Murmuration Inspired Form Finding

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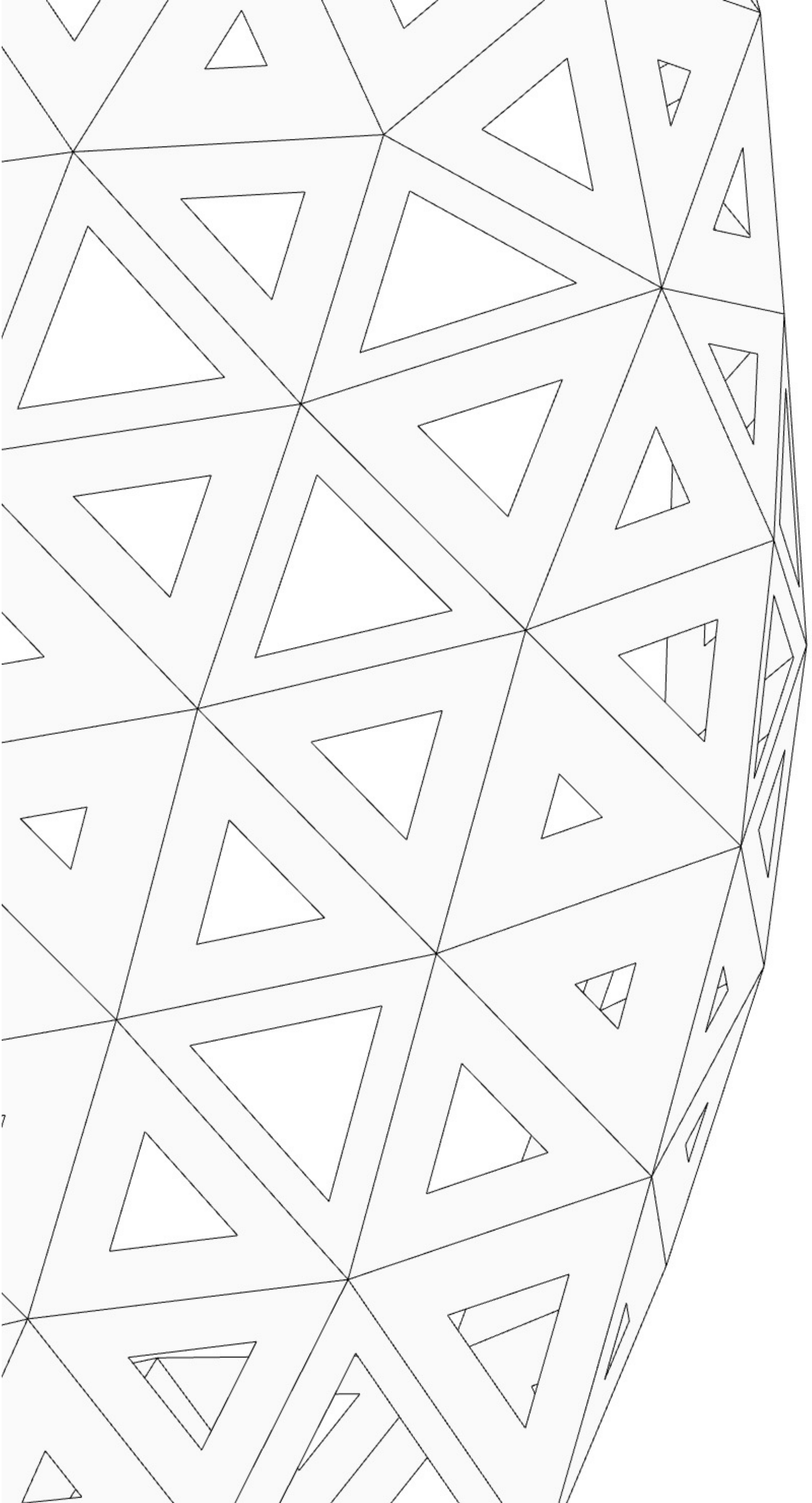
Logic to Artefact
2023



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Design Precedent

The task is a shelter design, with the chosen context of wilderness and a hide, for the observation of life in a natural environment.

This project aims to embody the context in both the design artefact and design process.

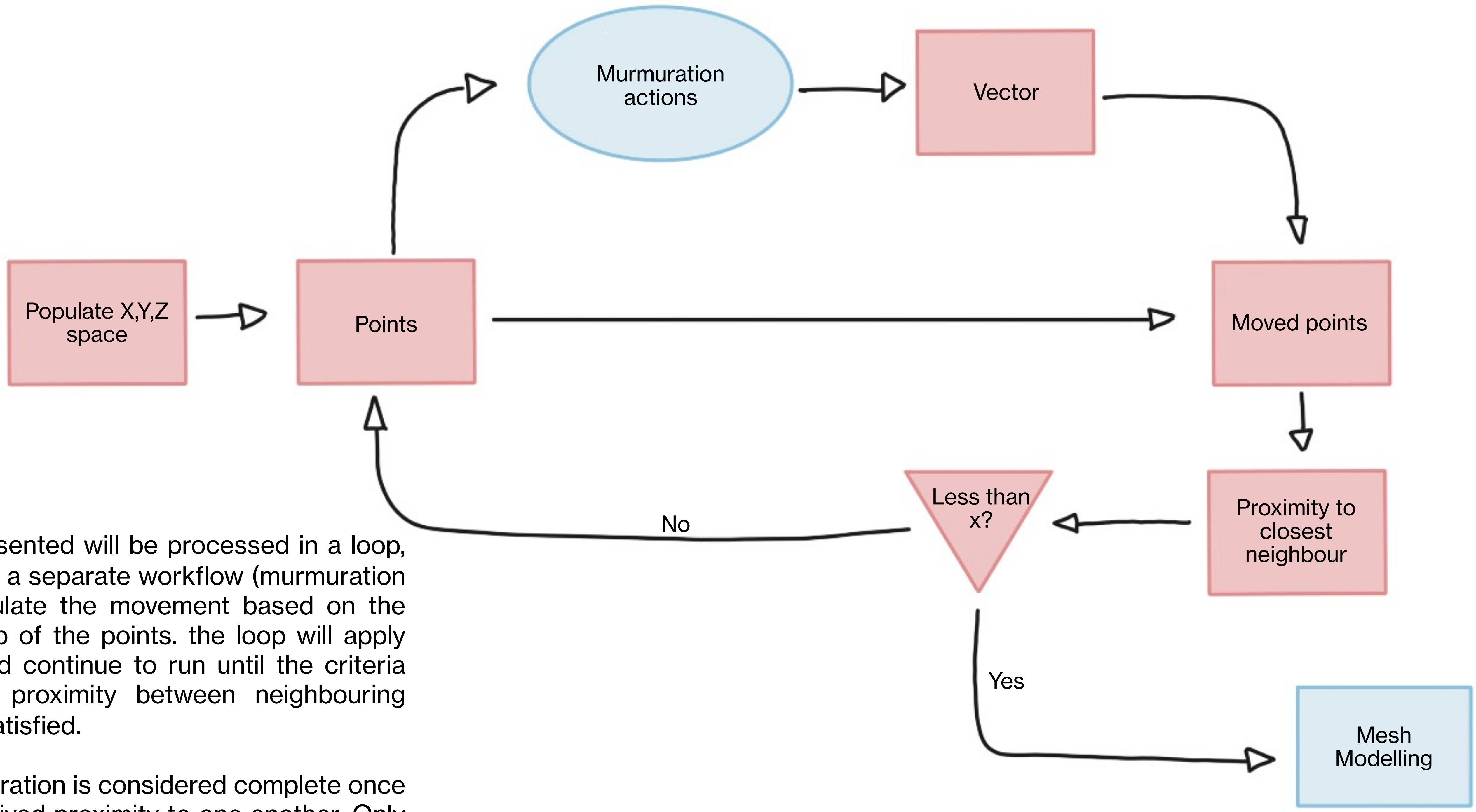
The purpose of a hide is to provide a structure which embodies the environment and disguises the user, to allow observation and connection to nature. Although the humanistic design is inherently unnatural, this design looks to learn from that which it observes, to provide a morphology better suited to the environment. Hence, reducing situational contention between object and observer and enriching the connection to nature through architectural design.

The focal point from which the form logic will be derived is that of bird murmurations and more specifically starlings.

The murmuration of starlings provides a unique look at natural form building, they exist as hundreds of self-sentient pieces which collectively congregate, developing an incidental form. This unintentional design is what makes the morphology of murmuration truly natural, and far from humanistic architectural choices. The movement and formation of the starlings can be mapped through a simplistic set of logics, which collectively can result in a unique form-finding process, embodying an architectural innocence and purity.

This project aims to abstract that, not to mimic the form but the action, to develop a workflow and artefact that bares the fruits of this natural form-finding method. Hence, producing a design of which is outwith the right-angled, methodical, symmetrical morphologies which imbue standardised shelter design.

Design Methodology

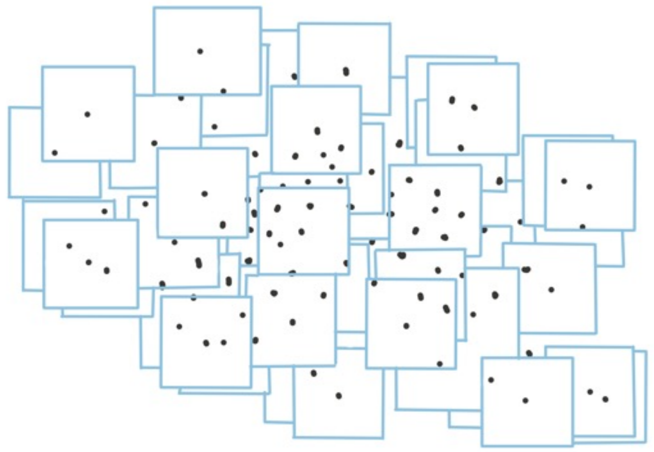


The workflow presented will be processed in a loop, for every iteration, a separate workflow (murmuration actions) will calculate the movement based on the spatial relationship of the points. the loop will apply the movement and continue to run until the criteria for the smallest proximity between neighbouring points has been satisfied.

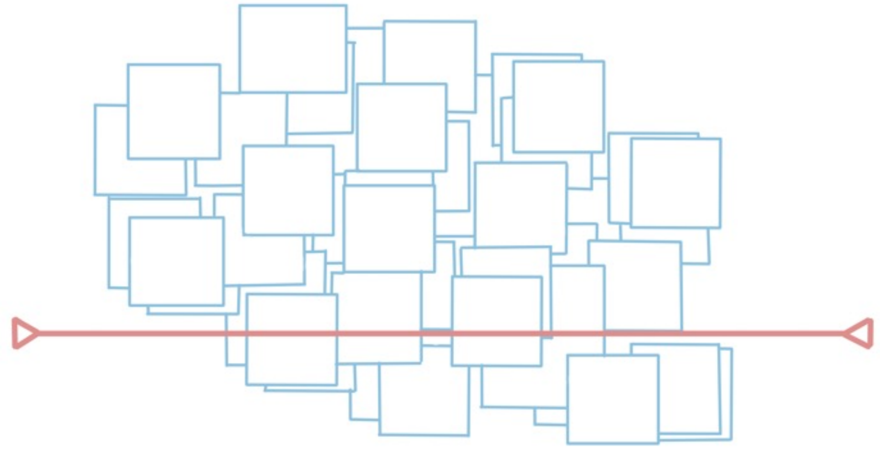
Hence, the murmuration is considered complete once all birds are in derived proximity to one another. Only at this point can the form be studied and developed as a shelter.

Mesh Modelling Process

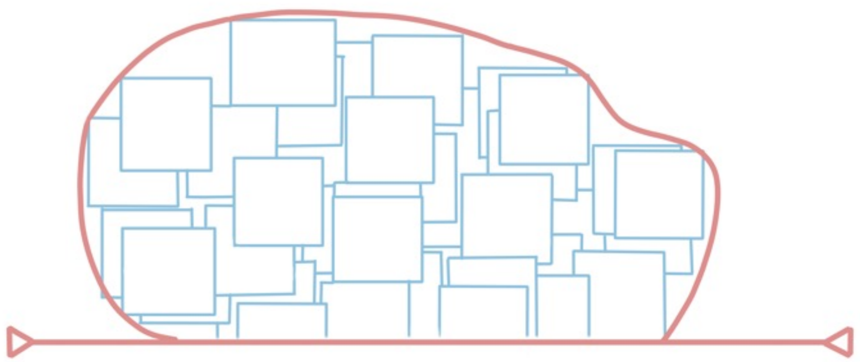
1. Point Generation



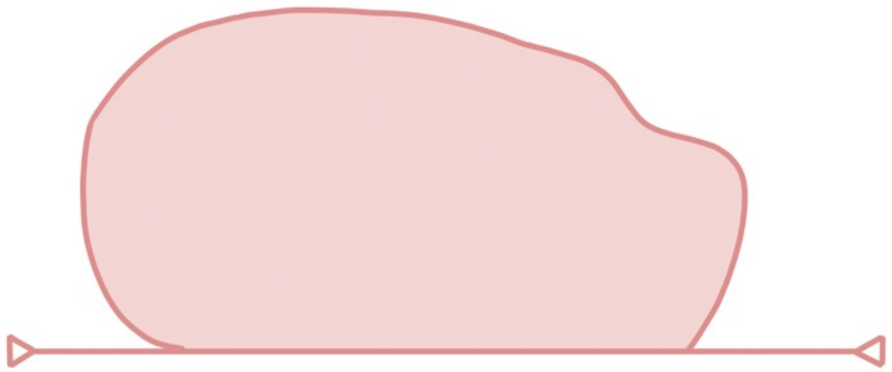
2. Void forming



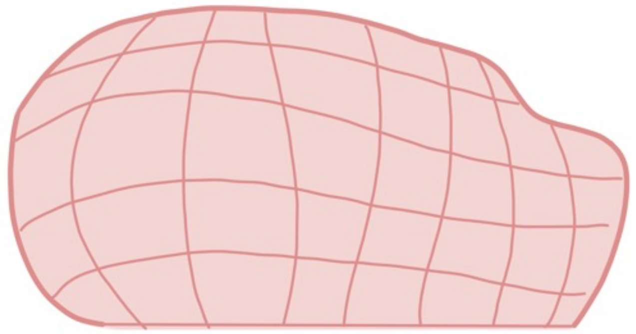
3. Levelling



4. Form Wrapping

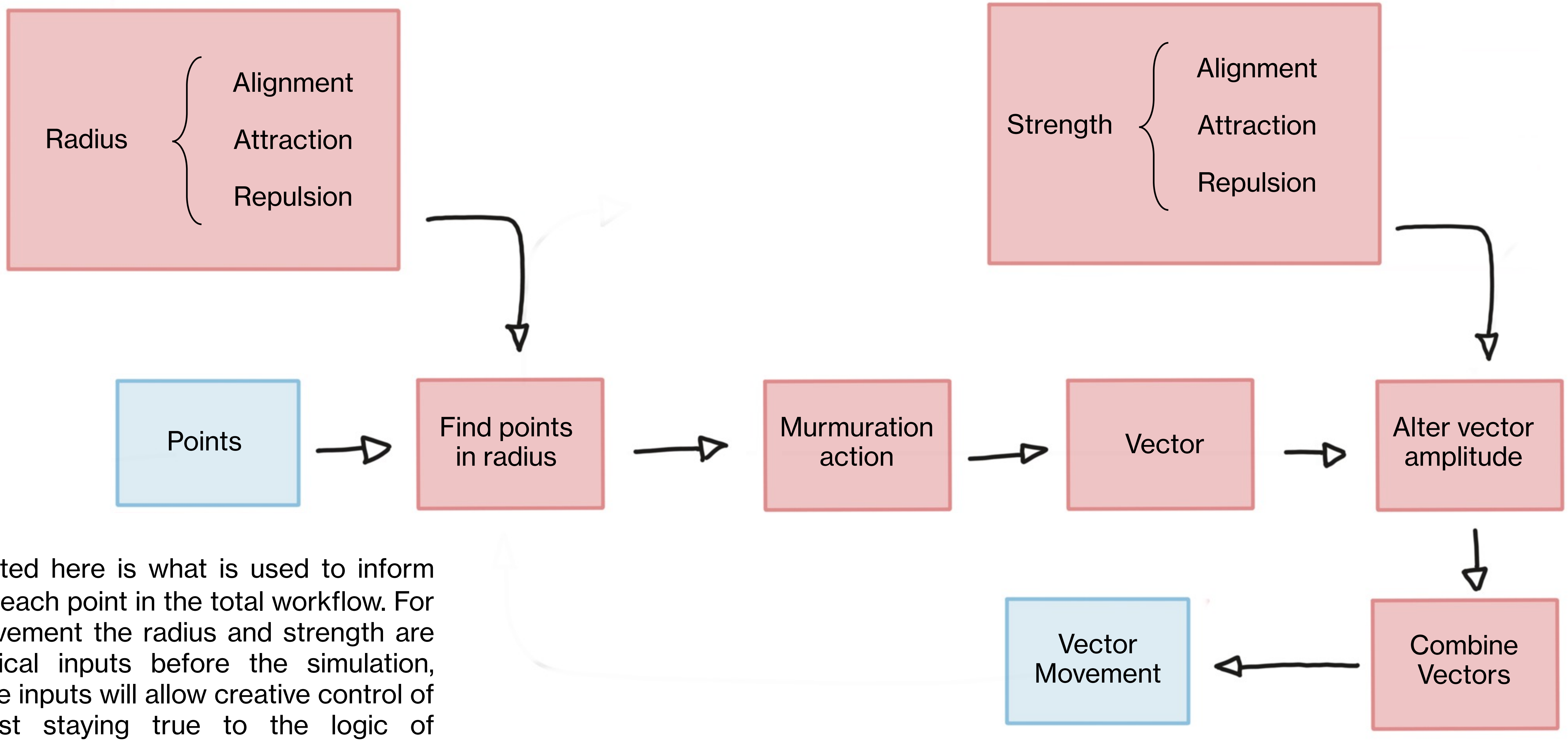


5. Mesh Wrapping



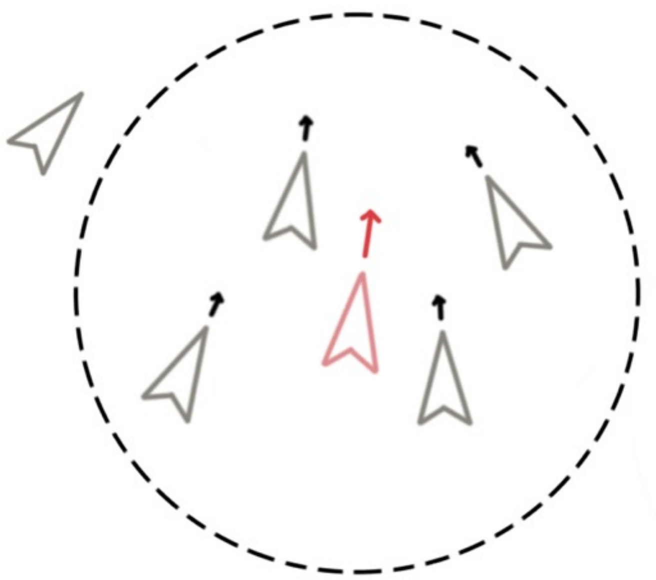
6. Mesh Pattern

Murmuration Actions



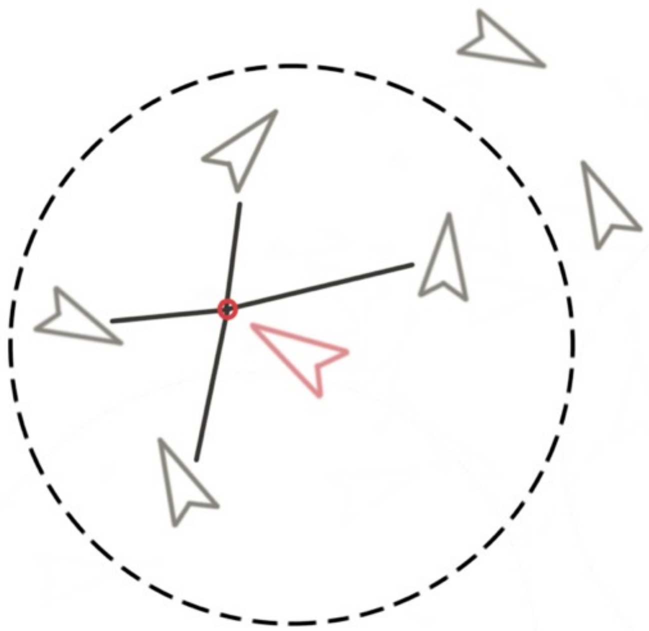
The logic presented here is what is used to inform the movement of each point in the total workflow. For each type of movement the radius and strength are taken as numerical inputs before the simulation, variations of these inputs will allow creative control of the design whilst staying true to the logic of murmurations.

A murmuration can be broken down into 3 main movements as shown, alignment, attraction and, repulsion.



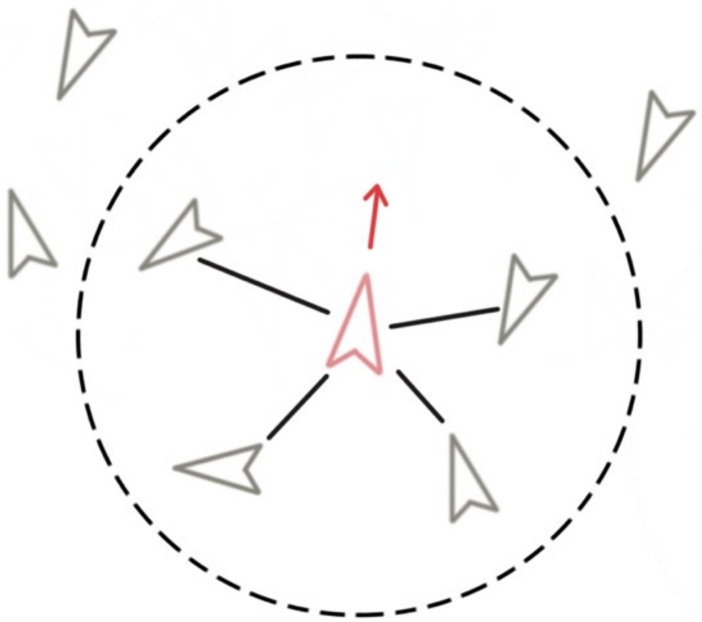
Alignment

The alignment force is a calculated perception of the direction of one bird's peers. In the simulation, this is achieved by receiving the movement vectors of points in proximity and applying an average of this movement to the observer point.



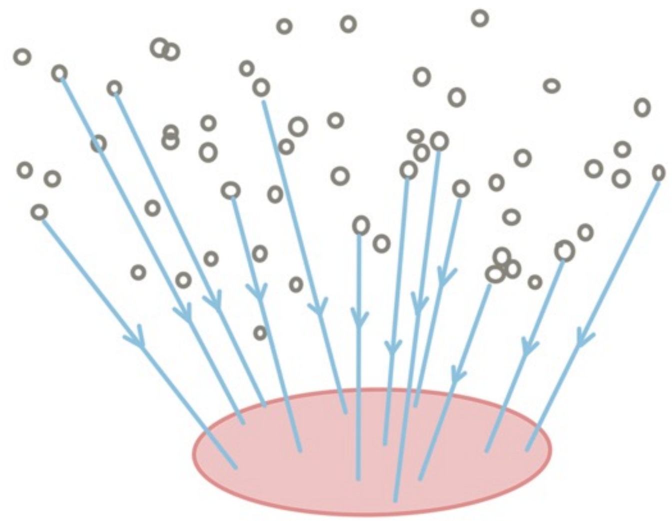
Attraction

As murmurations are assumed to be used as a form of protection for birds, each individual is actively trying to reach the middle, i.e the safest part. Observing the neighbouring points a centre point can be calculated and the bird(point) will move toward that location.



Repulsion

Although seeking the centre of the murmuration, each bird will repulse itself from birds that are too close to avoid a collision. This is simulated by calculating the inverse of the average vector of incoming birds.



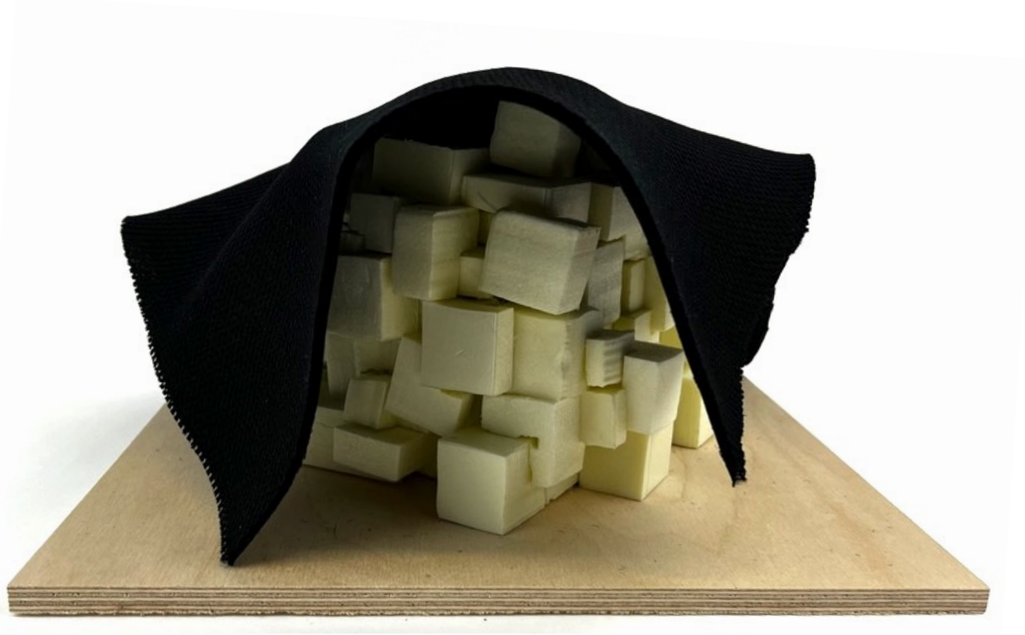
Form Seeking

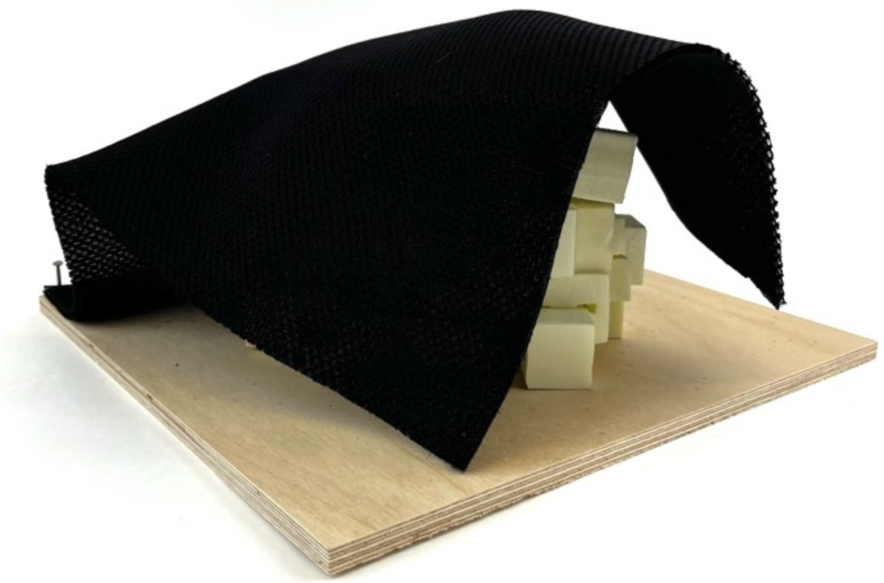
Form seeking isn’t inherent to the studied logic of murmuration, but the observation of movement and form can be shown to be influenced by both positive and negative elements exterior to the flock. This simulation will look to add some of these elements for design intervention.

The first stage of this design process was an experiment with physical form, considering how the herding of a repeated and simplistic geometry could develop a structure which represented a shelter. Due to its stackable and connectable shape, this sketch model uses cubes as an abstraction of birds in the murmuration.

The model demonstrates how the collective objects can be used to develop a void representative mass, which presents space and configuration for the shelter.

The seemingly ‘random’ approach to additive blocks allowed free experimentation with the relationship between the void and the surface wrap.





Simulation Modelling

Programming the ‘zero’ state of a murmuration involves a level of interpretation. There are no rules for the number of birds or density or swarm that defines it a murmuration, it is there for purely up to interpretation at what point the zero state occurs. Following this, the current simulation uses the logic that if at least one bird is being influenced by another then it is a murmuration.

This design seeks a state where all monitored points have joined a collective murmuration, simulating the intermediate state through attraction, alignment and repulsion. This is defined as the point in which all points are within a given proximity of their closest neighbour.

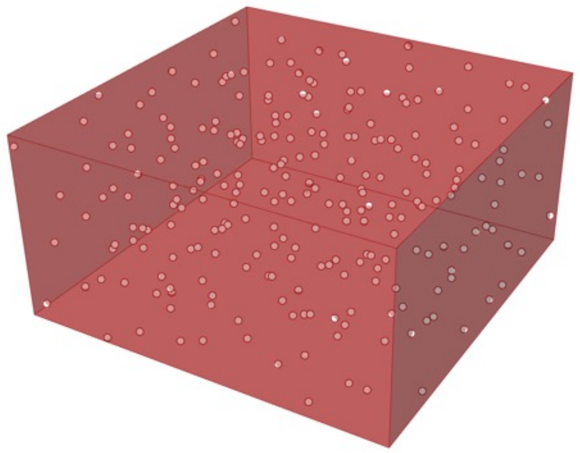
Stochastic search vs random placement

The simulation model provides two ‘zero’ state setups, one [1] being a random population of points in a controlled 3D design space. The second [2], is a stochastic search, which uses the same design space and places the points again using a random value generation. Whilst ensuring no newly placed point encroaches on the desired proximity of the murmuration and hence provides a ‘true’ zero state in which no bird is connected in a murmuration.

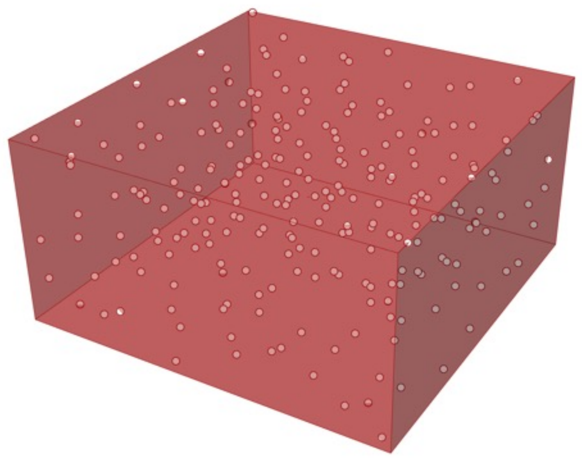
This simulation uses a design space of 5000x5000x3000, with a population of 500 birds. the design space is used for the initial generation of zero states and doesn’t confine the movement of points.

Once all points [birds] have joined the murmuration form the simulation enters the breaking point in which the loop ends and the resultant location of each point are collected.

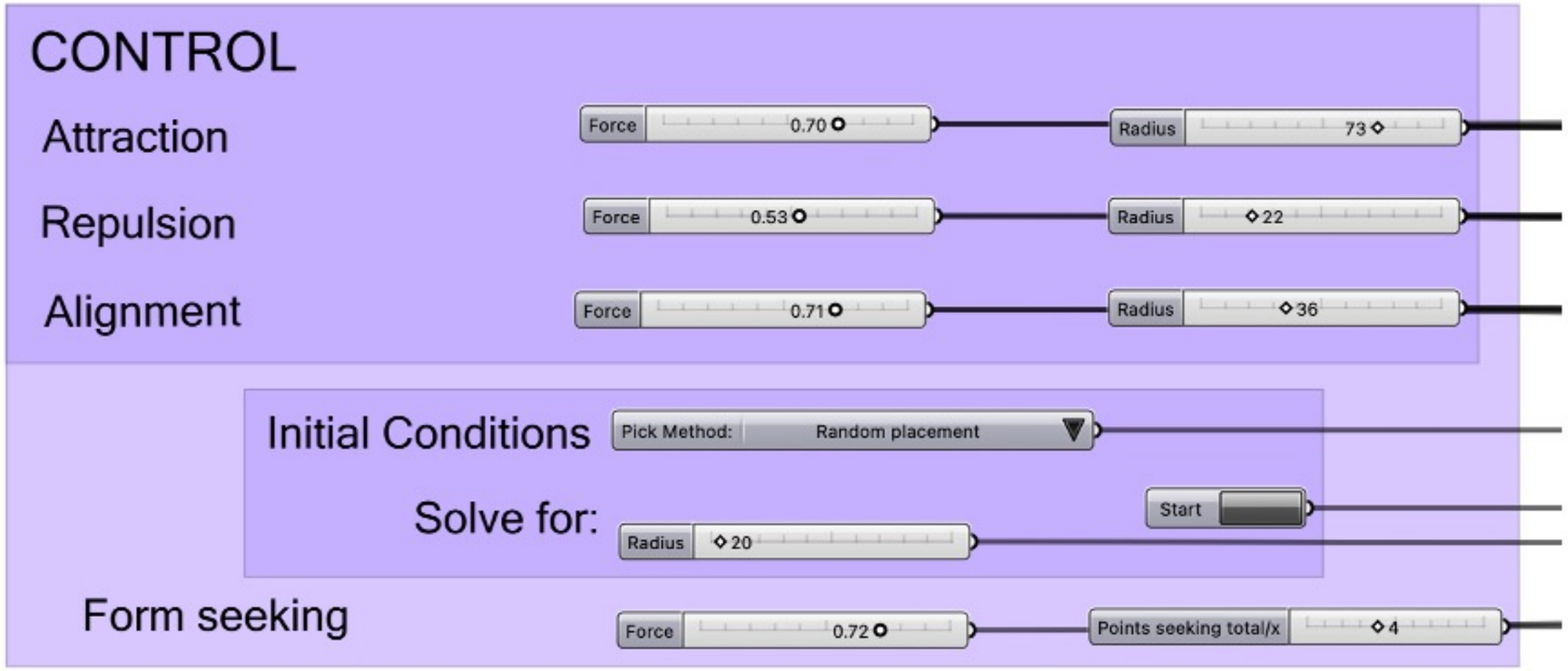
[1]

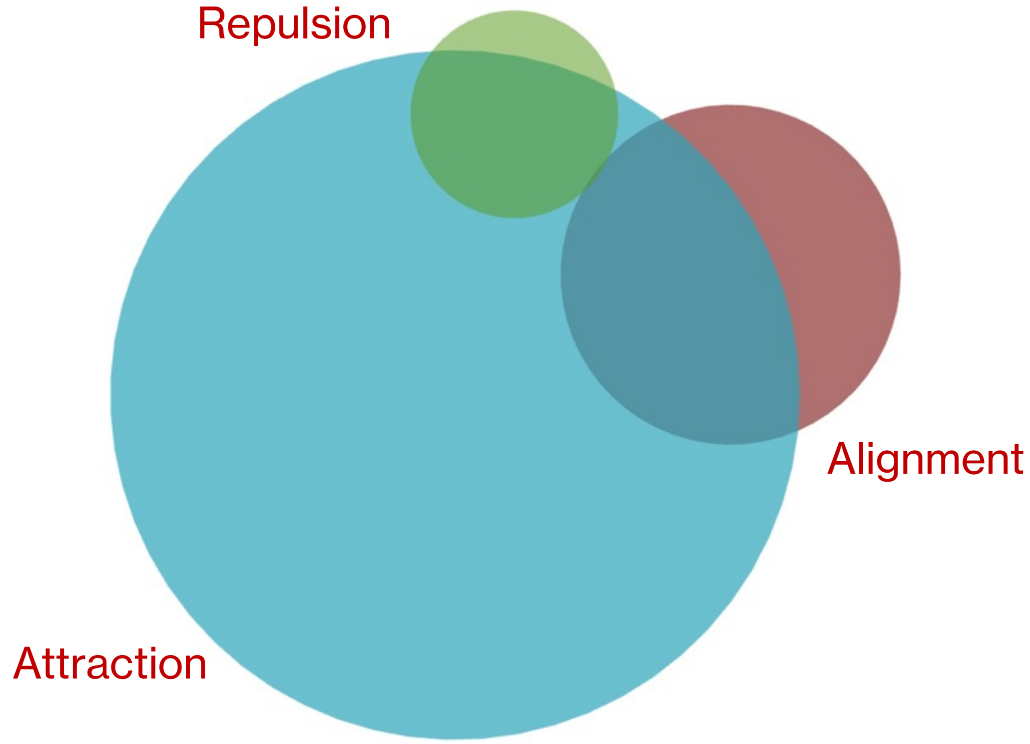


[2]



```python
import rhinoscriptsyntax as rs
import random

its = itterations
ext = extent
prox = proximity

x = random.randint(0,ext)   # assign random x in range {0,100}
y = random.randint(0,ext)   # assign random y in range {0,100}
z = random.randint(5,ext/2)

point0 = rs.CreatePoint(x,y,z)
points = []
points.append(point0)

for i in range(0,its-1):

    placed = 0

    while placed == 0:

        x = random.randint(0,ext)   # assign random x in range {0,500}
        y = random.randint(0,ext)   # assign random y in range {0,500}
        z = random.randint(0,ext/2)    # assign random z in range {5,250}
        pointNew = rs.CreatePoint(x,y,z)    #pointNew = (x,y,z) constructor

        "check if cube over laps another"

        overlap = 0 #no overlap

        for point in points:

            "if pointNew is in proximity of point: "

            vecCreate = rs.VectorCreate(point, pointNew)    #vector(point - pointNew)
            vecLength = rs.VectorLength(vecCreate)

            if vecLength < prox:   #if vectorNew > proximity
                overlap = 1 #overlap found

        if overlap == 0:
            placed = 1
            points.append(pointNew)

newPoints = points
```

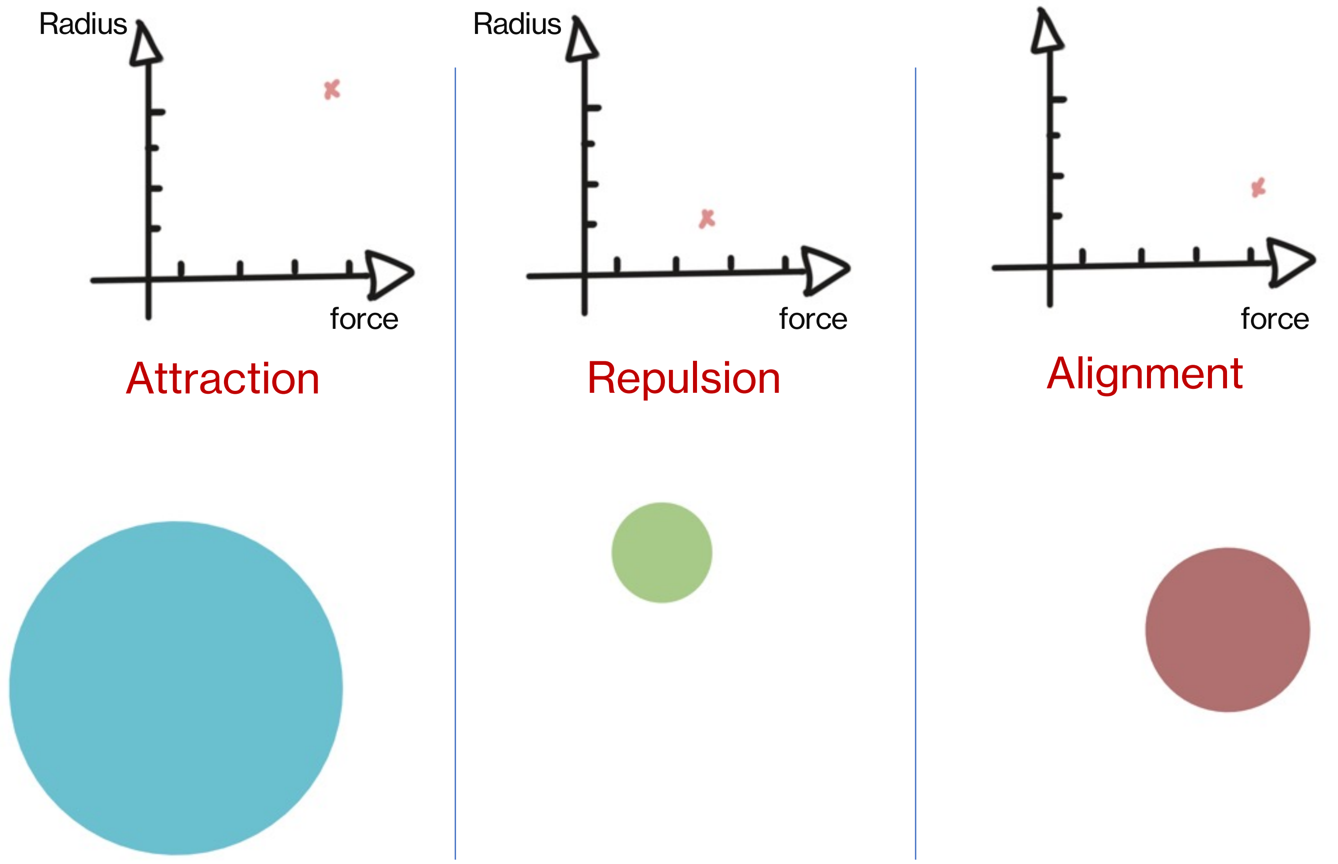




Control panel

The simulation defines the movement of each point in the murmuration by generating an attraction, repulsion and alignment vector. These are all parametrised by the two control sliders, force and radius. The radius defines the proximity field in which surrounding points are selected in movement calculations. The force slider is used as a weighting, each vector will be unitised and multiplied by the force factor, hence altering the strength of each action in the total movement.

Through the iterations the input parameters are presented as a series of circles, the radius of the circle translates to the radii of attraction, repulsion and alignment point proximities. The transparency of the circles represents the strength of the force.

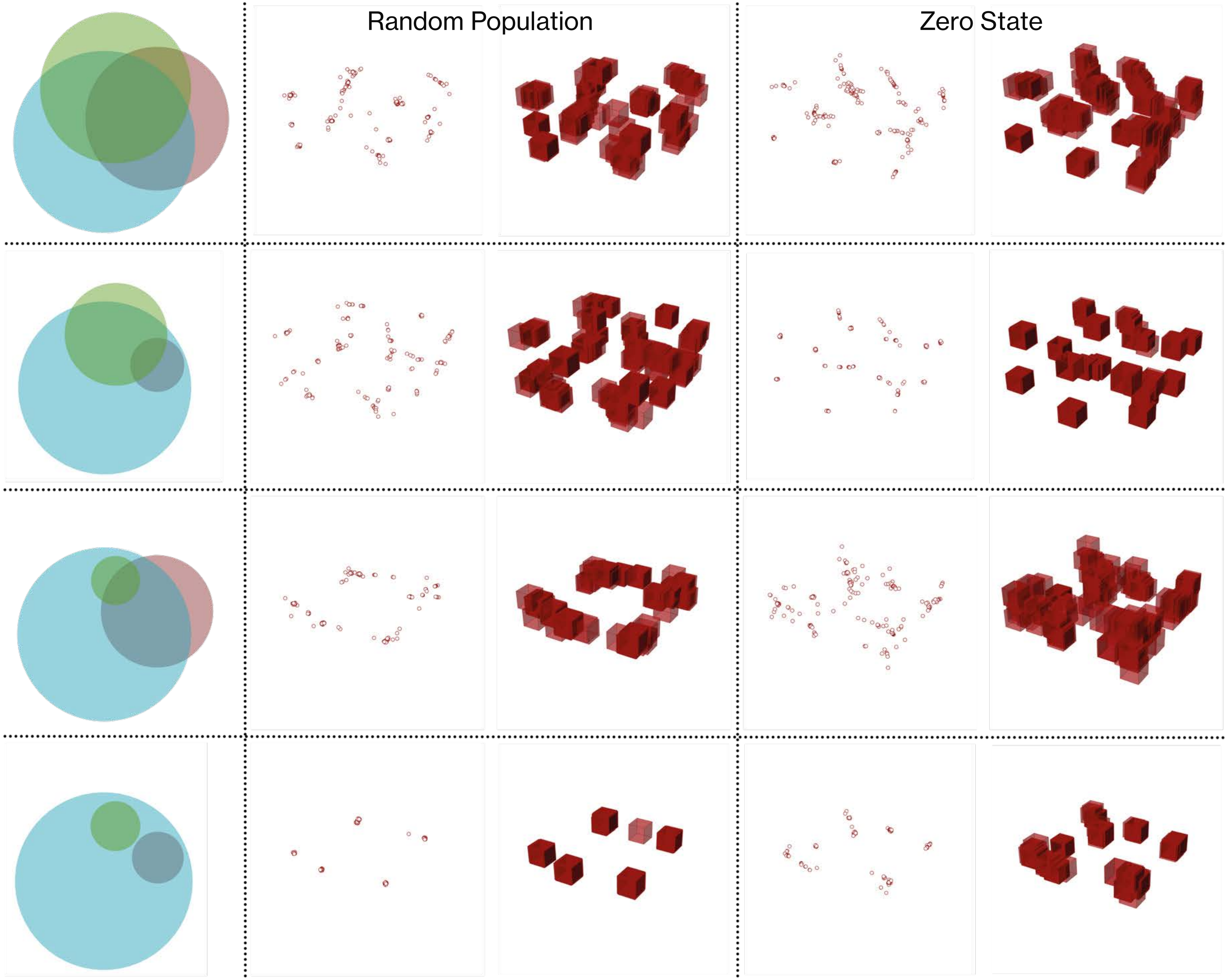


Iteration 3-6

These first iterations experiment with the varying permutations of radii of alignment and repulsion proximities.

It is clear that a reduction in these radii result in an lack of dispersion through the form, this is to be expected with such a dominance of attraction force.

These initial tests also show a true variation in the random population vs zero set up. Having a zero state helps prevent tightly overlapping blocks.

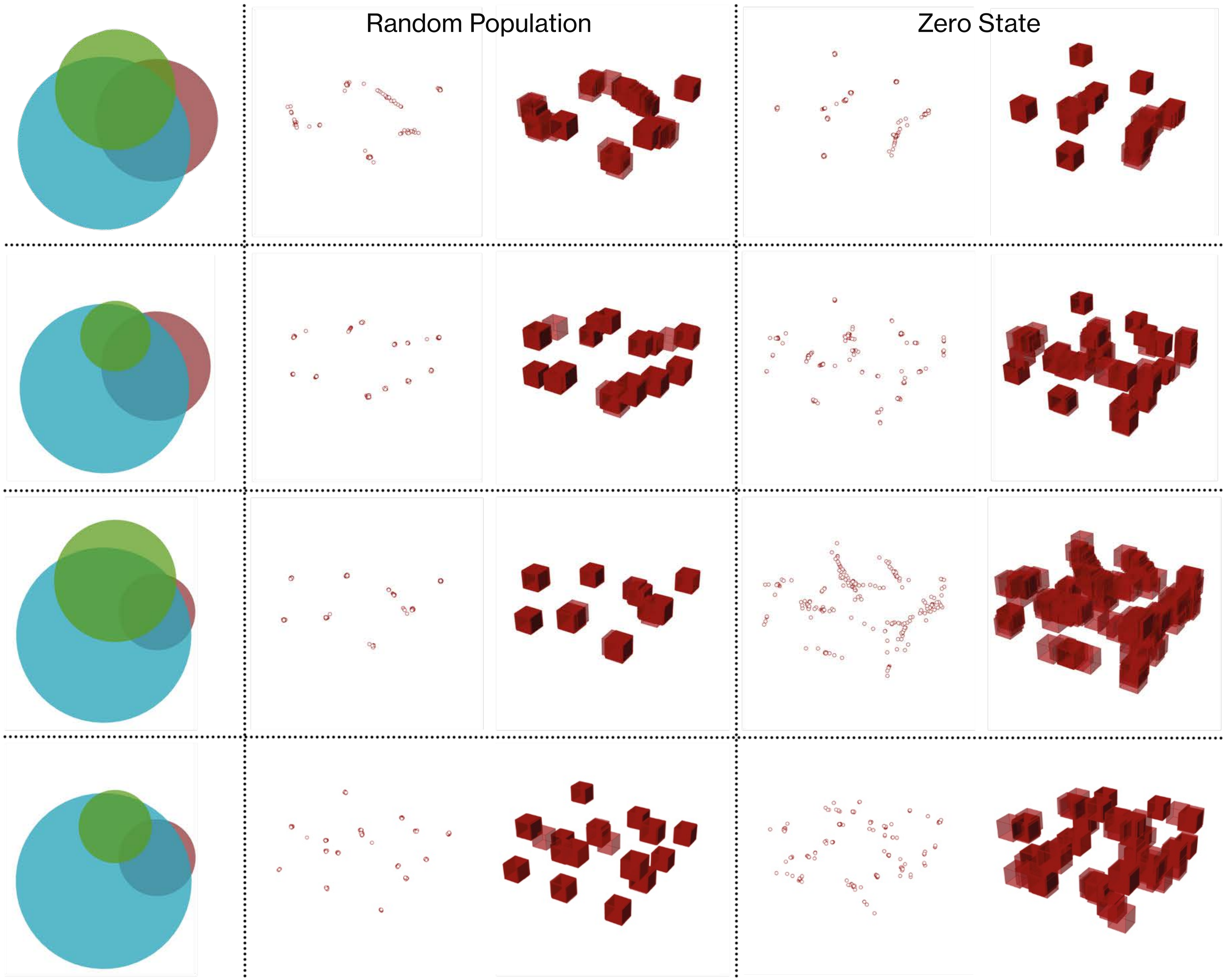


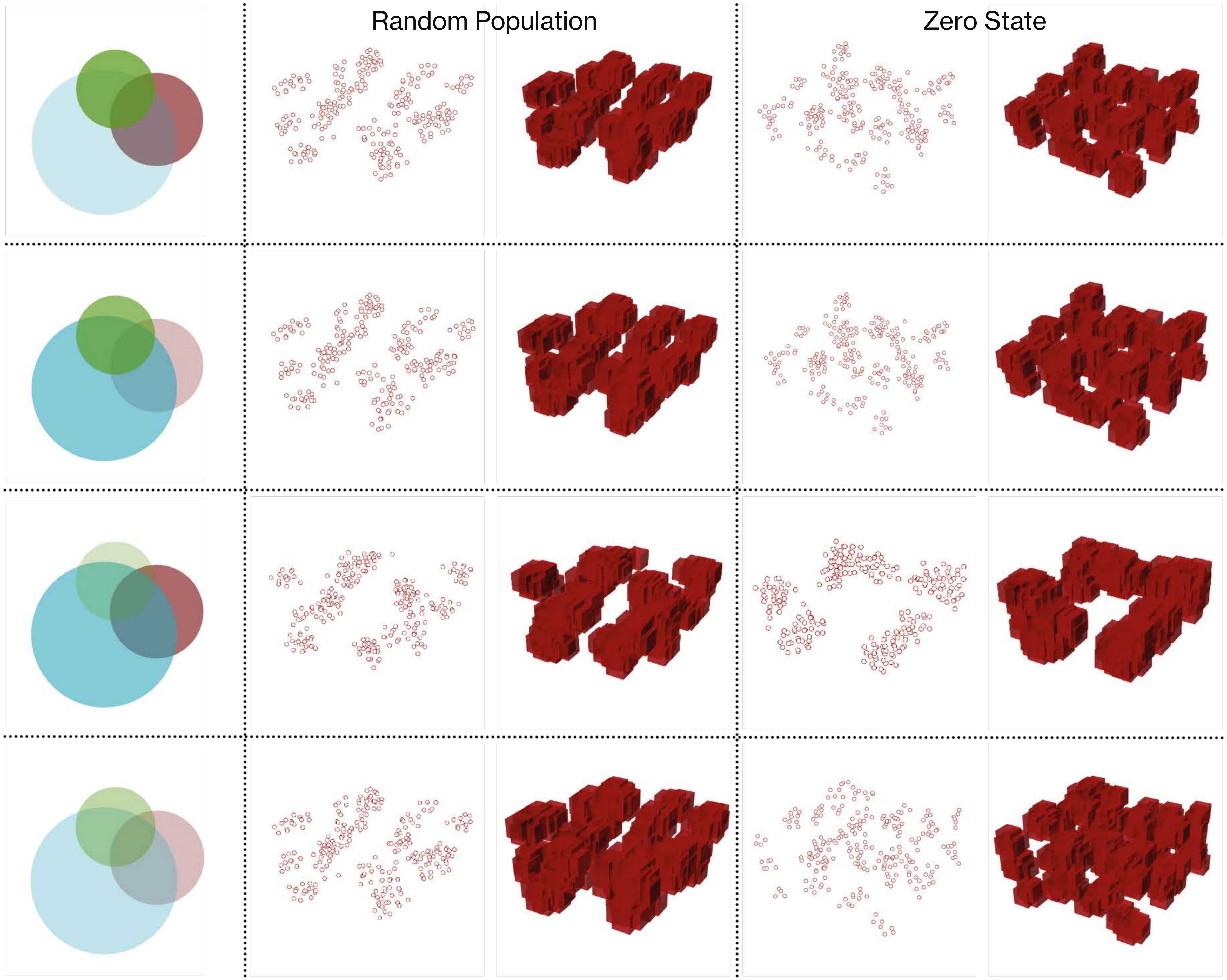
Iteration 7-10

Similar to the last test these iterations vary the size of the repulsion and alignment proximity radii.

Here a greater strength of vectors are used which are shown to have a more desirable effect on the flock formation .

Again, zero state set up is shown to have the greater influence for dispersion of blocks .





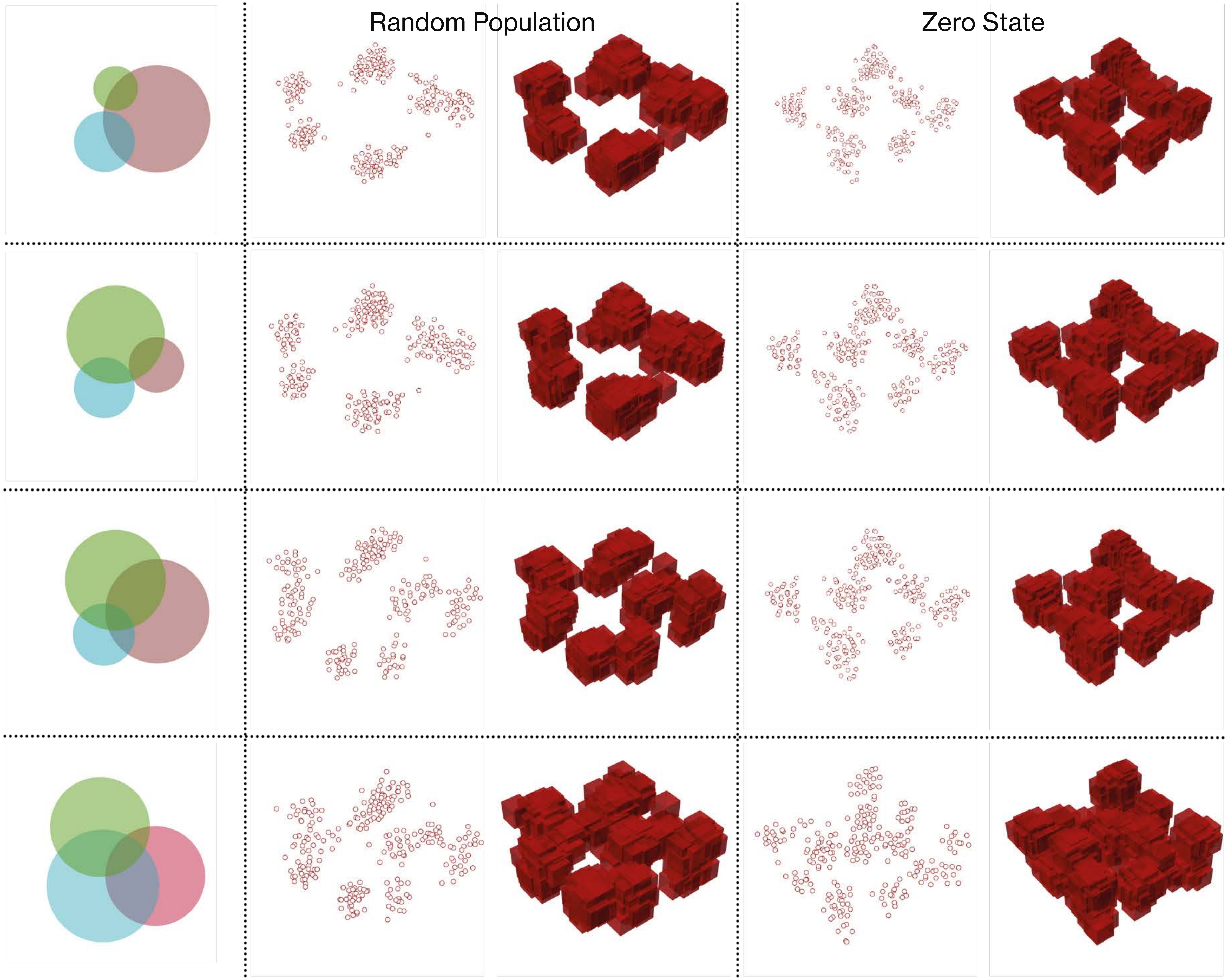
Iteration 11-14

Tested here is variations of strengths when applied at continual radii. Small variation is found between the itterations, but it is shown that compared to previous test a reduction in strength provides more desirable results. Seen in the form of more complex formations

Iteration 14-18

Building on the satisfactory strength values, these iterations keep a constant strength of 50% and play with the extremes for radii scaling.

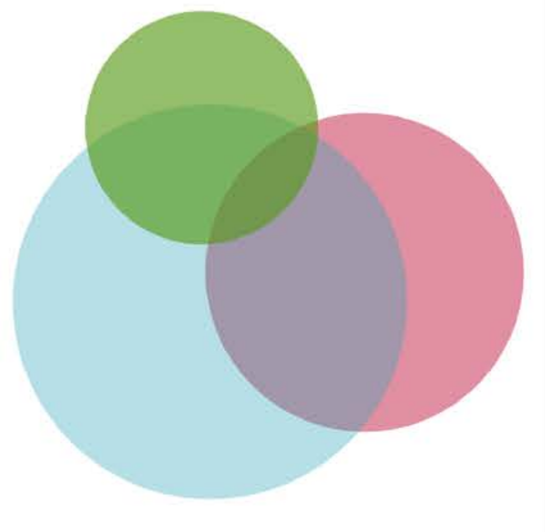
The results of these confirm a lack of a dominant attraction radii results in separation of the form into several murmuration's. It also concludes that the greatest results appeared at a harmonious scale of equal size and intensity.

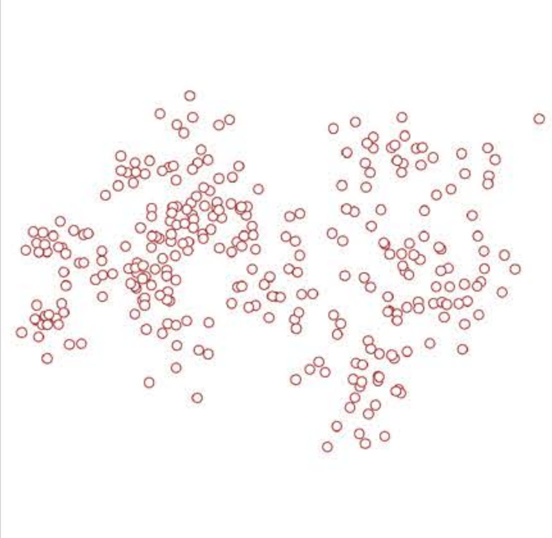


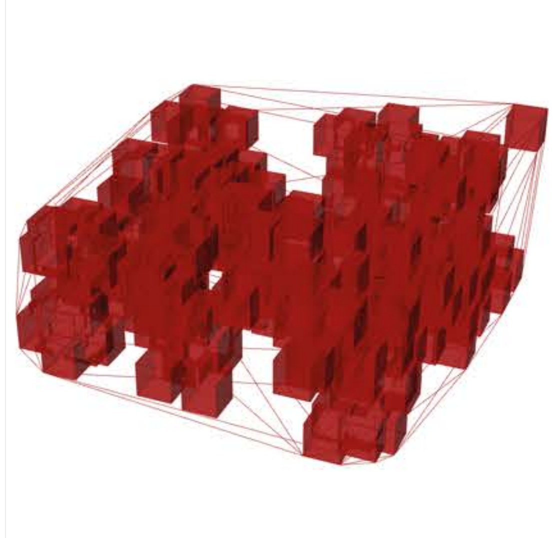
Design Selection

The final form was chosen based on design iteration preference and also the accuracy of the parameters to actual bird movements, the inherent logic that a dominant attraction force must drive the movement of the murmuration is used as well selection of the harmonious strengths as it was found to process a greater flow and more movement variation than the more intense vector movements

The final form made use of the ‘zero state’ set up, as it was shown to produce preferential results at all stages of iteration.



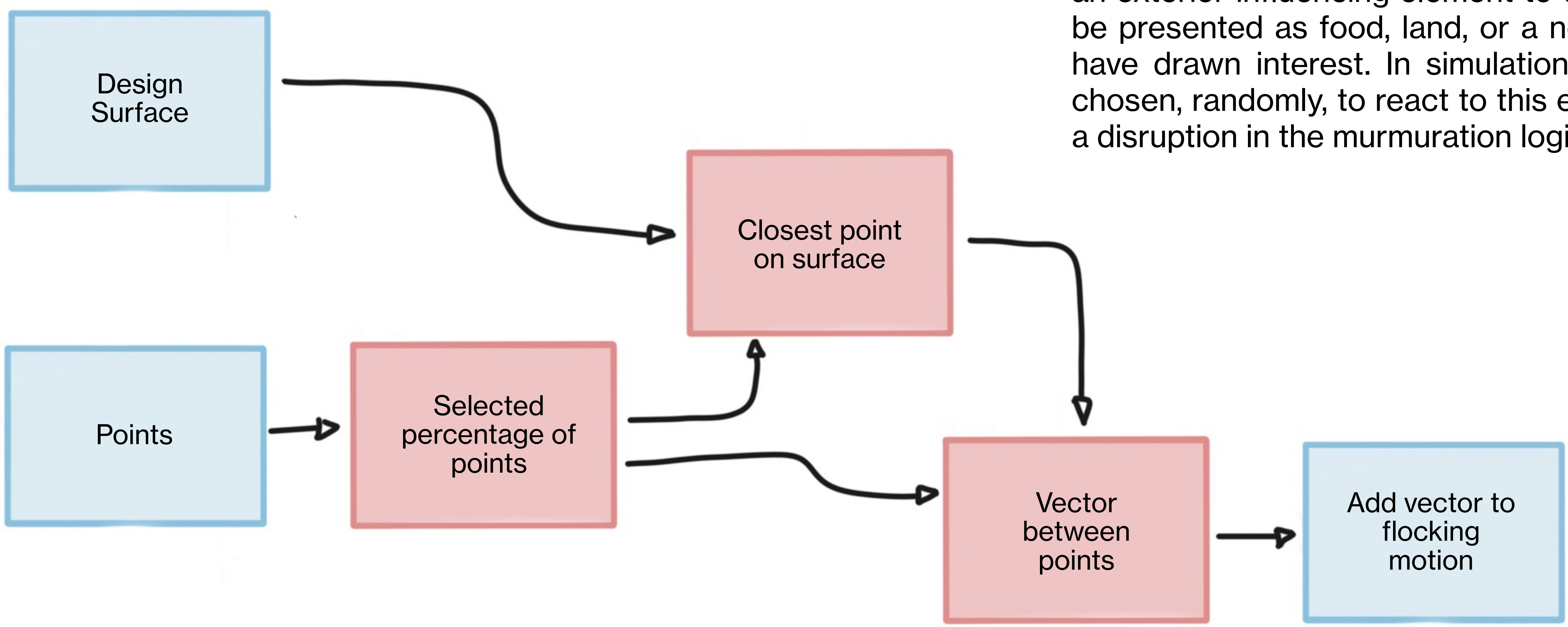


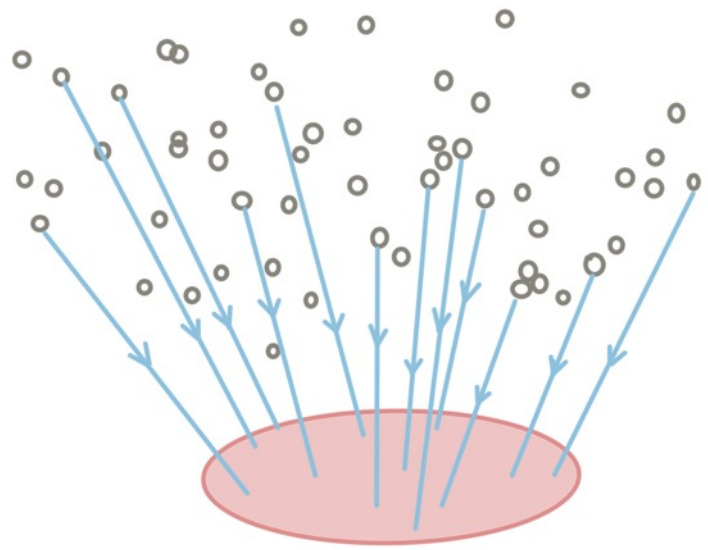


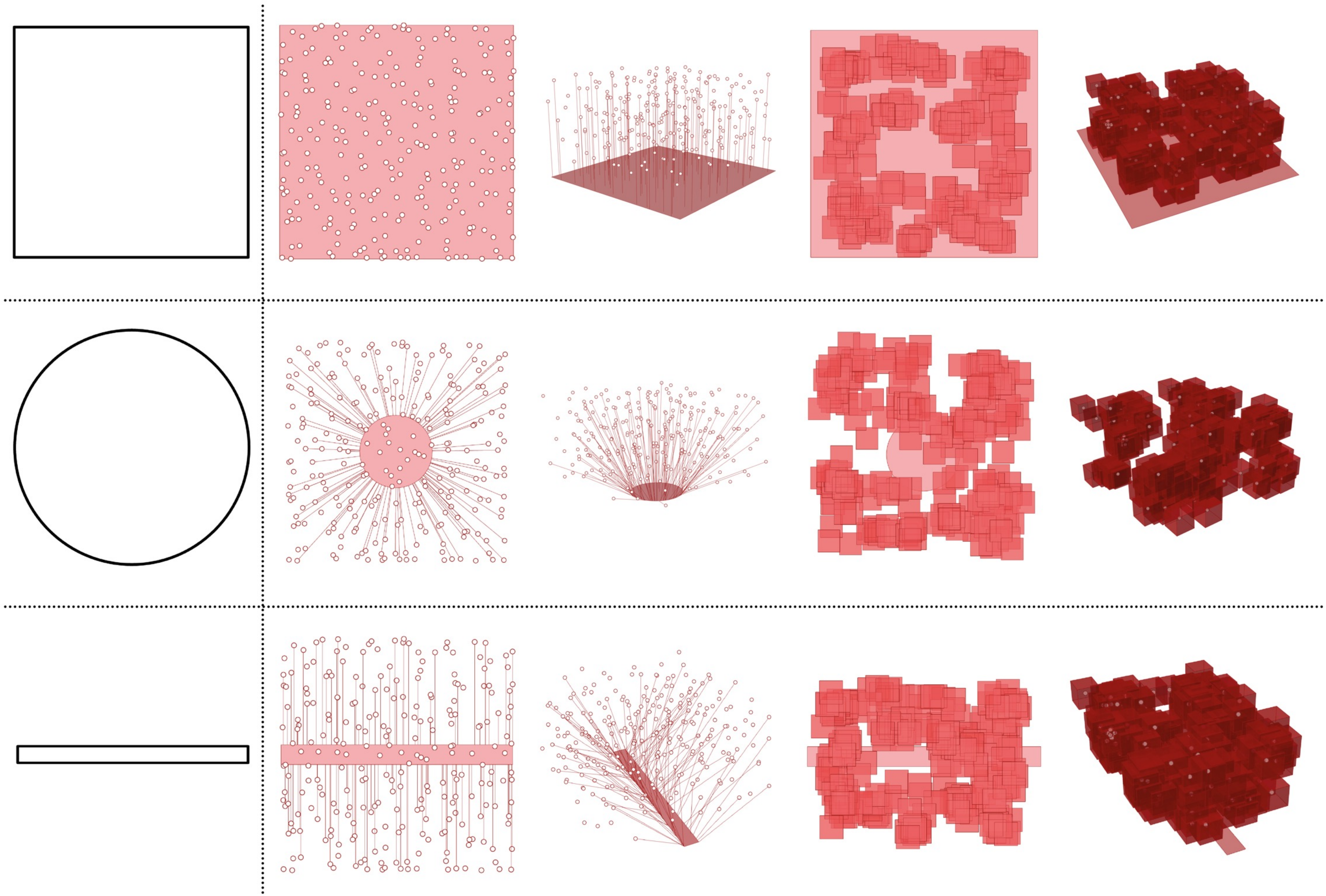
A mock test of form finding was modelled on the preliminary results as shown, creating the first look at the relationship between the movements and the shelters formwork.

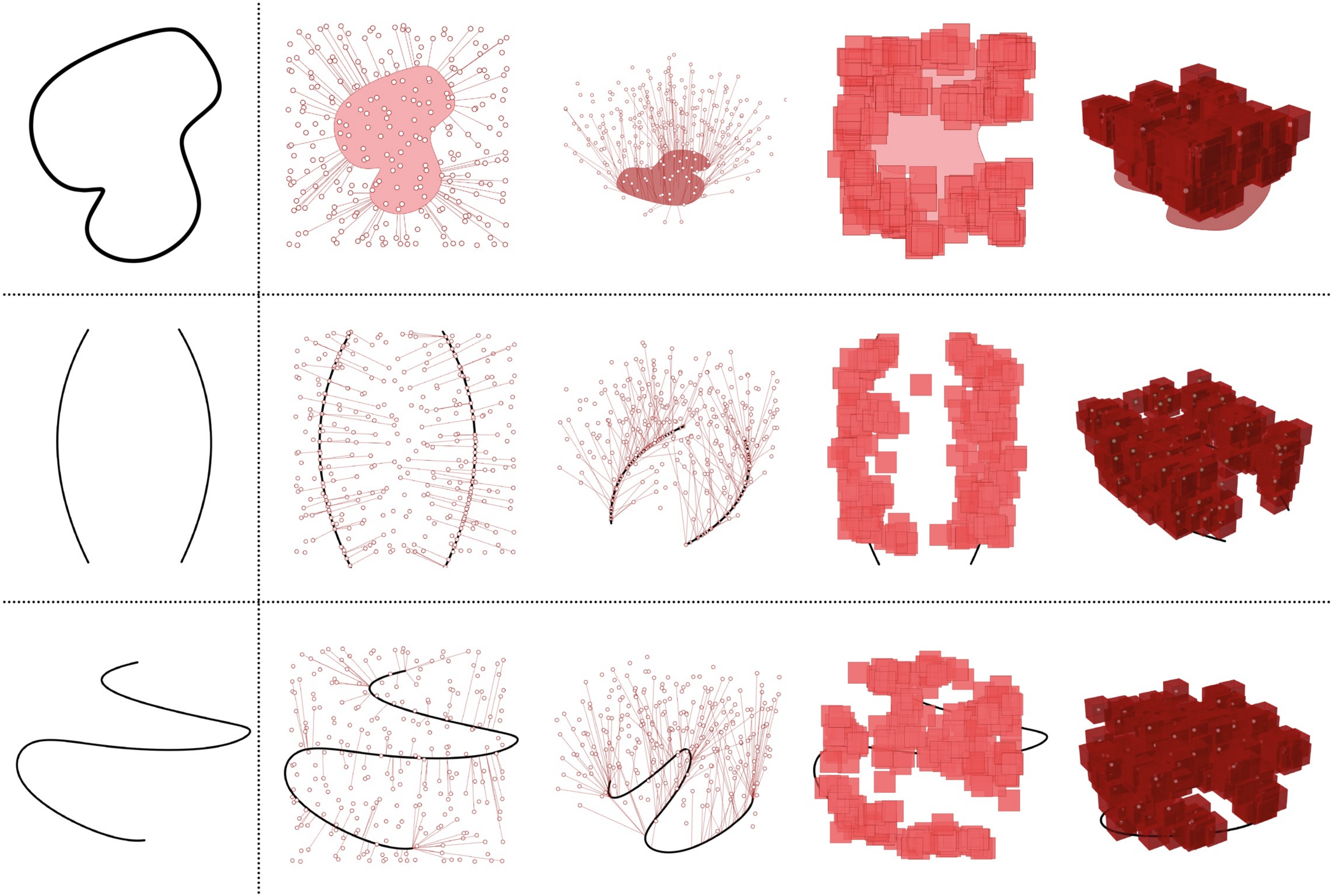
Form Finding, Design Intervention

The next stage of design intervention and exploration is the adoption of an exterior influencing element to the murmuration. In nature, this could be presented as food, land, or a nest to which the birds or some birds have drawn interest. In simulation terms, some number of points are chosen, randomly, to react to this element, seeking it and there creating a disruption in the murmuration logic of low.



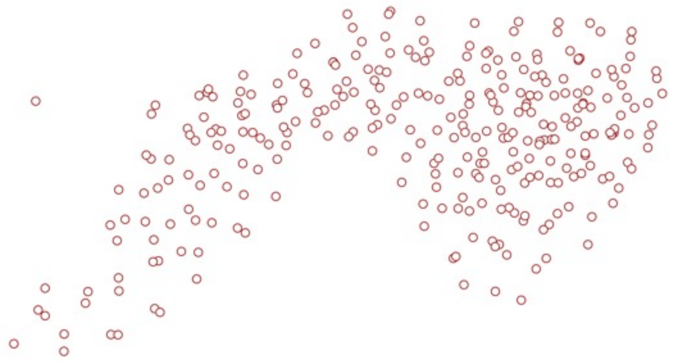




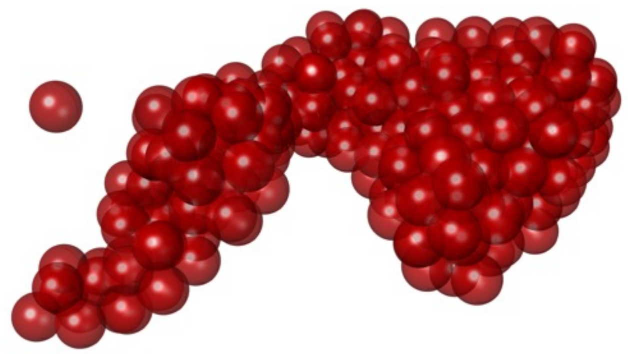


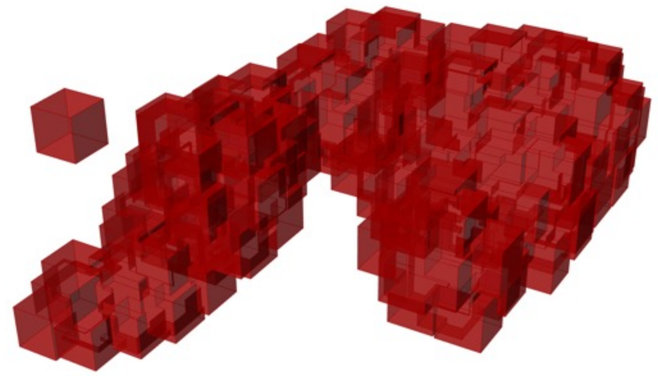
Settled Upon Results

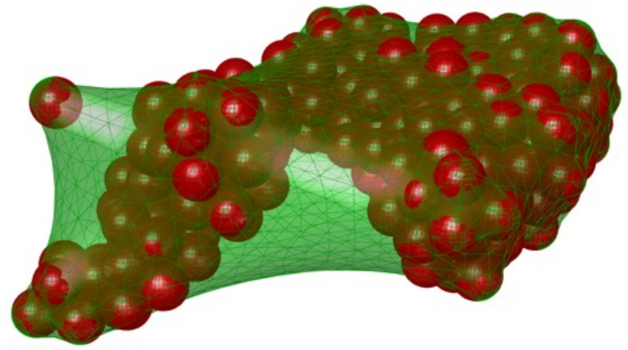
The final settled-upon iteration was the chosen point cloud above, this was chosen for a number of reasons found through testing but ultimately it is a preferential design outcome. It was found to be accurate to the expectations of murmuration form whilst embodying properties for the formation of a shelter.

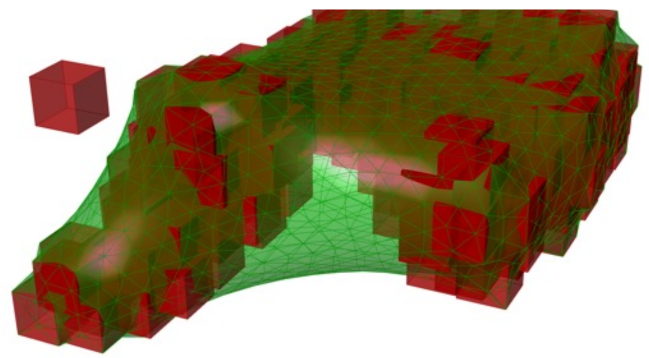


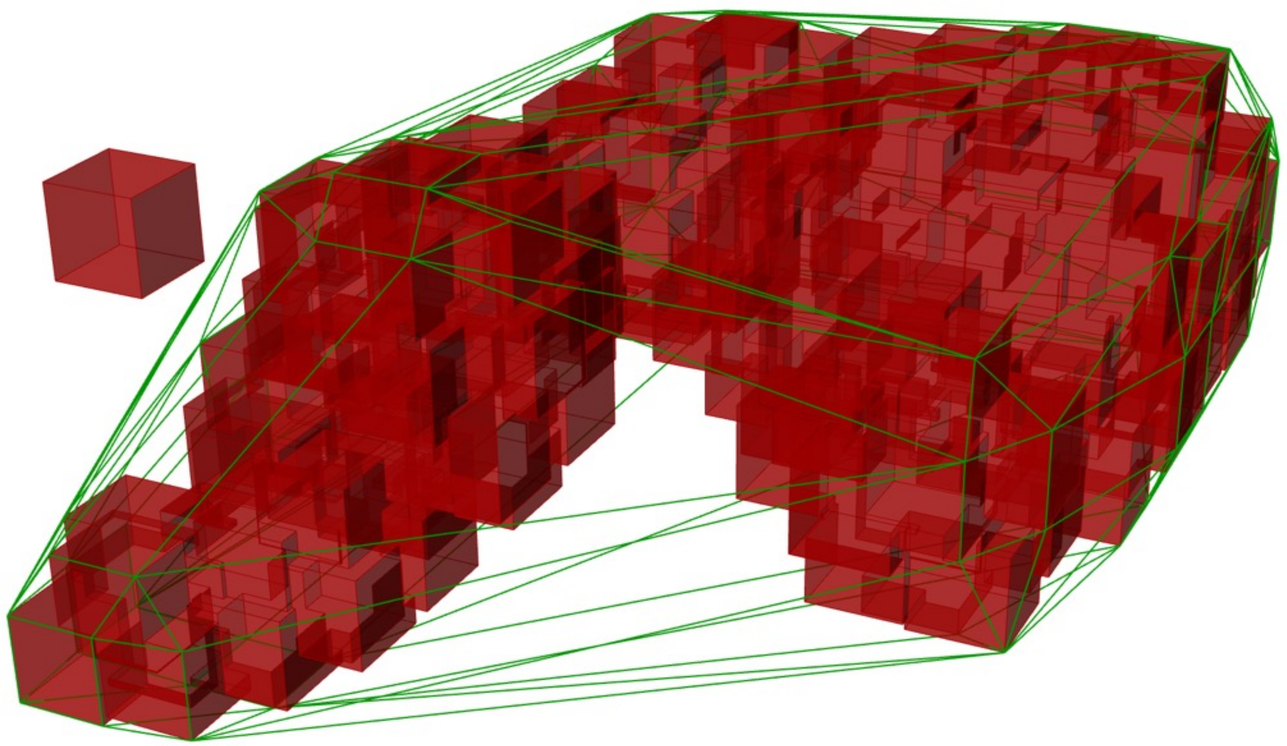
Testing both spheres and cubes for void mass forming. Spheres had an initially more pleasing form but the use of cubes was found to produce fewer issues in mesh forming. And also stayed true to the concept modelling and work flow of the project.

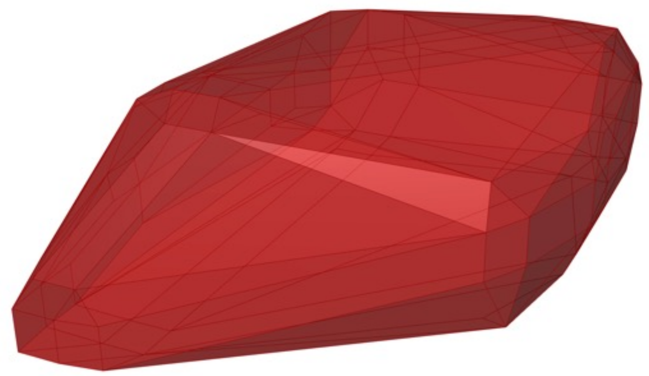




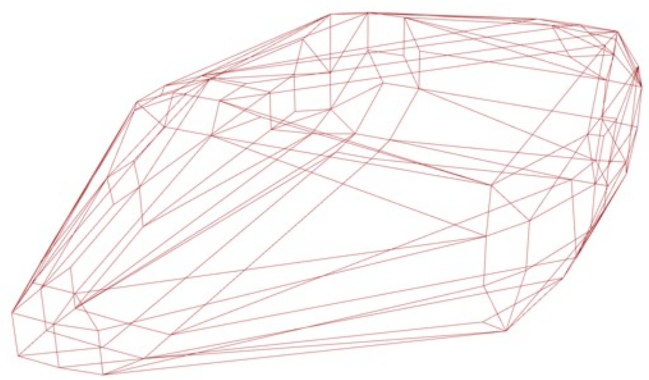


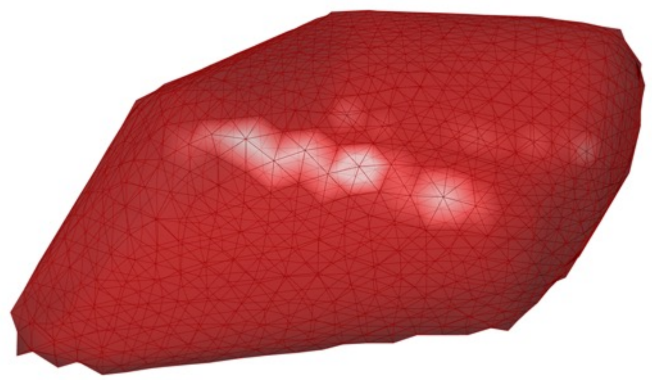


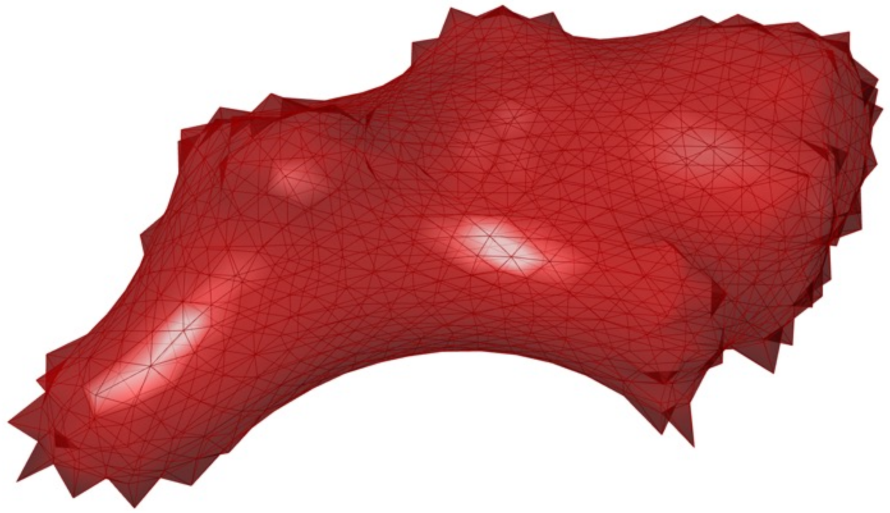




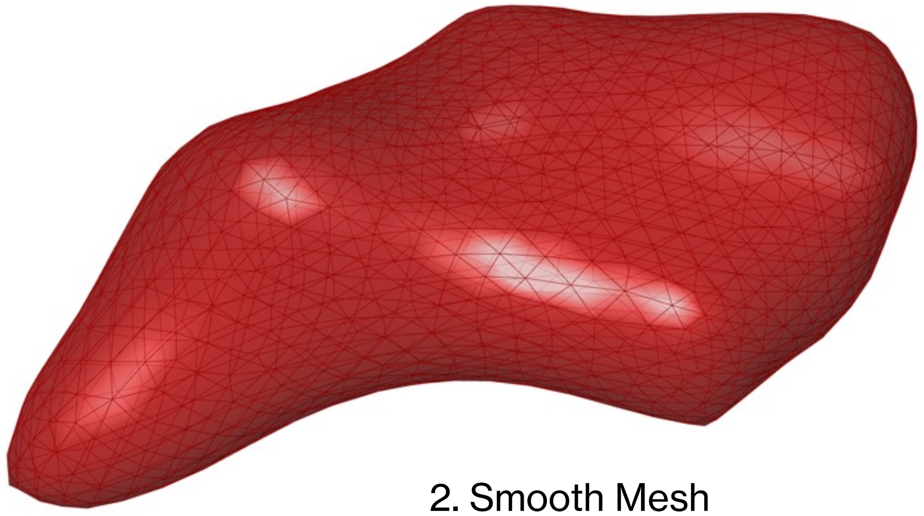
The following workflow shows how this mesh was manipulated to form a shelter, using kangaroo physics to stretch the mesh to the form and then adjusted to a desired finish.



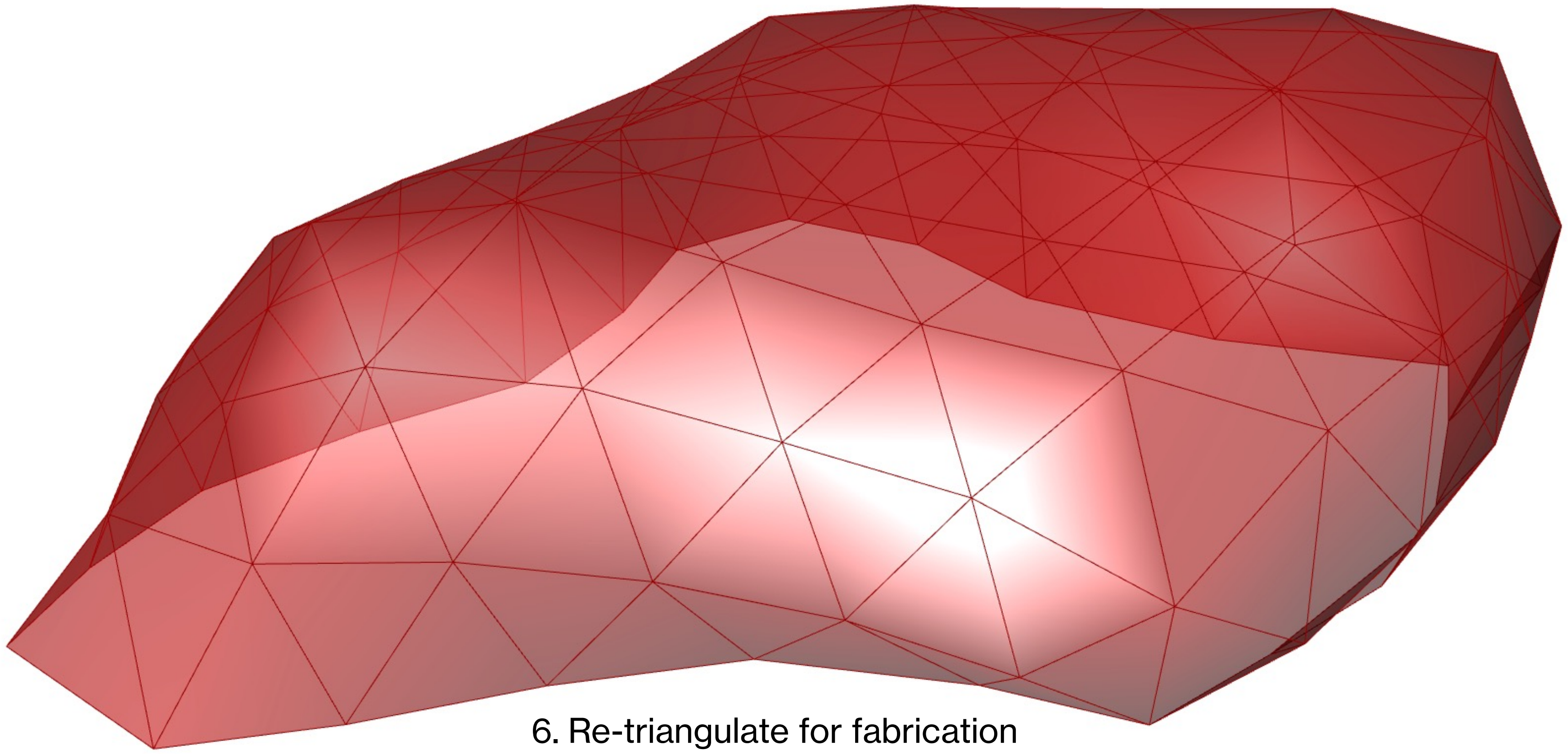




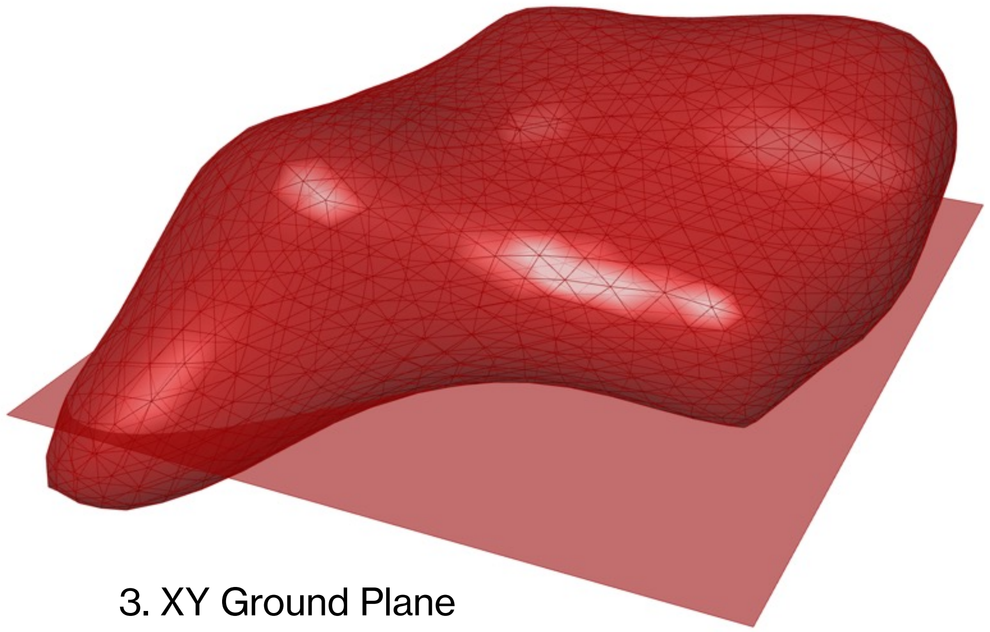
1. Shrink Wrap (Kangaroo)



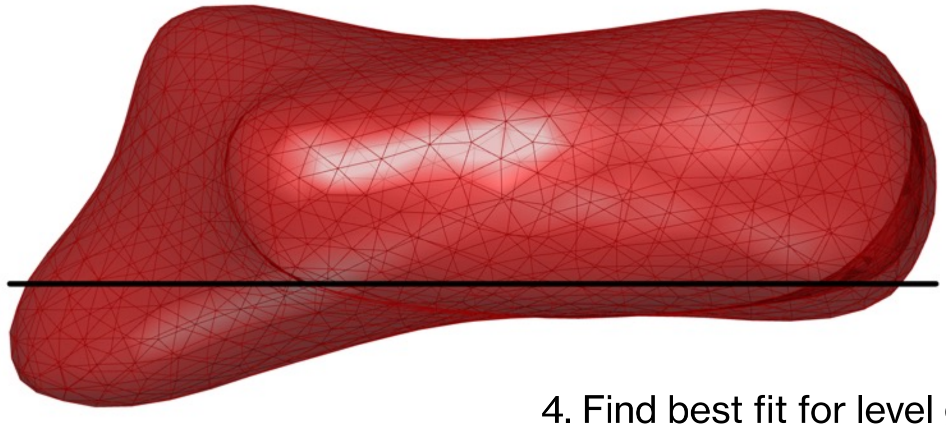
2. Smooth Mesh



6. Re-triangulate for fabrication

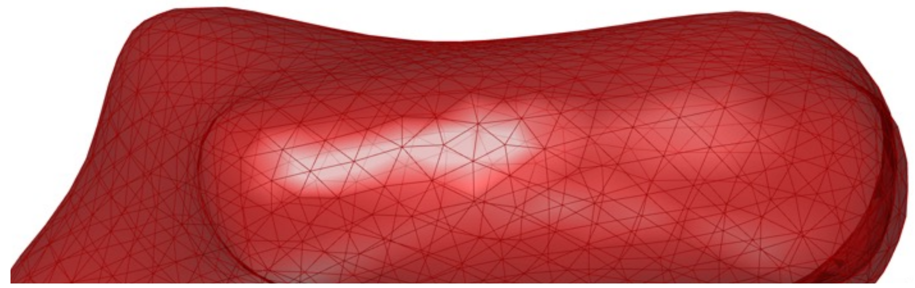


3. XY Ground Plane

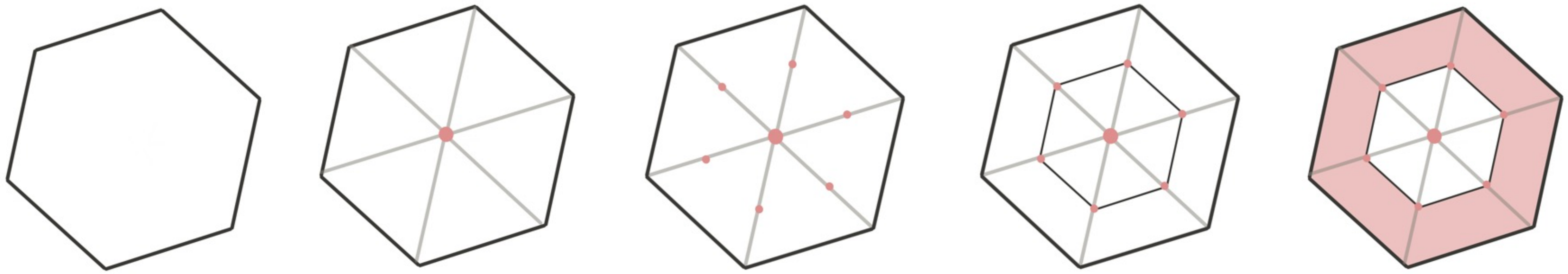


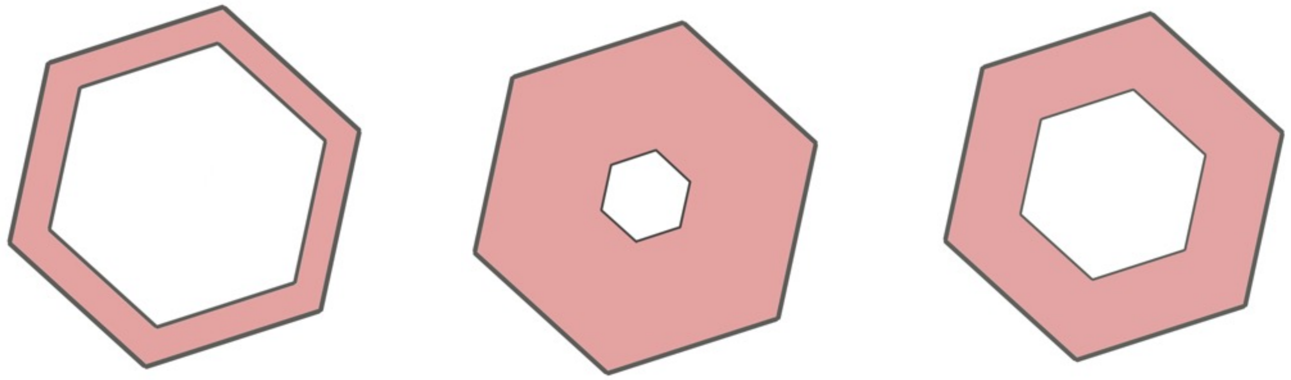
4. Find best fit for level ground

5. Trim Mesh

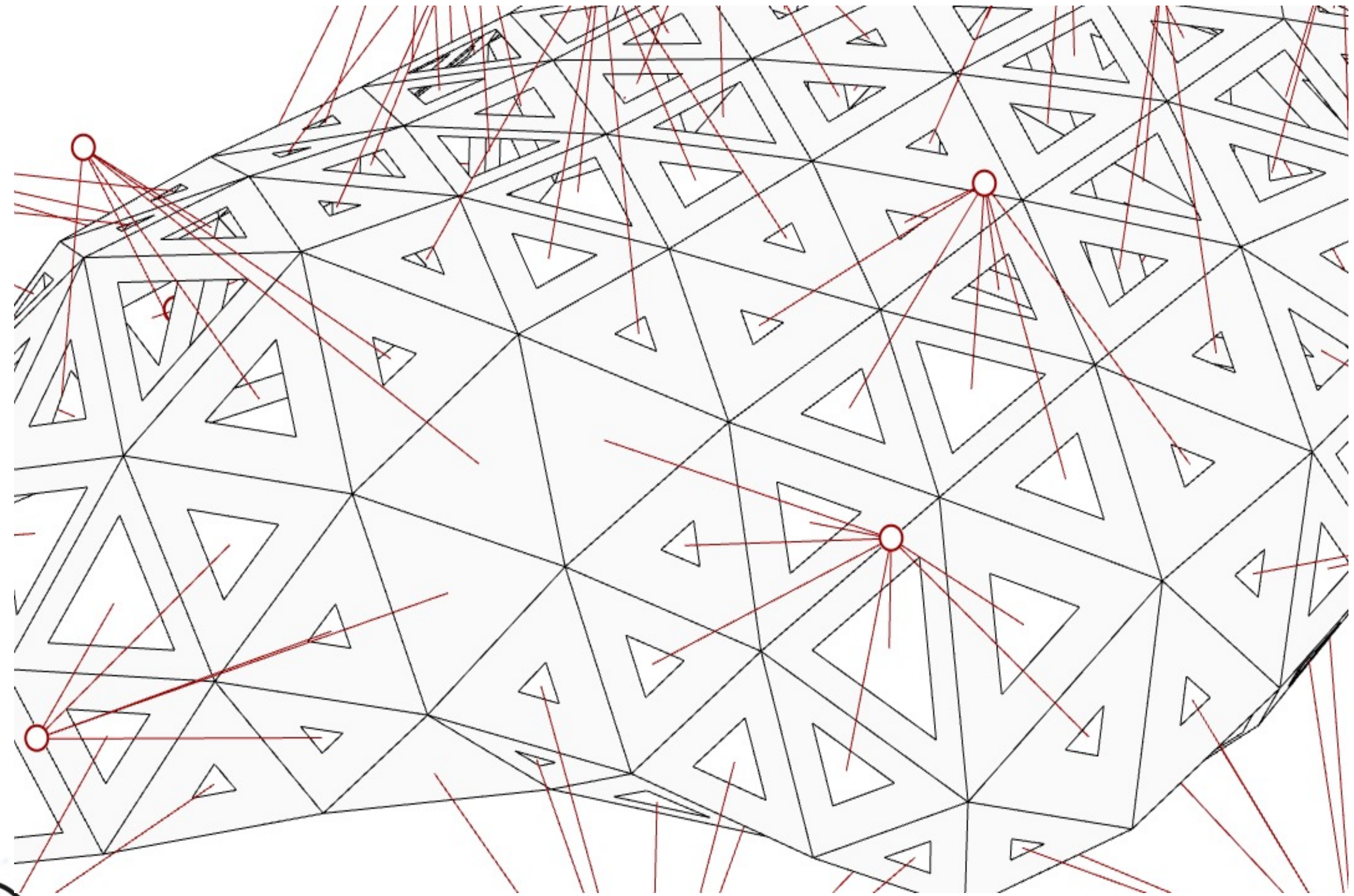


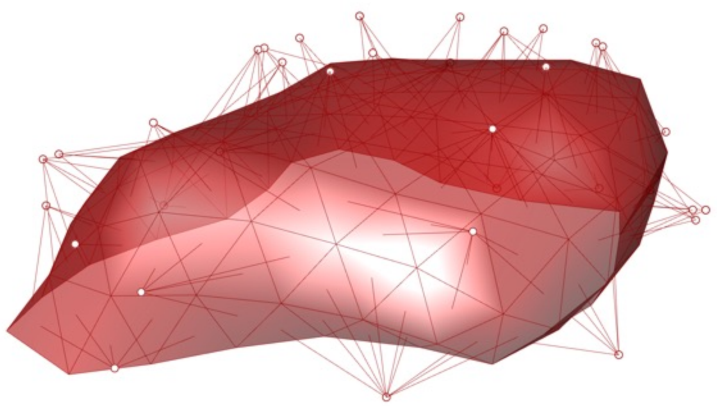
Predator Prey Surface Pattern

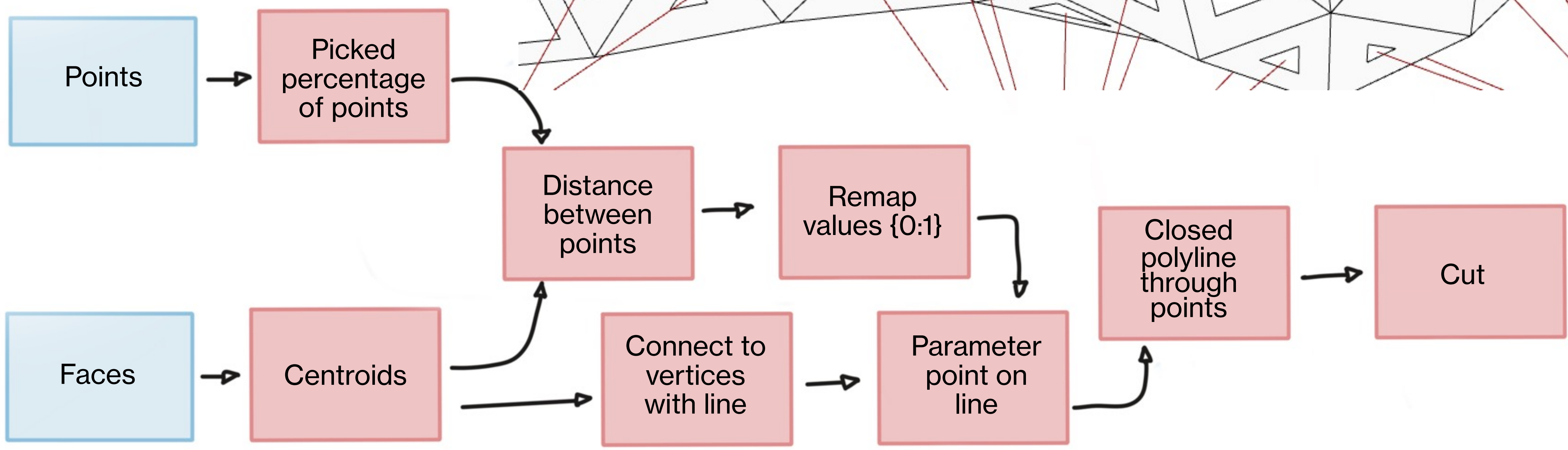


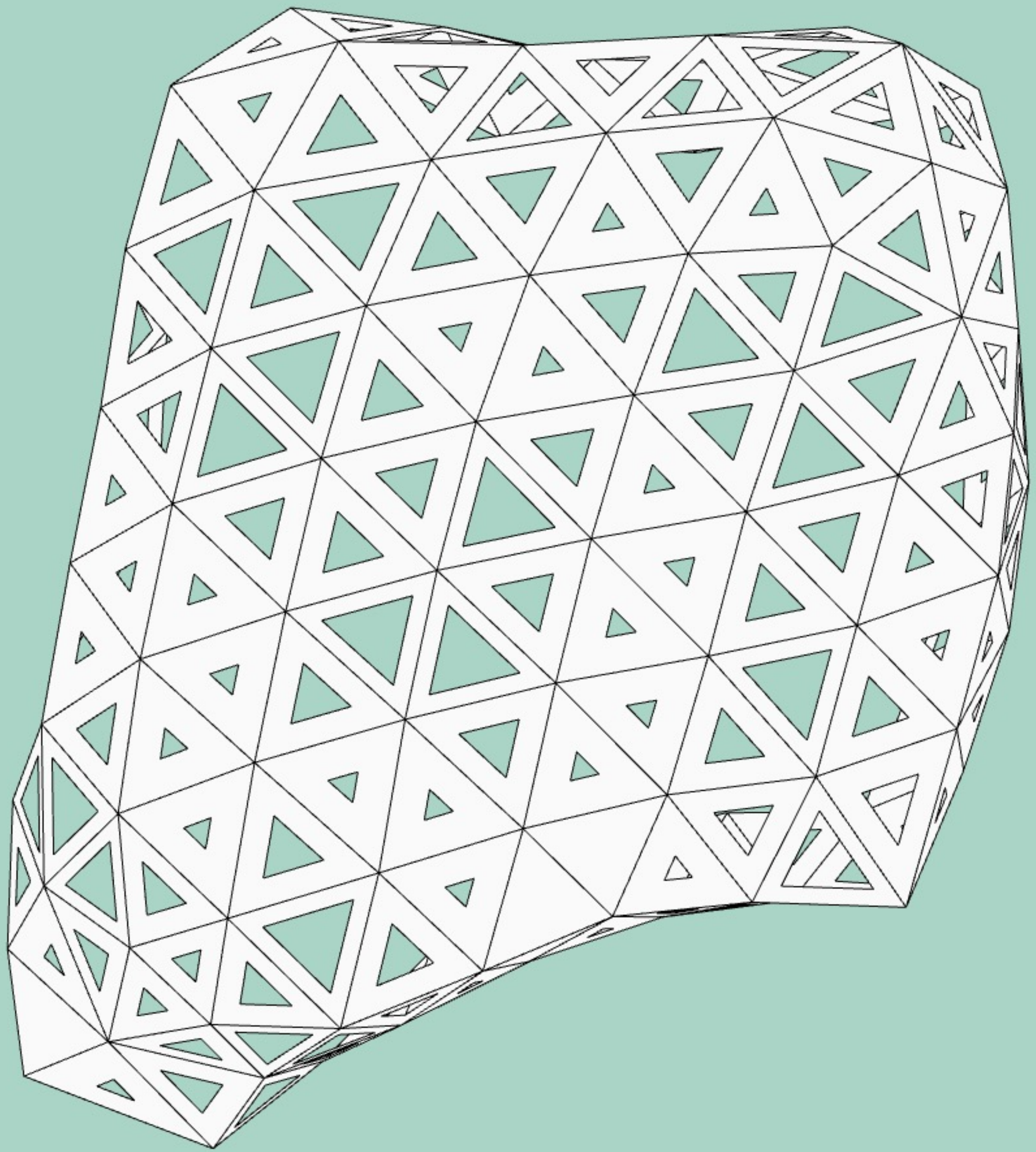


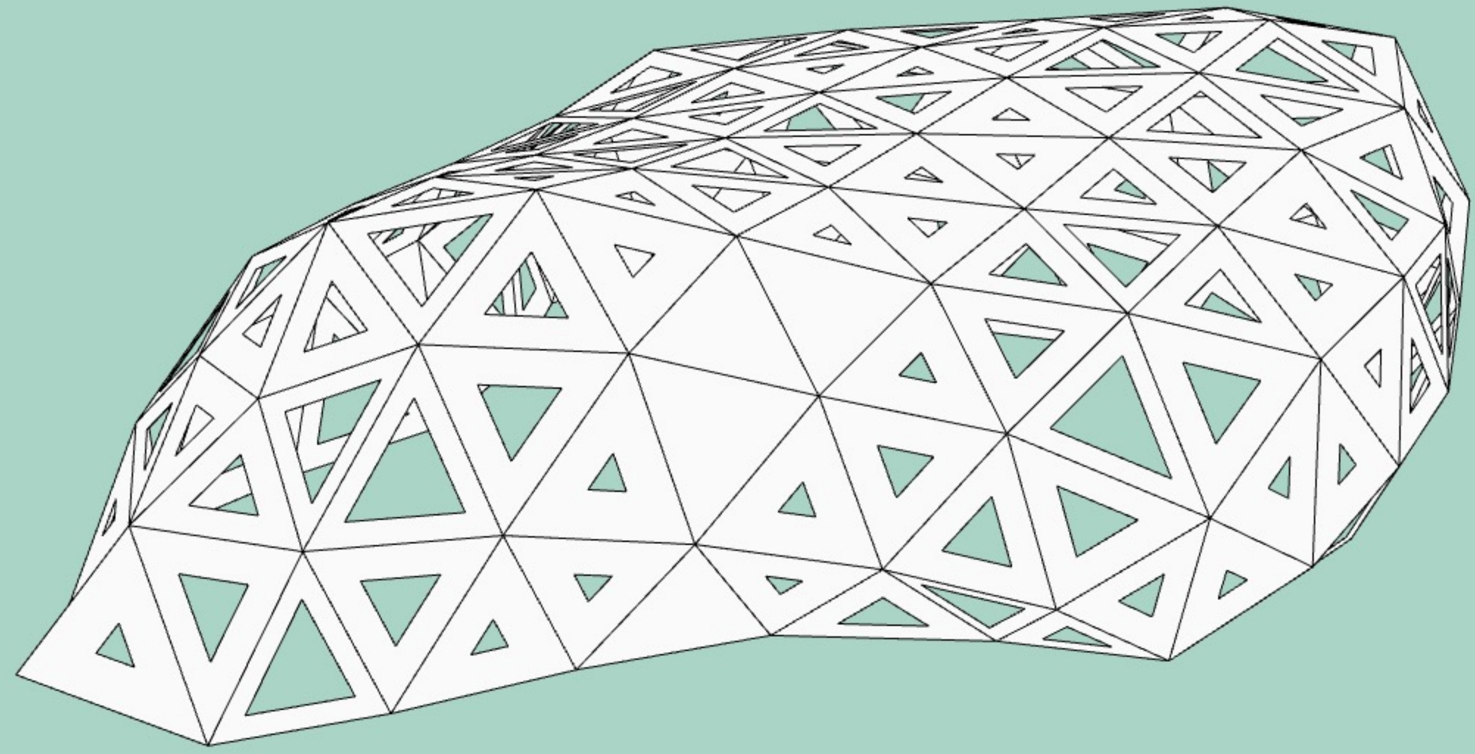
a continuation of bird logic design is the adoption of a prey element. There is a calculation of threat to relative distance in the movement of starlings to prey. In this surface model the abstraction of this distance to prey in the system results in relative levels of reaction from the form, greater escape and abstraction are present in the proximity of imminent danger, seeing greater openings in the breakdown of the murmuration.

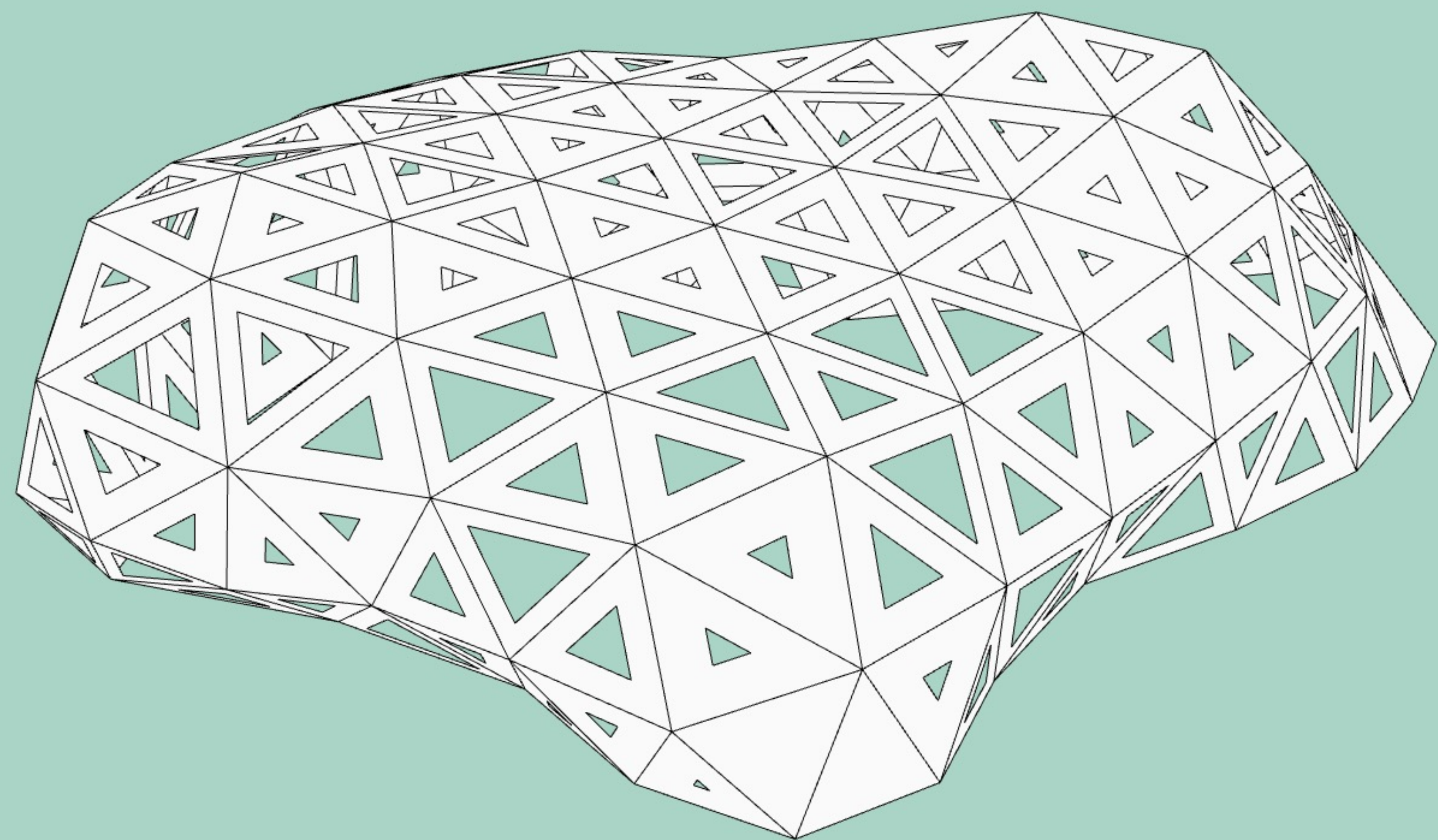


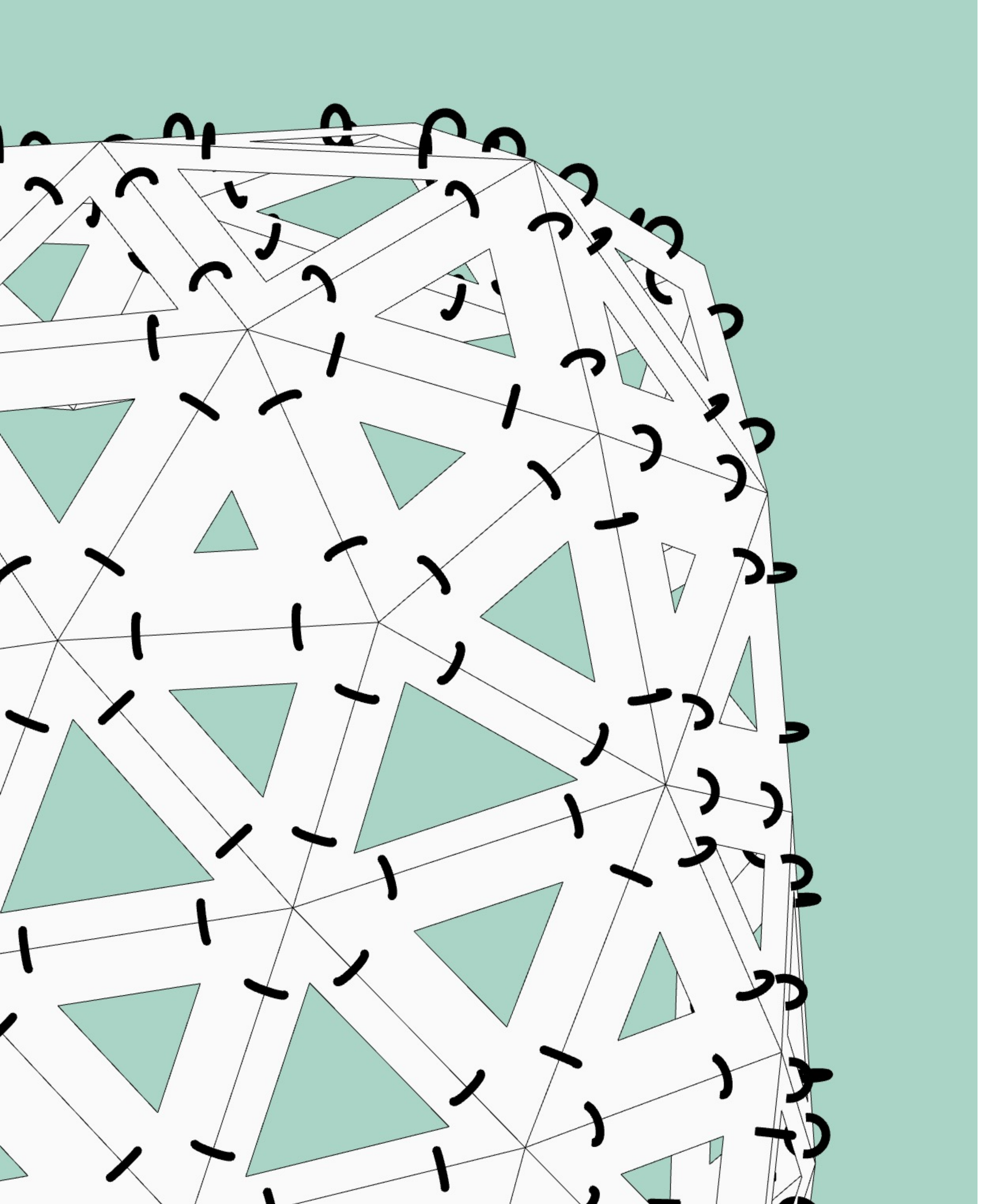








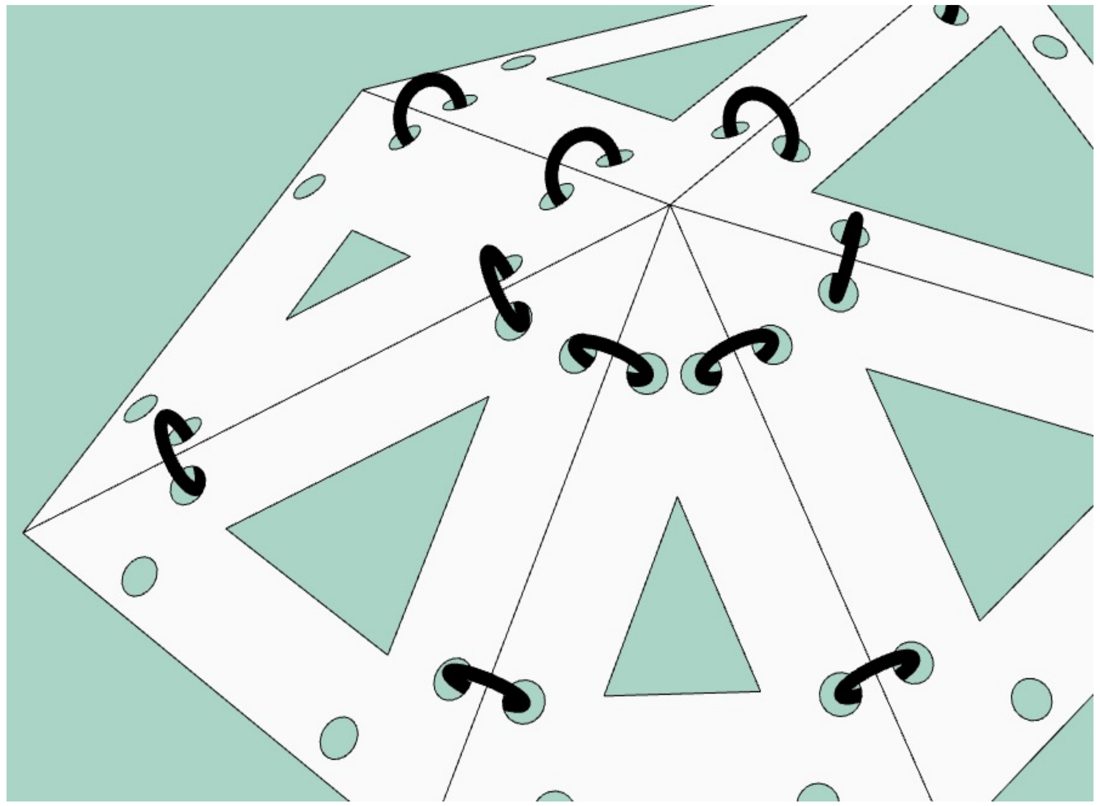




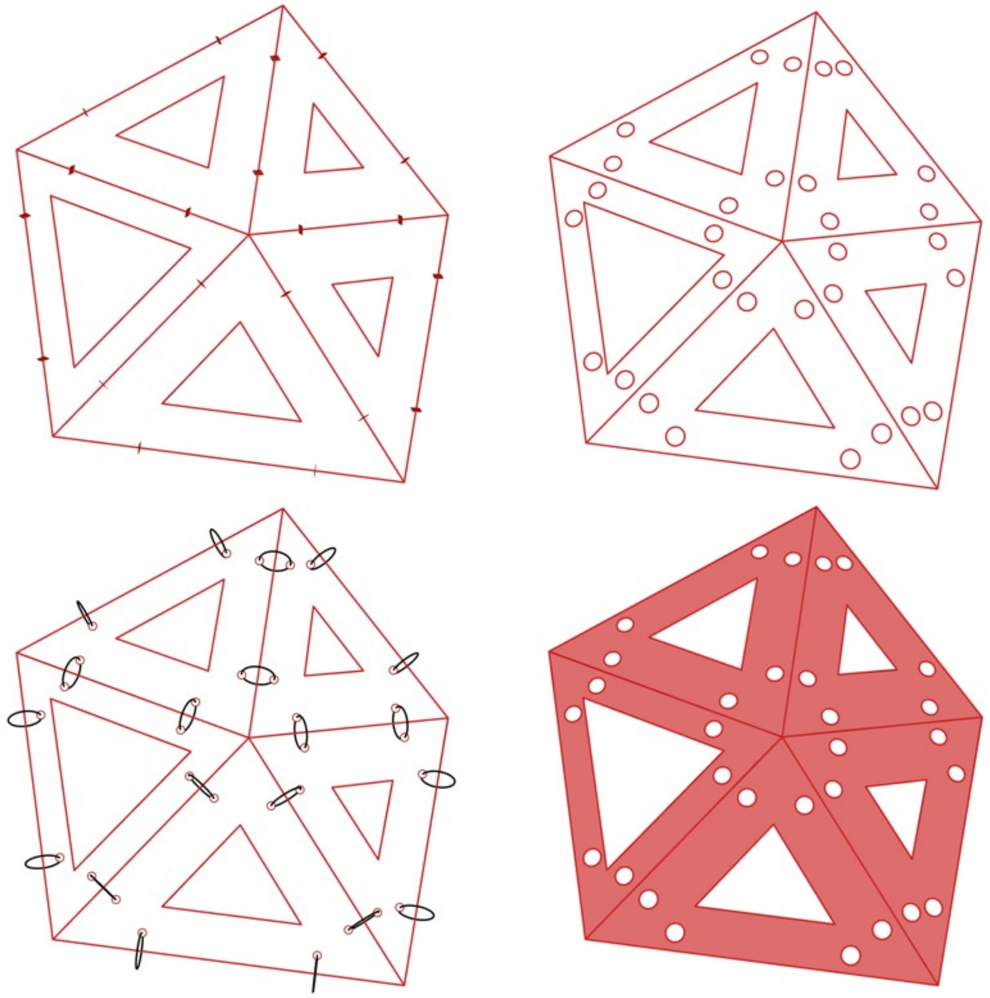
Fabrication

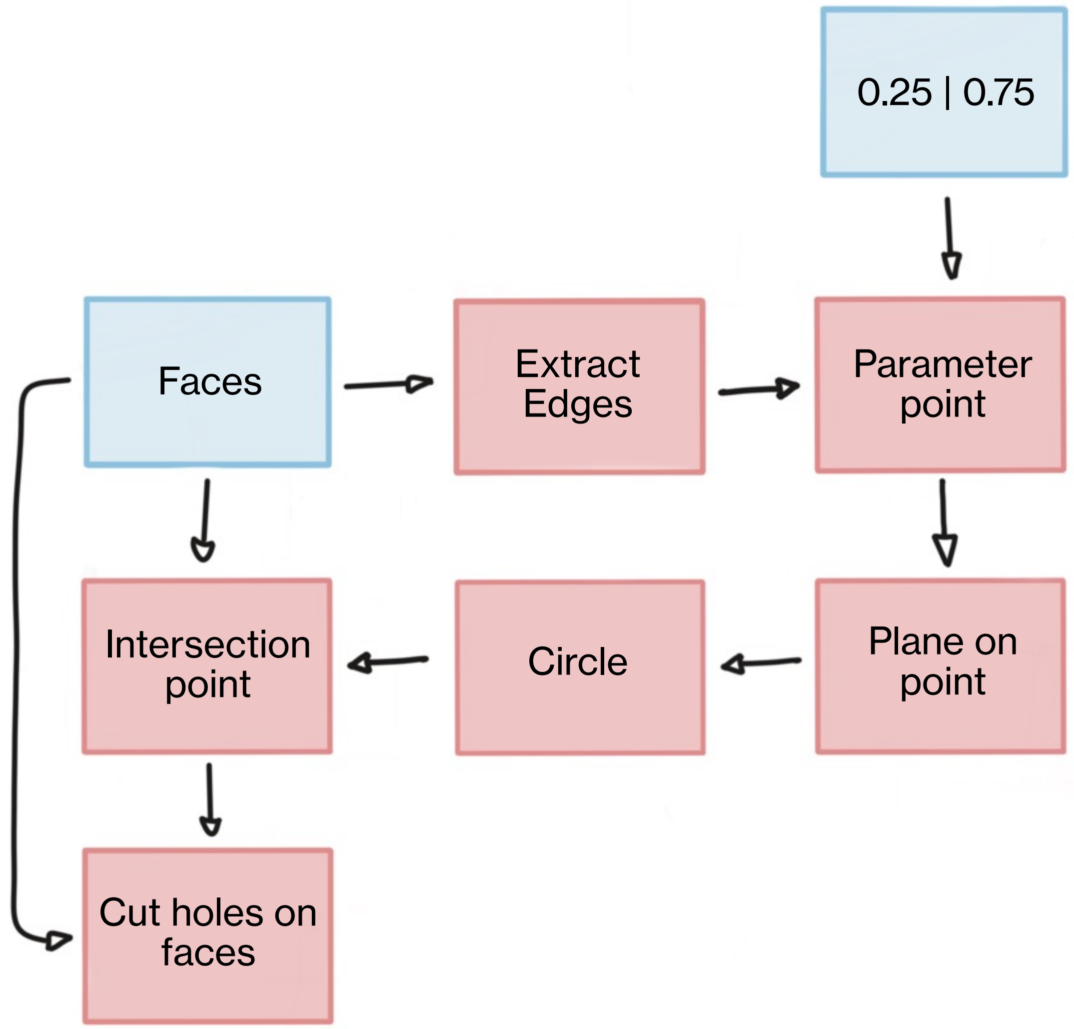
The primary objective of the fabrication process was to find a way to join the surface panels, robustly enough it will hold its weight and stay true to the modelled form.

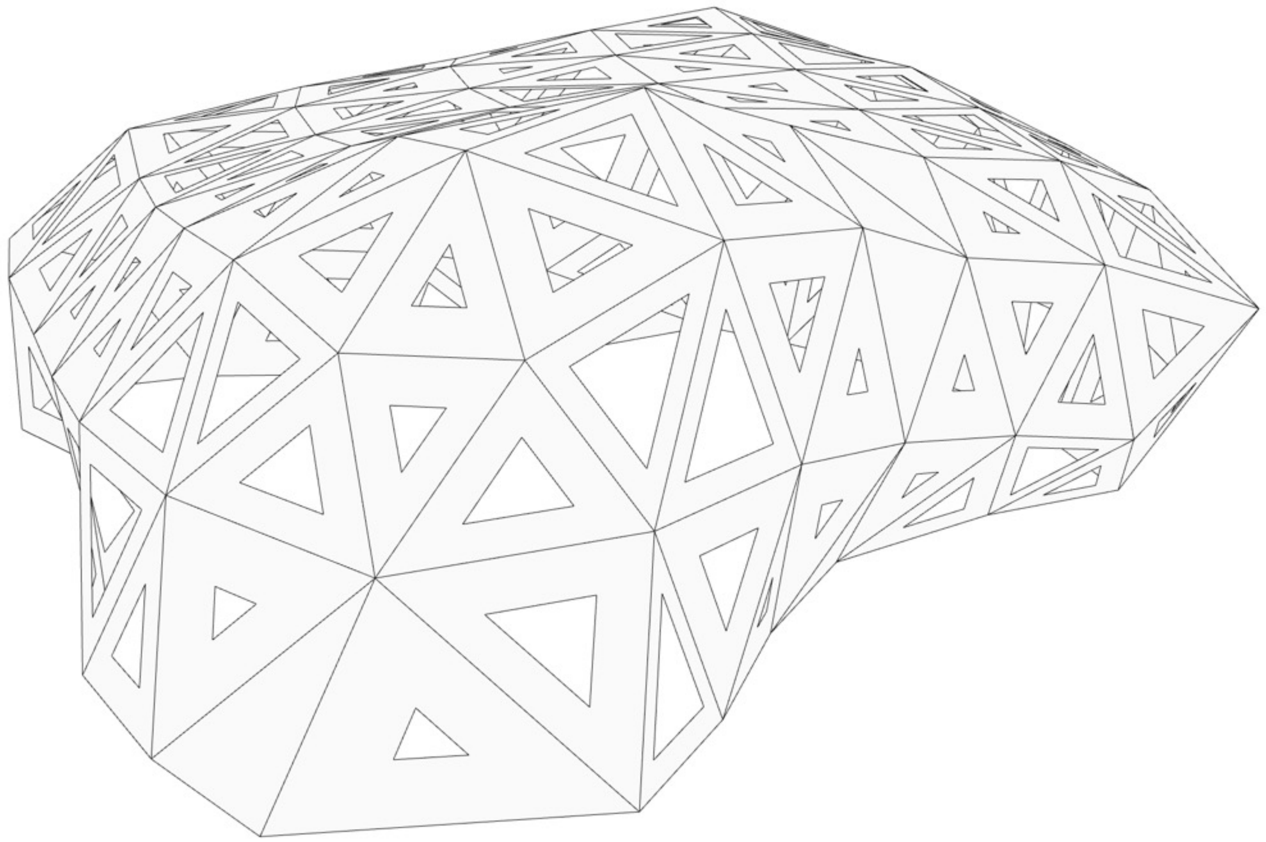
Due to the number of panels (165) there would be nearly 500 connectors at 1000 connection points. there for, the chosen method had to be cost effective, material resourceful and also feasible for assembly. Cable ties were chosen due to the low cost and quick application. Using two ties for every connection supplied sufficient strength across the faces.



A minimal size (2.5mm) of tie was used, holes of 3mm were cut and the model was scaled to an appropriately sized surface are of each panel to fit the holes.

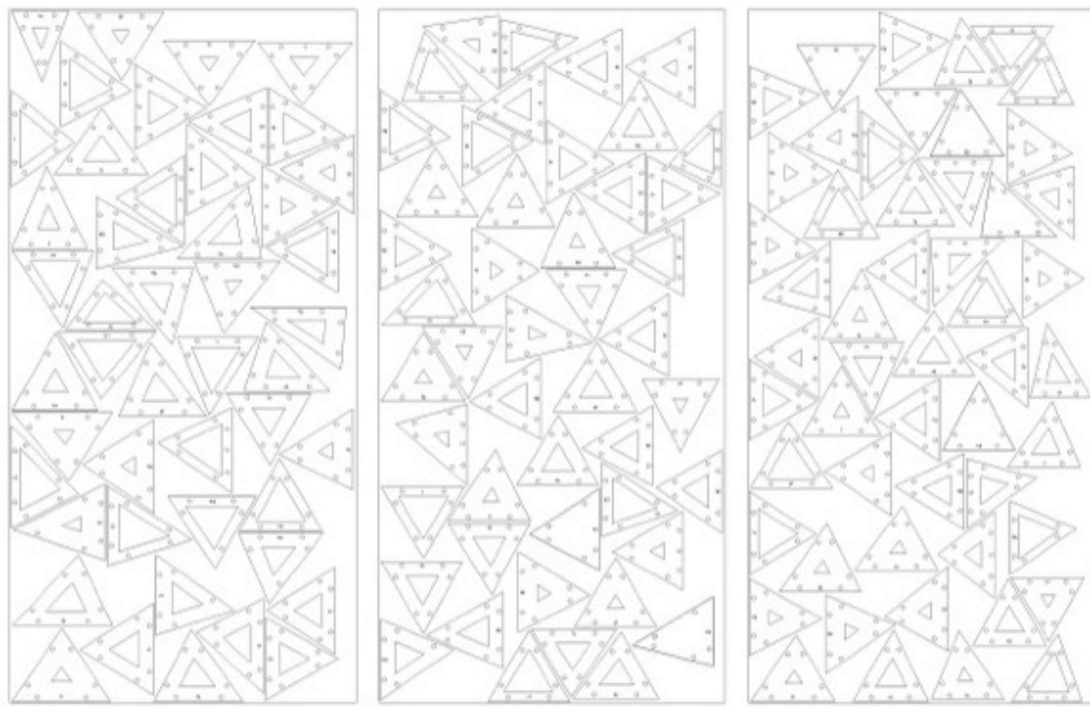


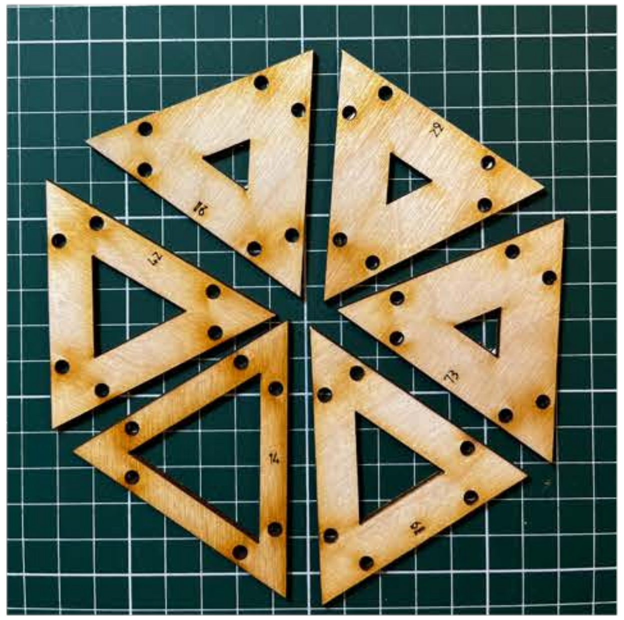
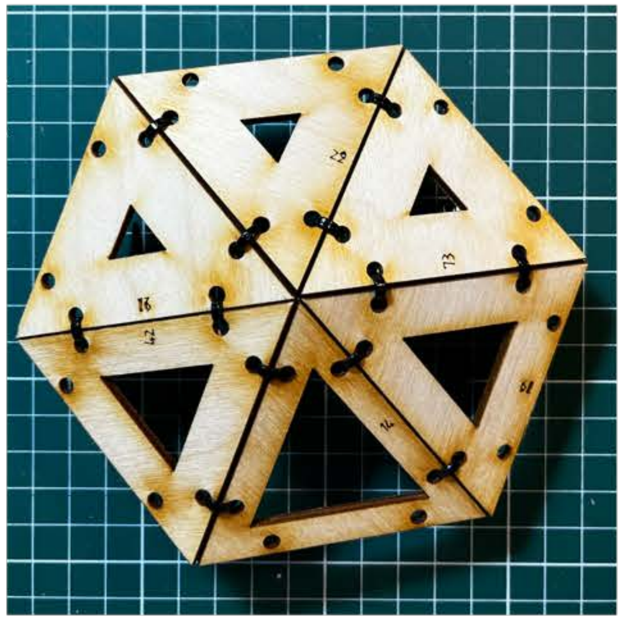
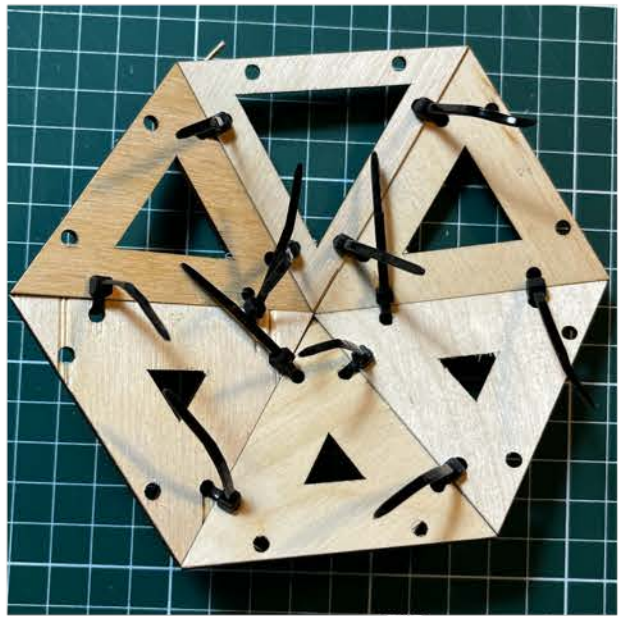
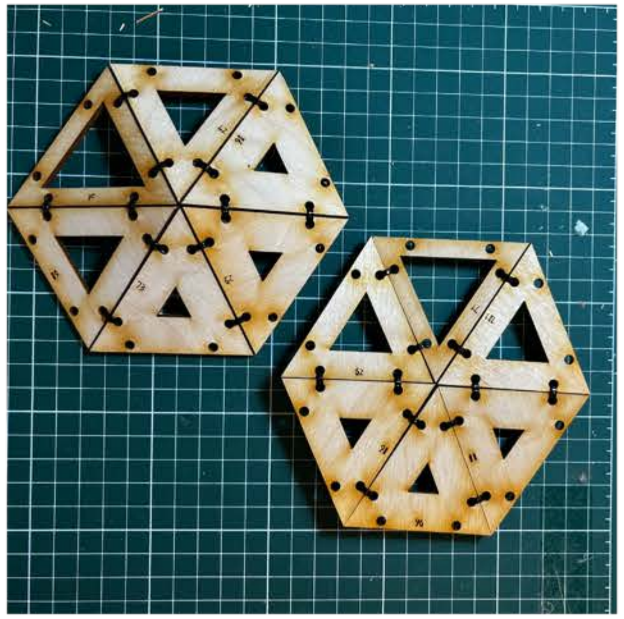
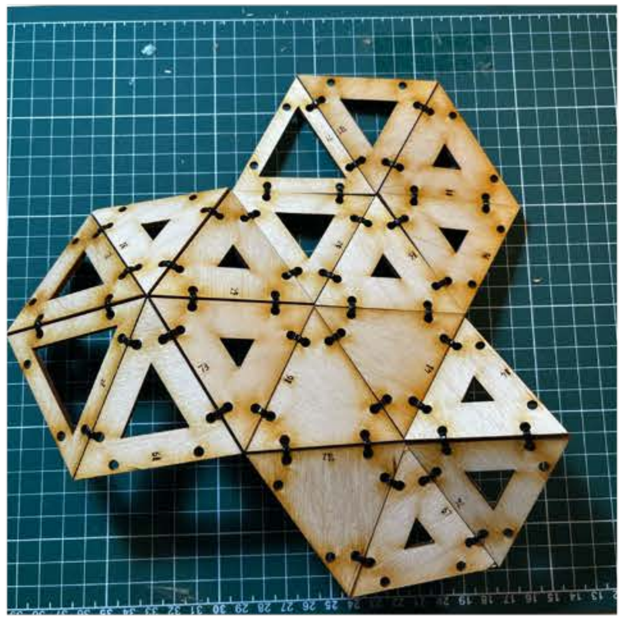
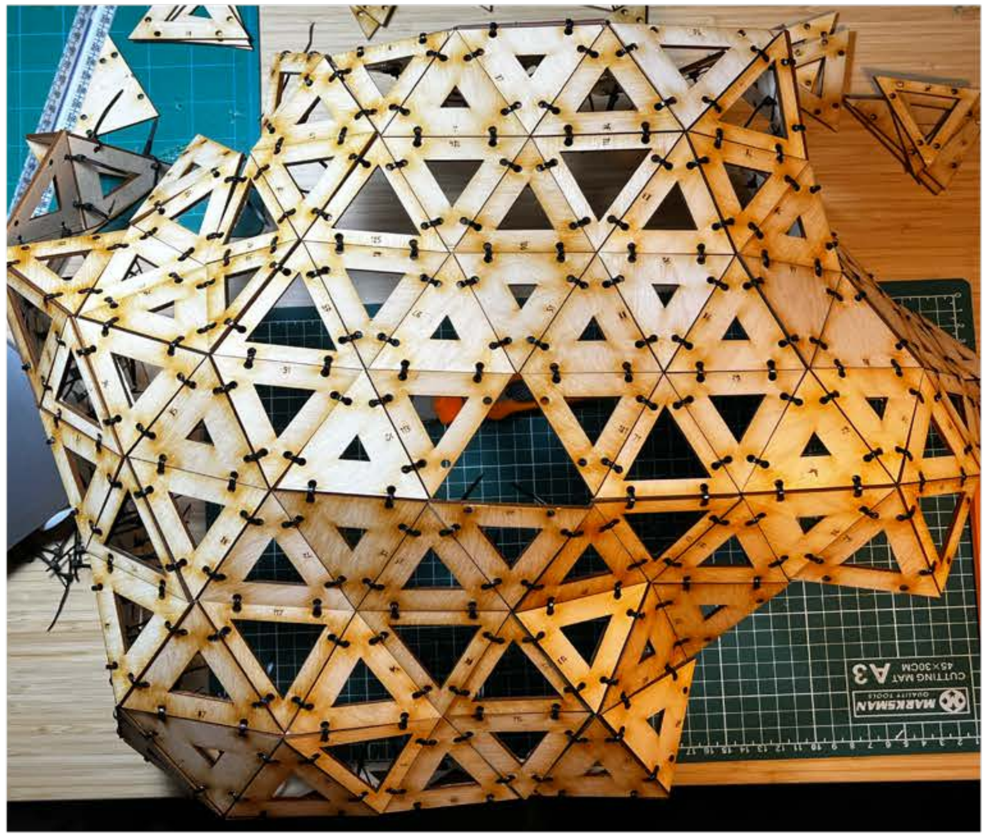
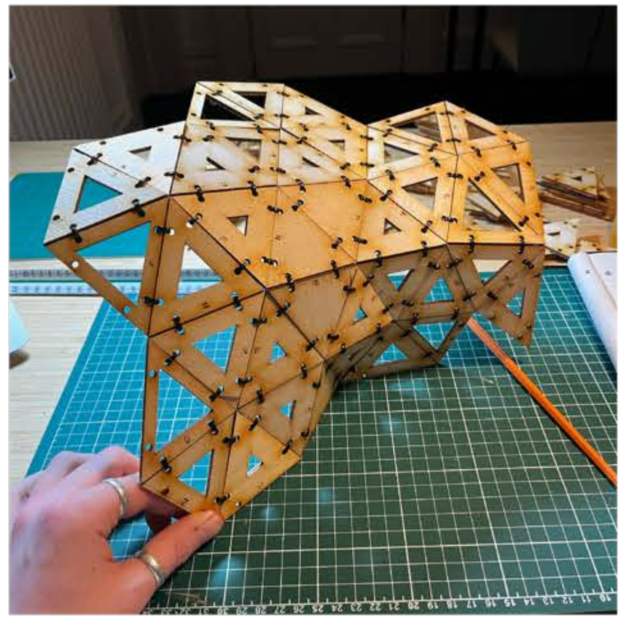
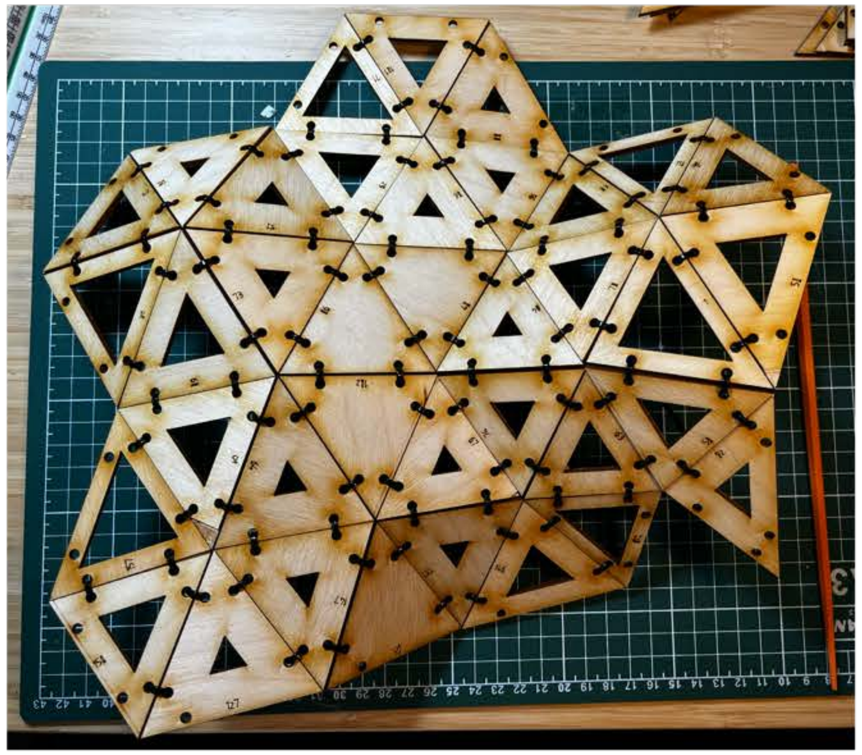
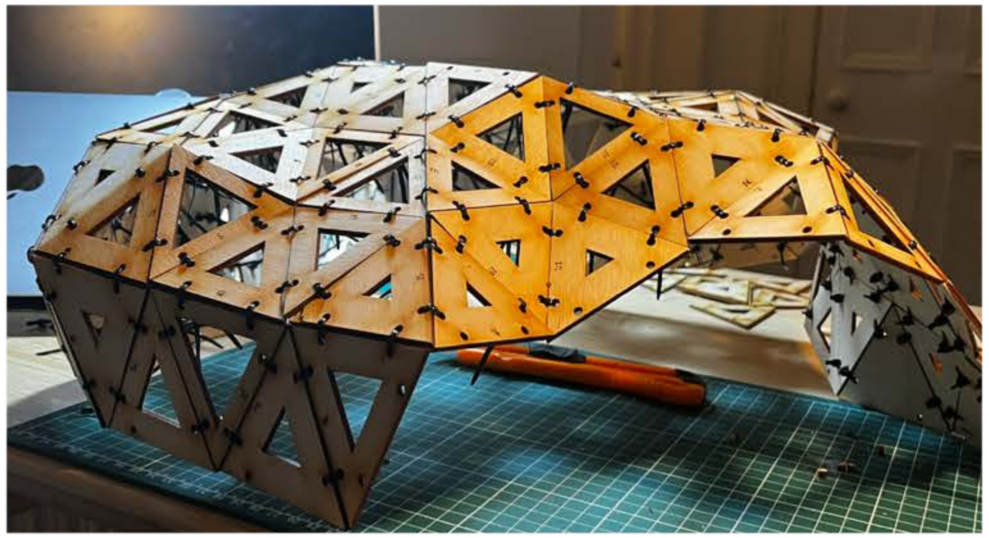


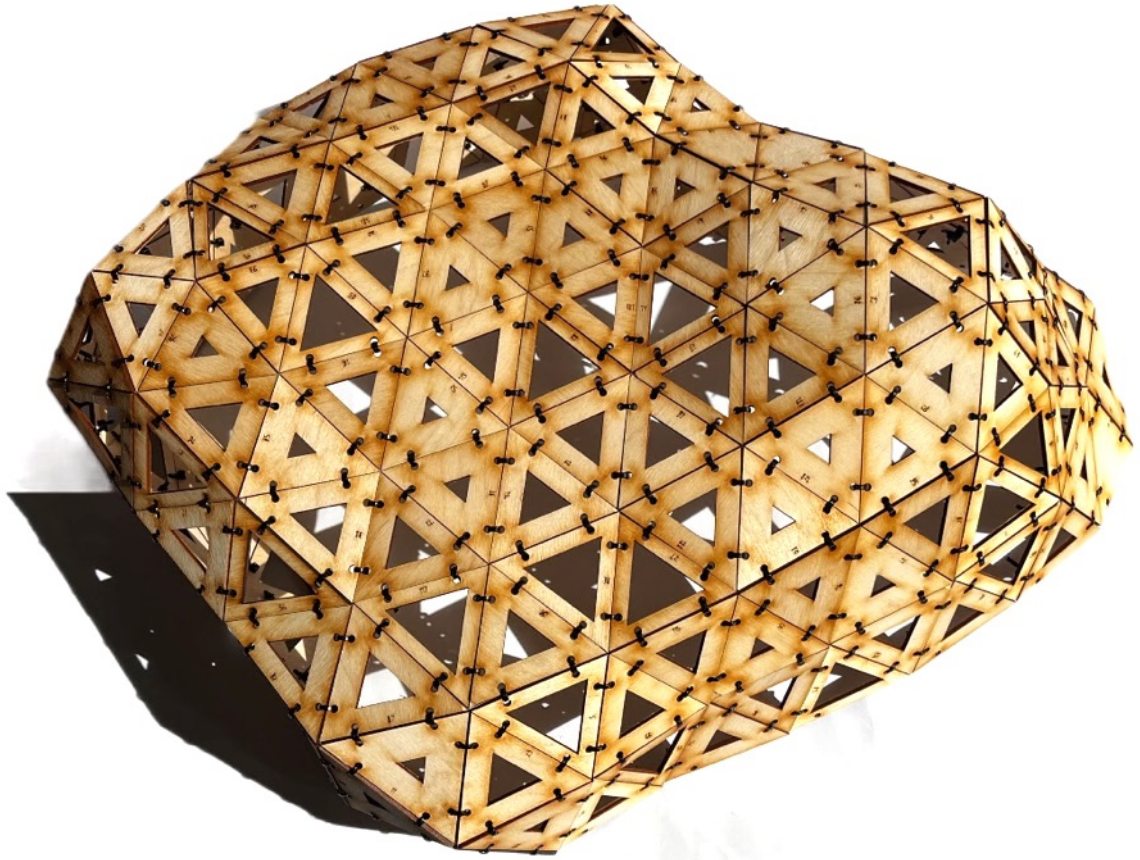
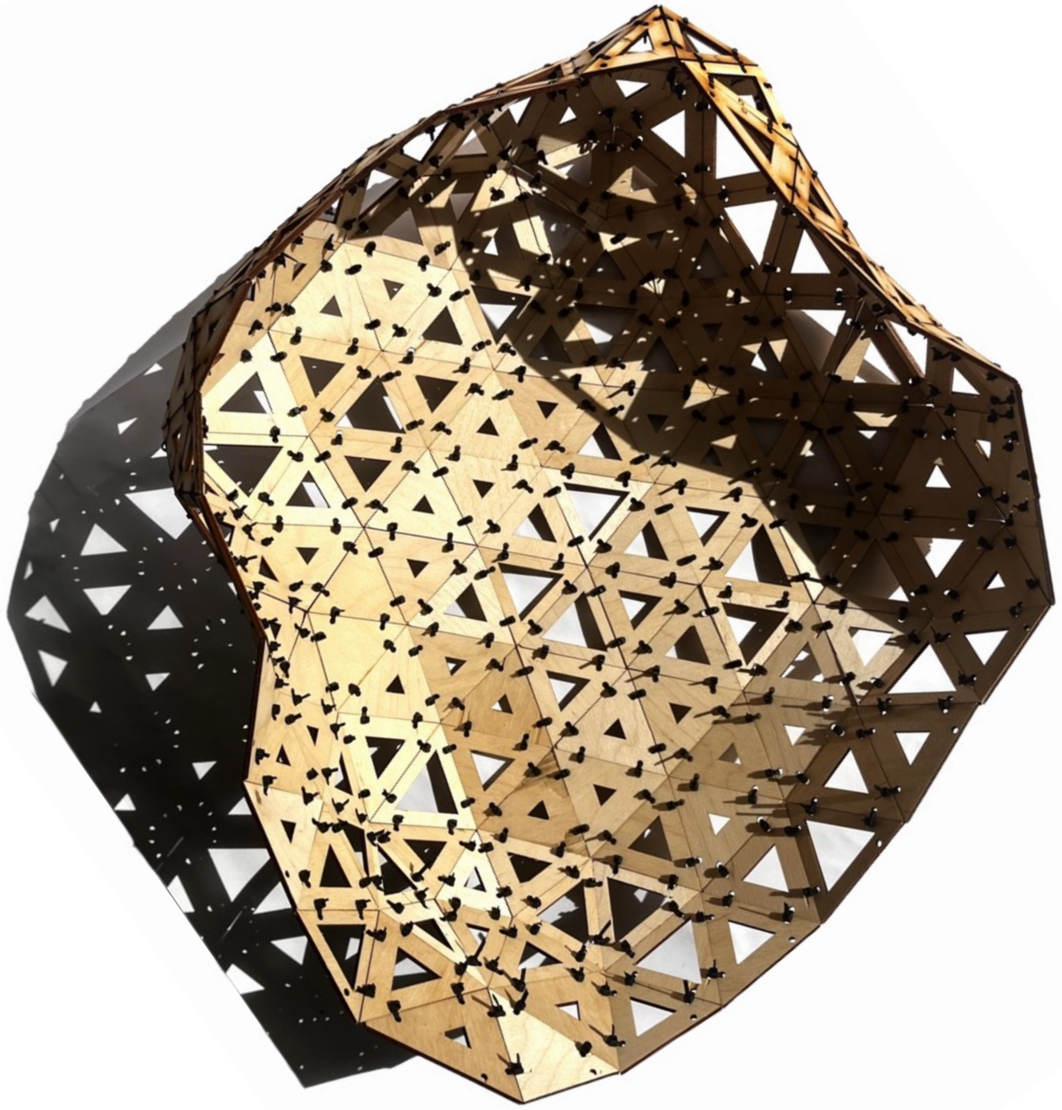
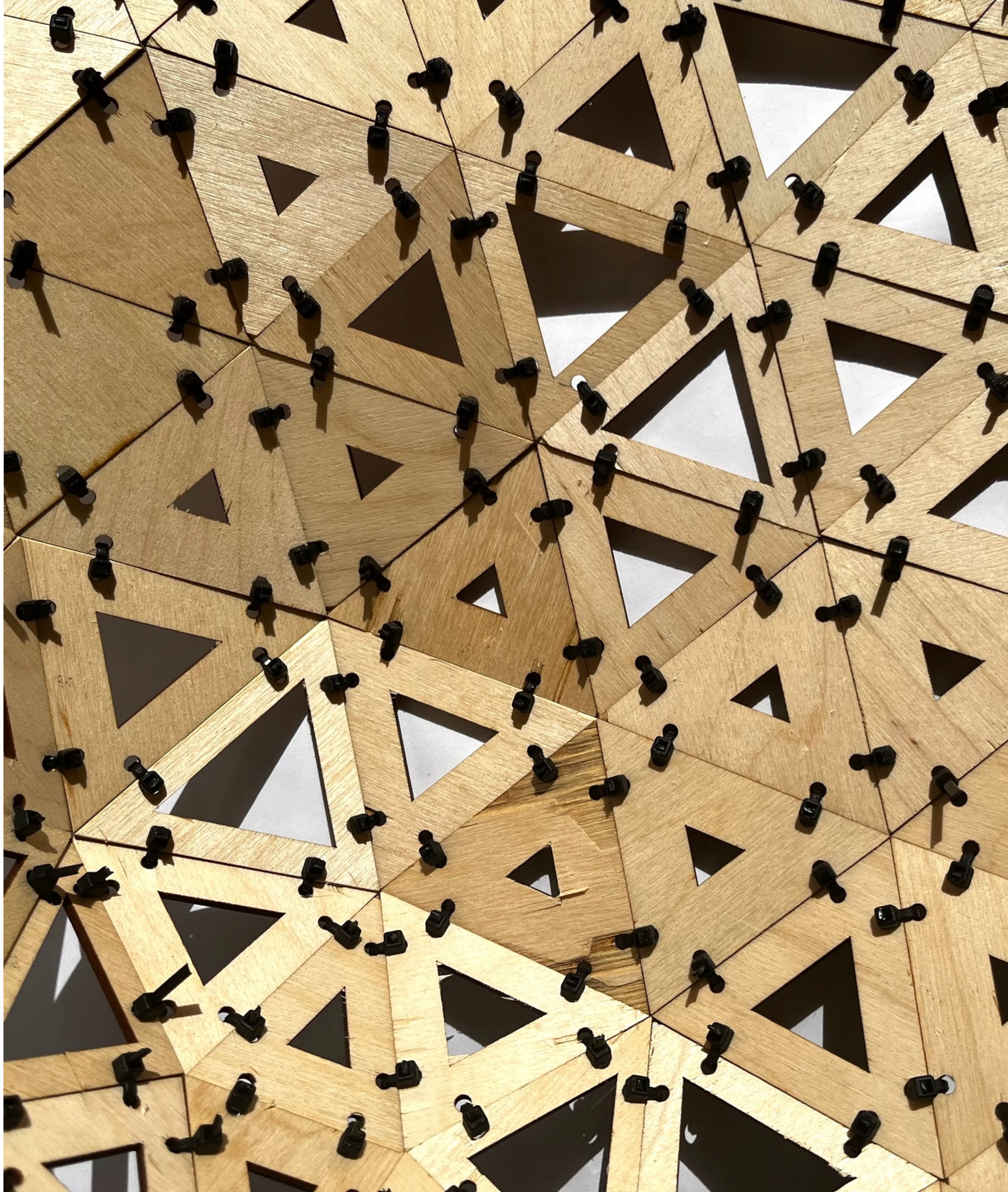


Laser cutting was chosen for the fabrication method as it is an effective way to produce the geometry incisions accurately. Since each face is triangular it was there for planar and could be sketched on 2D sheets. A packing system (open nest) was utilised to transform the geometry of each panel onto sheets of 3mm plywood.

Open Nest packing for laser cut



Design Achievement?

The aim was to create something designed through a workflow that is inherently 'un-humanistic'

In truth, it is hard to, if not impossible to, qualitatively conclude the successfulness of the aim, for the form-finding artefact has to be one that's not designed by humans, but in fact, it was overly parameterised to values of strength and radii and tweaked and controlled by space, size and quantities. In nature none of those things are known, set or controlled so this artefact can only consider one representation of the design potential but a still far from natural for – existing as just one that satisfied the desires of the designer.

Although, the true merit of this process is that of the workflow, which showcases the vast range of morphologies that are possible when architecture and from finding look beyond our world and into the context of nature.