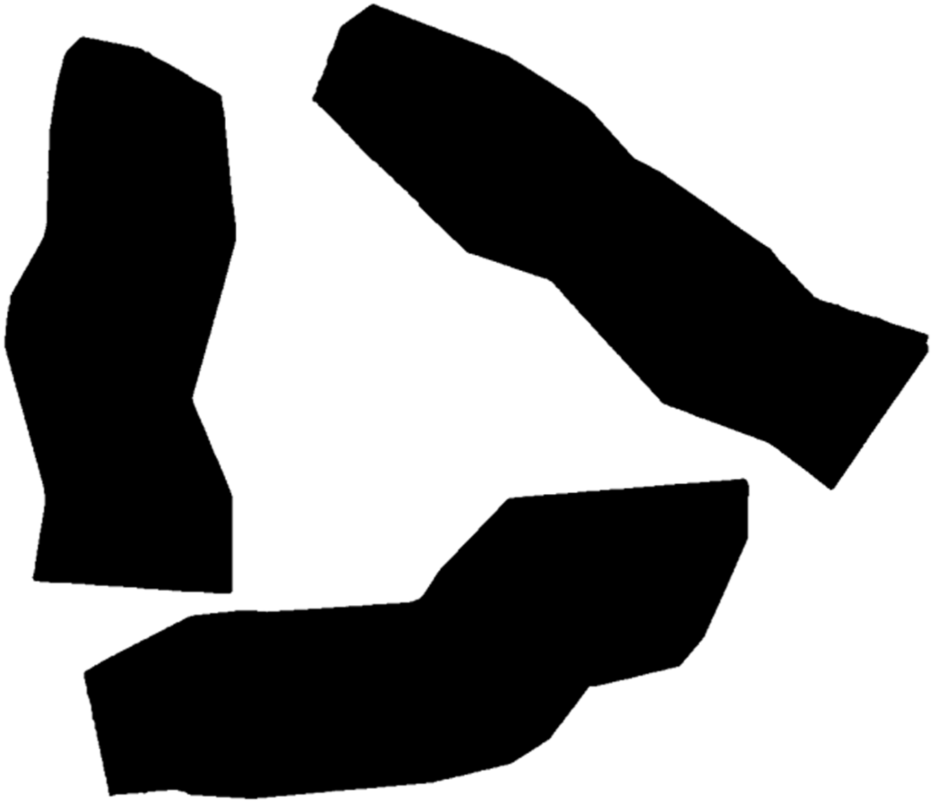
And the whole image is warped to fix any misalignments between the frame and the camera. The pixels of the image can then be converted into physical units using the frame as a reference object.

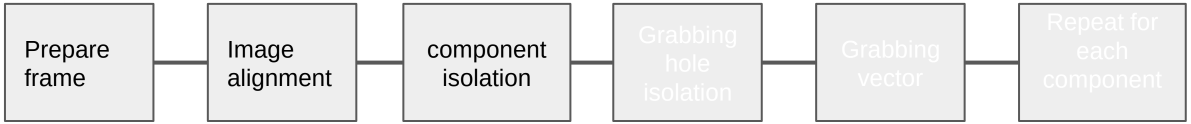
At this point the image can be used to guide any robot that is also connected to the coordinate system of the frame. We will continue to process the image so that a robot can interact with the components more autonomously.



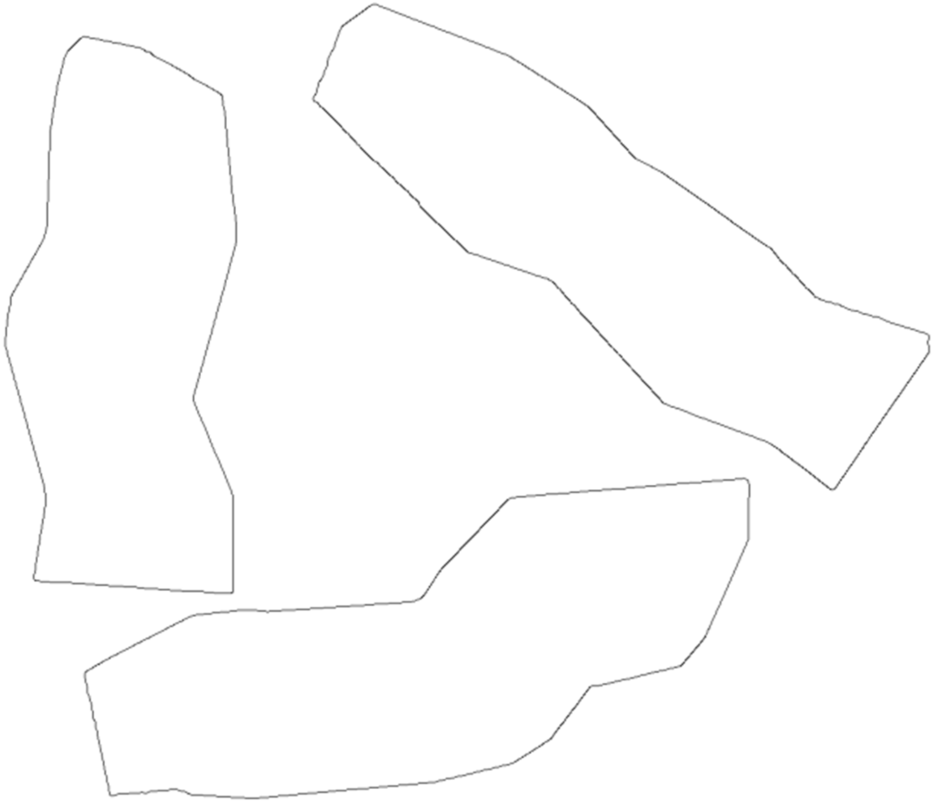


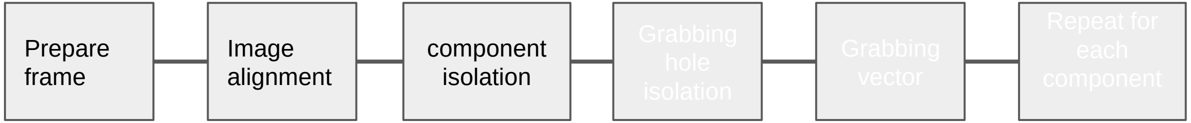
We first isolate the components by using a grayscale contrast threshold. Any value that is whiter than 240 is made white, and any value darker than 240 is made black.



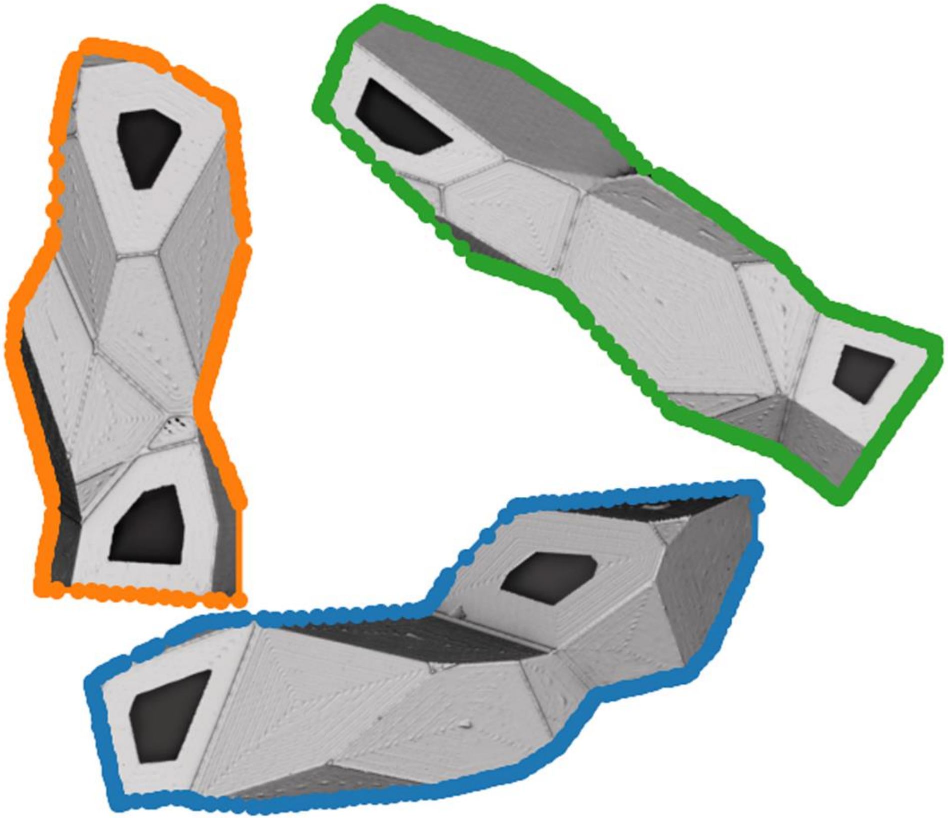


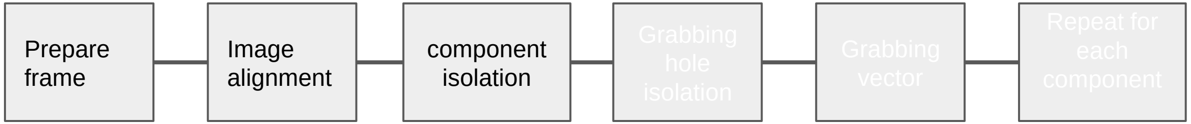
Running an edge detection and a findcontours becomes trivial.



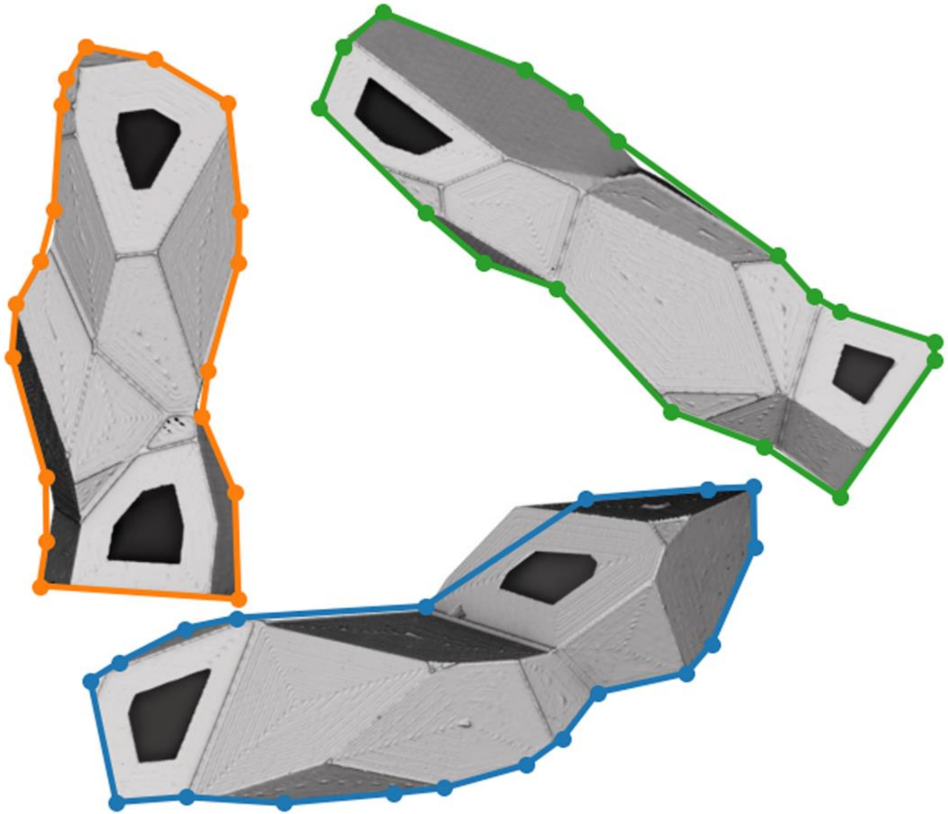


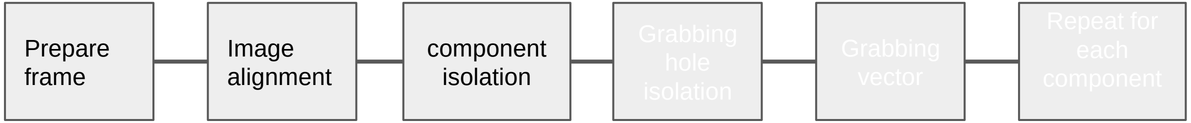
Running an edge detection and a findcontours becomes trivial.



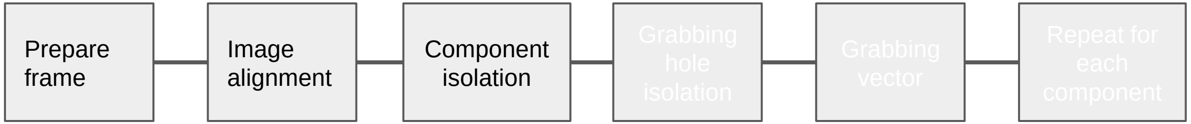


The contours are simplified to make the later steps cleaner.

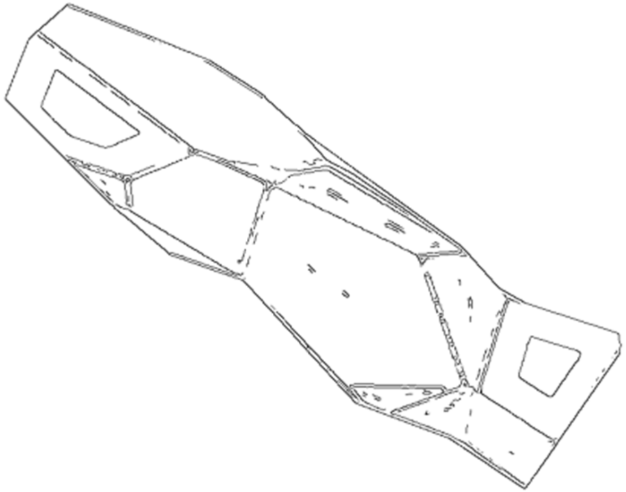


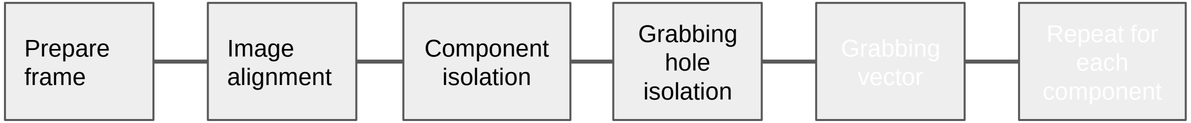


From here we just select a contour
and use it as a mask to isolate the respective component

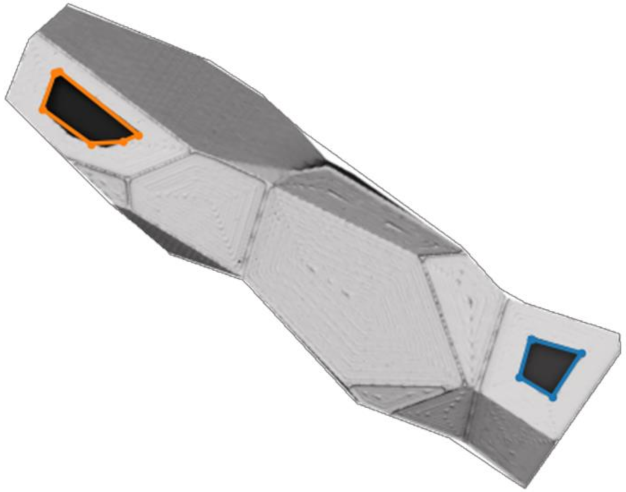


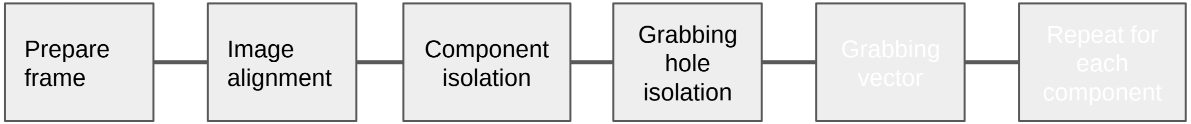
We run an additional edge detection algorithm. and again run the findcontours. In this step a bluring of the image before the edge detection can be useful to reduce the complexity of the edges and eliminate false gaps.



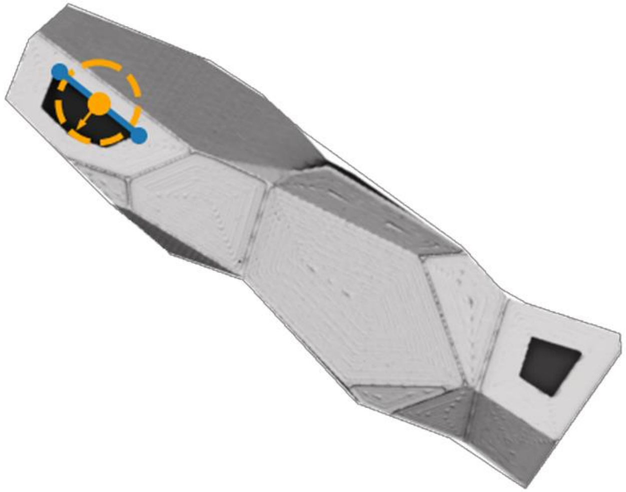


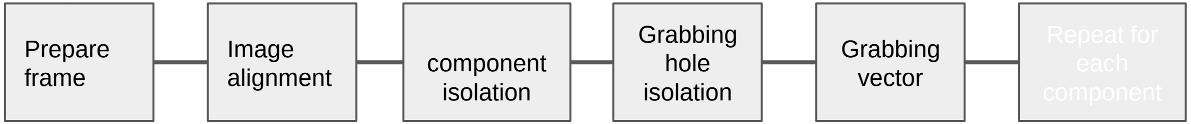
We identify the holes by looking for contours with an area between two values.

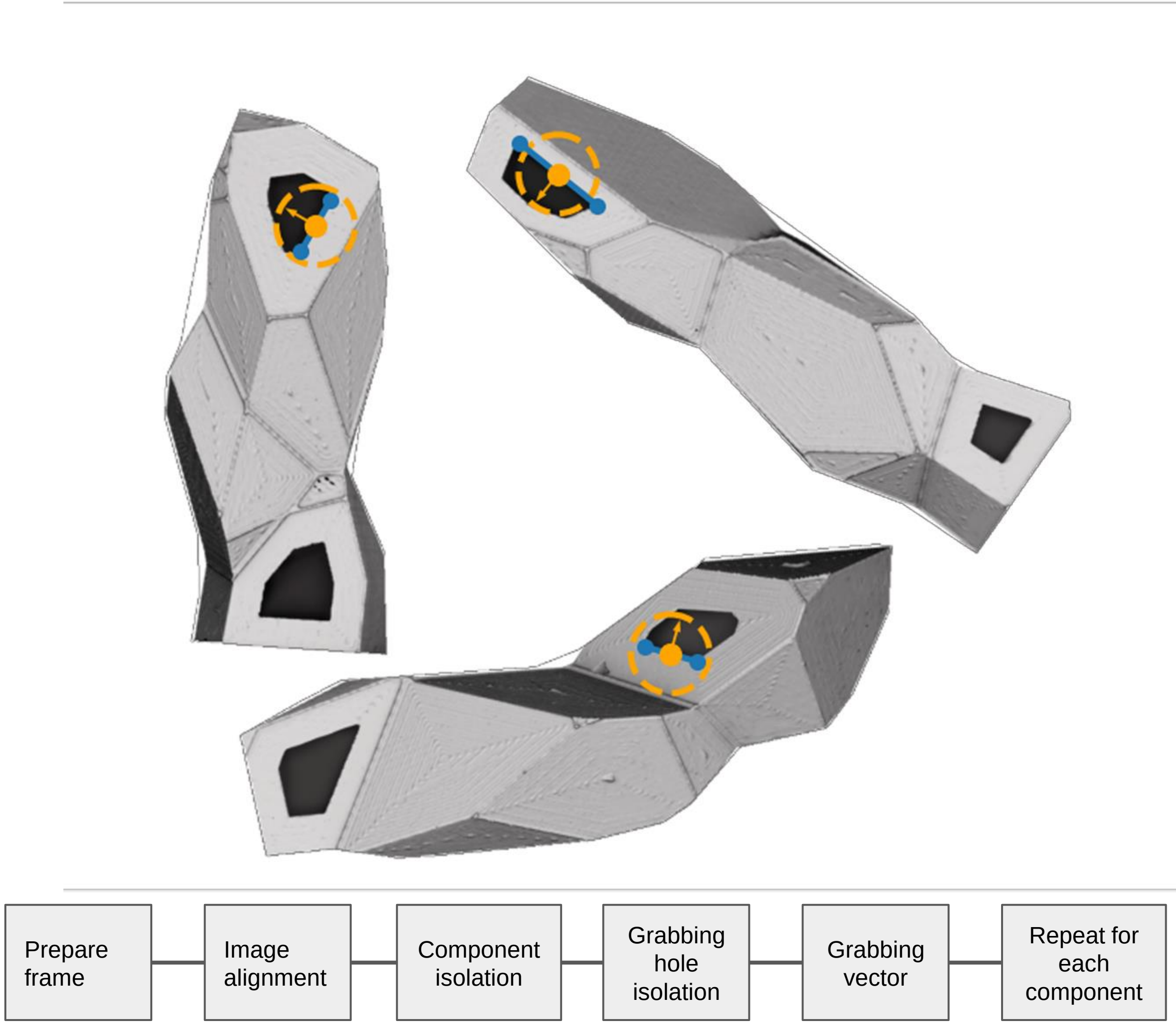




And finally for the robot we create a grabbing vector. We do this by creating a vector between 2 points, the contour centroid and the midpoints of the longest edge of the contour.

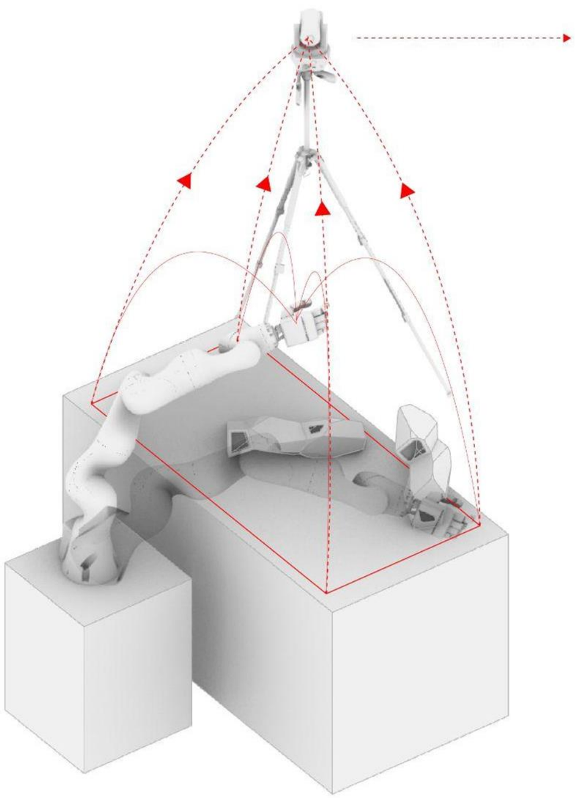




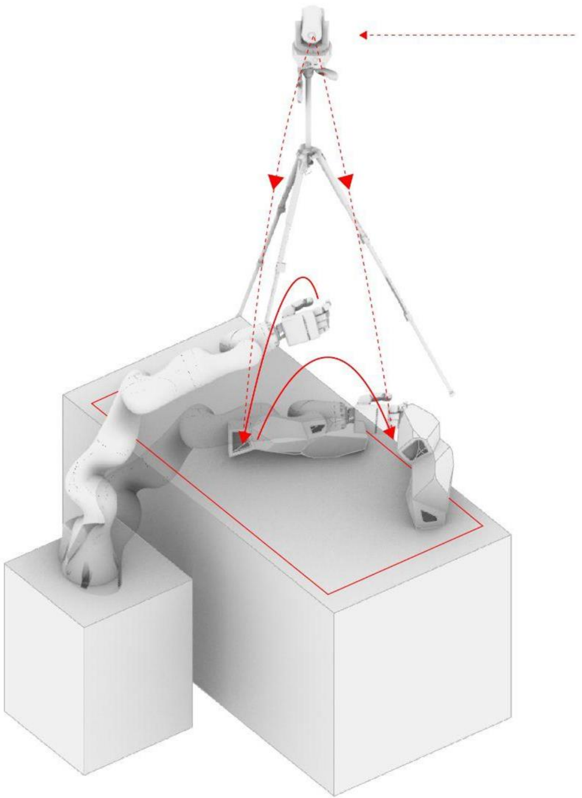

Prepare frame
Image alignment
Component isolation
Grabbing hole isolation
Grabbing vector
Repeat for each component

HRI

Relationships between robot, camera, computer and components

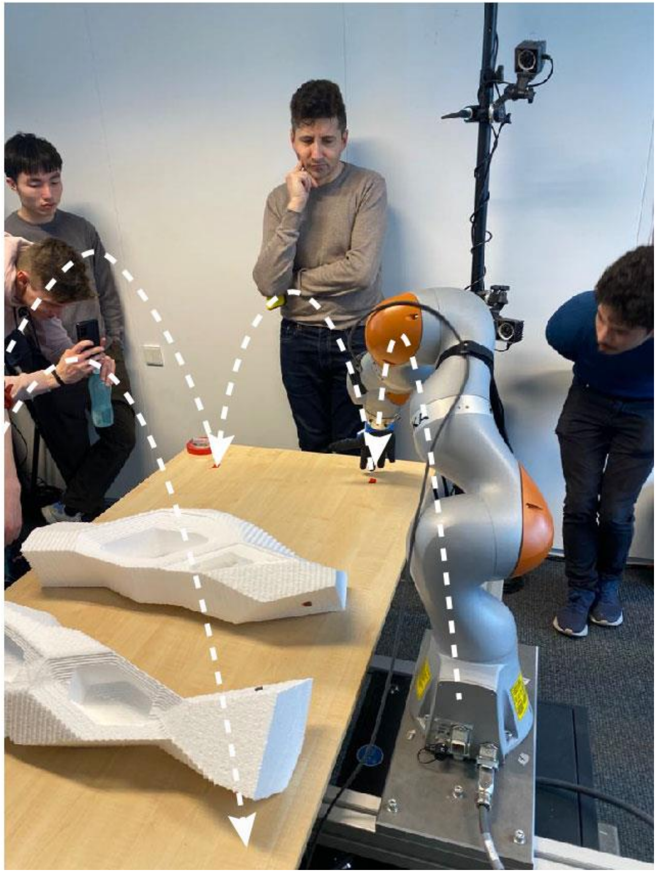


Robot to computer

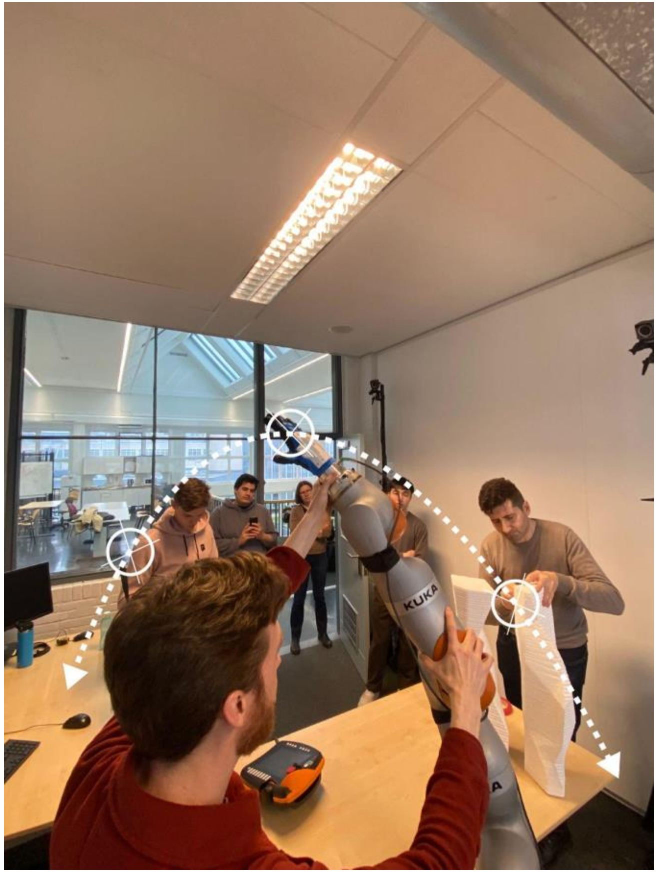


Computer to robot

1. The robot needs to know the exact location of the frame and table. This can be done by directing the robotic arm(hand) to the vertices of the frame, and marking the location of corresponding vertices in images captured by the camera in the computer.



2. For safety, the robot needs to know its moving area. We define certain mid-air node points to which the robot goes when in standby and to use when moving large distances to avoid collision. We adjust the moving speed. This way we make sure the robot operates safely and no object gets damaged.



Setting up boundary — Safe nodes — Safe movement — Height Calibration — Grabbing

3. Robot needs to know both the exact and relative position of the components to integrate them. For example, to move a cell in the right towards the cell in the left, the hand of the robot should grab the right side of the components to prevent crashing of the arm to the left cell. Moreover, the robot should slow down when it is approaching the target cell.

Setting up boundary — Safe nodes — Safe movement — Height Calibration — Grabbing

4. As in-accuracy occurs during the translation of 3D vision in camera into 2D control frame in computer, pointing the component hole in the computer does not bring the robotic arm to the exact location of the hole. The robot hand stays above the holes, and calibration of height error needs to be instructed with human collaboration.

Setting up boundary → Safe nodes → Safe movement → Height Calibration → Grabbing

5. After the robot hand reaches the hole, it needs to be instructed by humans regarding how to grab the hole, and how much force to grab and lift the component with. Then the robot lifts the component to its final destination.

Setting up boundary — Safe nodes — Safe movement — Height Calibration — Grabbing

Thank you.