AA VISITING SCHOOL TORONTO

Summer 2021

F^2

Morphological Experiments between form and force

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Group 1

Payal Merja
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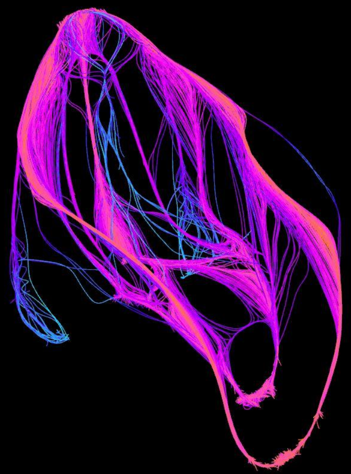

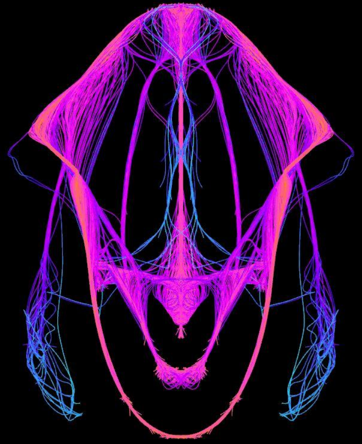

CHRYSALIS

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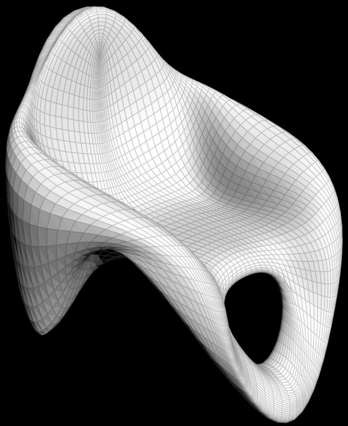
Base Geometry

AXONOMETRIC



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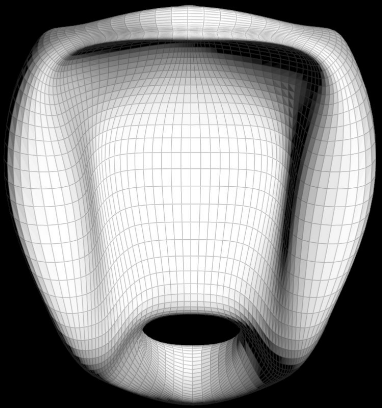

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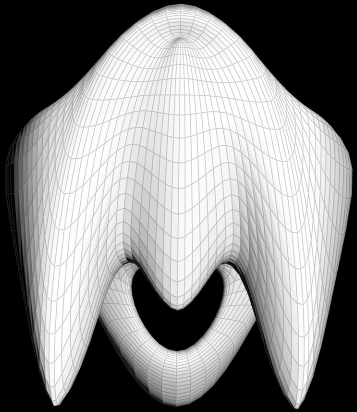

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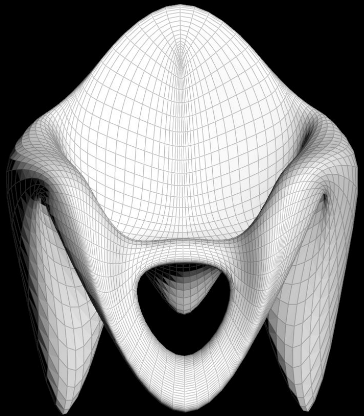
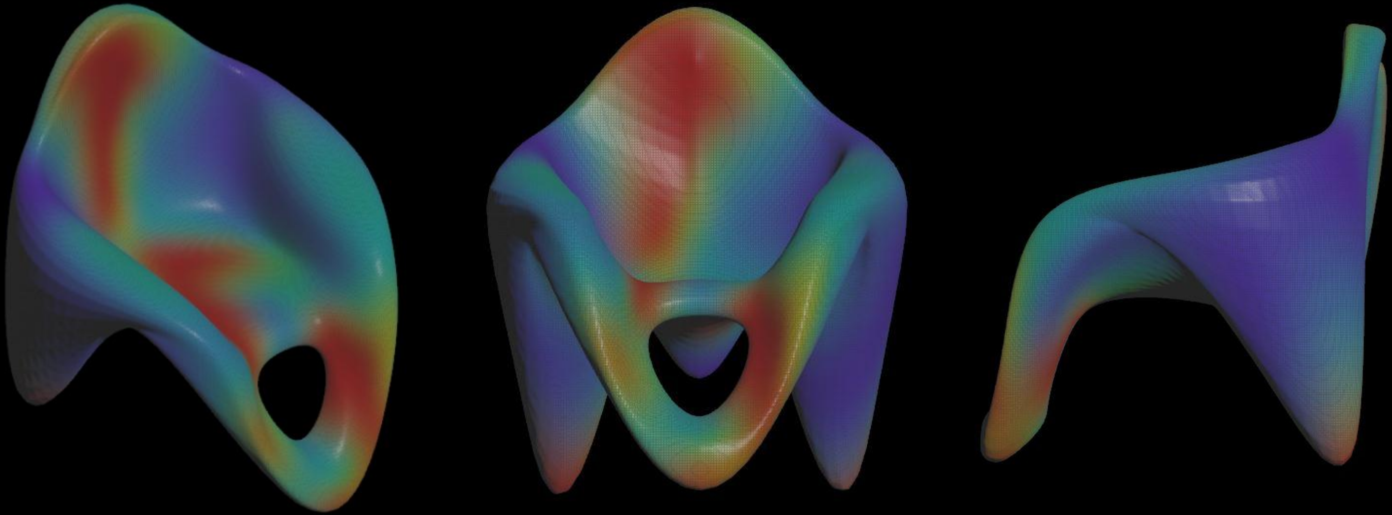


Stress

(normalised)

Low stress

High stress

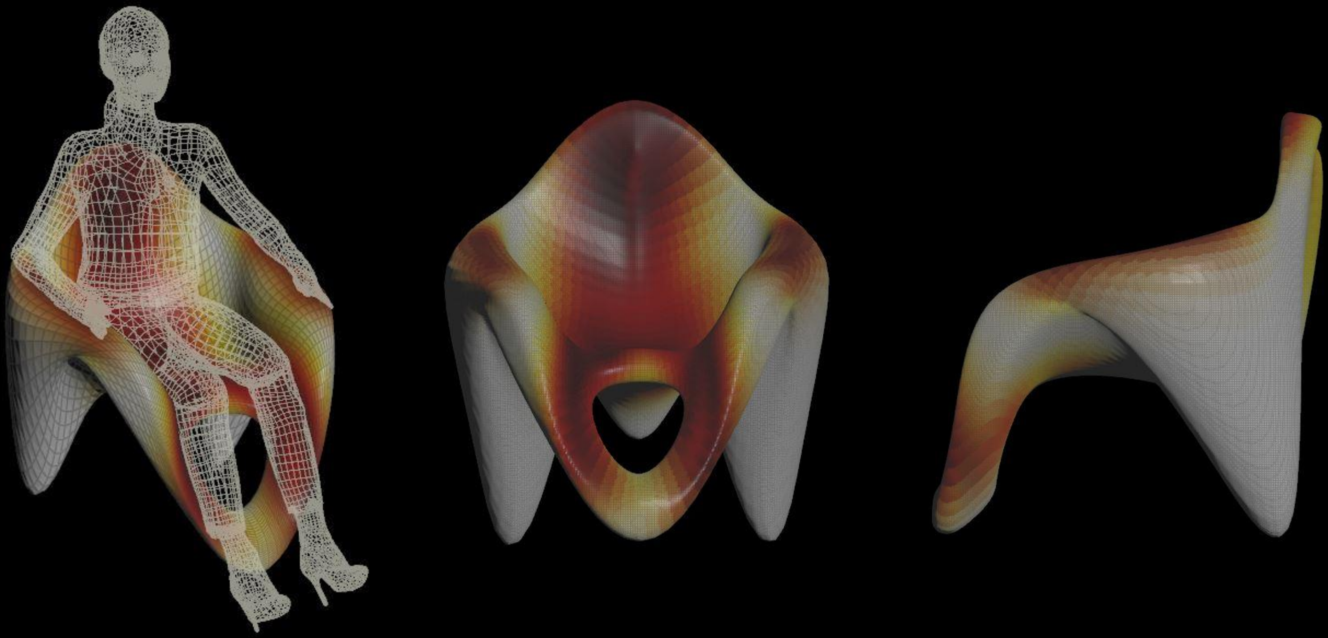


Body Proximity

(Contact map)

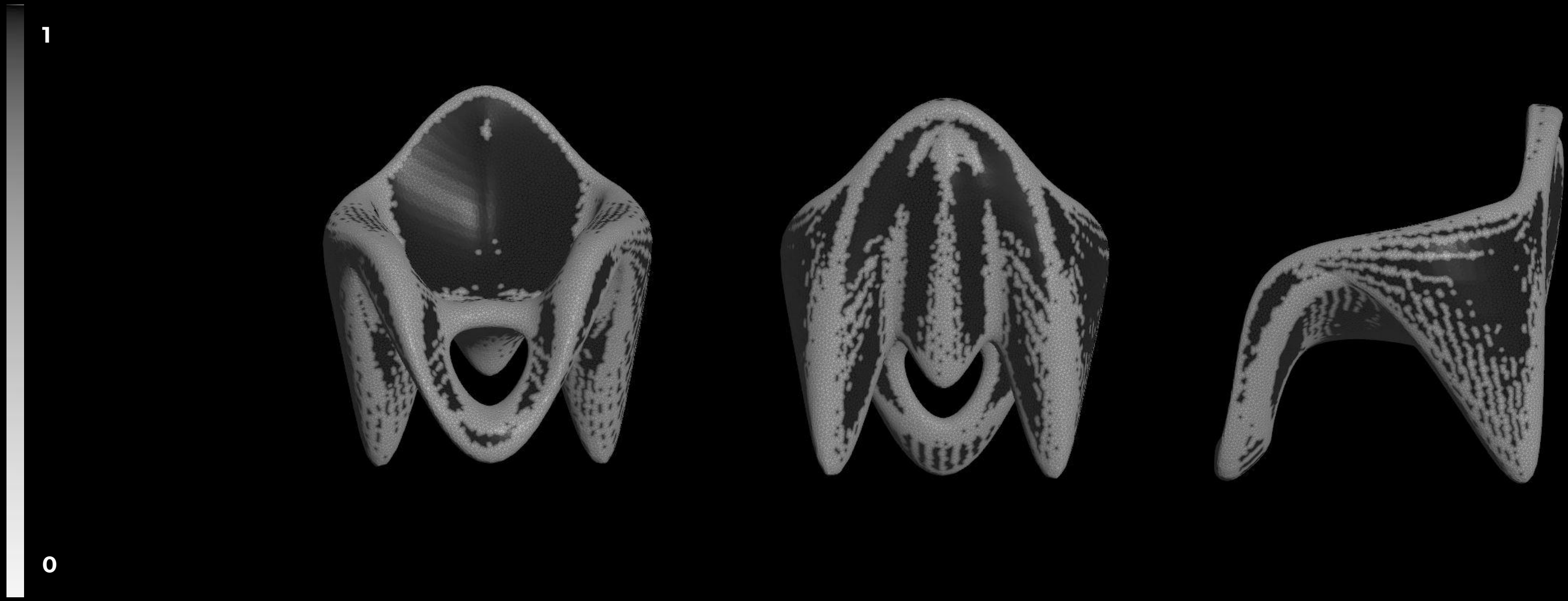
Low contact

High contact



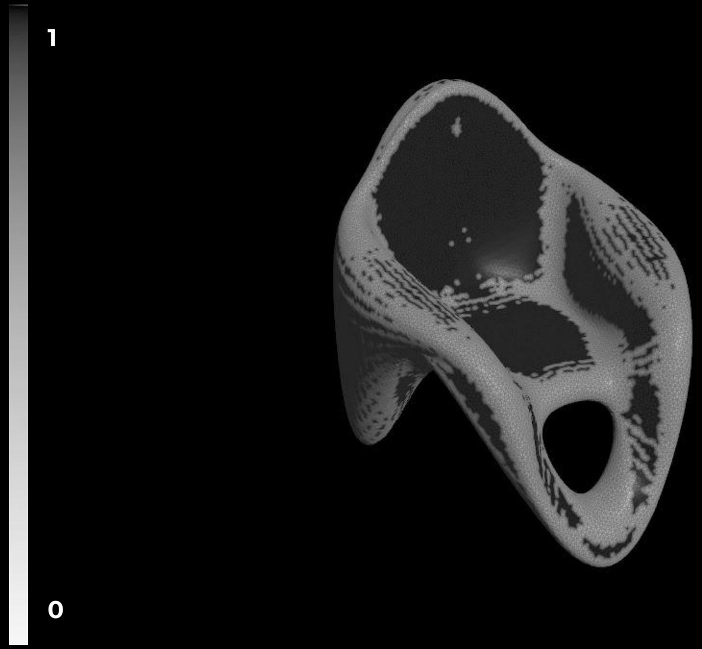
Edge Stress

For reinforced edges



Edge Stress

For reinforced edges



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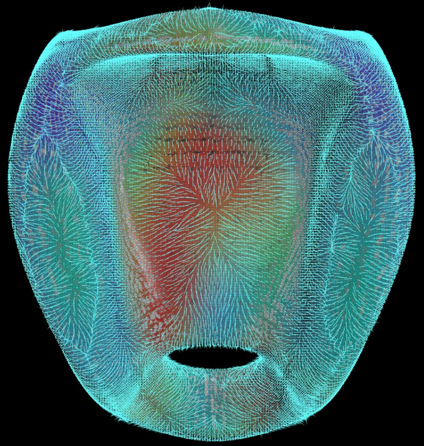
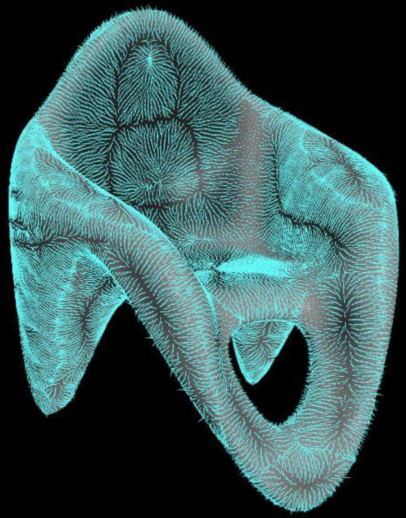
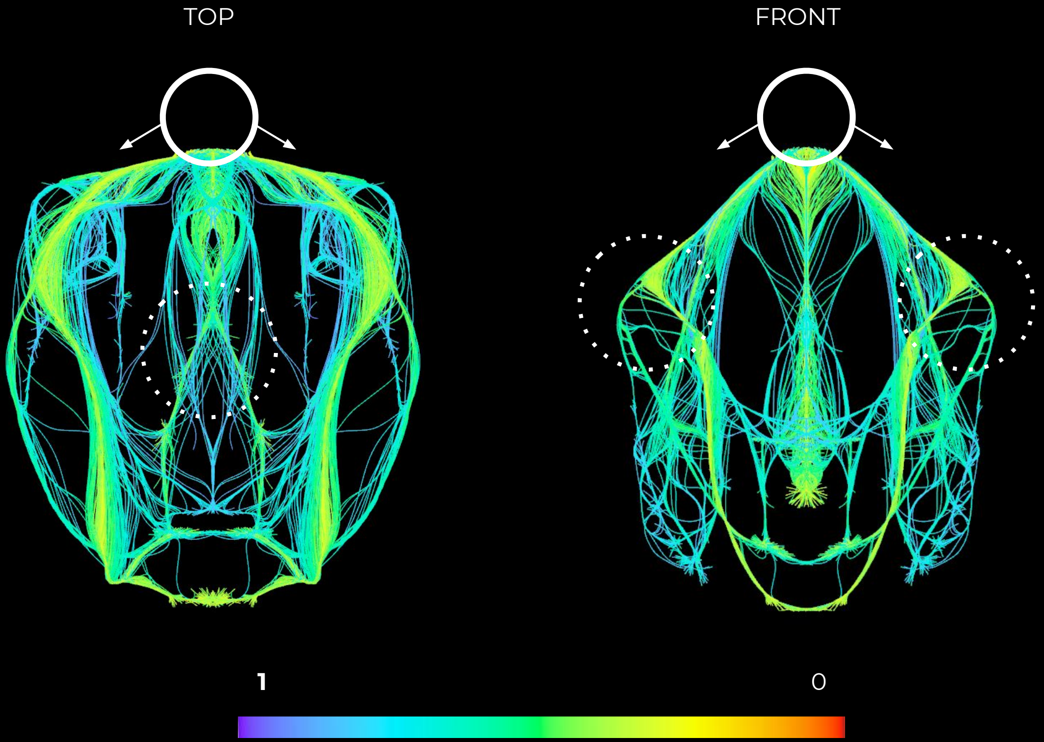


AXONOMETRIC



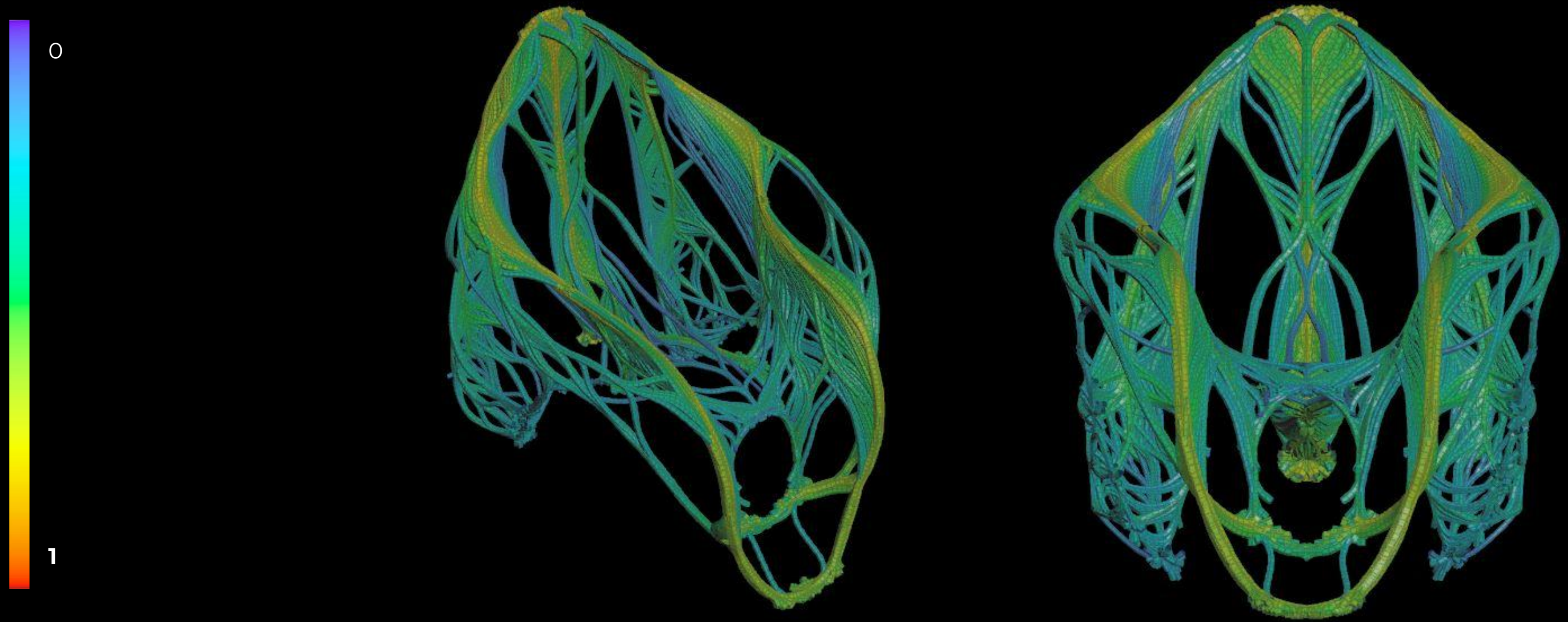
Direction of normals

Agent Paths



Agent Paths

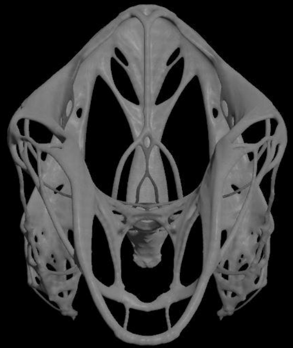
Density

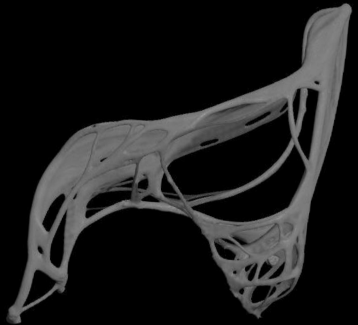


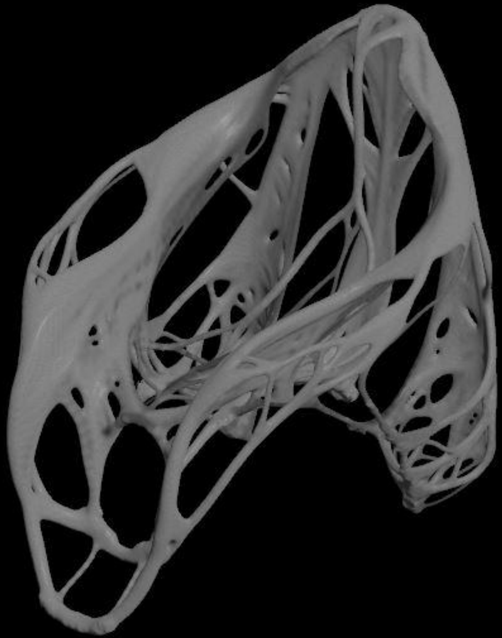
Mesh Output

Density

Max Speed	**5**
Max Force	**0.35**
Search Radius	**50**
Separation Radius	**40**
Separation Multiplier	**1**
Cohesion Radius	**30**
Cohesion Multiplier	**1.8**
Alignment Radius	**10**
Alignment Multiplier	**1**







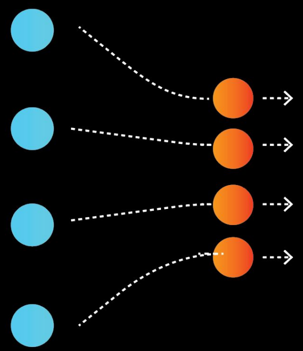
Mapped forces

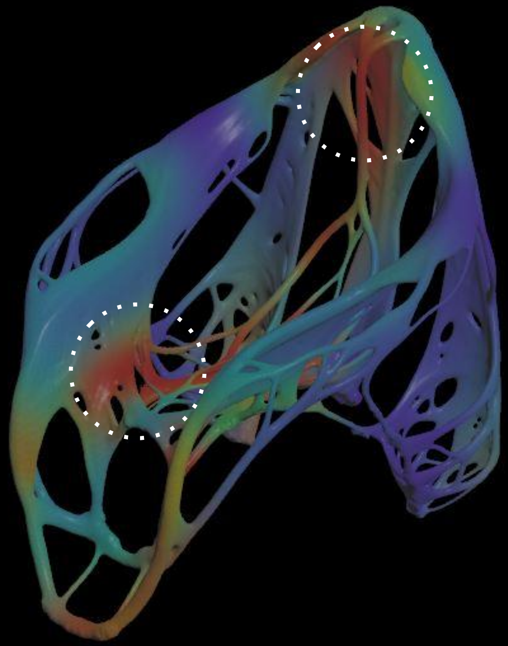
Stress map cohesion

Cohesion Radius **30**
Cohesion Multiplier **1.8**

0 1

Stress

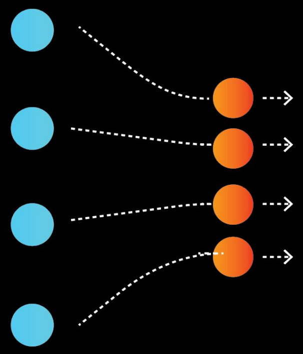


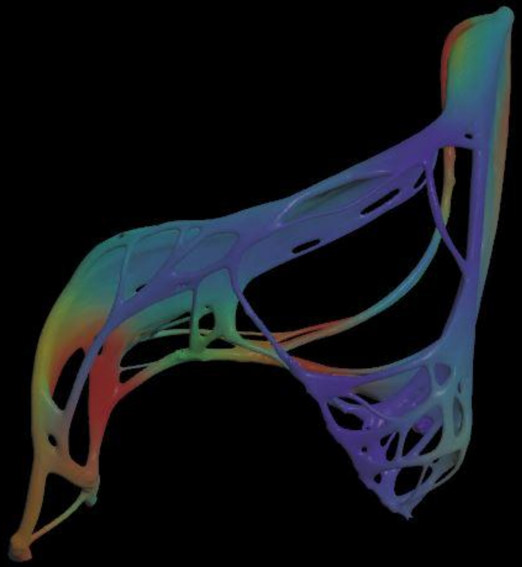


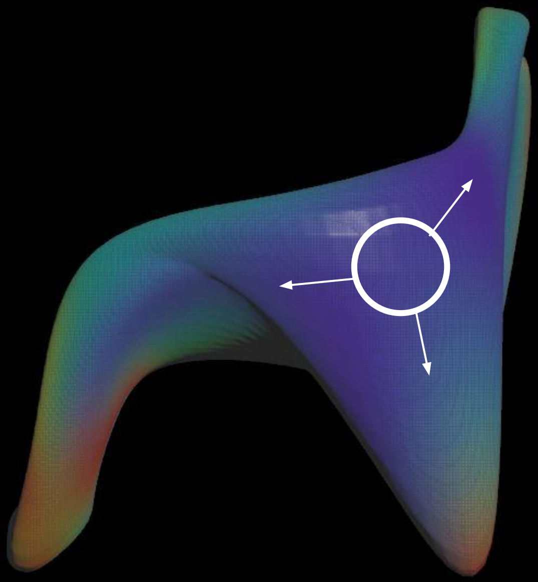
Cohesion Radius	**30**
Cohesion Multiplier	**1.8**

0 — 1

Stress







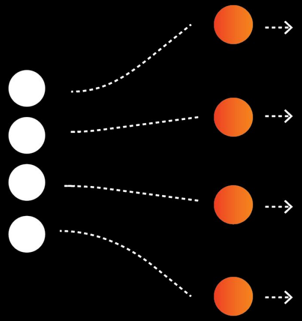
Mapped forces

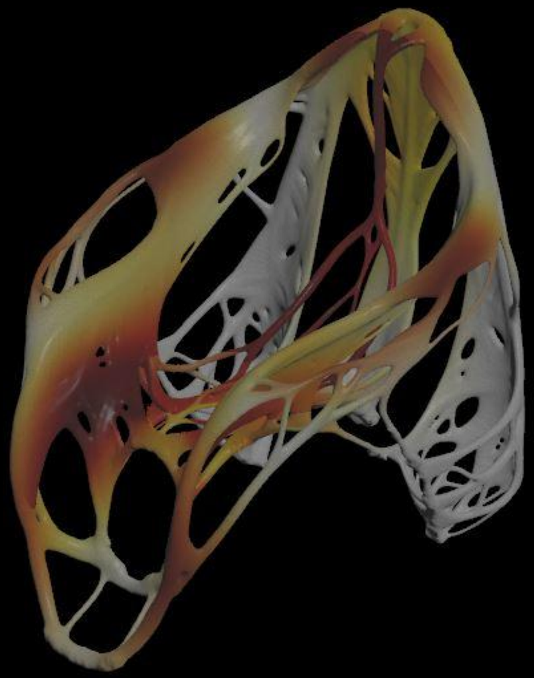
Body proximity separation

Separation Radius **40**
Separation Multiplier **1**

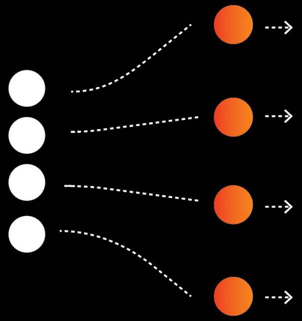
0 1

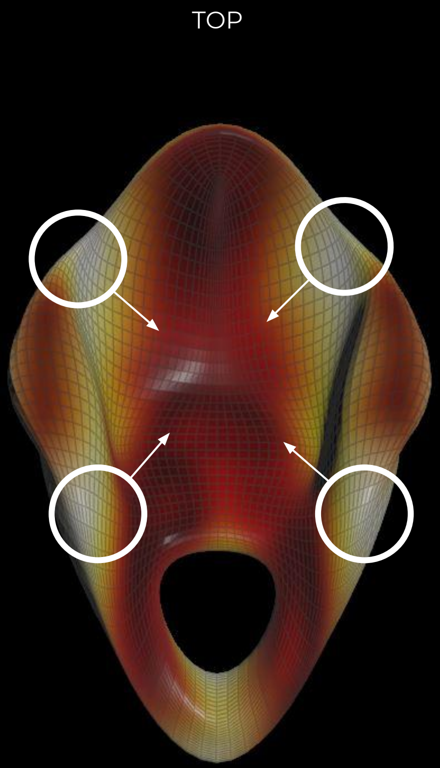
Body proximity



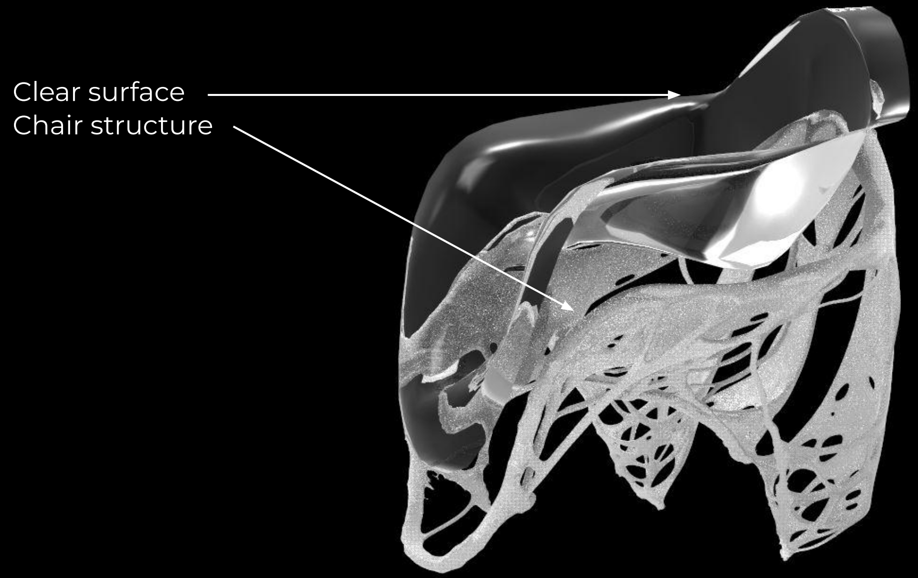


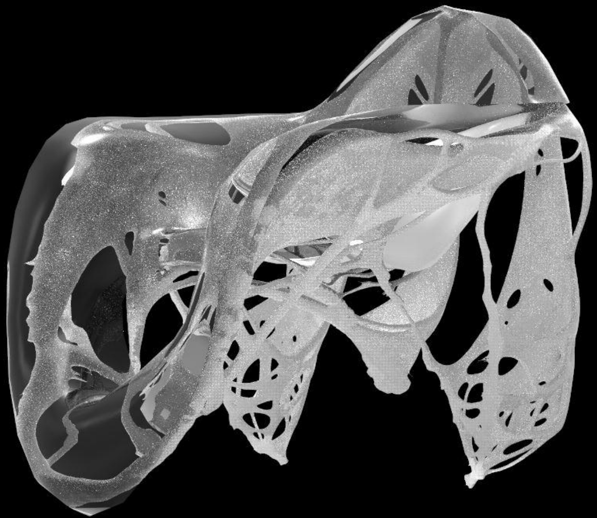
Separation Radius **40**
Separation Multiplier **1**





Material exploration





Thank You.

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SUMMER 2021

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MORPHOLOGICAL EXPERIMENTS BETWEEN FORM AND FORCE

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Architectural Association School of Architecture

Growth, Agency, and Adaptation

Lounge Chair

Ariel Weiss, Vinu Subashini Rajus
Dami Akinniyi, Bruno Marsino

Architectural Association
School of Architecture

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Initial thoughts

Idea of a chair:
- Well defined features of chairs (no arms)
- Modular
- Connection (emotional)/spatial relationship

Features
- Arm Rest, Seat, Backrest, Legs

Context: Outdoors
- Integration with the environment - contact with the ground
- MARS, Sky, Earth, Water

Earth	Underwater	Mars	Moon
Forces - Wind - Gravity - Sun - Rain	Forces - Buoyancy - Gravity - Currents - Life	Forces - Lower Gravity - Sandstorm / Windstorms	Forces - Lower Gravity

Goal:
Agents: What do we want the agents to do?
What drives the agent's decisions?
- Structure loads (function)
- Sustainable chair (Reduce the loads)

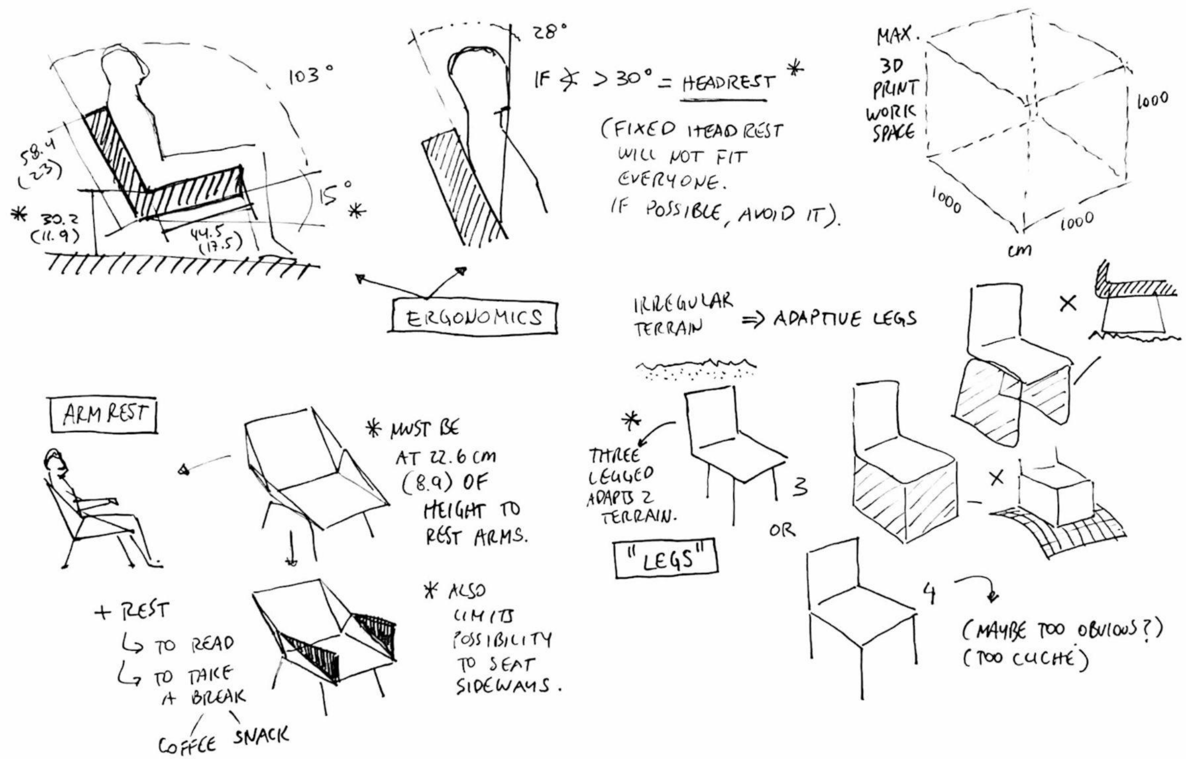
Notes:
- Growth simulation
- Cool renders

Agents
- Adapts to the environment

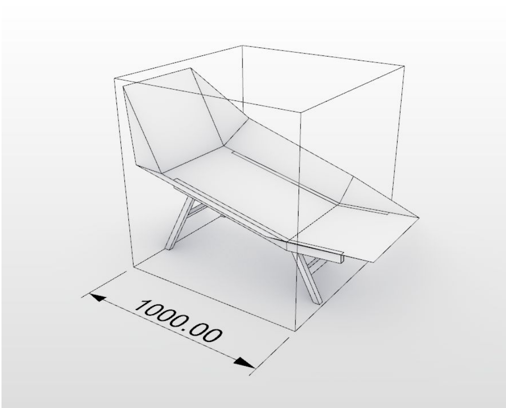
Fabrication
- Material thickness

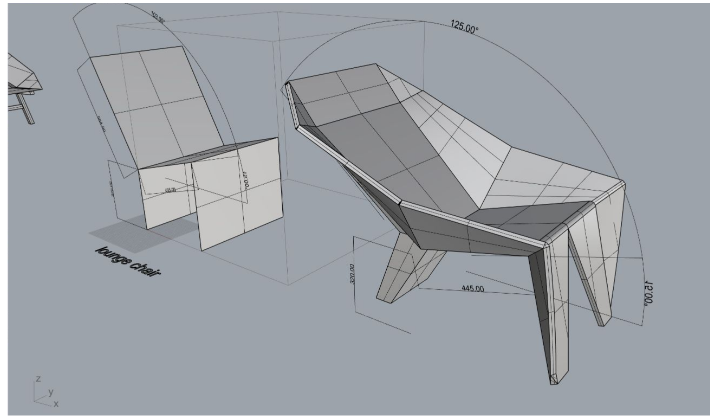
Base Form

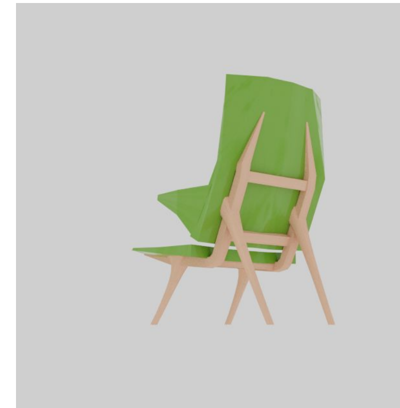
Initial Sketches

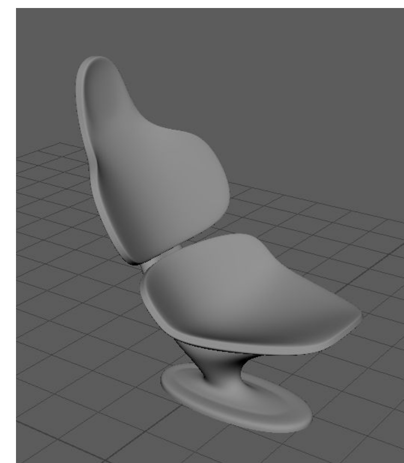


First Iterations









Base Chair Form

Two elements, modeled in Maya

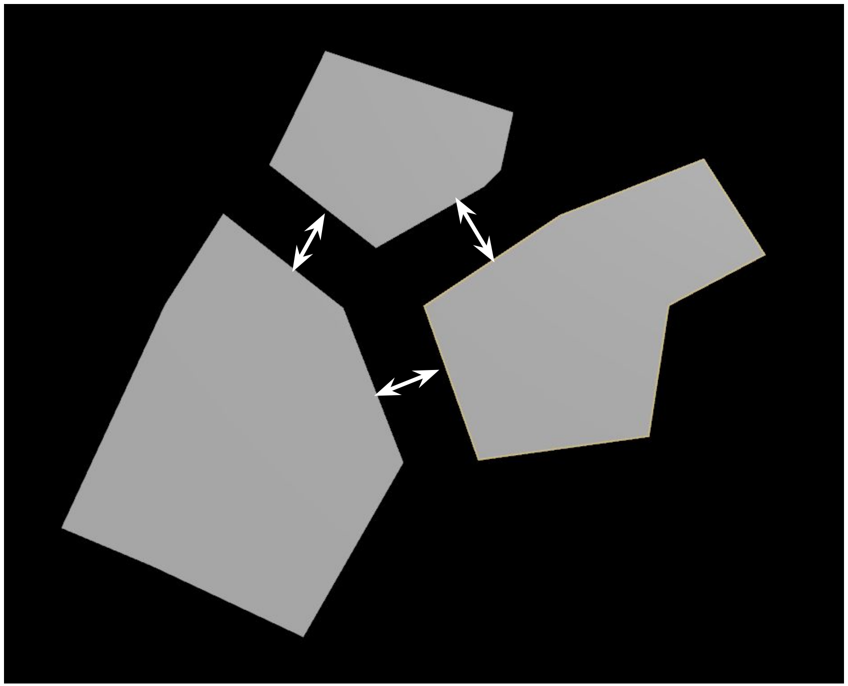
Single Leg Support

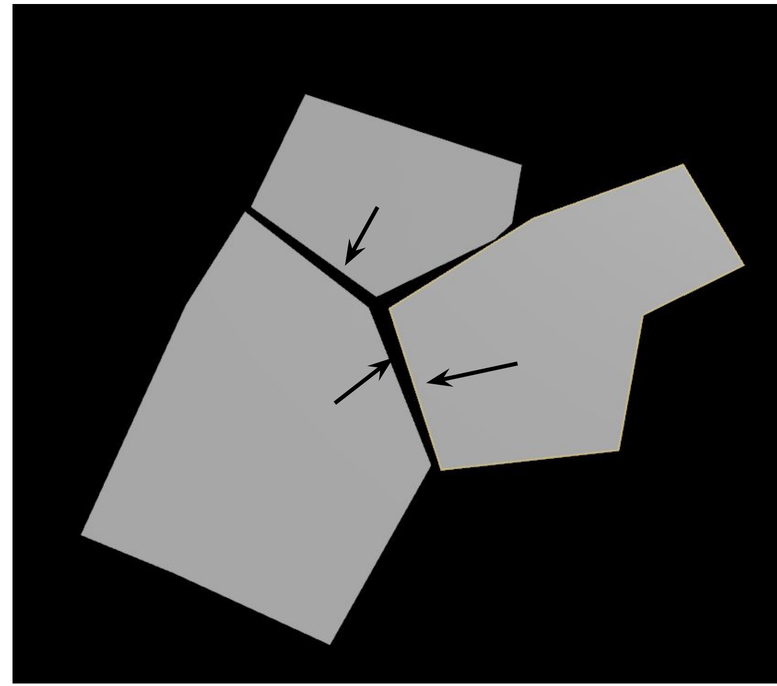
Typological Lounge Chair

Reclined Bucket Seating

Force Behavior - Mirror Spider

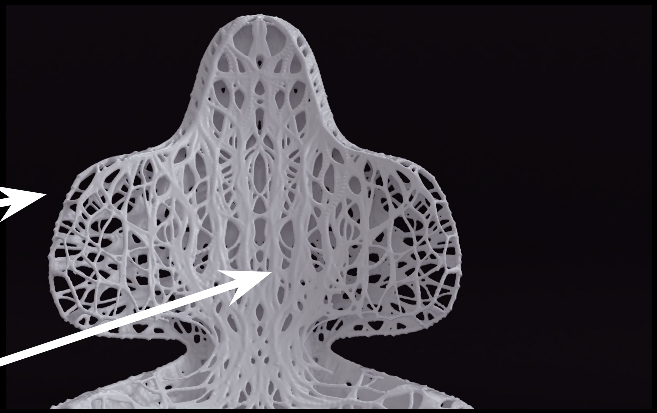
Force Behavior - Mirror Spider

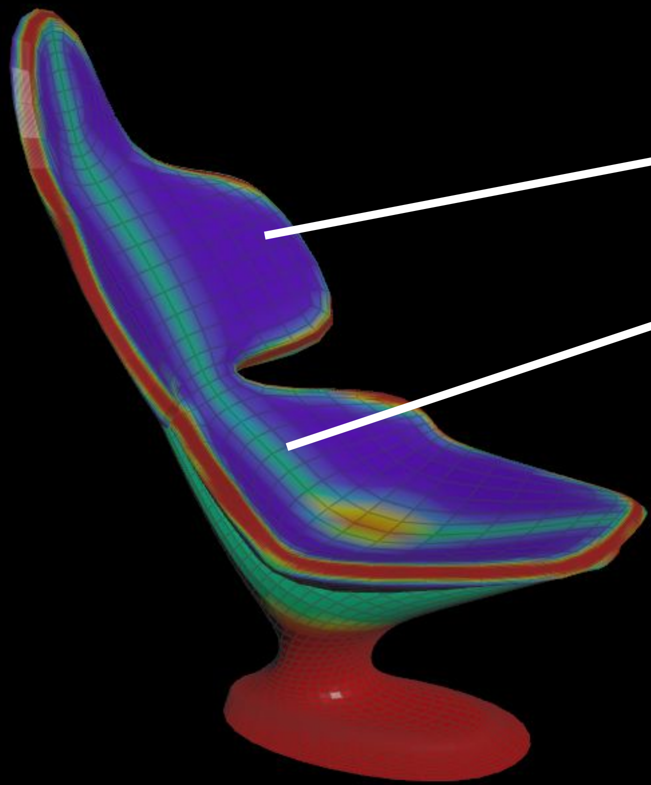




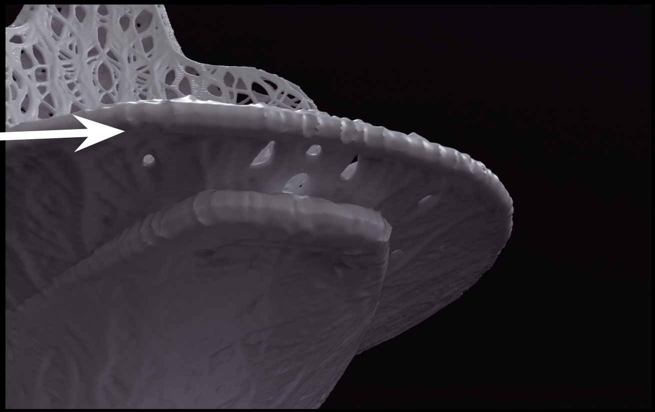
Force Behavior - Mirror Spider

Lower Stress Areas Create
Thinner Members





Simulated Stress Map



High Stress Areas Create
Thicker Members

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Force Behaviors

1 - Cohesion

2 - Separation

3 - Target

(1–3: Behavioural Forces)

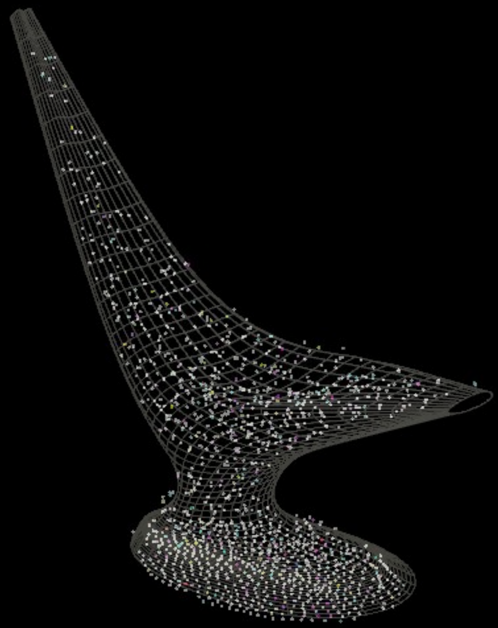
4 - Tangent Field

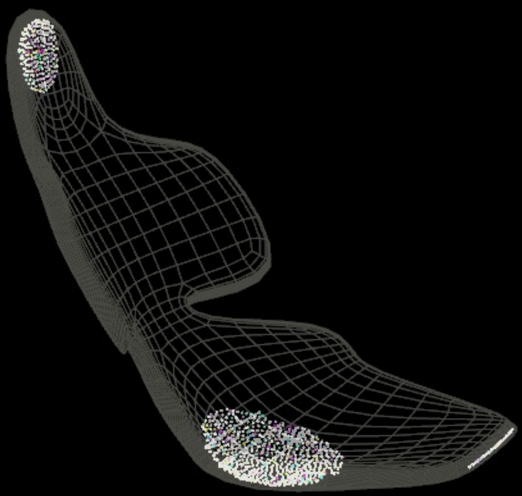
5 - Gradient Field

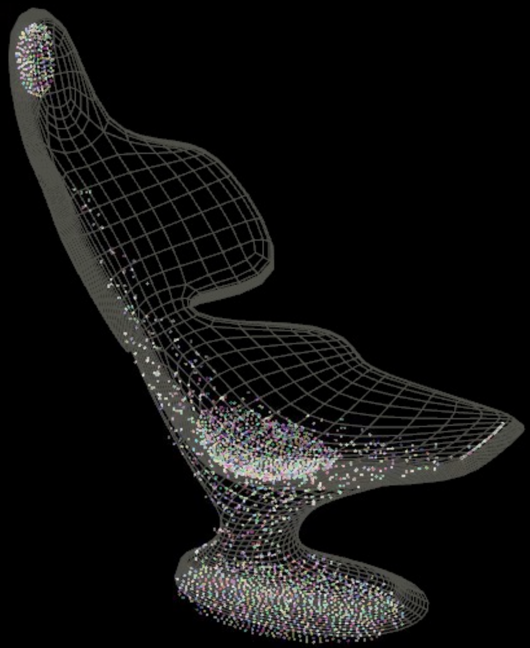
(4–5: Environmental Force Fields)

Agent Based Growth

Agents are spawned in response to form and intention







Volumetric Agents in The Base

- Agents are spawned in the volume in order to create interior structures
- More agents are spawned in order to create more mass for structural support

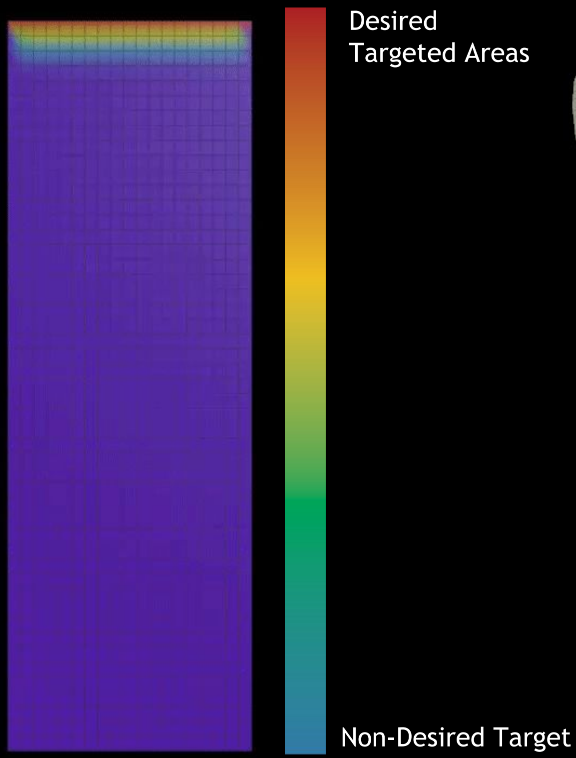
Surface Agents in The Seat

- Agents are spawned on the surface in order to create expressive void spaces
- Agents spawned in contact between the chair and the base

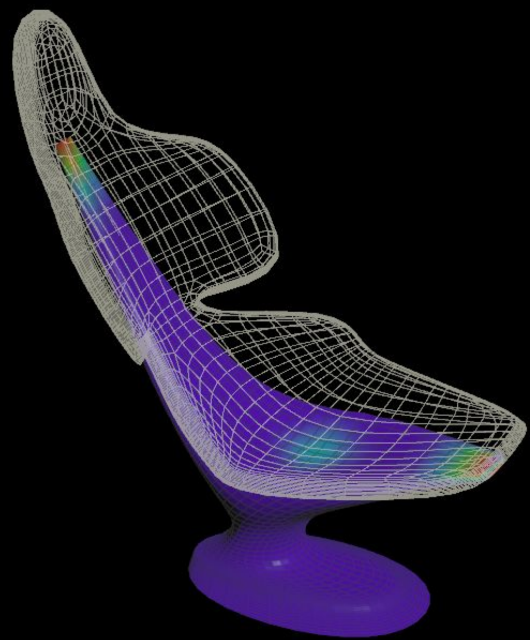
Initial Conditions Drive Intention

Target Force

Provides a desired destination for the agents to flock towards



Isolated Target Behaviour



Target Positions on Geometry

Agent Flocking Towards Targets
On Geometry

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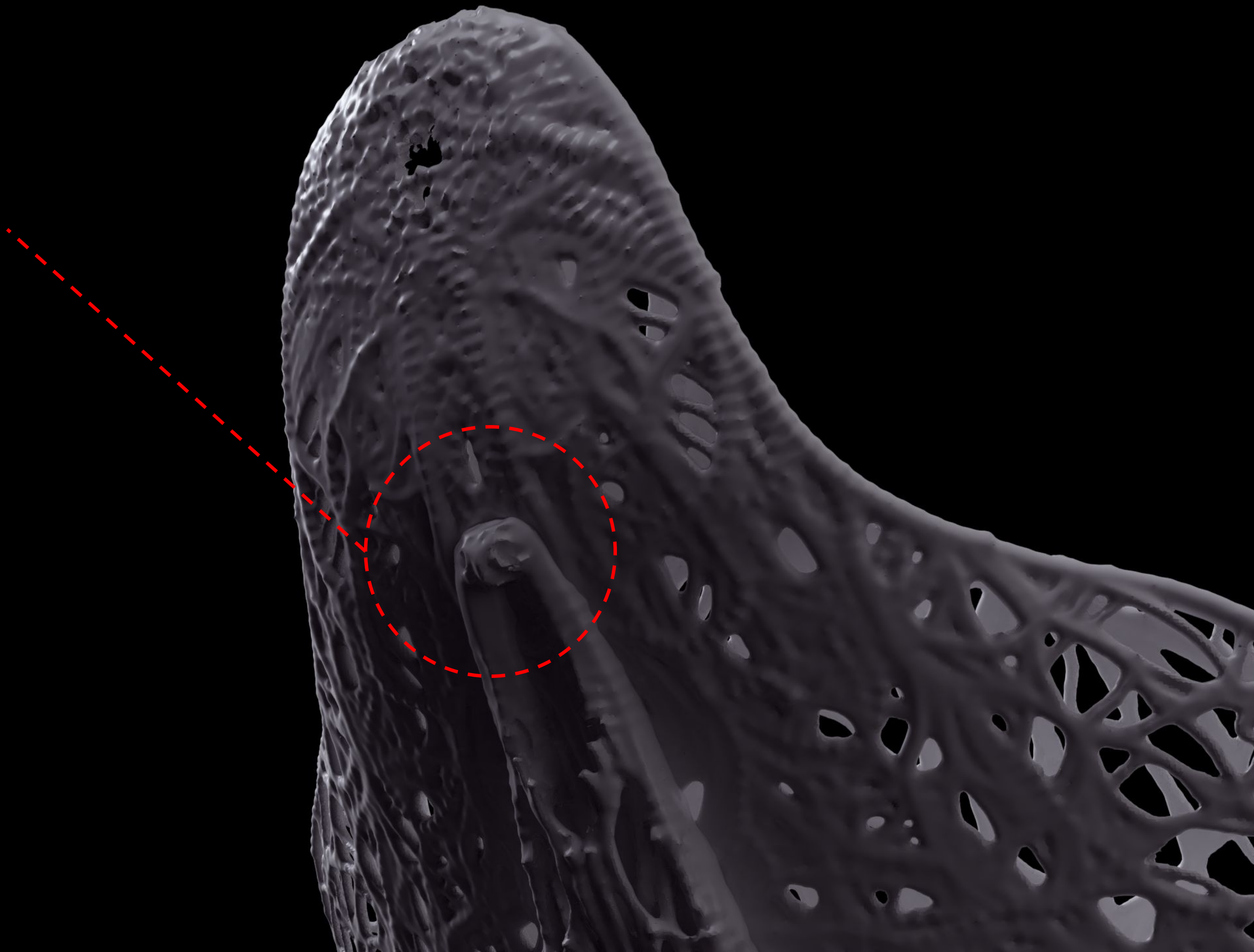
Targeted Point

Target Multiplier = 1

Cohesion Multiplier = 0.6

Separation Multiplier = 0.2



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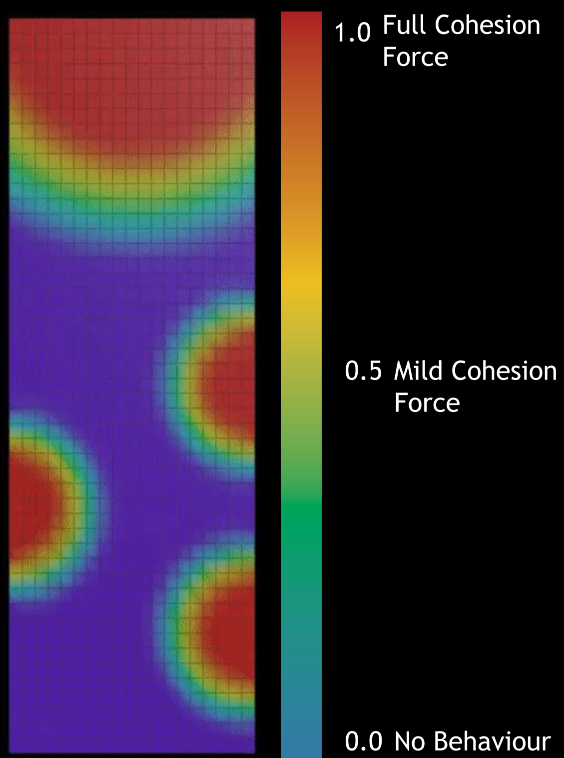
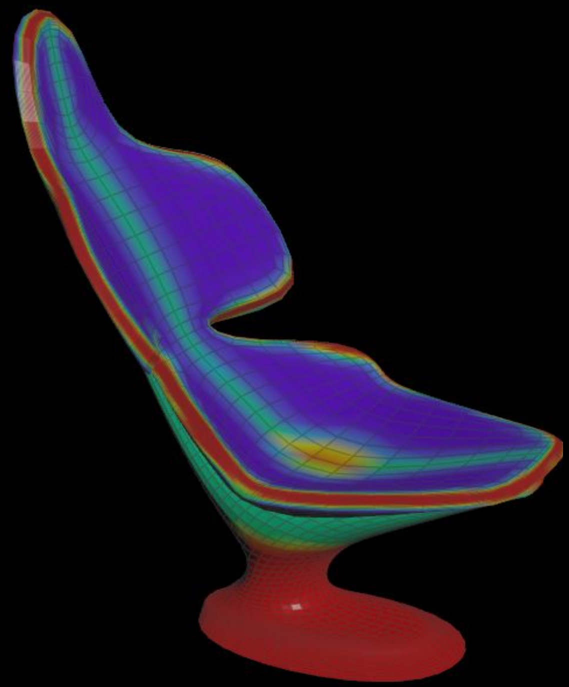
Cohesion Force

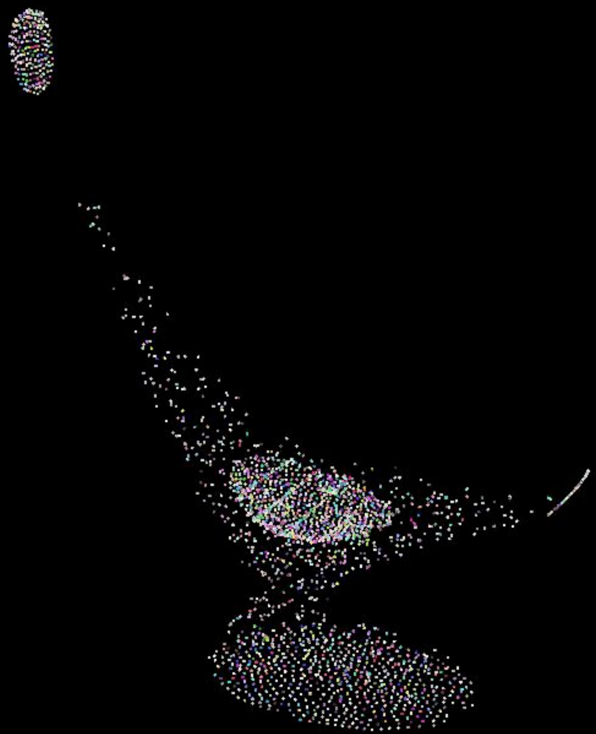
Drives the cohesion of agents flocking towards each other



Isolated Cohesion Behaviour



Cohesion Positions on Geometry



Agents Flocking Towards Highest Cohesion Points On Geometry

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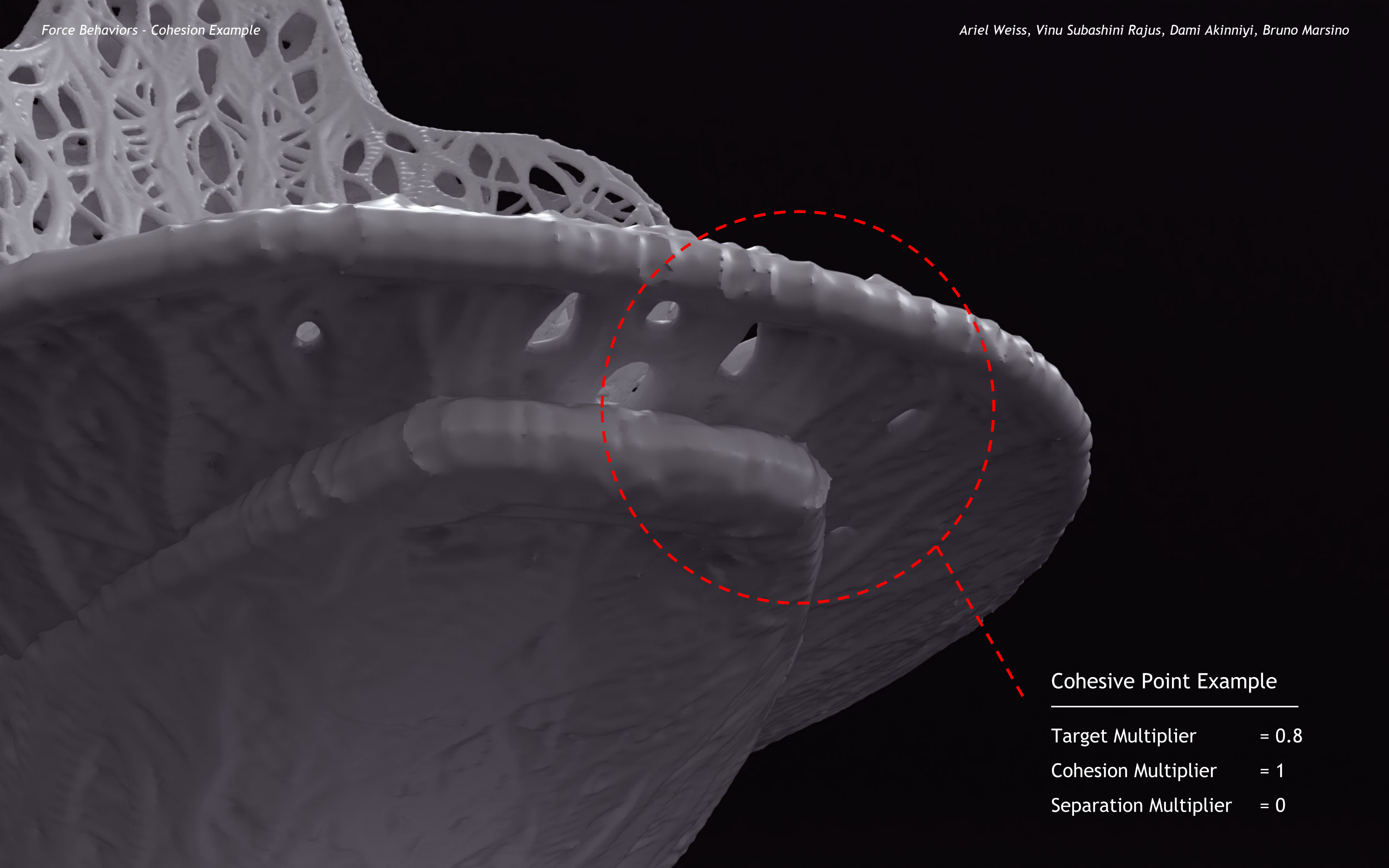

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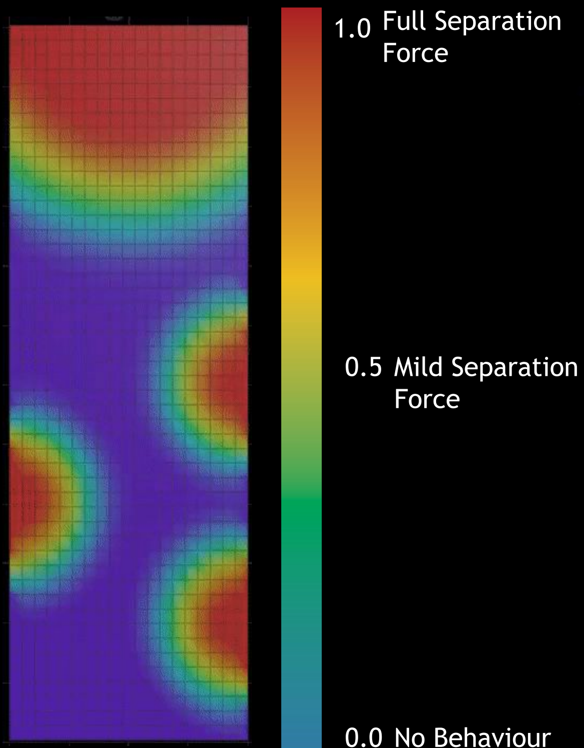
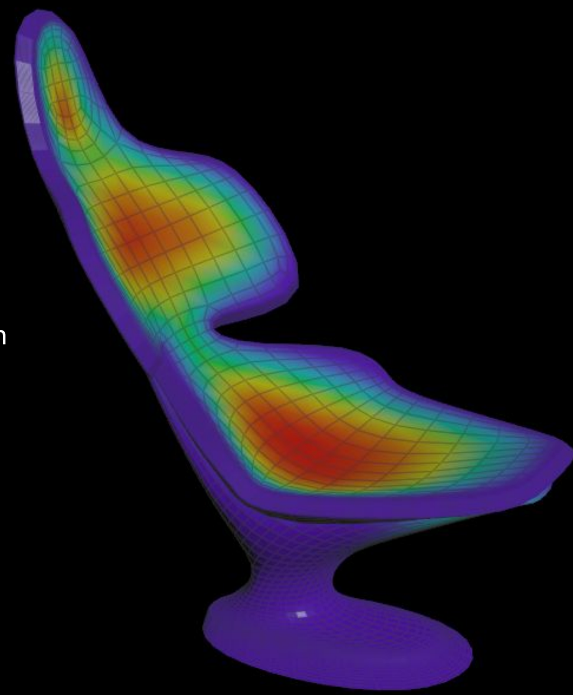
Seperation Force

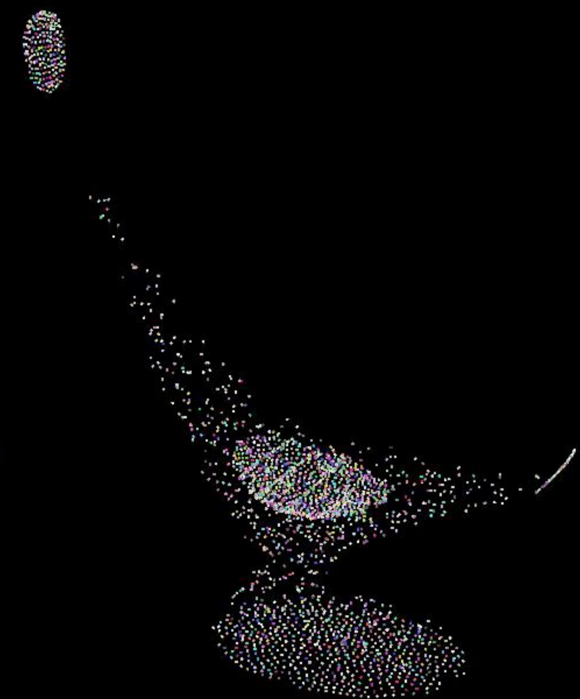
Drives the separation of agents flocking away from each other



Isolated Separation Behaviour



Separation Positions on Geometry



Agents Scattering in Highest Separation Points On Geometry

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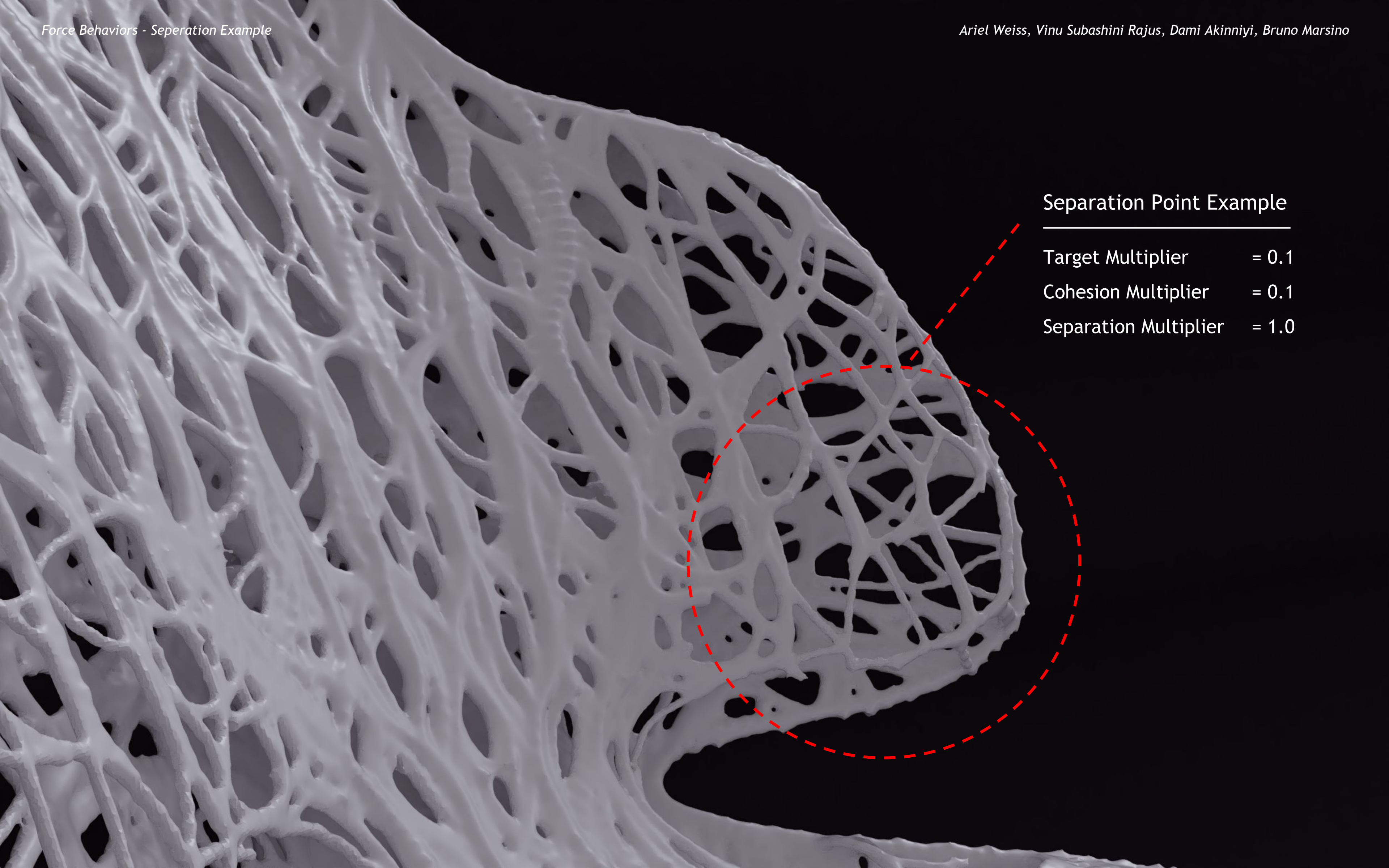

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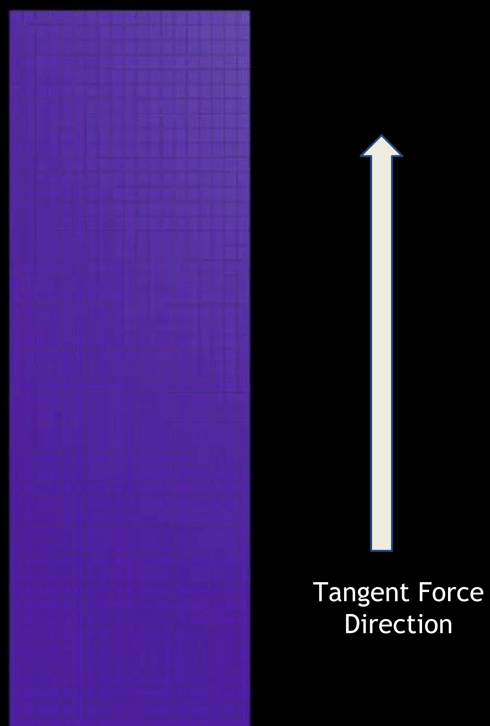
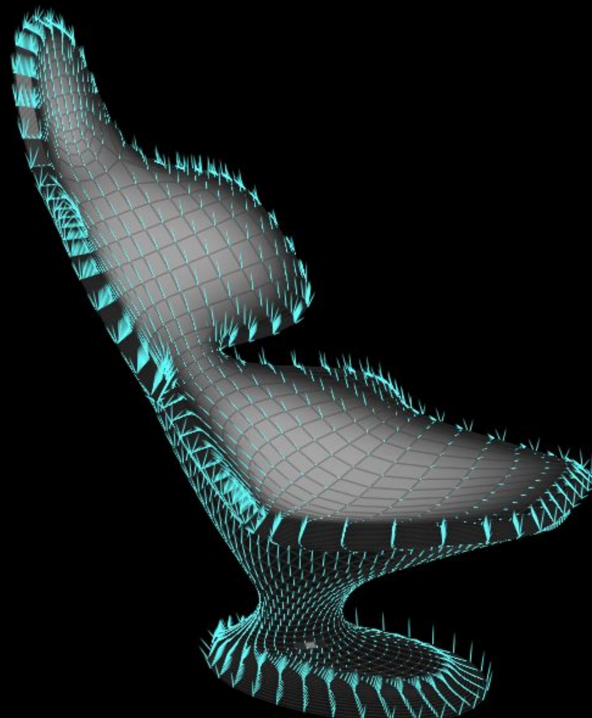
Tangent Field Force

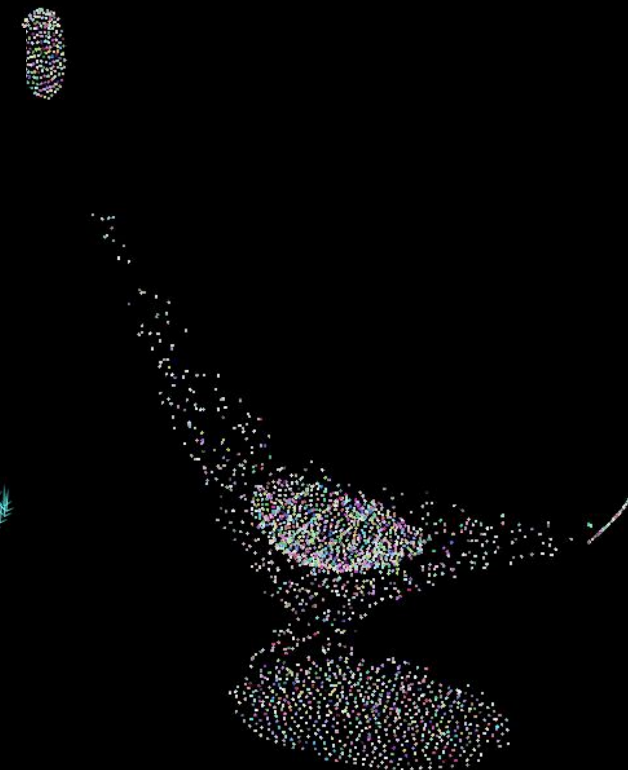
Creates a general direction flow for the flock to follow



Isolated Tangent Force Direction Behaviour



Tangent Directions on Geometry



Agents Aligning Towards Tangent Directions On Geometry

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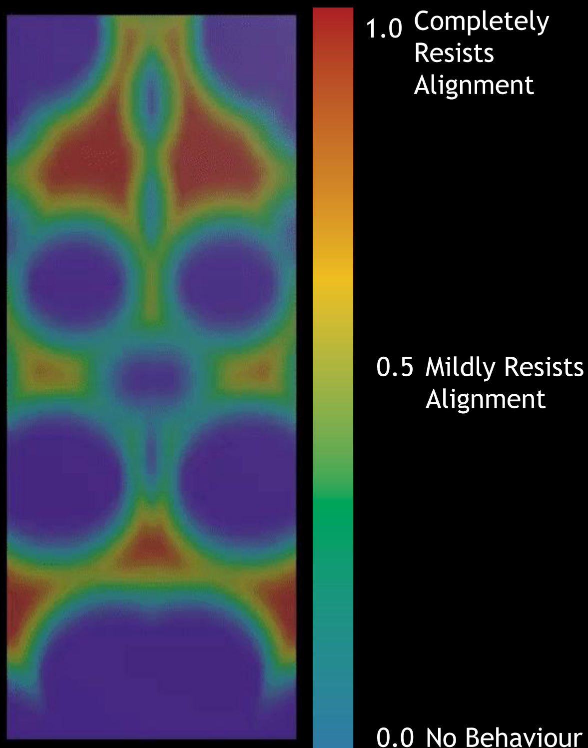
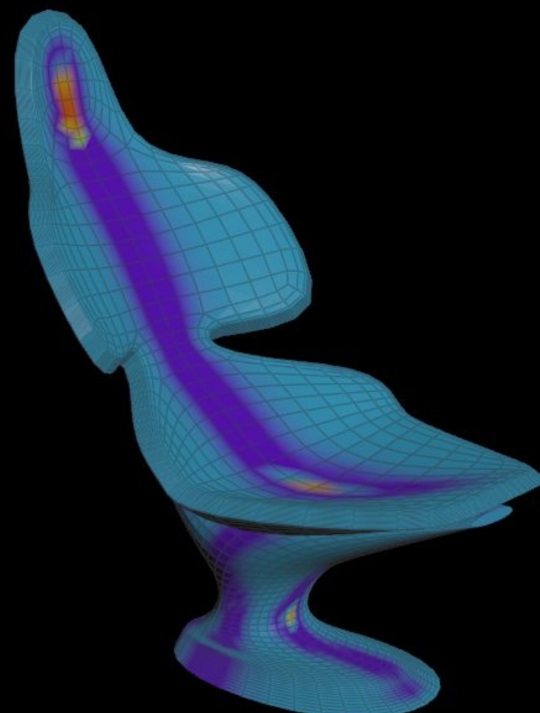
Gradient Field Force

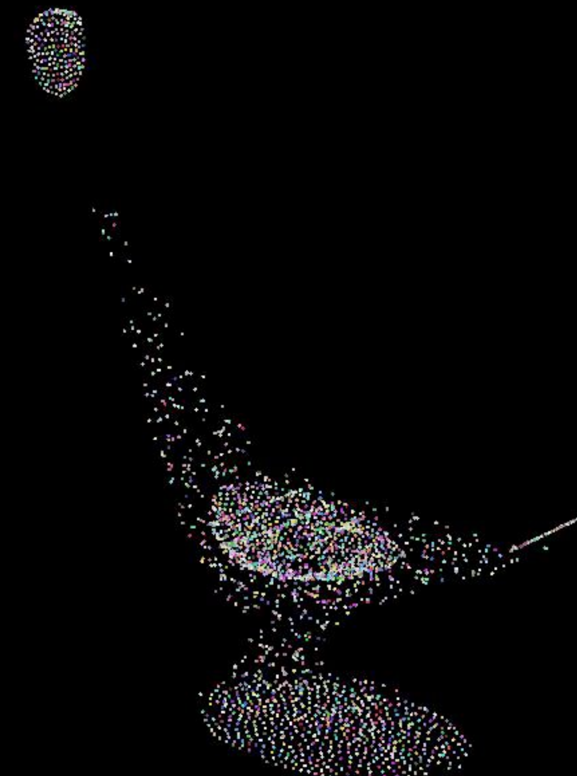
Creates a directional grid for flocking agents to align with



Isolated Gradient Field Behaviour



Gradient Field Positions on Geometry



Agents Aligning in Least Resistant Paths Of Geometry

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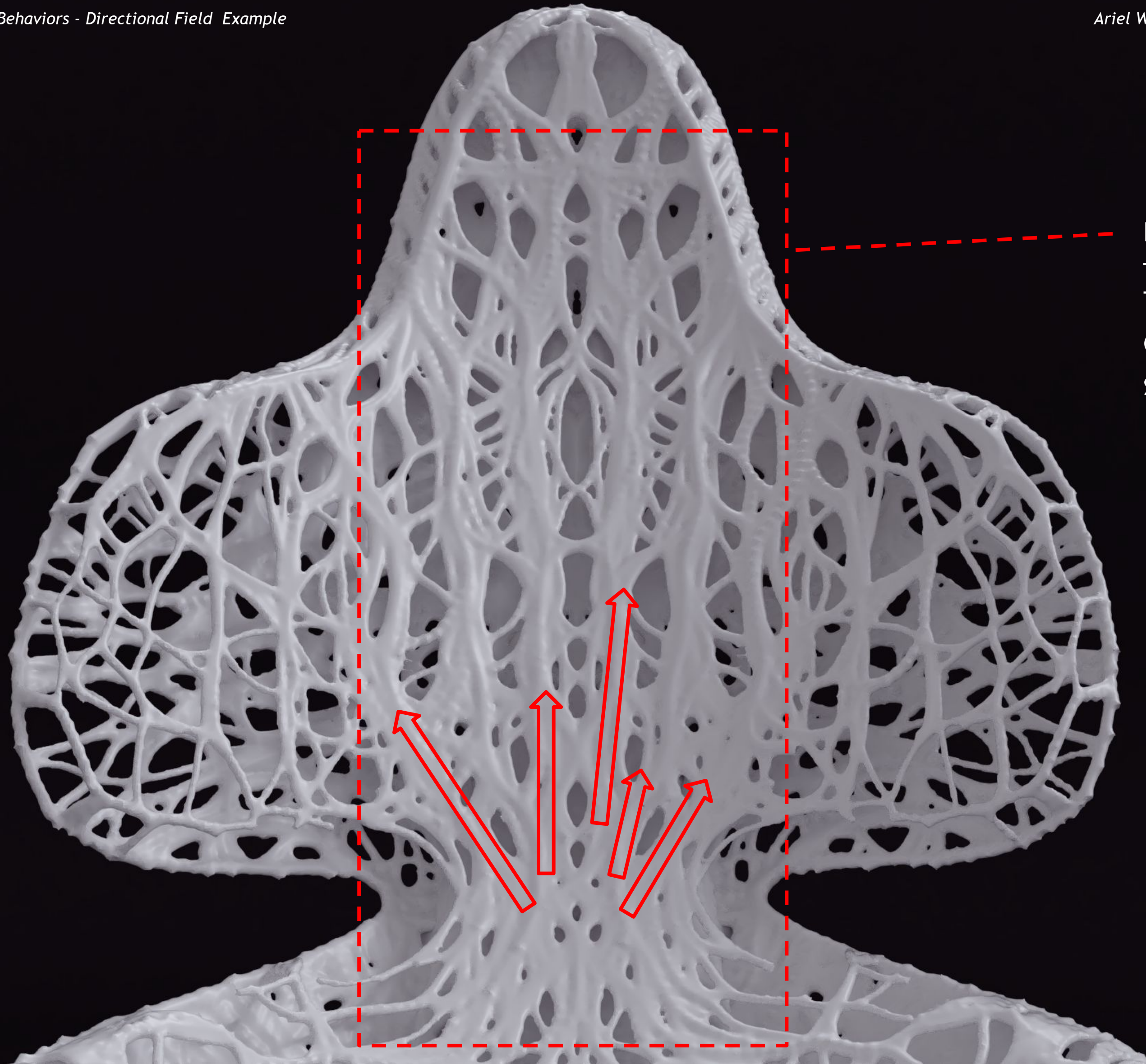


Directional Field Example

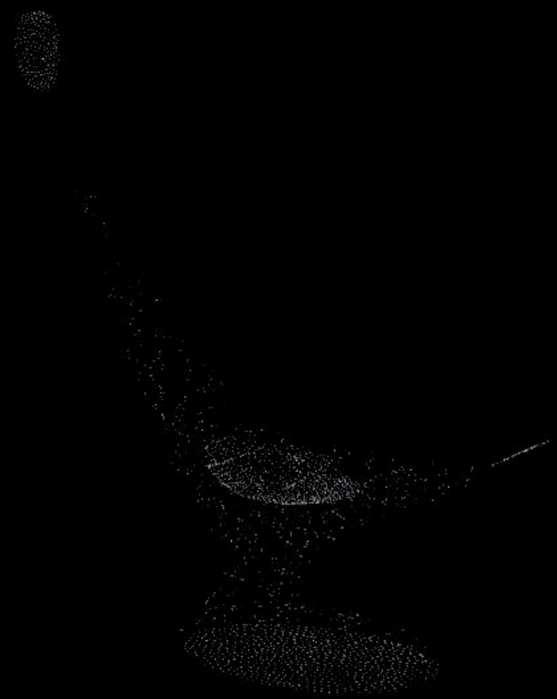
Target Multiplier = 0.3 -> 0.5

Cohesion Multiplier = 0.1 -> 0.3

Separation Multiplier = 0.6 -> 1.0

Resulting Agent Simulation

Individual Agent Growth



Agent Path Growth

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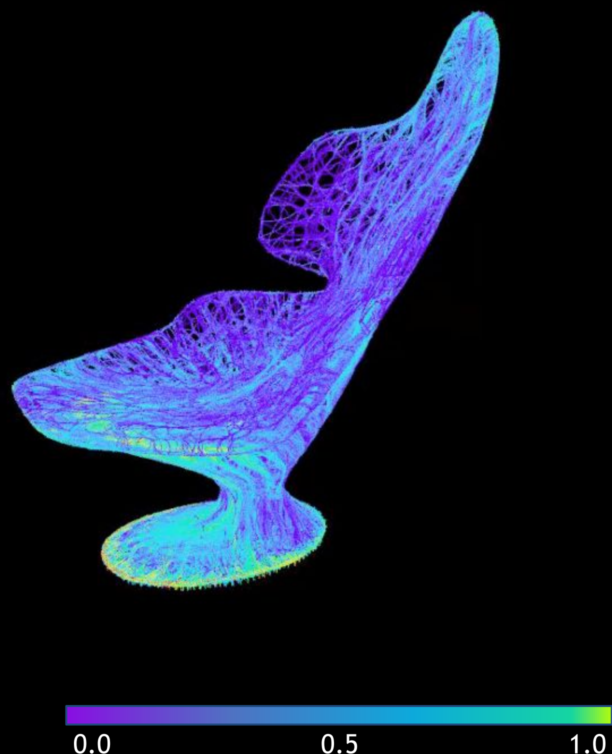
Resulting Agent Paths

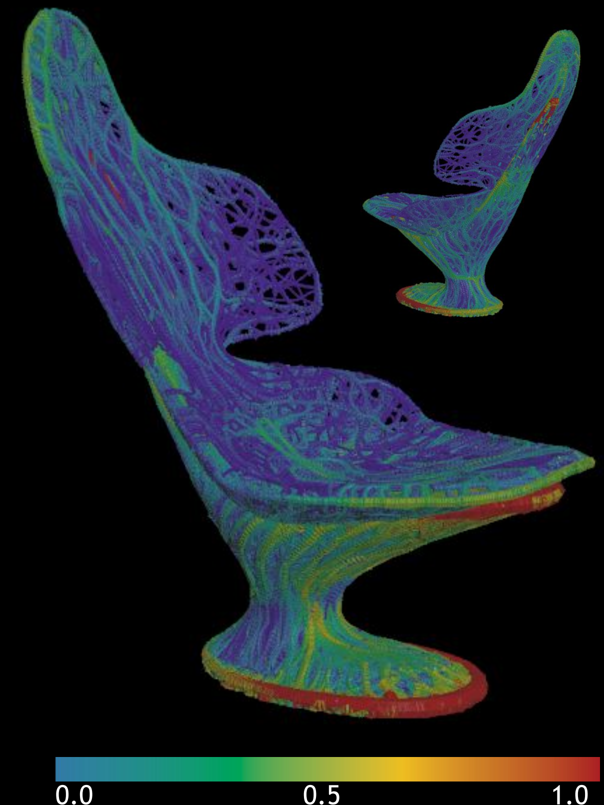
Result from kernel density based edge bundling

Parameters Used for Growth

Max Speed	**2**
Max Force	**0.12**
Search Radius	**150**
Separation Radius	**40**
Separation Multiplier	**1.2**
Cohesion Radius	**20**
Cohesion Multiplier	**0.3**
Aligment Radius	**15**
Alignment Multiplier	**0.35**
Vector Field Multiplier	**0.3**
Target Follow Weight	**0.5**
Volume Containment Multiplier (Only for Leg)	**0.15**
Number of Agents (Leg)	**700**
Number of Agents (Seat)	**1000**



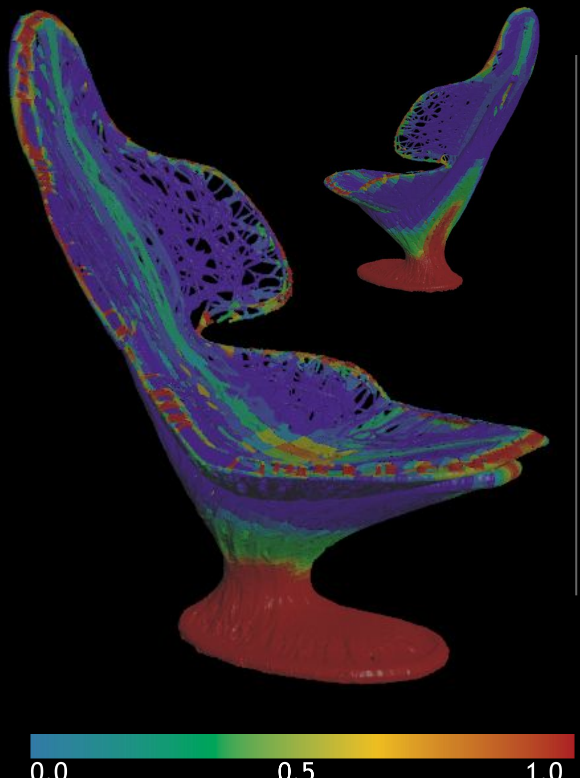
Result Curves - Density Visualization



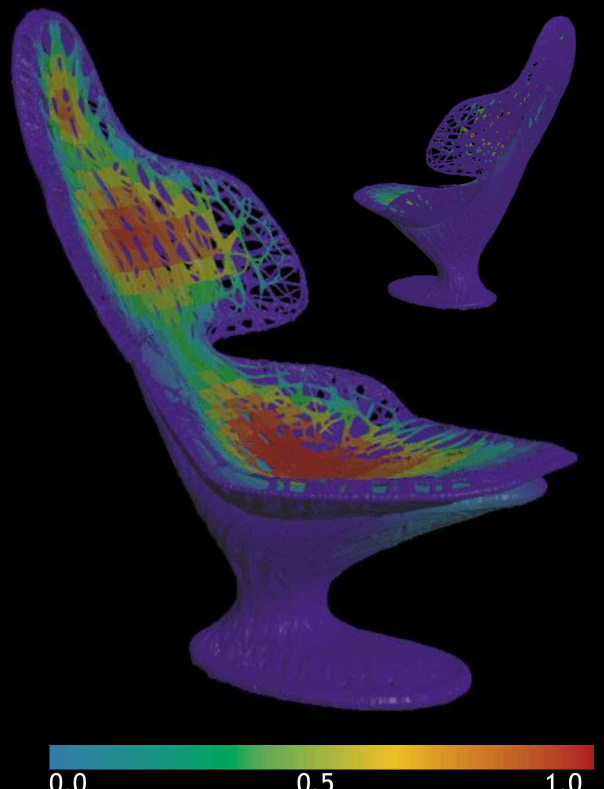
Result Pipes - Density Visualization

Ariel Weiss, Vinu Subashini Rajus, Dami Akinniyi, Bruno Marsino

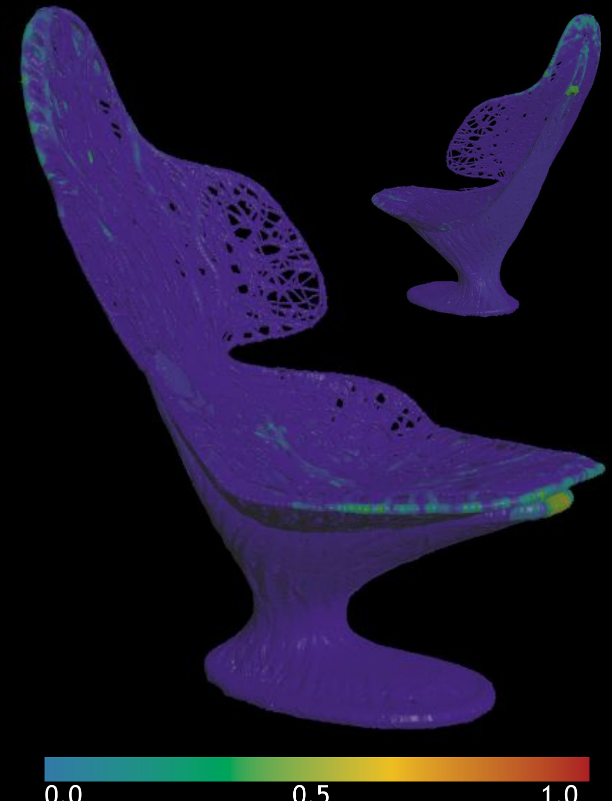
Behavioural Force Visualization



Cohesion - Stress Force Visualization

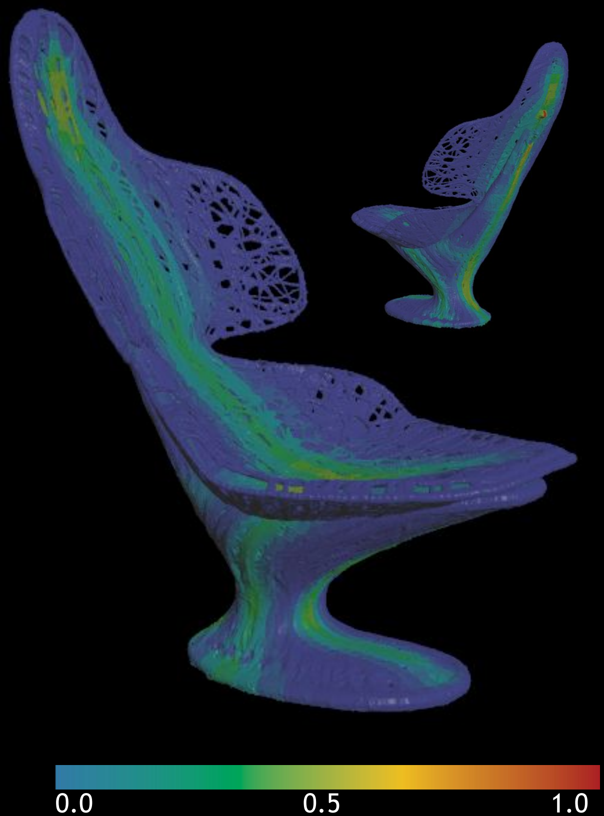


Separation - Contact Force Visualization

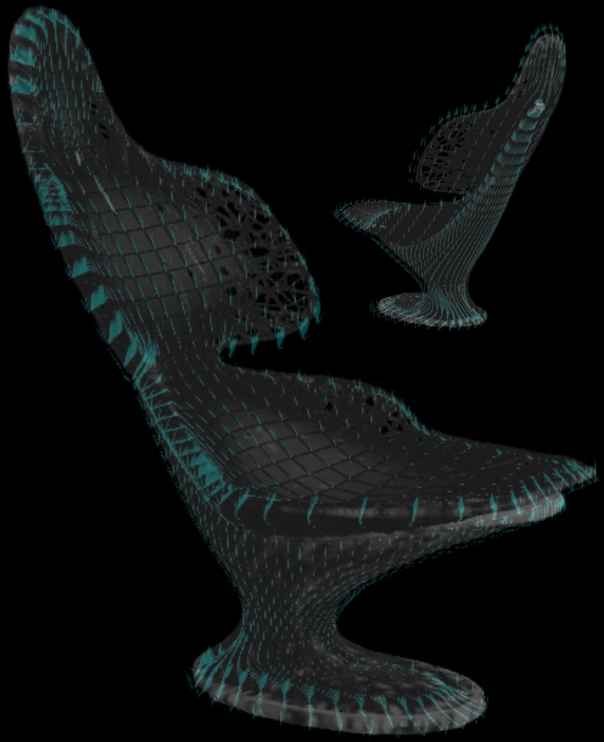


Targets - Desired Force Visualization

Environmental Force Visualization



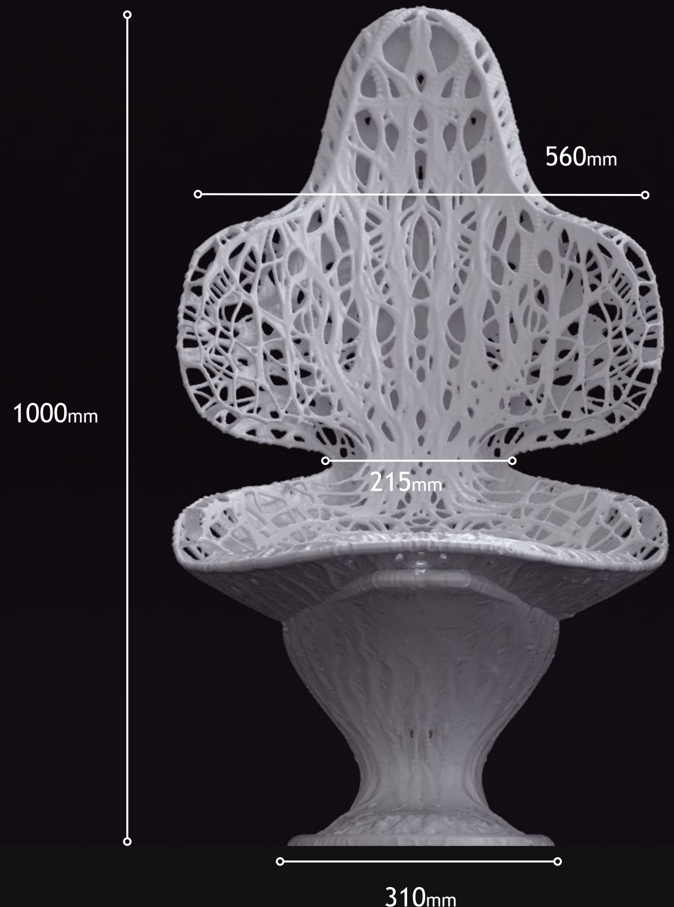
Gradient Field - Alignment Force Visualization

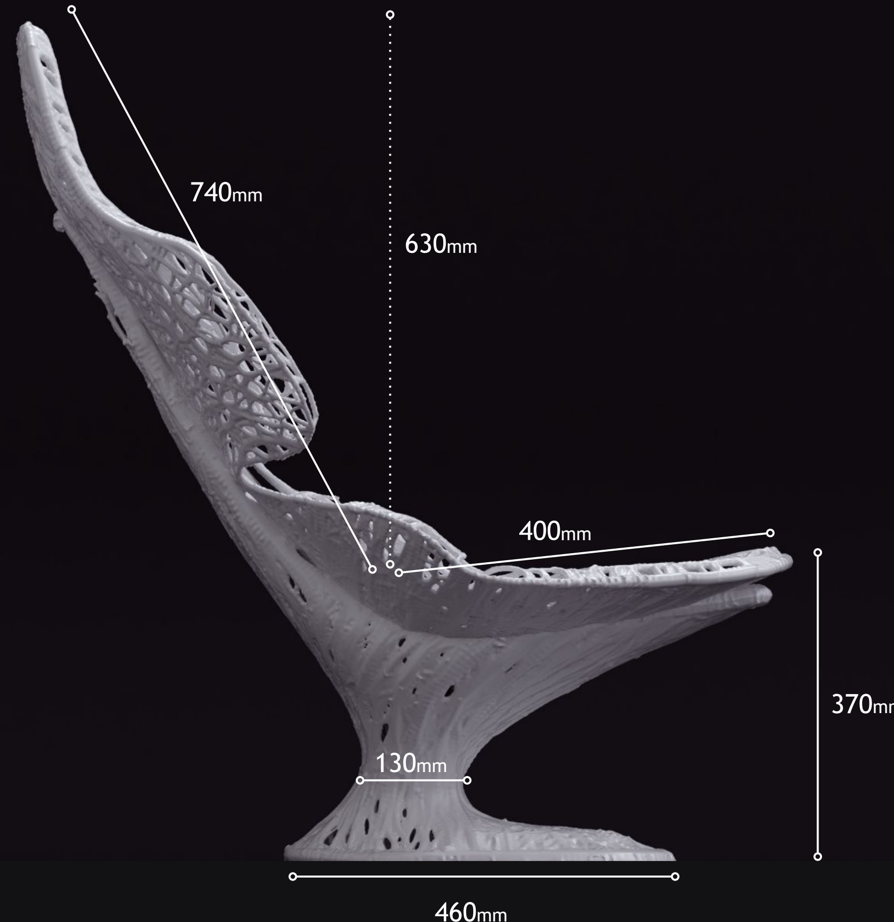


Tangent Field - Directional Force Visualization

Ariel Weiss, Vinu Subashini Rajus, Dami Akinniyi, Bruno Marsino

Chair Dimensions *(mm)*





Ariel Weiss, Vinu Subashini Rajus, Dami Akinniyi, Bruno Marsino

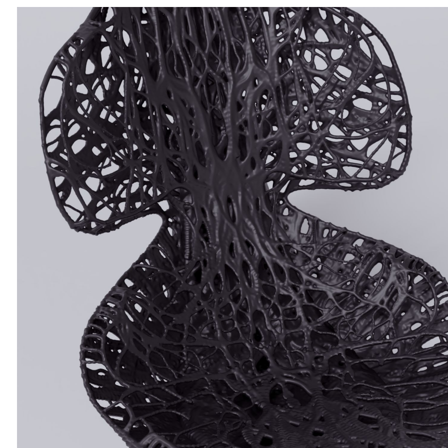
The End

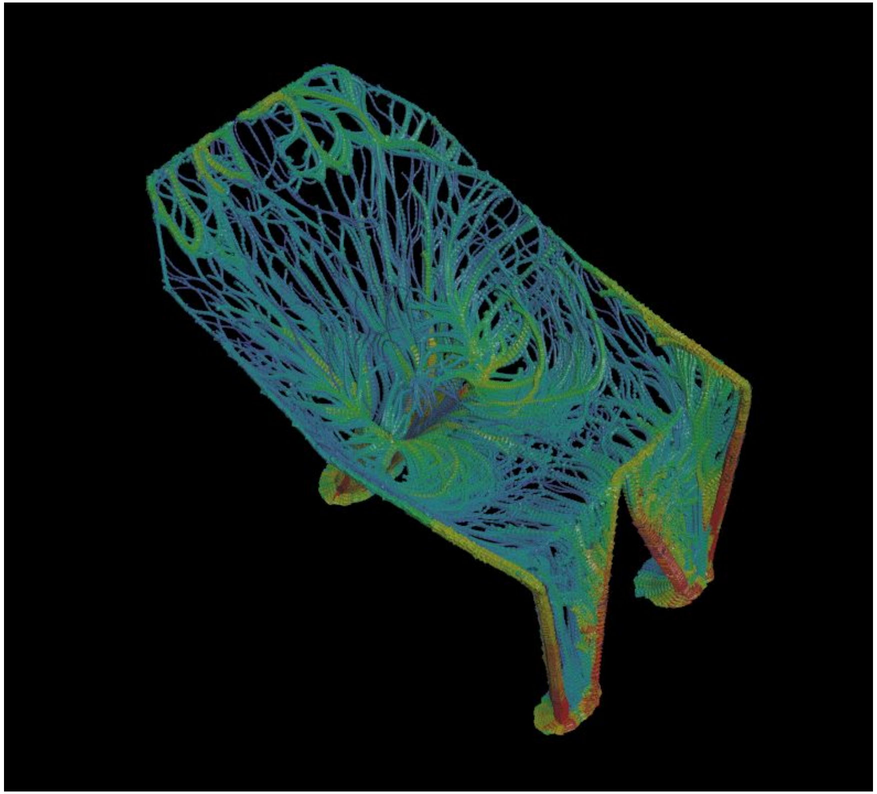
Extra Slides...

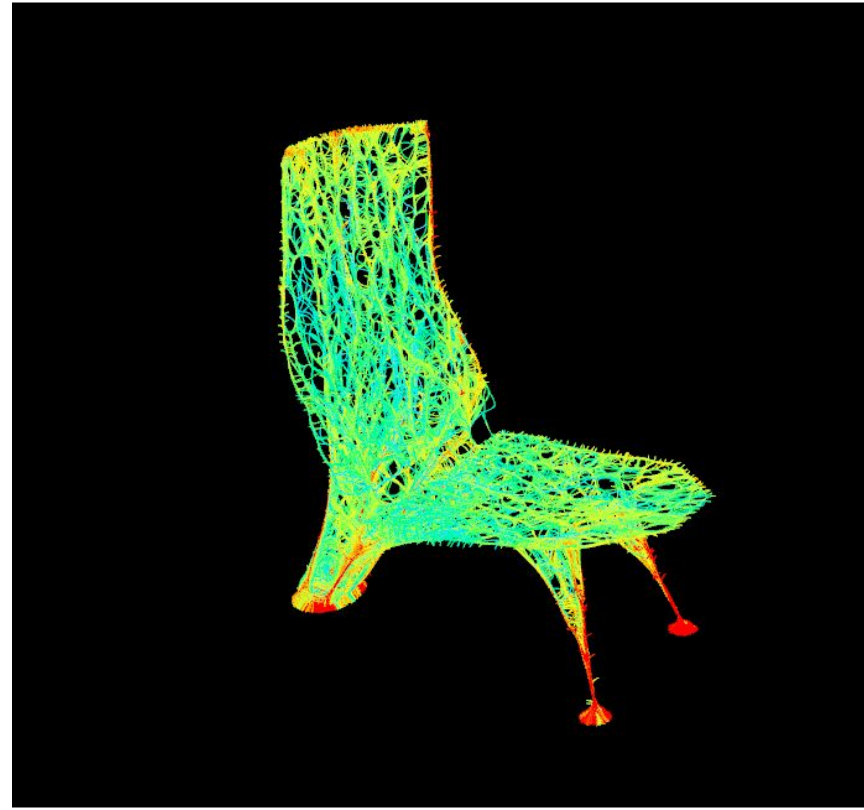




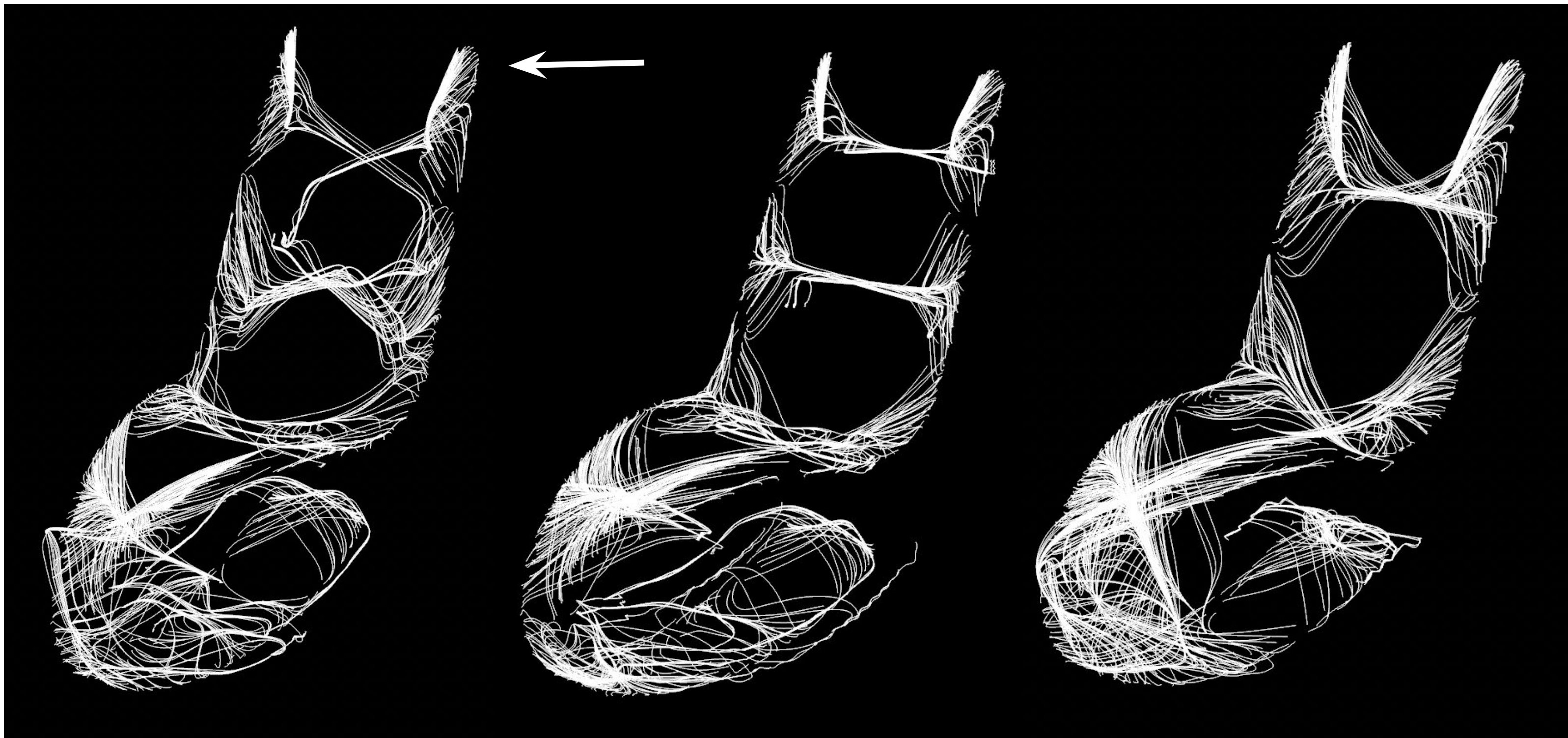






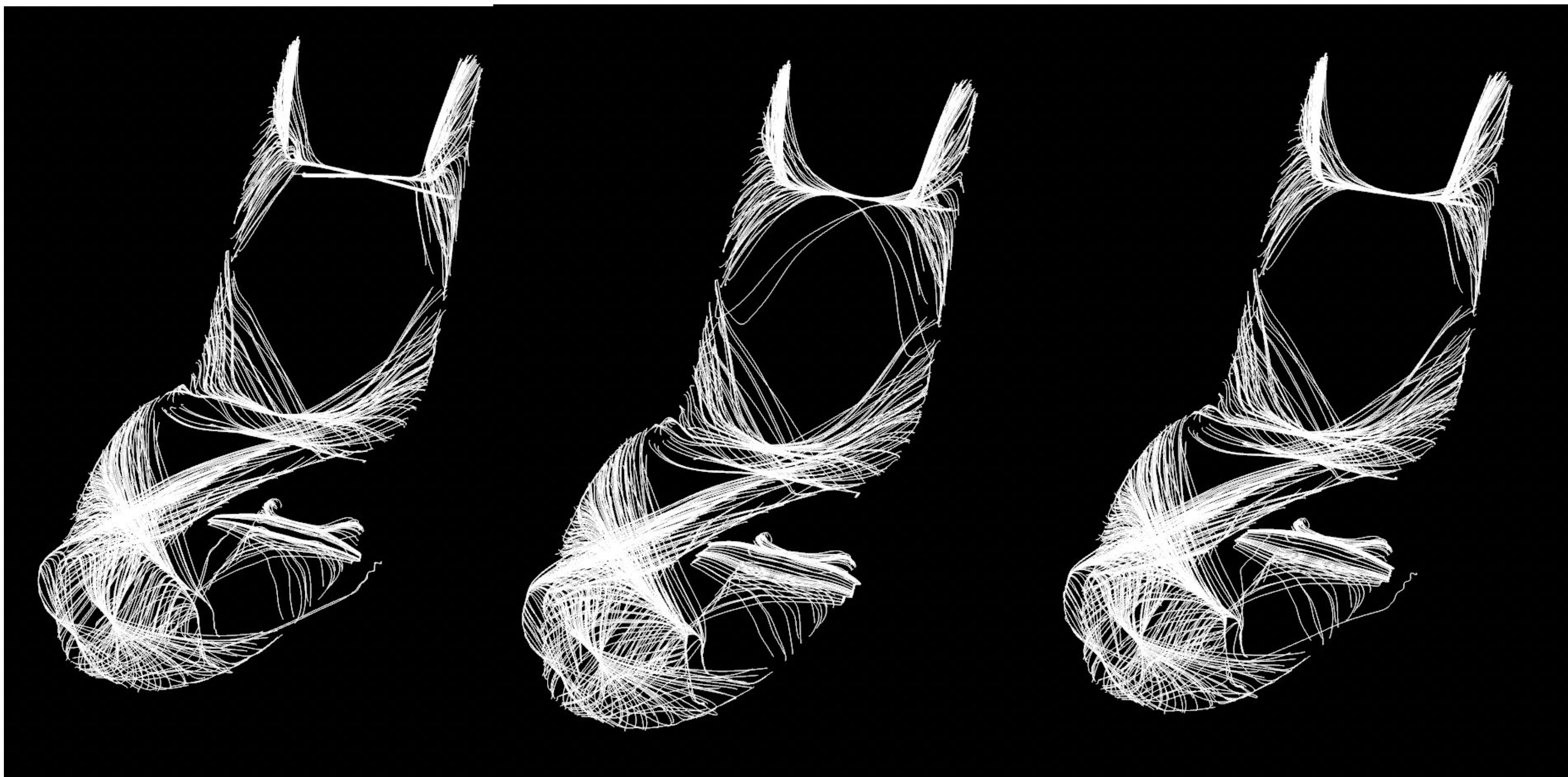


Force Behavior exploration - Cohesion



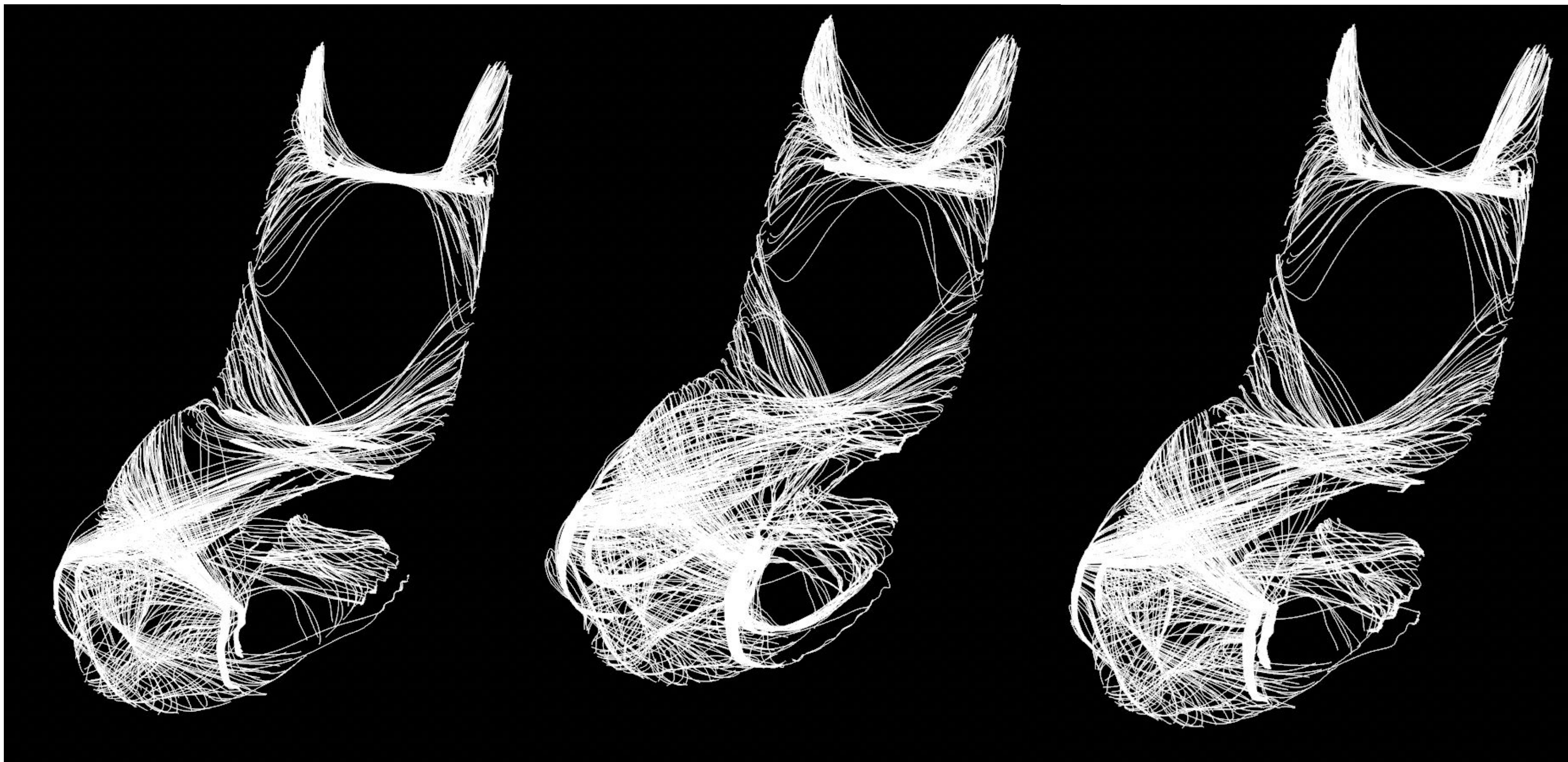
Cohesion Radius	0.0	0.0	0.0
Cohesion Multiplier	0.0	0.0	0.0

Force Behavior exploration- Alignment



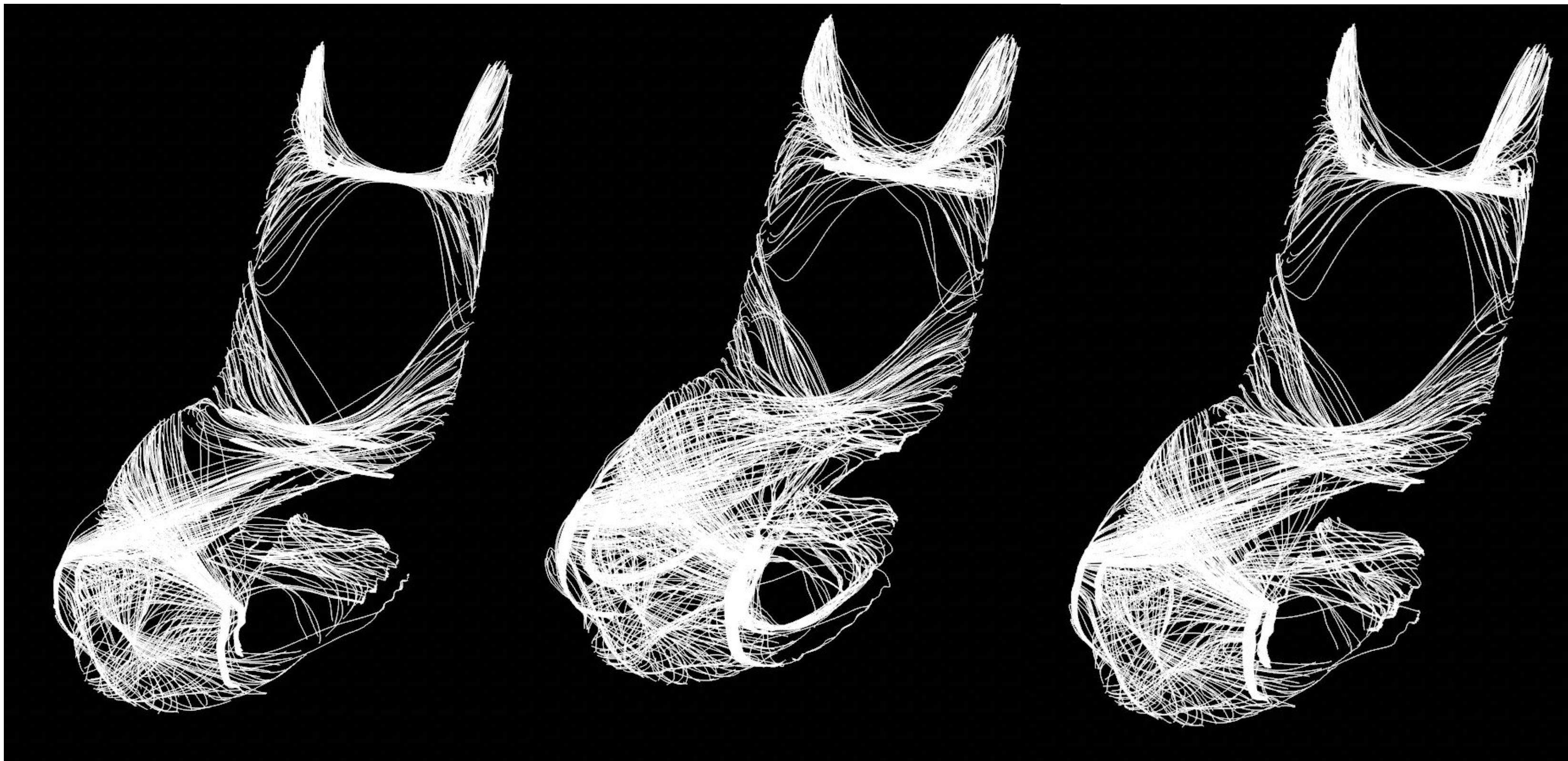
Alignment Radius	0.0	0.0	0.0
Alignment Multiplier	0.0	0.0	0.0

Force Behavior exploration- Separation



Separation Radius	0.0	0.0	0.0
Separation Multiplier	0.0	0.0	0.0

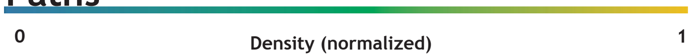
Force Behavior exploration- Target

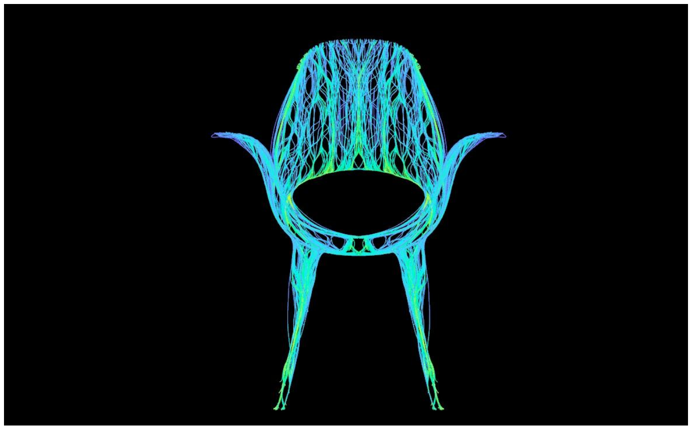


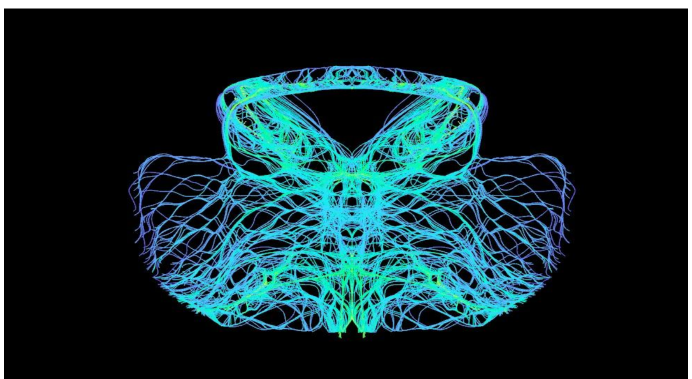
Target Follow Weight 0.0 0.0 0.0



Agent Paths

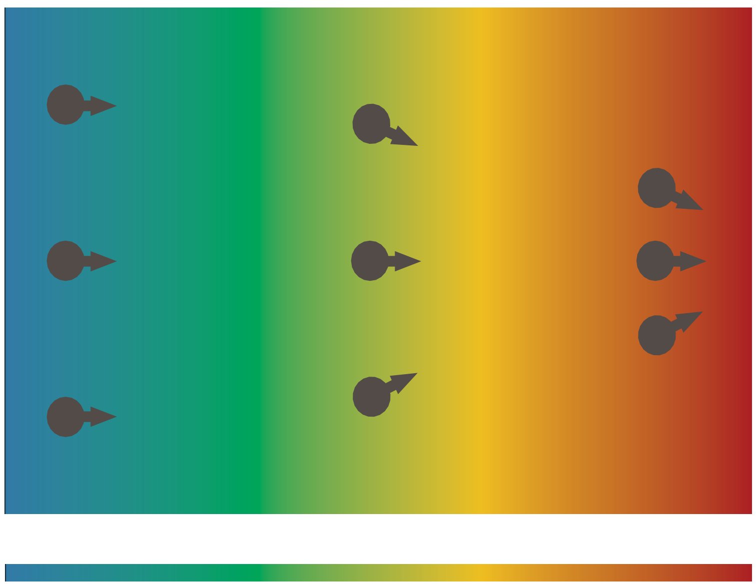




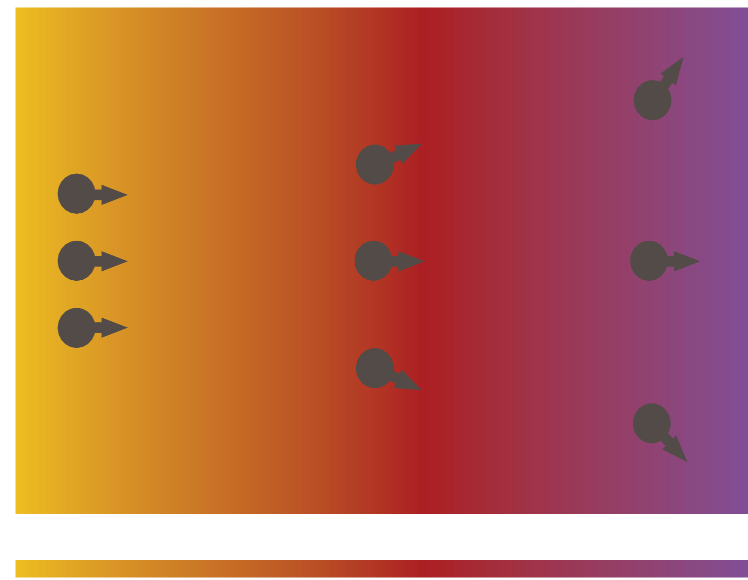


Max Speed	3
Max Force	0.35
Search Radius	50
Separation Radius	40
Separation Multiplier	1.5
Cohesion Radius	35
Cohesion Multiplier	1.2
Aligment Radius	15
Alignment Multiplier	1.2
Vector Field Multiplier	1
Target Follow Weight	2
Number of Agents	500

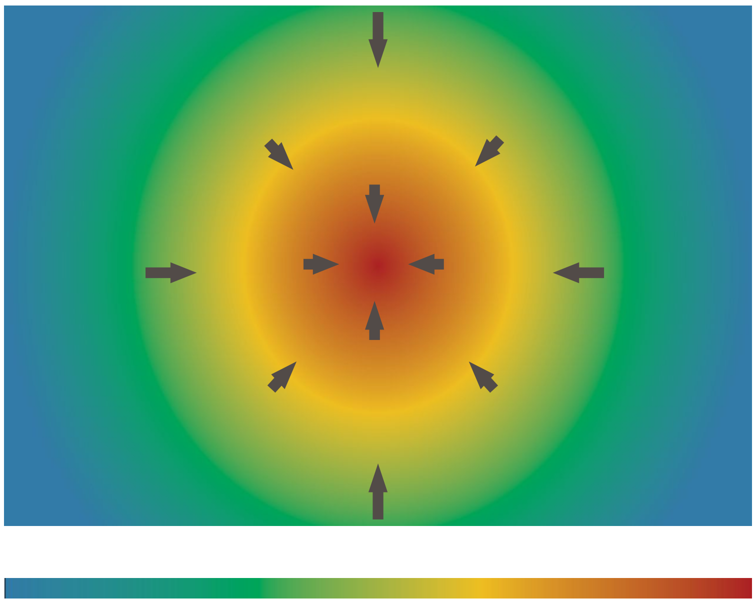
Dynamic Behavior 1
Stress Mapped Cohesion



Dynamic Behavior 2
Proximity Mapped Separation



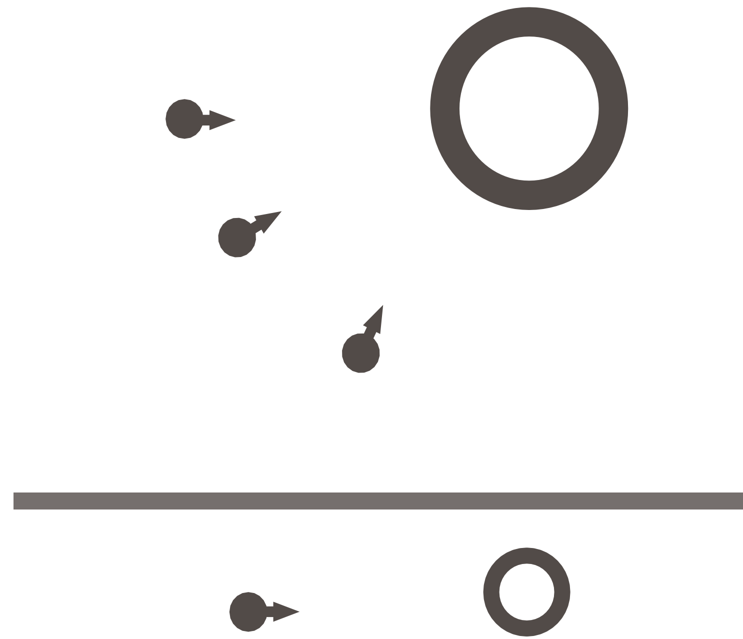
Static Behavior 1
Stress Gradient Flow



0 **Stress (normalized)** **1**

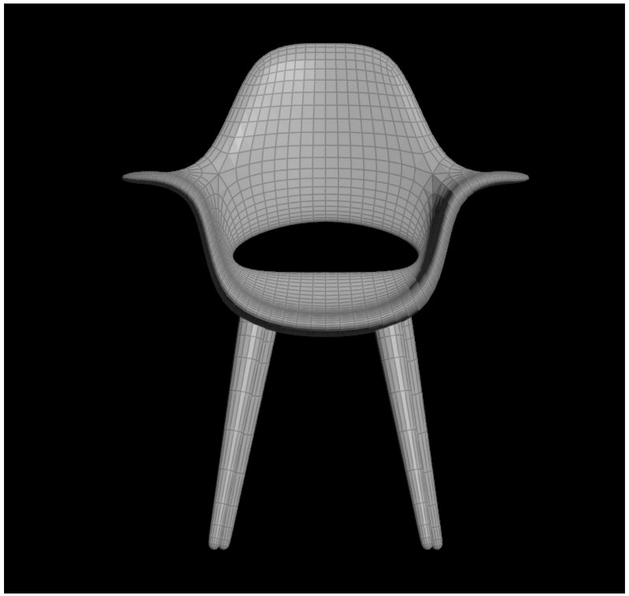
Gradient Vector

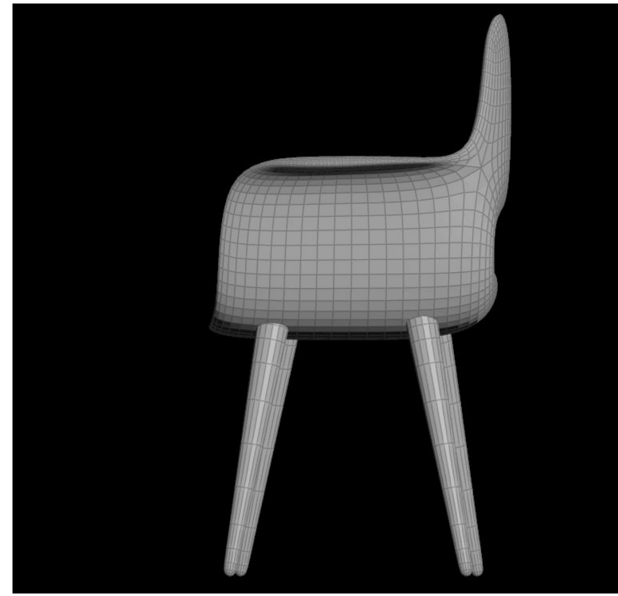
Static Behavior 2
Target Following



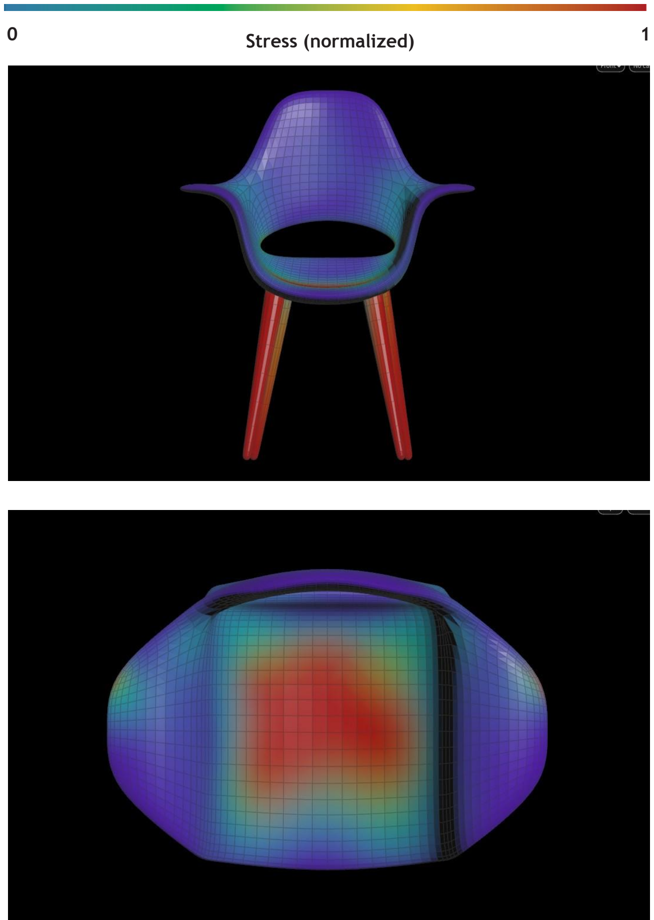
Agent **Targe**
t

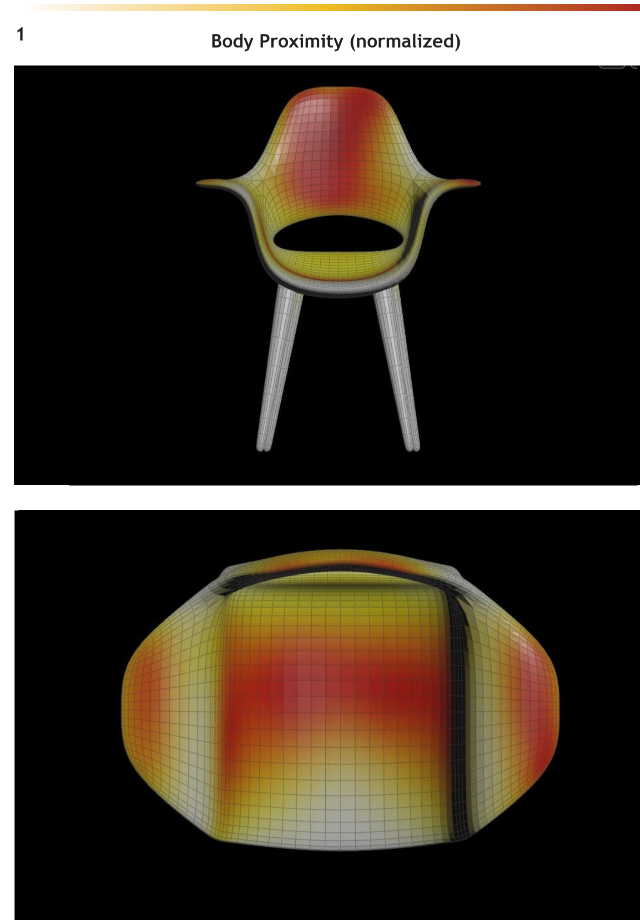
Base Model





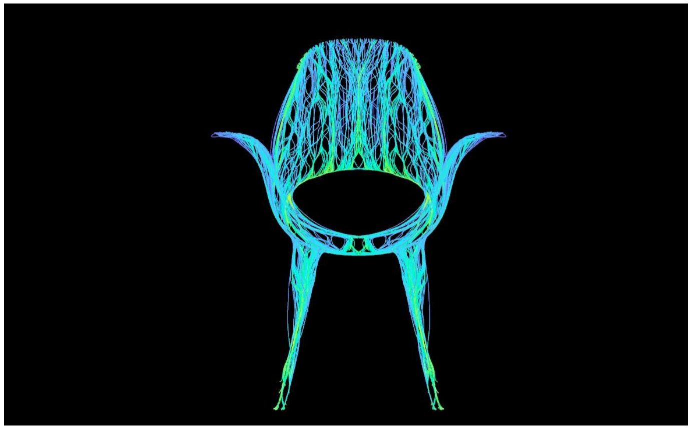
Driving Forces

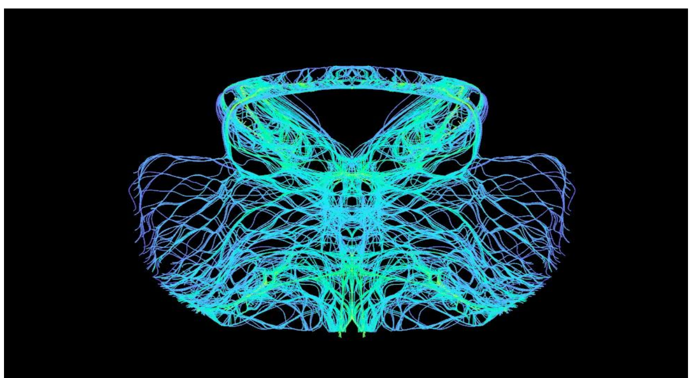




Agent Paths

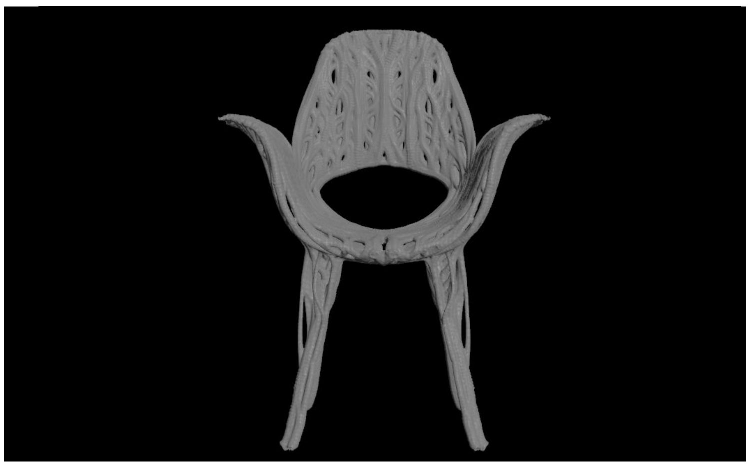
0 Density (normalized) 1

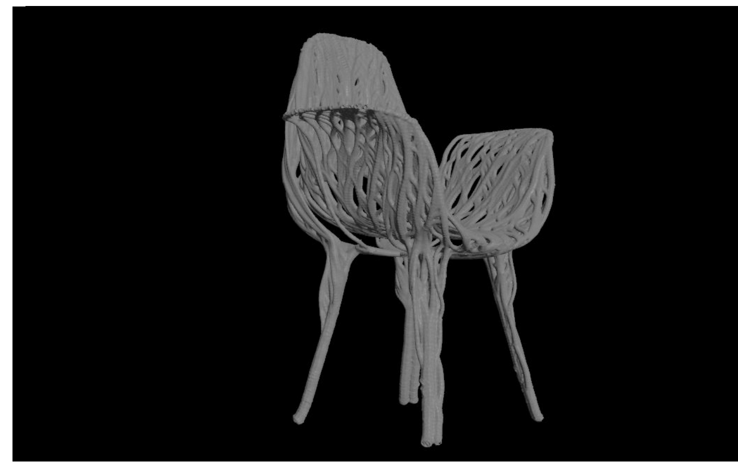




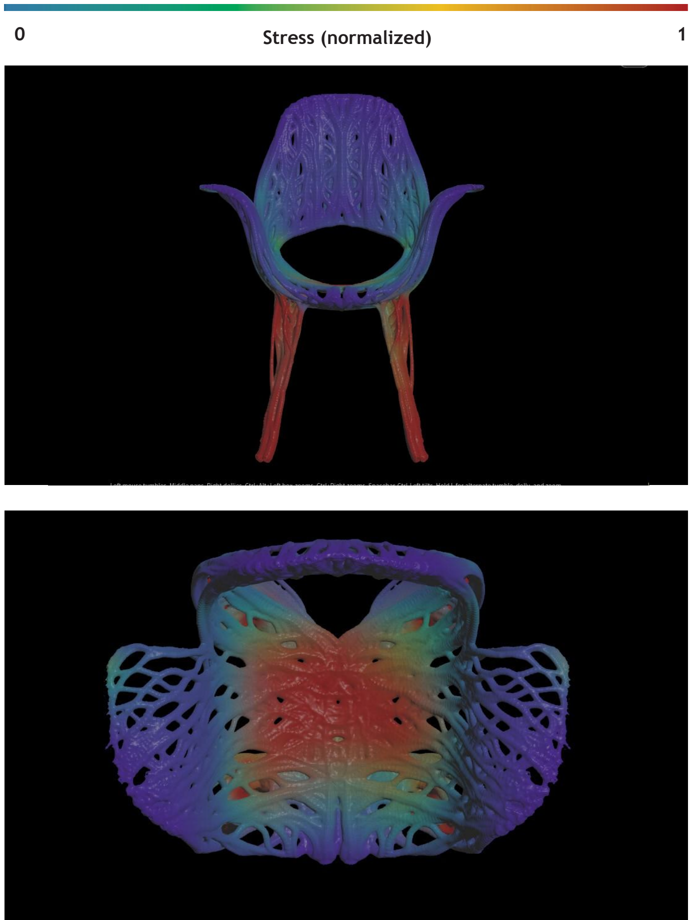
Max Speed	3
Max Force	0.35
Search Radius	50
Separation Radius	40
Separation Multiplier	1.5
Cohesion Radius	35
Cohesion Multiplier	1.2
Aligment Radius	15
Alignment Multiplier	1.2
Vector Field Multiplier	1
Target Follow Weight	2
Number of Agents	500

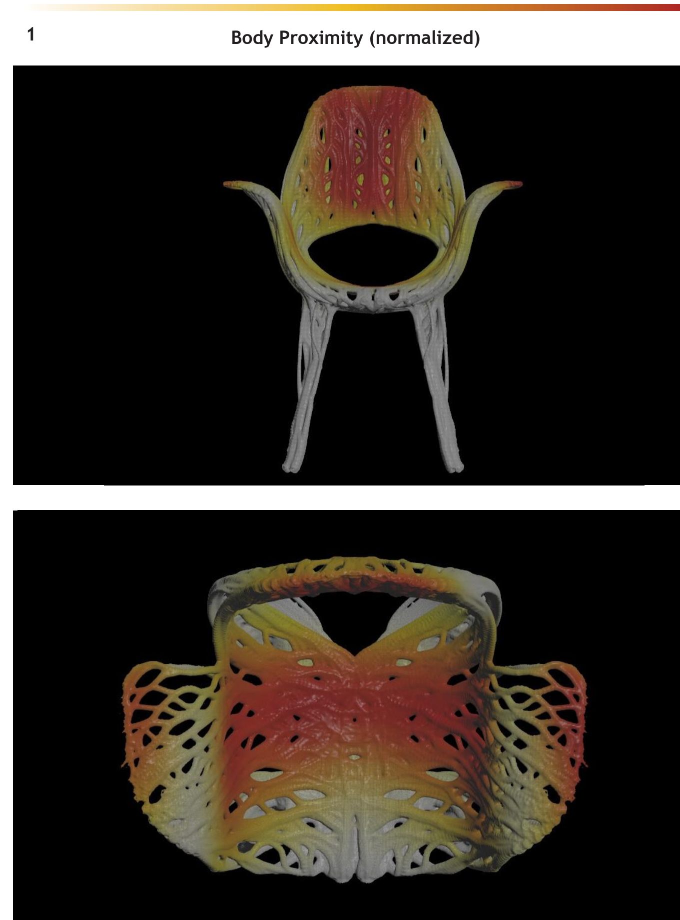
Meshed Output





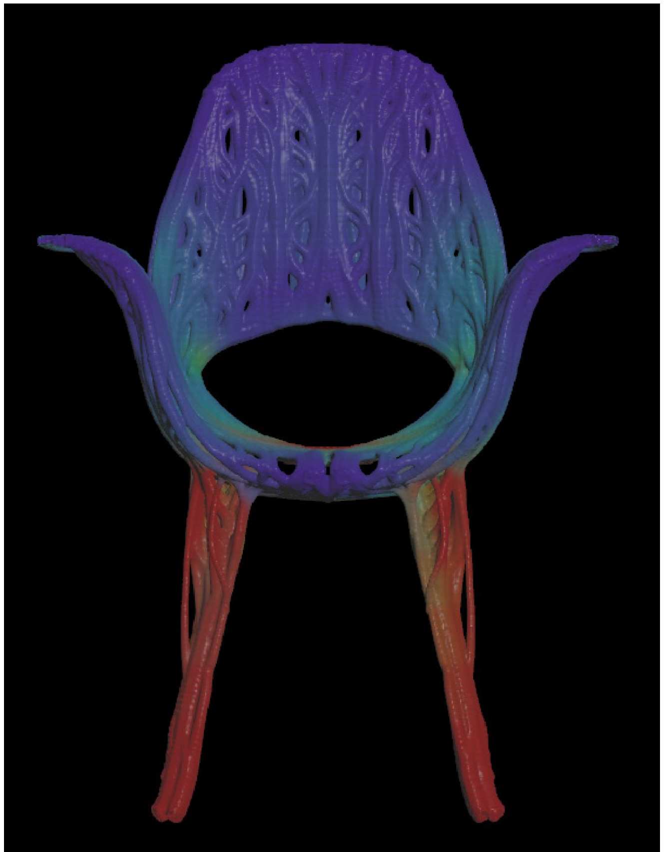
Mapped Forces

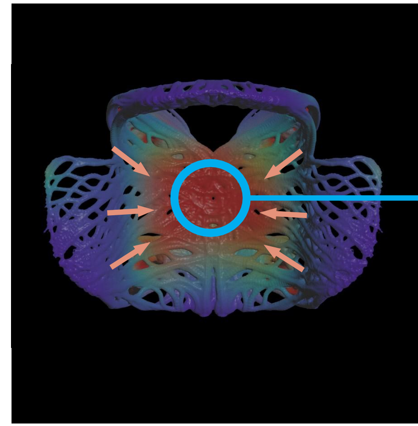




Mapped Forces

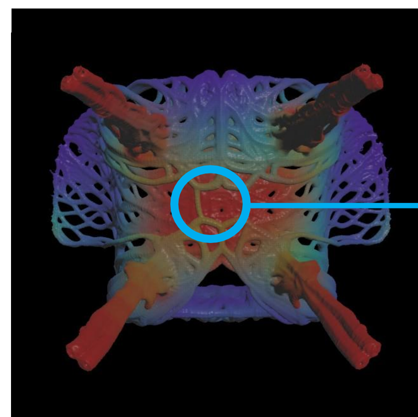
0 Stress (normalized) 1





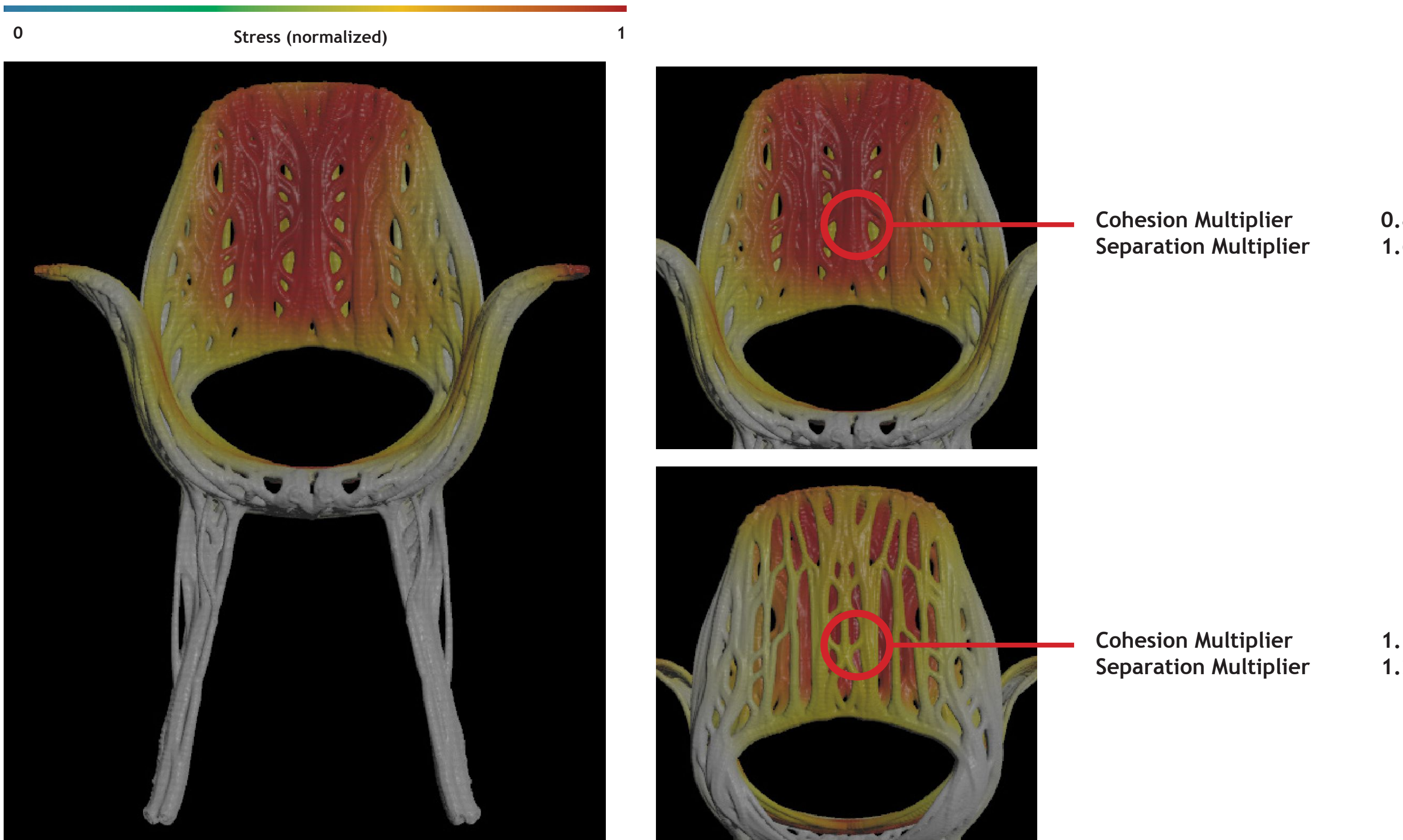
Cohesion Multiplier 1.8
Separation Multiplier 1.7

Force Gradient



Cohesion Multiplier 1.6
Separation Multiplier 0.8

Mapped Forces



AA TORONTO

AA VISITING SCHOOL TORONTO
SUMMER 2021

F^2
MORPHOLOGICAL EXPERIMENTS BETWEEN FORM AND FORCE

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AUTODESK. TECHNOLOGY CENTERS

A V S A

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Loai Essaleh

Alberto Longhin

Inspiration Vitis Chair

vitis (Latin)

Origin & history I

From Proto-Indo-European *wéh$_1$itis ("that which twines or bends, branch, switch"), from *weh$_1$y- ("to turn, wind, bend"). See Latin vieō (/vieo/#Latin) and English *withe (/withe/#English)*.

Noun

vītis (*genitive* **vītis**) *(fem.)*

1. vine (/vine/)
   - **Virgil**, *Georgicon* 4.
     "*vel psithia passos de **vite** racemos*"
     […] or dried clusters of grapes from Psithian vine[s]
   - **c. 160-220 CE**, Tertullian (/Tertullian/), *De Judicio Domini*, 22
     quid faciat laetis ut **vitis** abaestuet uvis
     What makes a **vine** hang down richly with grapes
2. (*historical (/historical/)*) a vine staff (/vine_staff/), the baton (/baton/) or cane (/cane/) of a Roman (/Roman/) centurion (/centurion/)

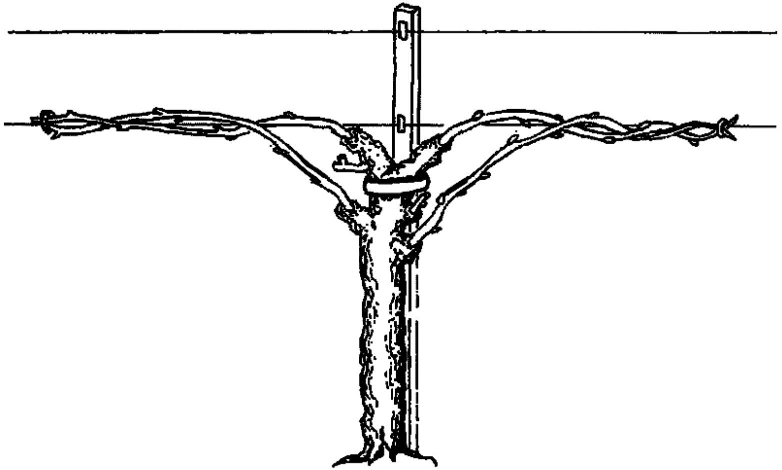
Inspiration Vitis Chair

We found inspiration through the growth of the common vine grape plant.

Performative branching by human guidance for the cultivation of nature to generate natural produce with century old tradition.

Inspiration Vitis Chair

Grapevines usually only produce fruit on shoots that came from buds that were developed during the previous growing season.

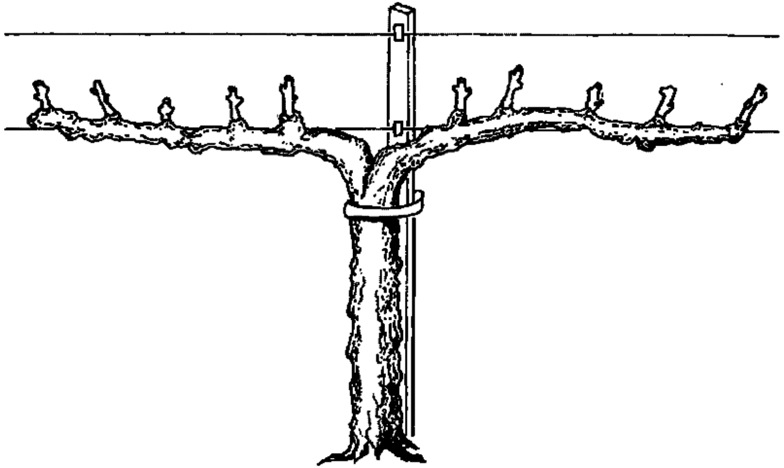


Grape vine pruning process

Inspiration Vitis Chair

Grapevines usually only produce fruit on shoots that came from buds that were developed during the previous growing season.

In viticulture, this is one of the principles behind pruning the previous year's growth (or "One year old wood") that includes shoots that have turned hard and woody during the winter.



Grape vine pruning process

Inspiration Vitis Chair

Grapevines usually only produce fruit on shoots that came from buds that were developed during the previous growing season.

In viticulture, this is one of the principles behind pruning the previous year's growth (or "One year old wood") that includes shoots that have turned hard and woody during the winter.

These vines will be pruned either into a cane which will support 8 to 15 buds or to a smaller spur which holds 2 to 3 buds.

Grape vine pruning process

Function Bistro high chair

The intent was to create a very light and elegant bistro chair designed by an emergent computation procedure.

We found inspiration through the growth of the common vine grape plant.

"Vitis (grapevines) is a genus of 79 accepted species of vining plants in the flowering plant family Vitaceae."

Contact Diagram

Within the first steps of the procedural design of this chair, the base geometry is used to calculate the body proximity and the resulting areas of high contact.

The resulting map is fed into the script to allow for a change of force and the resulting behaviour of the agents while exploring the geometry.

Areas of higher body proximity will force the agents to separate and more likely led to larger surfaces in the final result.

Body Proximity normalized

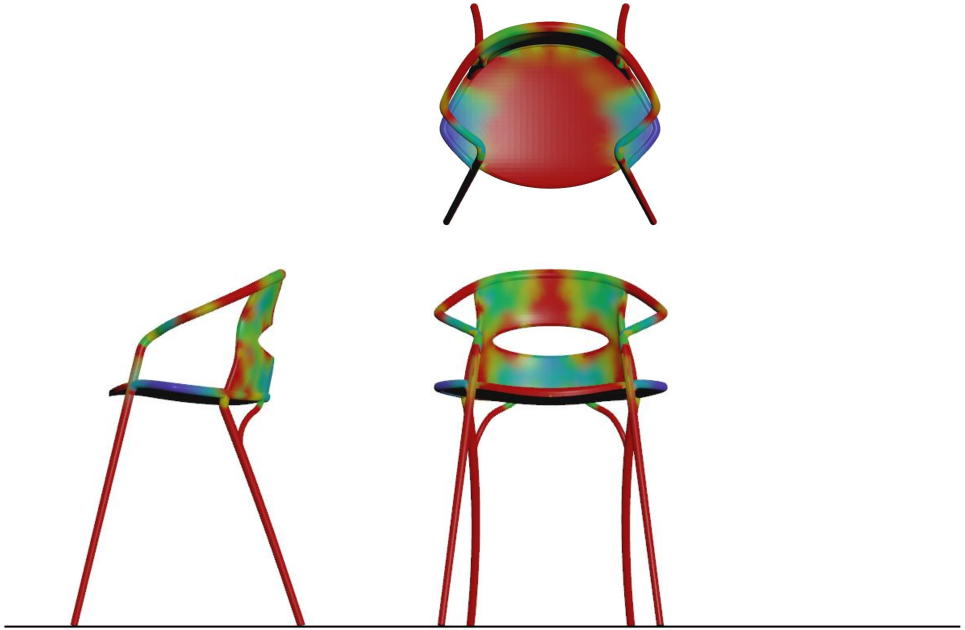
Contact Map

Force Diagram

The finite element solver method (FEM) approximates the physics of continuous materials by splitting them up into a finite number of elements.

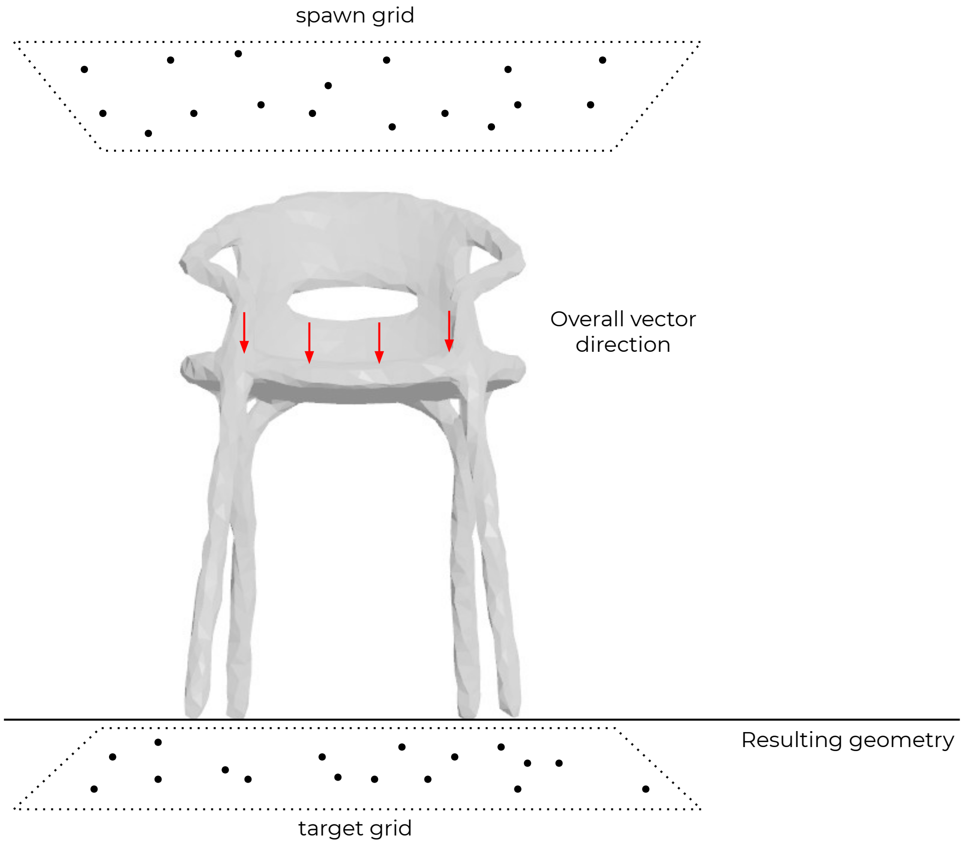
In the case of our chair, the base geometry is remeshed into a single less-detailed mesh and this solid object is determined by 3D tetrahedrons.

This lets the solver realistically simulate bending, elasticity, internal mass, chipping, crumbling, and shattering.



Boundary and Directionality

Setting up certain rules like a global boundary opposing weights and directions.



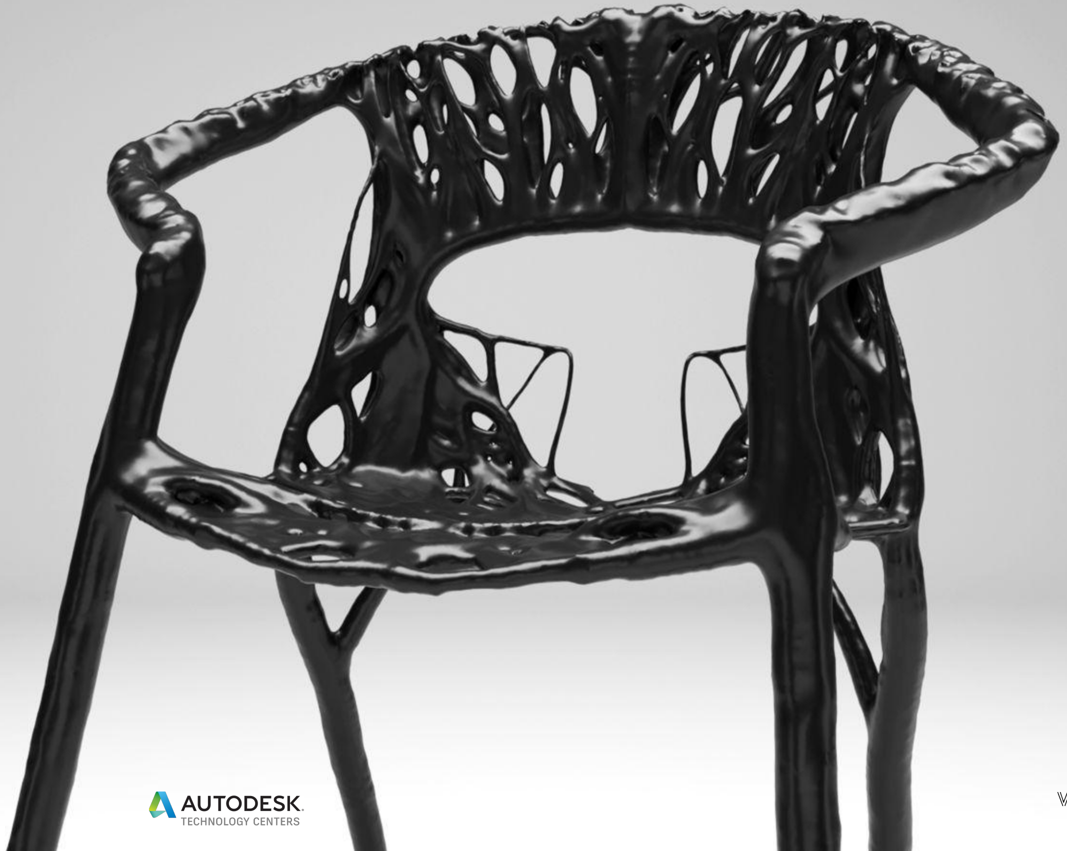
Boundary and Directionality

Setting up certain rules like a global boundary opposing weights and directions.

Growth animation


Force Map

Group 3 // Vitis Chair



Emergent System

The use of a procedural system based on agent movement while being directed by multiple opposing forces simultaneously, simulates a behaviour close to natural growth.

Through observation of vast amount of iterations and precisely regulating the outer forces, the designer can gain control over the system.

Like, dislike and a finally chosen result is often based on the happy accident.

Final geometry

Values // Weights

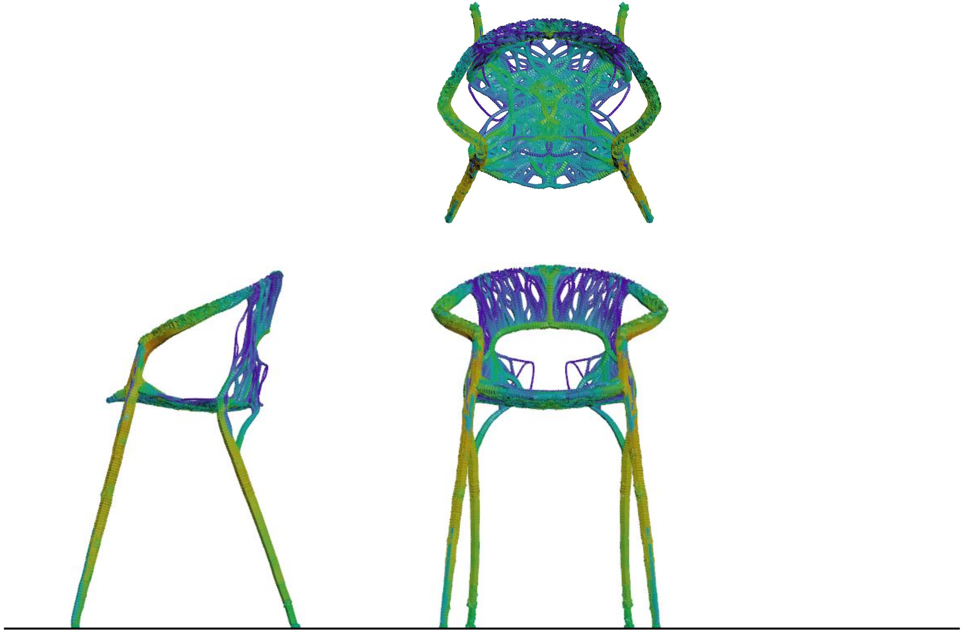
Max. Speed	**3.00**
Max. Force	**0.35**
Search Radius	50
Separation Radius	40
Separation Multiplier	**1.50**
Cohesion Radius	25
Cohesion Multiplier	**1.20**
Alignment Radius	10
Alignment Multiplier	**1.50**
Vector Field Multiplier	**1.00**
Target Follow Weight	**2.00**
Number of Agents	500

Resulting geometry

Values // Weights

Max. Speed	**3.00**
Max. Force	**0.35**
Search Radius	50
Separation Radius	40
Separation Multiplier	**1.50**
Cohesion Radius	25
Cohesion Multiplier	**1.20**
Alignment Radius	10
Alignment Multiplier	**1.50**
Vector Field Multiplier	**1.00**
Target Follow Weight	**2.00**
Number of Agents	500

Trail density normalized



Density Map

Values // Weights

Max. Speed	**3.00**
Max. Force	**0.35**
Search Radius	50
Separation Radius	40
Separation Multiplier	**1.50**
Cohesion Radius	25
Cohesion Multiplier	**1.20**
Alignment Radius	10
Alignment Multiplier	**1.50**
Vector Field Multiplier	**1.00**
Target Follow Weight	**2.00**
Number of Agents	500

0 **1**

Body Proximity normalized

Contact Map

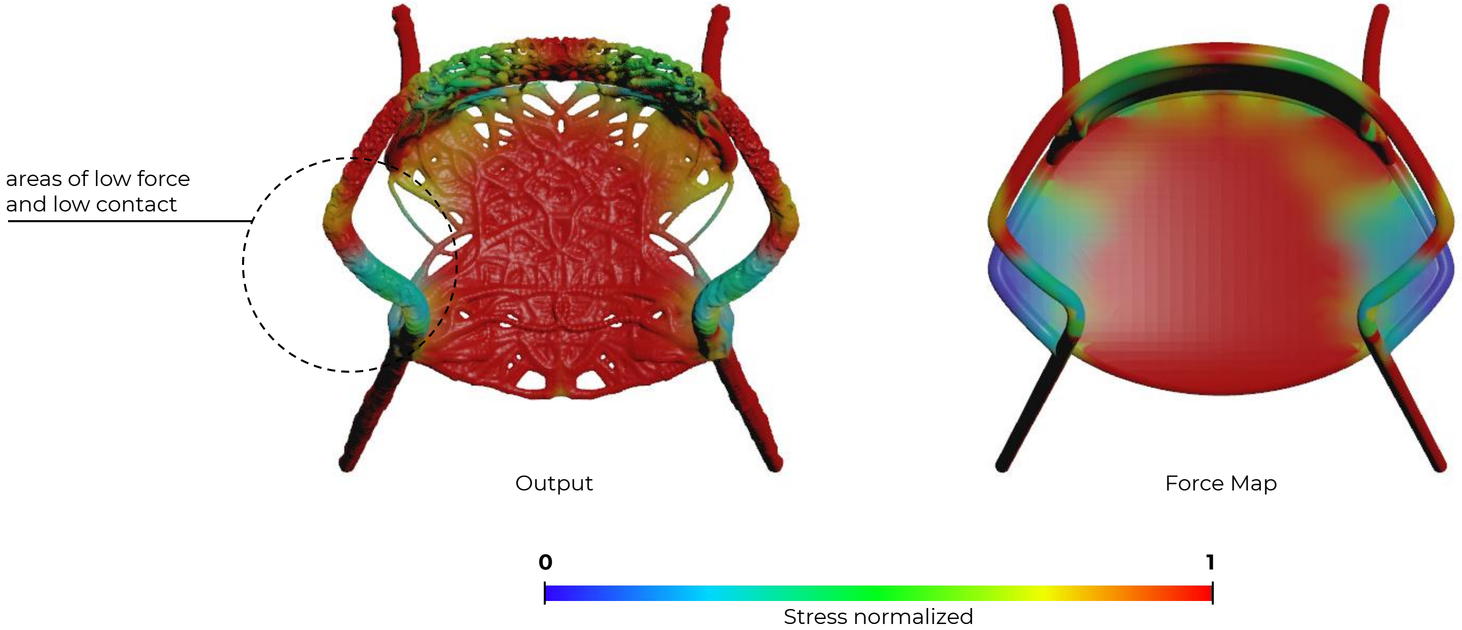
Values // Weights

Max. Speed	**3.00**
Max. Force	**0.35**
Search Radius	50
Separation Radius	40
Separation Multiplier	**1.50**
Cohesion Radius	25
Cohesion Multiplier	**1.20**
Alignment Radius	10
Alignment Multiplier	**1.50**
Vector Field Multiplier	**1.00**
Target Follow Weight	**2.00**
Number of Agents	500

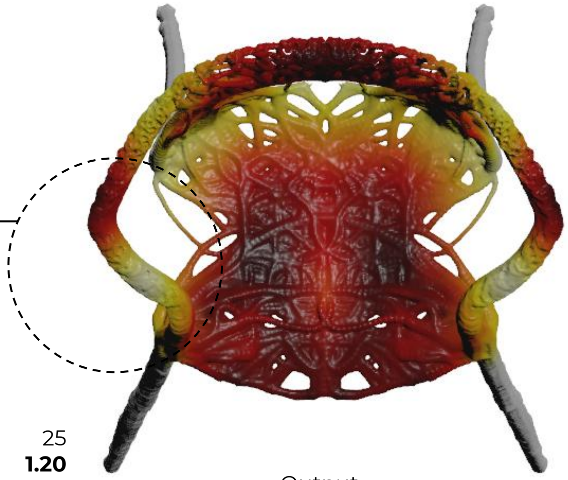
0 **1**

Stress normalized

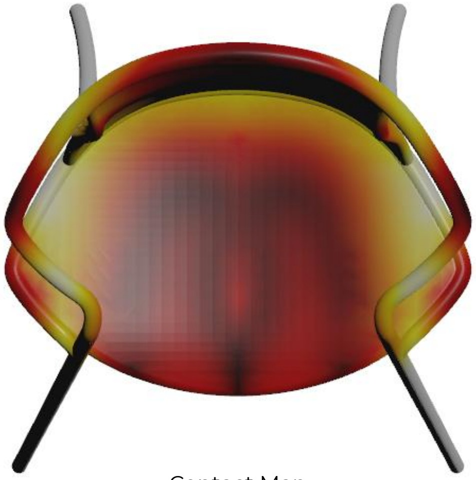
Force Map


areas of low force
and low contact
Output
Force Map
0
1
Stress normalized

areas of low force
and low contact



Output

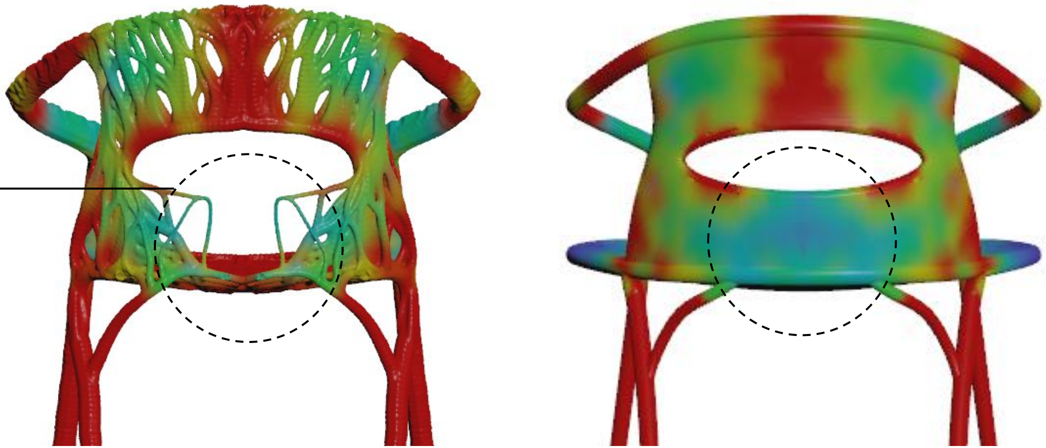


Contact Map

Separation Radius 25
Separation Multiplier **1.20**

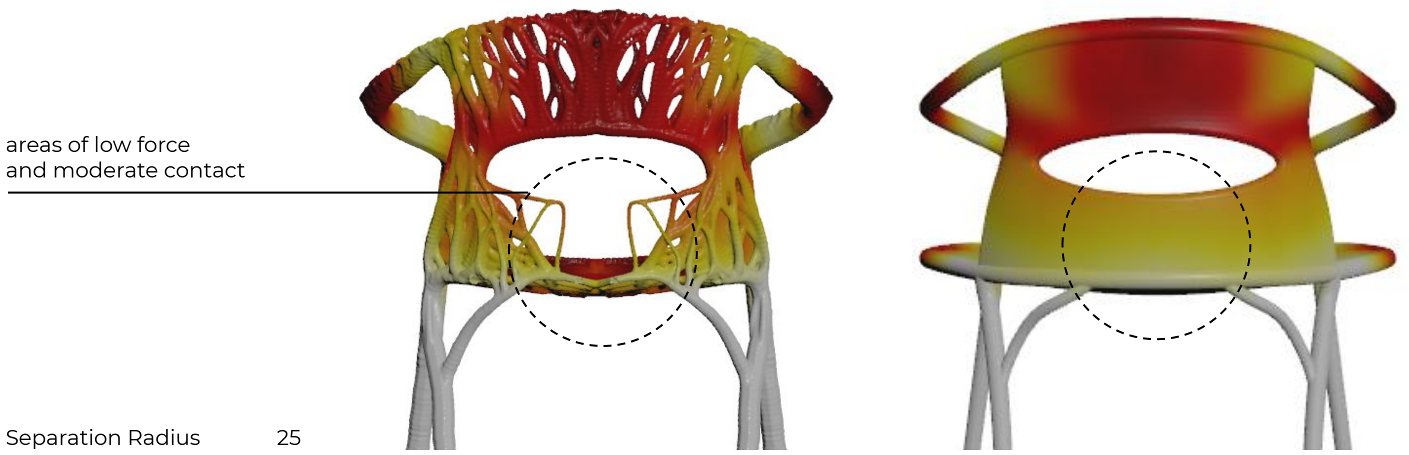
Cohesion Radius 10
Cohesion Multiplier **1.50**

0 — **1**
Body Proximity normalized

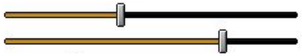


Separation Radius 25
Separation Multiplier **1.20**

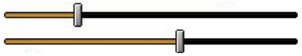
Cohesion Radius 10
Cohesion Multiplier **1.50**



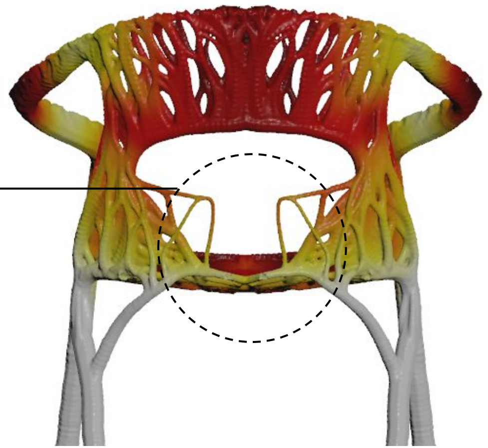
Separation Radius 25
Separation Multiplier **1.20**

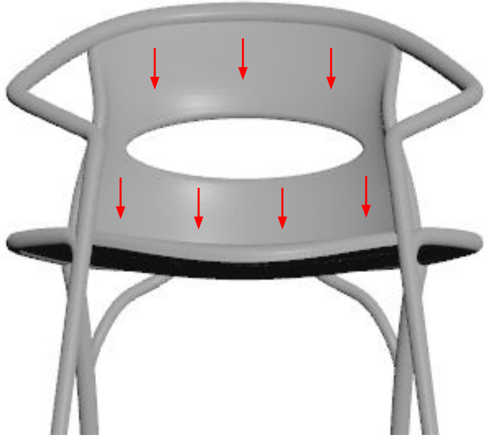


Cohesion Radius 10
Cohesion Multiplier **1.50**

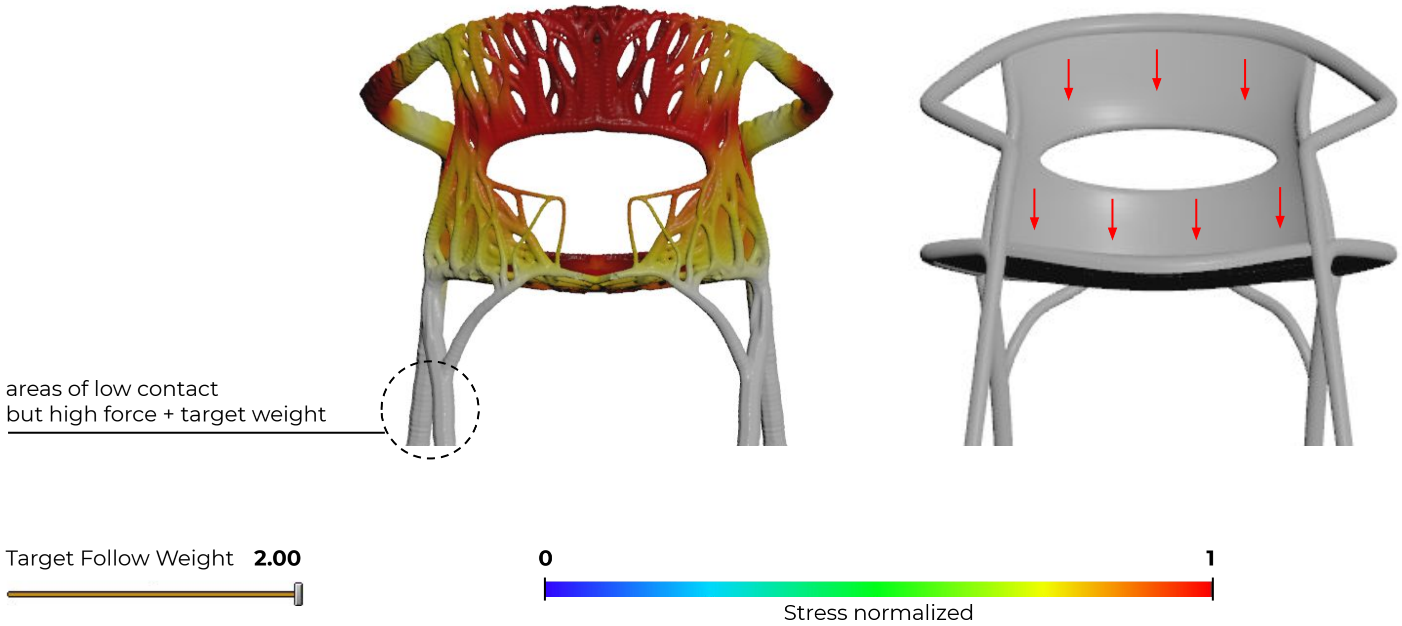


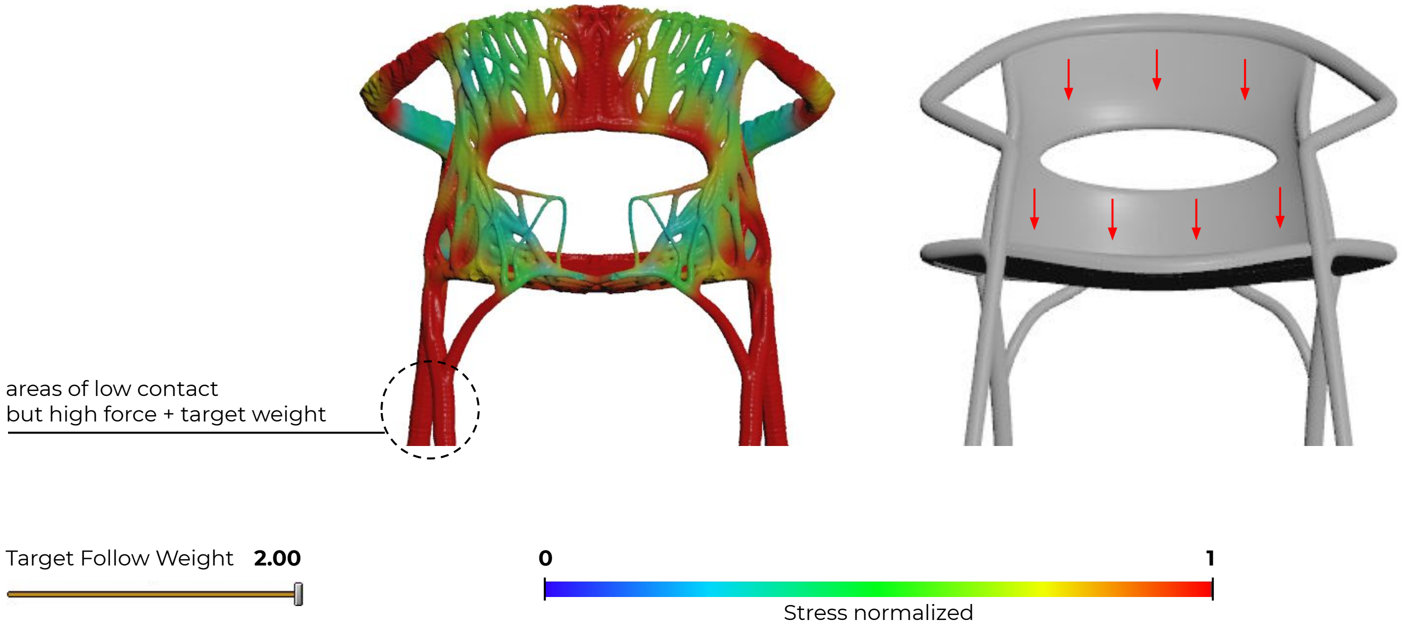
areas of low force
and moderate contact

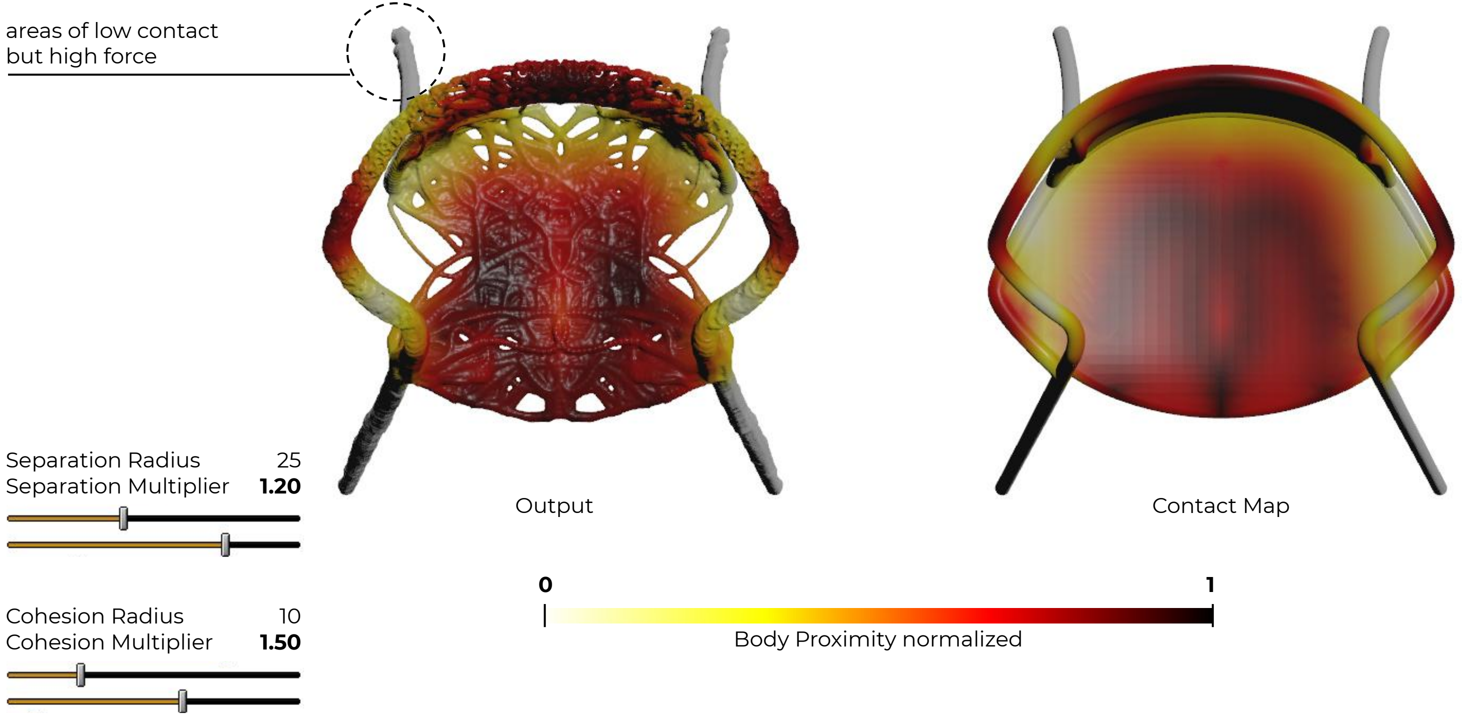




Target Follow Weight **2.00**

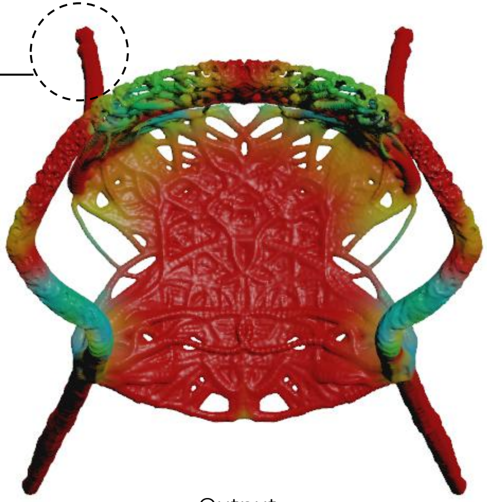

areas of low contact
but high force + target weight
Target Follow Weight 2.00
0
1
Stress normalized


areas of low contact
but high force + target weight
Target Follow Weight 2.00
0
1
Stress normalized


areas of low contact
but high force
Separation Radius 25
Separation Multiplier **1.20**
Cohesion Radius 10
Cohesion Multiplier **1.50**
Output
Contact Map
0
1
Body Proximity normalized

AAVS Toronto // Morphological Experiments between Form and Force
Group 3 // Vitis Chair

areas of low contact
but high force



Output

Force Map

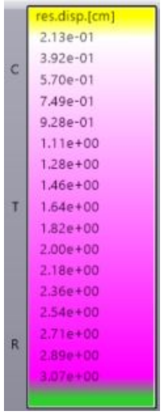
Separation Radius 25
Separation Multiplier **1.20**

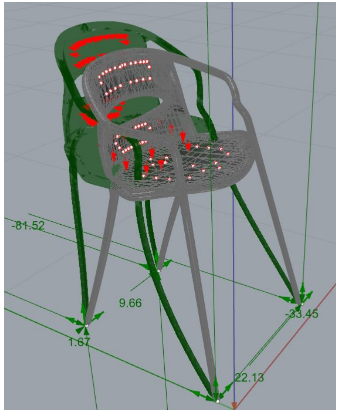
Cohesion Radius 10
Cohesion Multiplier **1.50**

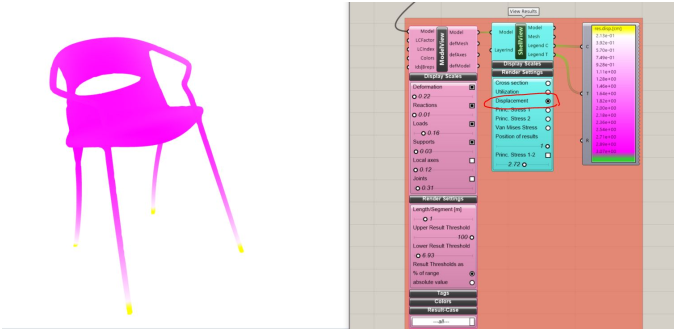
Stress normalized

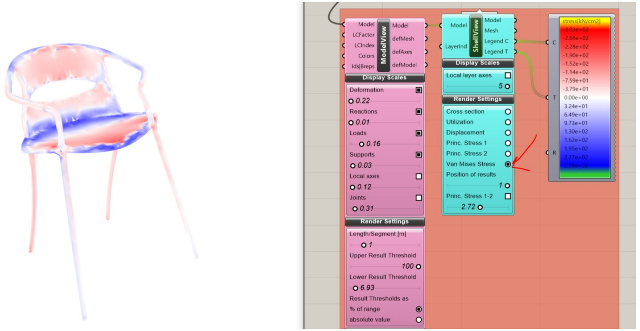
Displacement Test

Structural Analysis: Displacement and Force Methods clearly explains the two fundamental methods of structural analysis: the displacement method and the force method.
We Analysis our last Geometry in Karamba and control the displacement, which is acceptable.







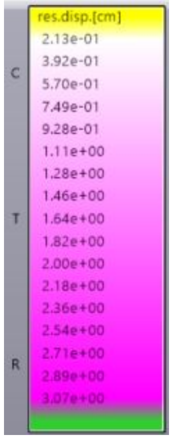


0 0.156

Displacement

Displacement

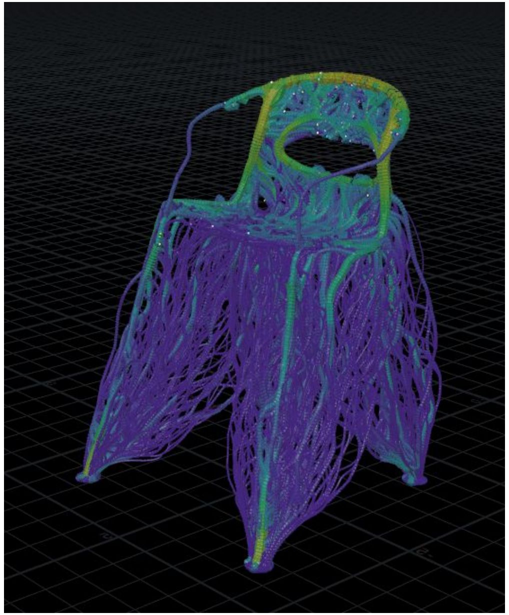
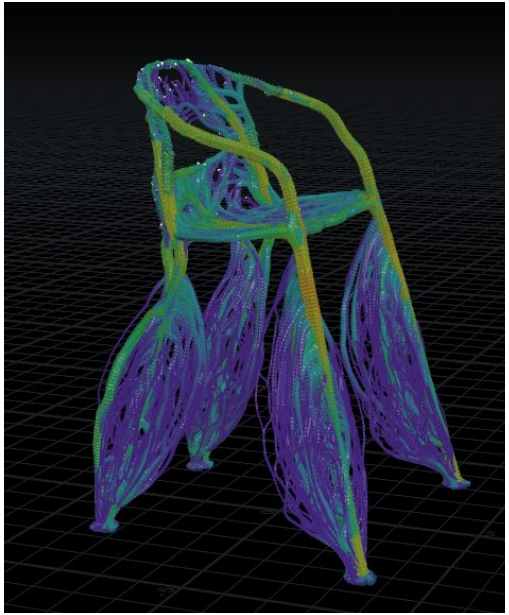
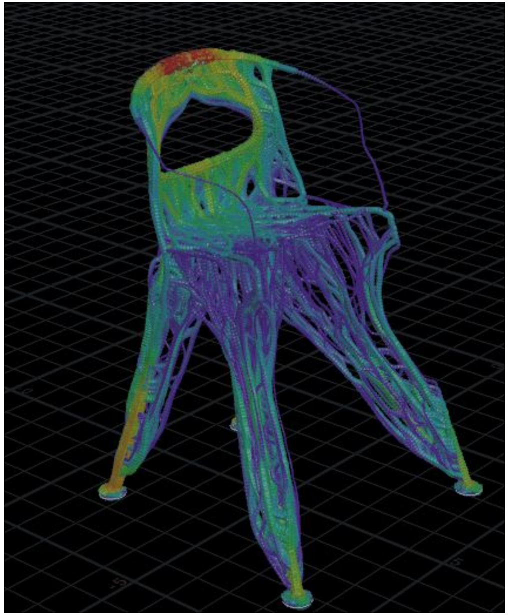
Structural Analysis: Displacement and Force Methods clearly explains the two fundamental methods of structural analysis: the displacement method and the force method.
We Analysis our last Geometry in Karamba and control the displacement, which is acceptable.



0 0.156

Displacement

Displacement

Iterations with increased branching by Z-value

Group 3 // *Vitis Chair*

Side View

Rear View

Front View

Data Sheet

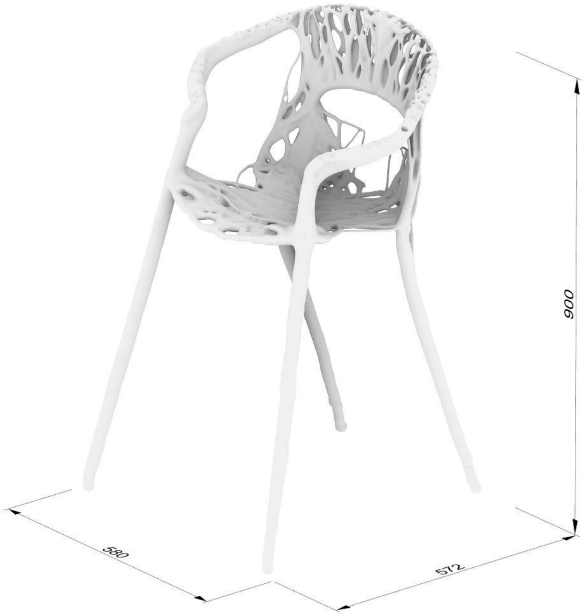
Vitis Chair

Function:
- *Bistro High Chair*

Dimensions:
- *580 x 572 x 900 mm*

Colours:
- *Sauvignon Blanc*
- *Pinot Noir*
- *Bordeaux*

Fabrication:
- *3D printing*



Final geometry animation

Colour Scheme: Sauvignon Blanc, Pinot Noir and Bordeaux

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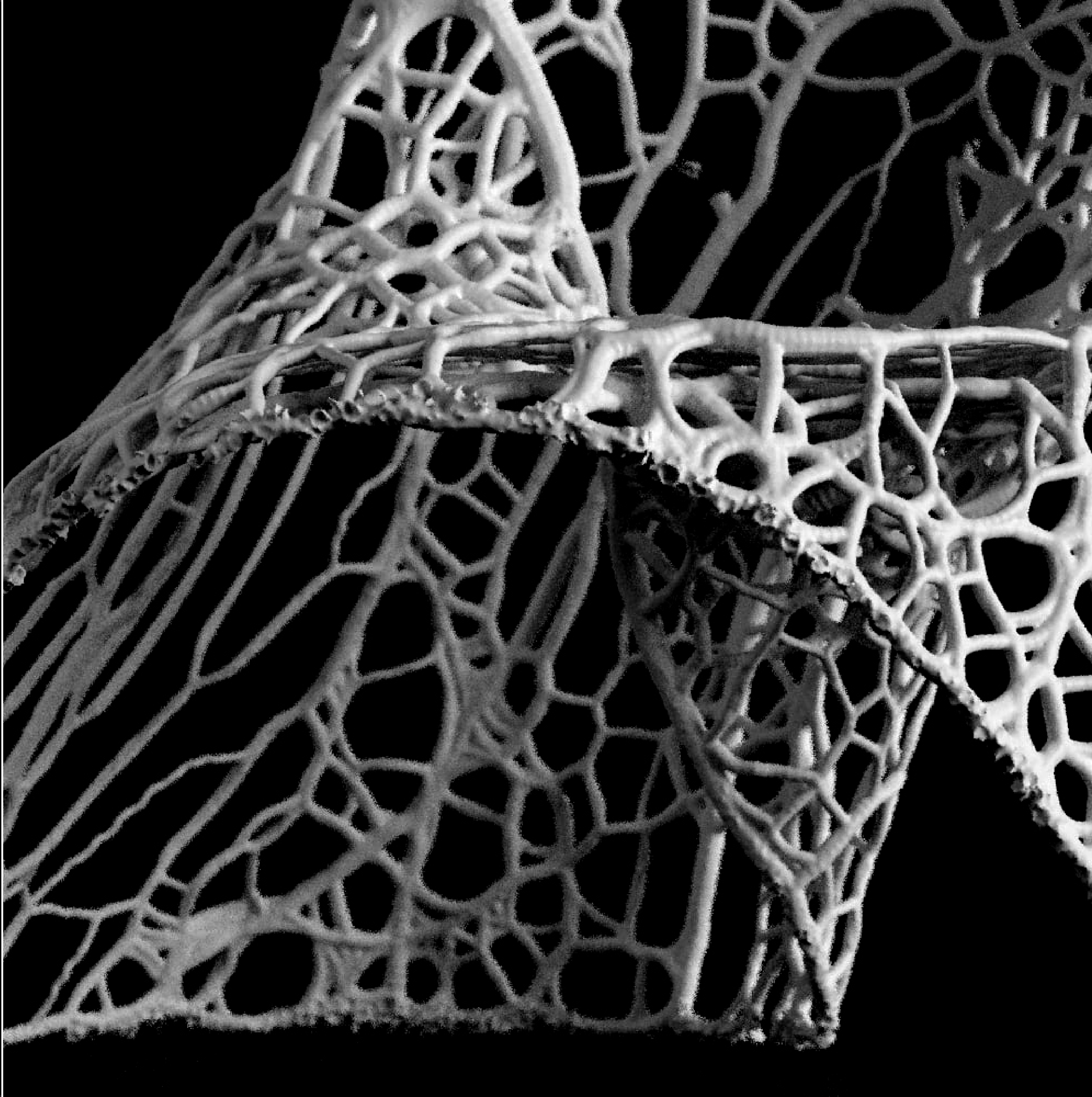
***Group 3** // Vitis Chair*

Product Catalogue

THANK YOU

Growth-Agency-Adaptation

Hossein Maghami
Viana Ahmadyar
Campbell Scott
Veronika Khasapova



AA TORONTO

AA VISITING SCHOOL TORONTO
SUMMER 2021

F^2

MORPHOLOGICAL EXPERIMENTS BETWEEN **F**ORM AND **F**ORCE

DIRECTORS

ALI FARZANEH
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UNIT TUTORS

DAVID CORREA
ISABEL OCHOA
JAMES CLARKE-HICKS
JAMES DALESSANDRO
NICHOLAS ALEXANDER LEE

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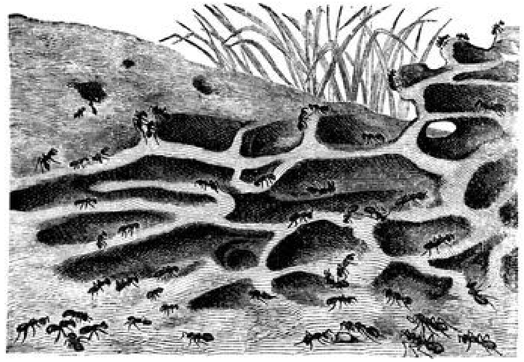
CONCEPTUAL FORM

Growth

Nest

» At nest, ants make holes underground to make spaces for living and the pattern makes the nest stable and it can be extended throughout the time



Trees roots

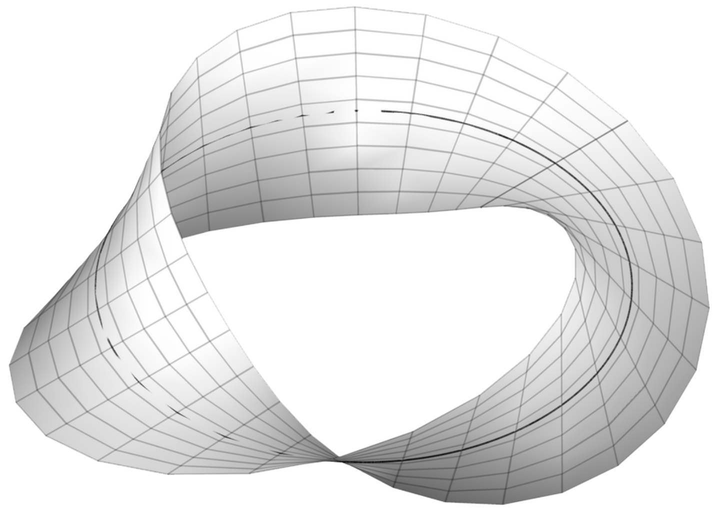
» Trees roots, they find their path to reach water and make a shape to provide stability for upper body

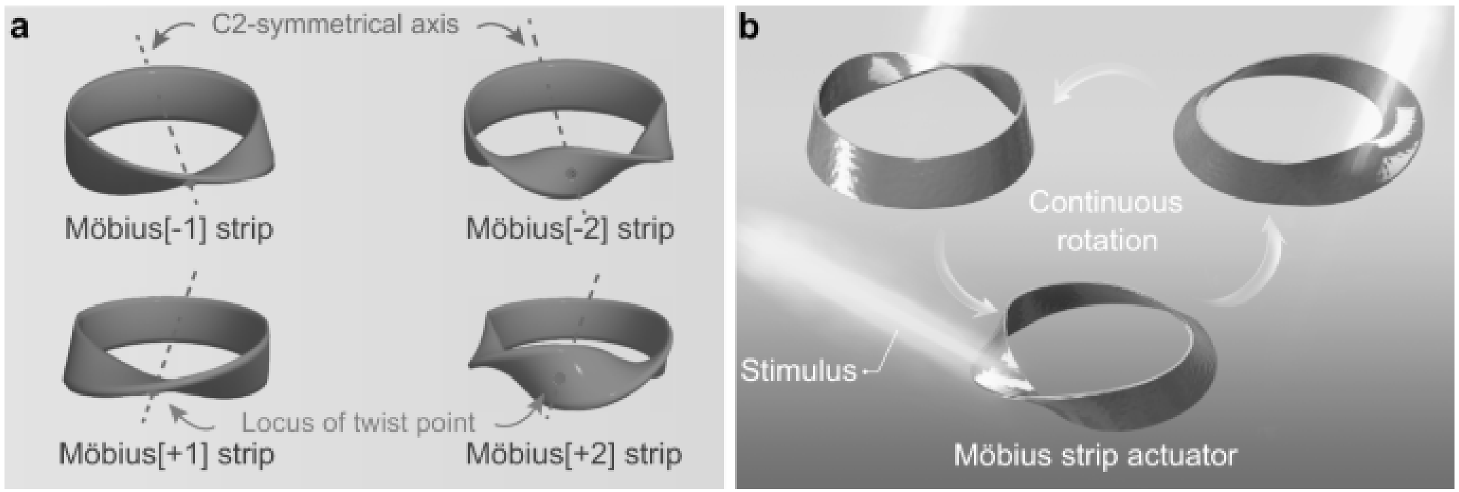
Mycelium

» Mycelium are the thin root-like fibres from fungi which run underneath the ground, when dried it can be used as a super strong, water, mould and fire resistant building material that can be grown into specific forms, thus reducing the processing requirements

Mobius Strip

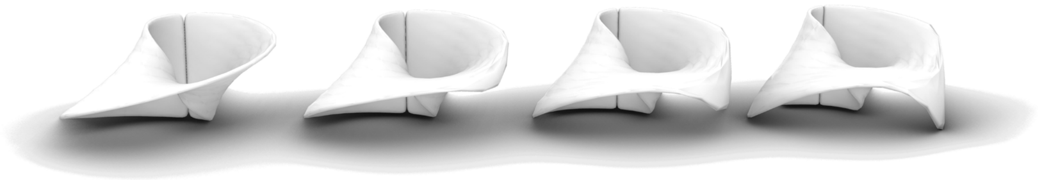
- A one-sided surface that can be constructed by affixing the ends of a rectangular strip after first having given one of the ends a one-half twist
- Forms a loop

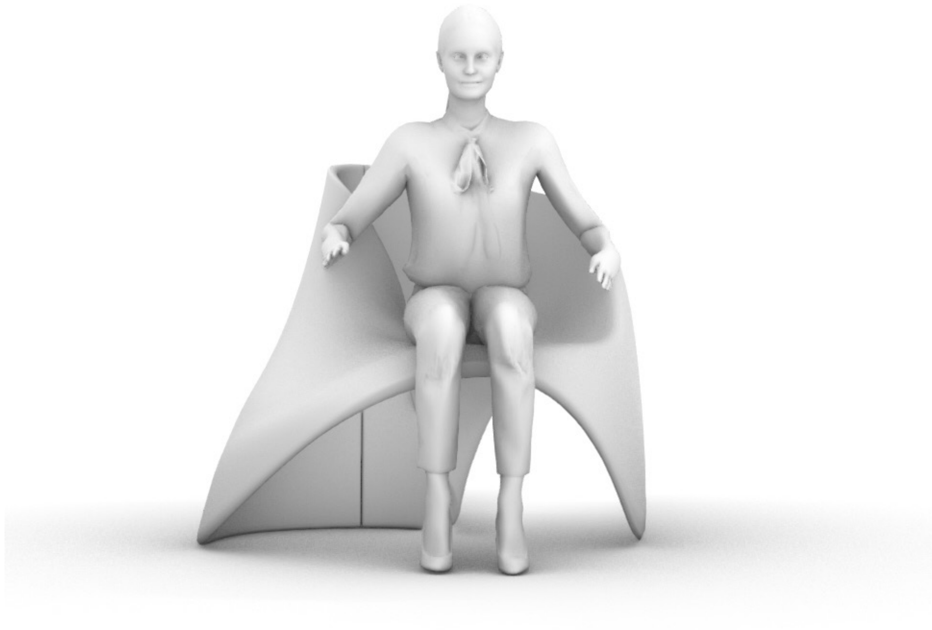




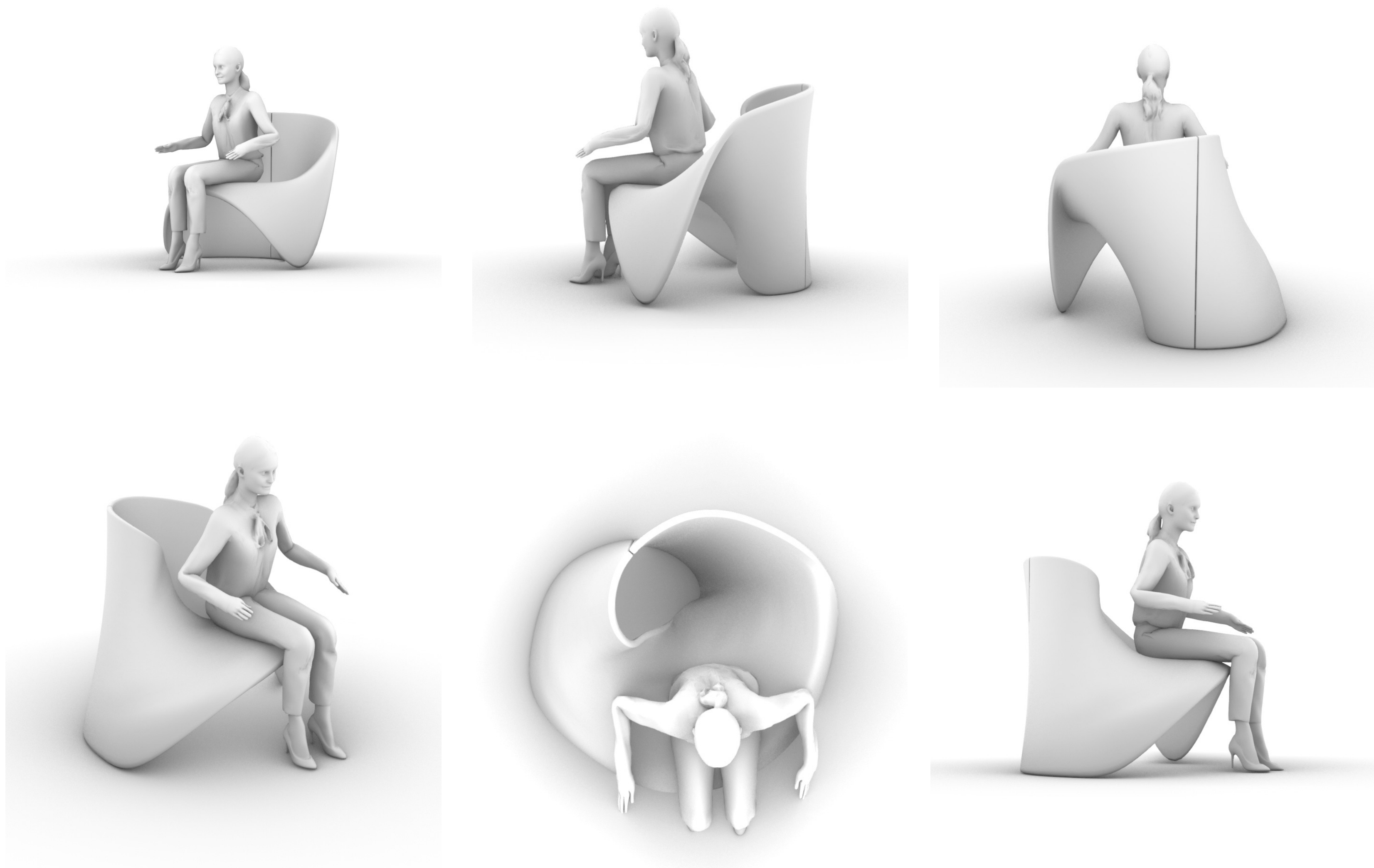
BASE MODEL

1. An organic chair without legs
2. Its mathematical form enhances the structural property of the chair
3. Continues surface make it more stable
4. Particles movement is more fluid through a single surface form



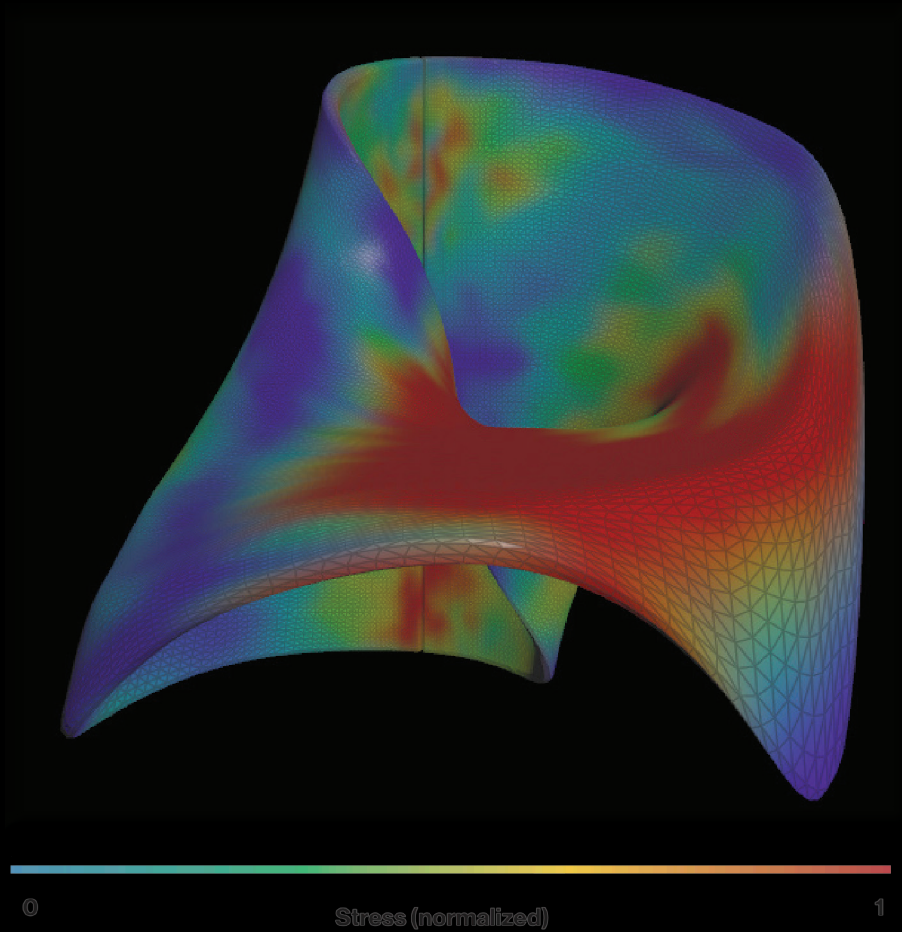


BASE MODEL

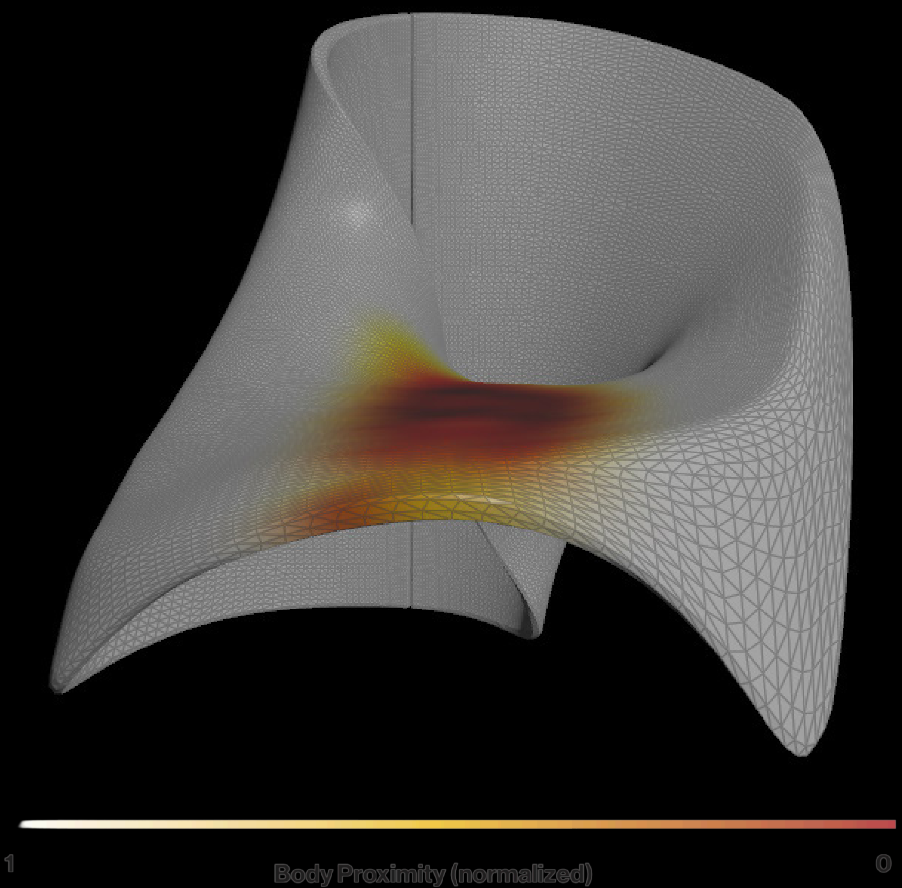


DRIVING FORCES

FORCE MAP

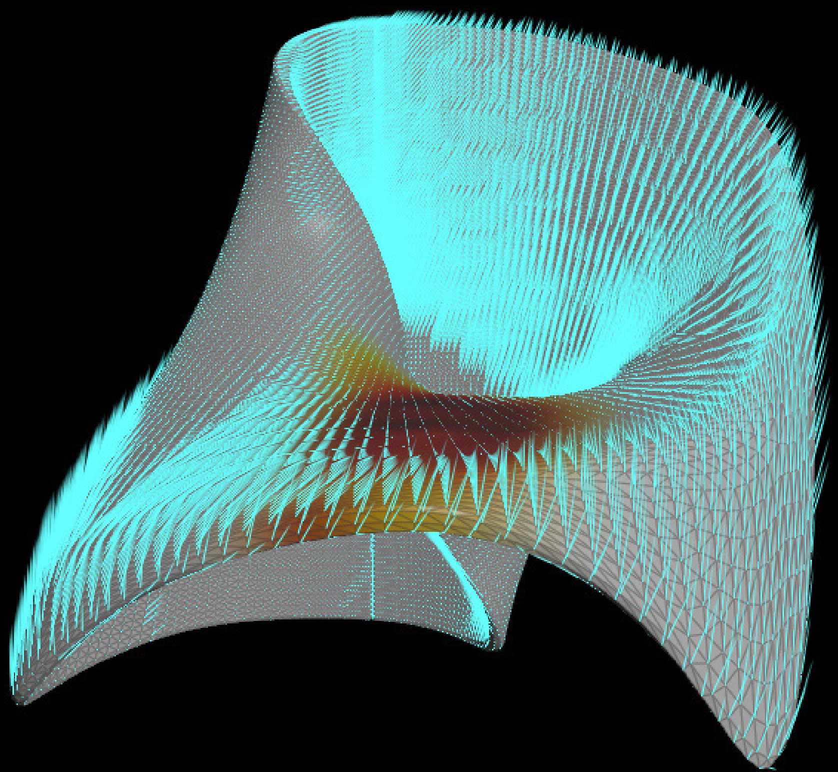


CONTACT MAP

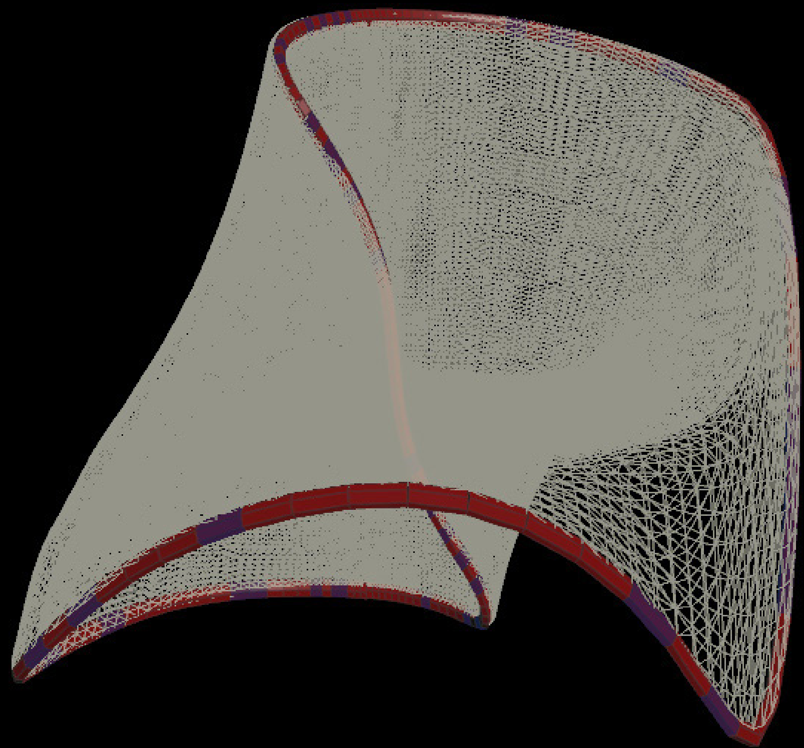


DRIVING FORCES

TANGENT FIELD



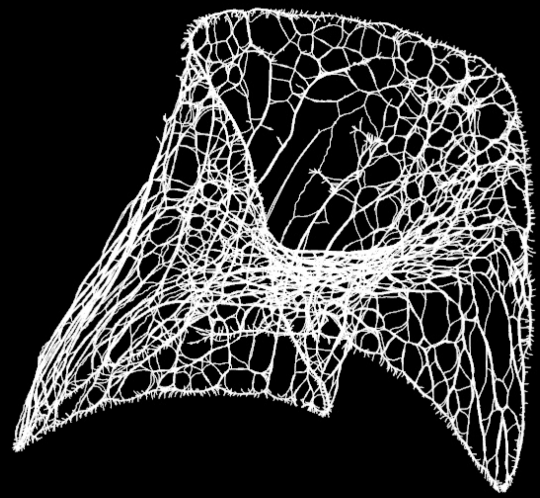
EMITTER - RED



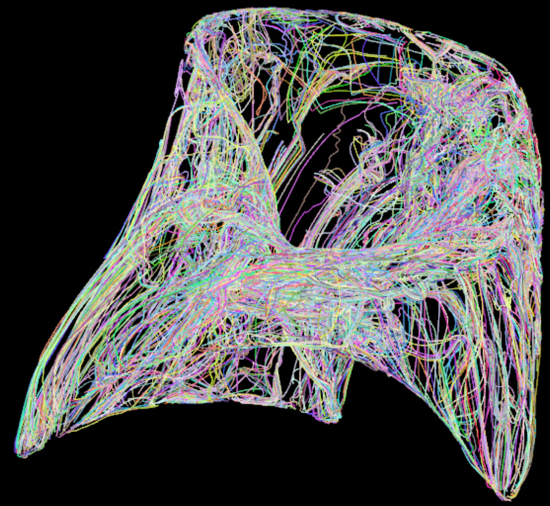
AGENT PATHS

Max Speed	5
Max Force	0.25
Seach Radius	50
Separation Radius	50
Separation Multiplier	3
Cohesion Radius	50
Cohesion Multiplier	1
Alignment Radius	25
Alignment Multiplier	1
Vector Field Multiplier	1
Target Flow Weight	0
Volume Contain Multiplier	0.1
Number Of Agents	1200

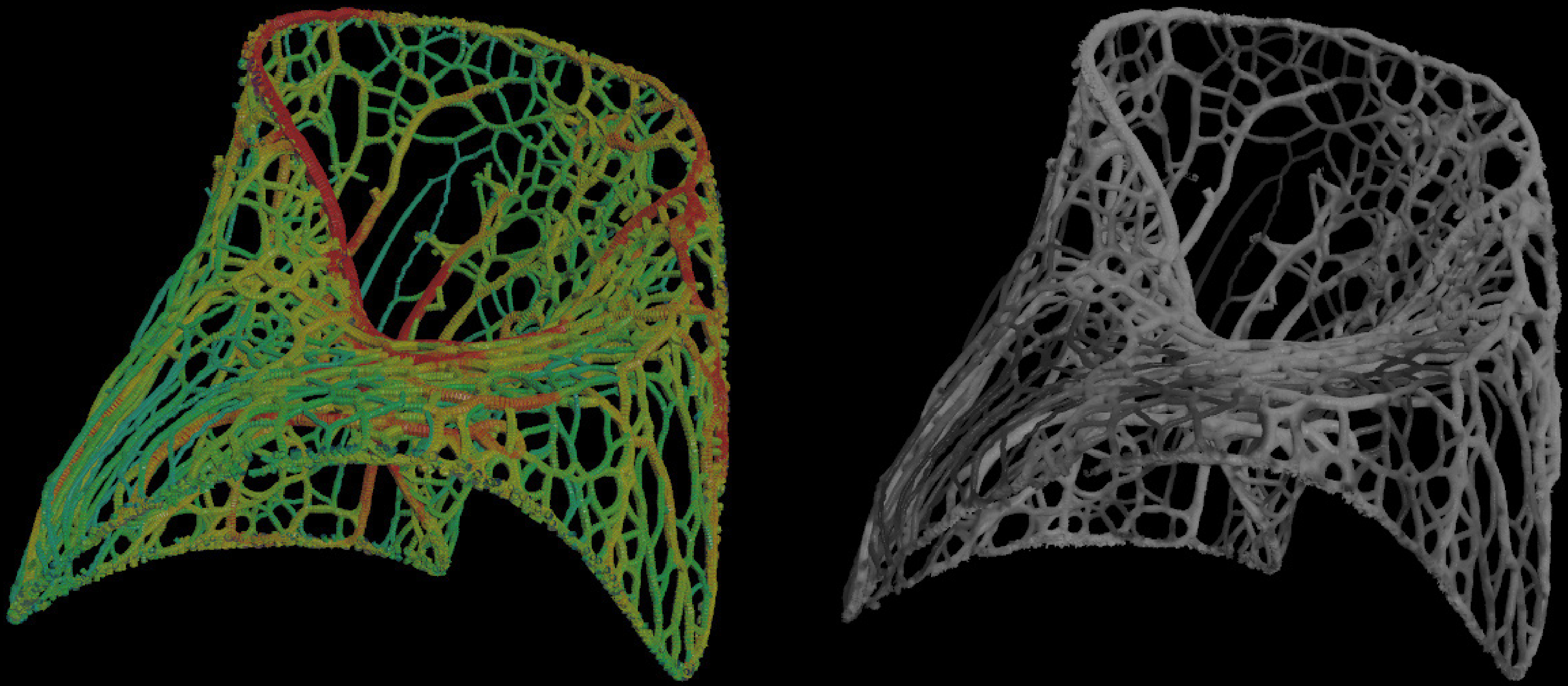
EDGE BUNDLING



TRAILS

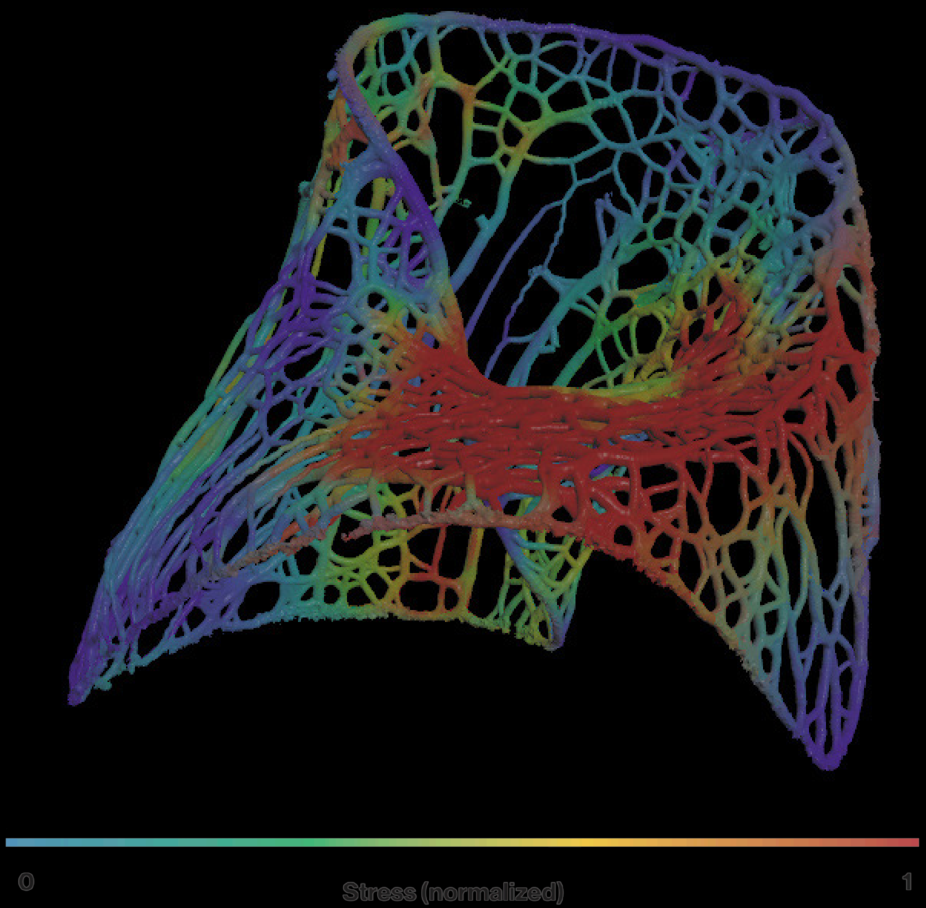


MESHED OUTPUT

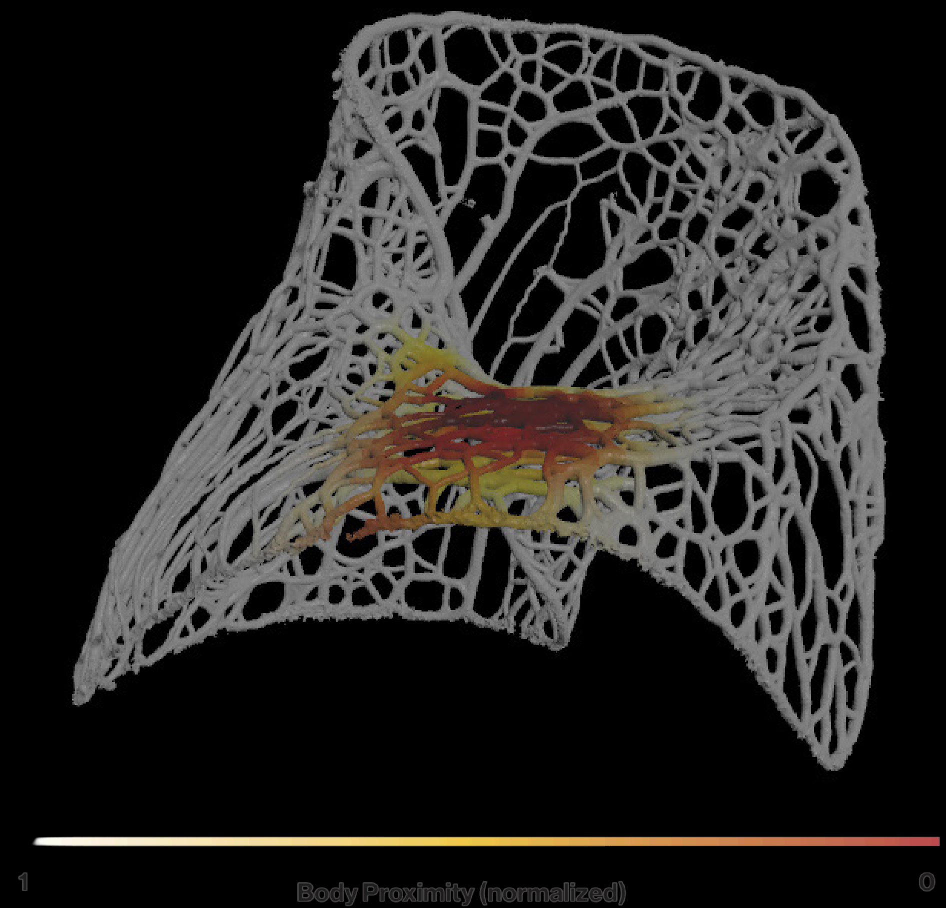


MAPPED FORCES

FORCE MAP



CONTACT MAP



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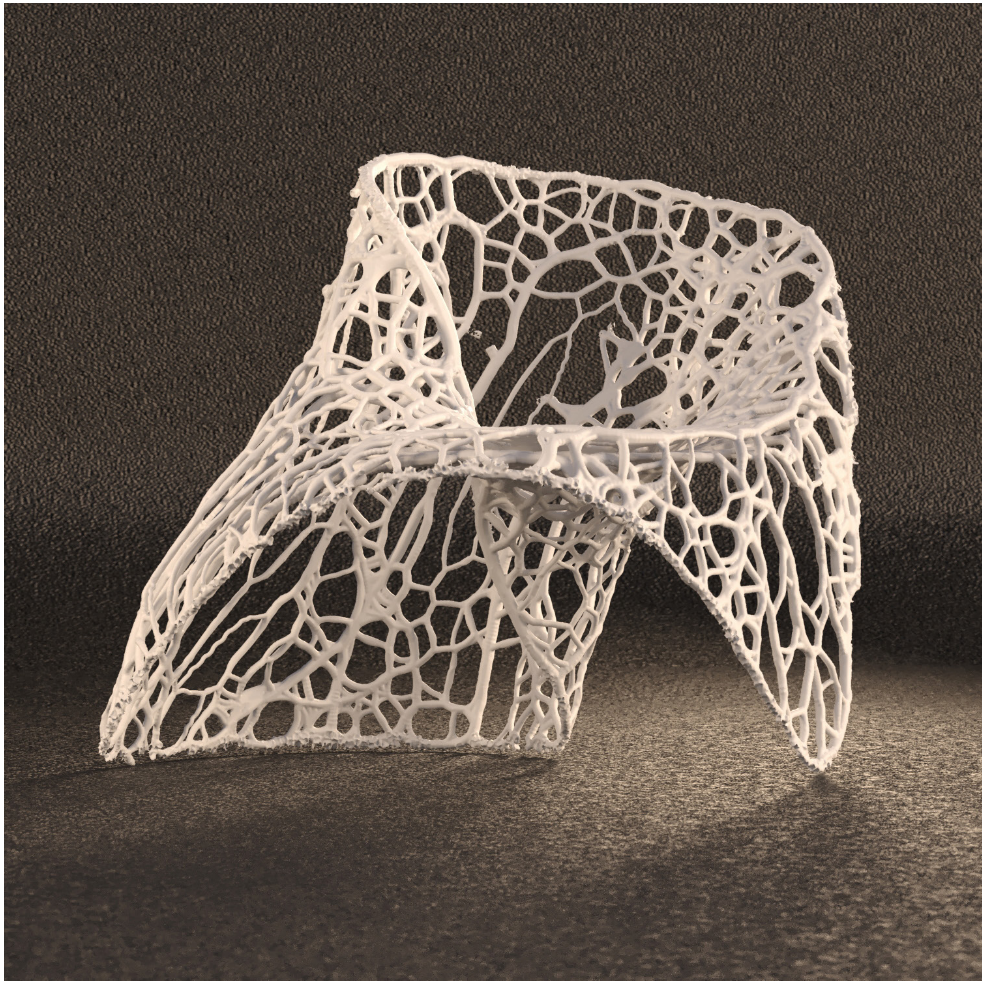
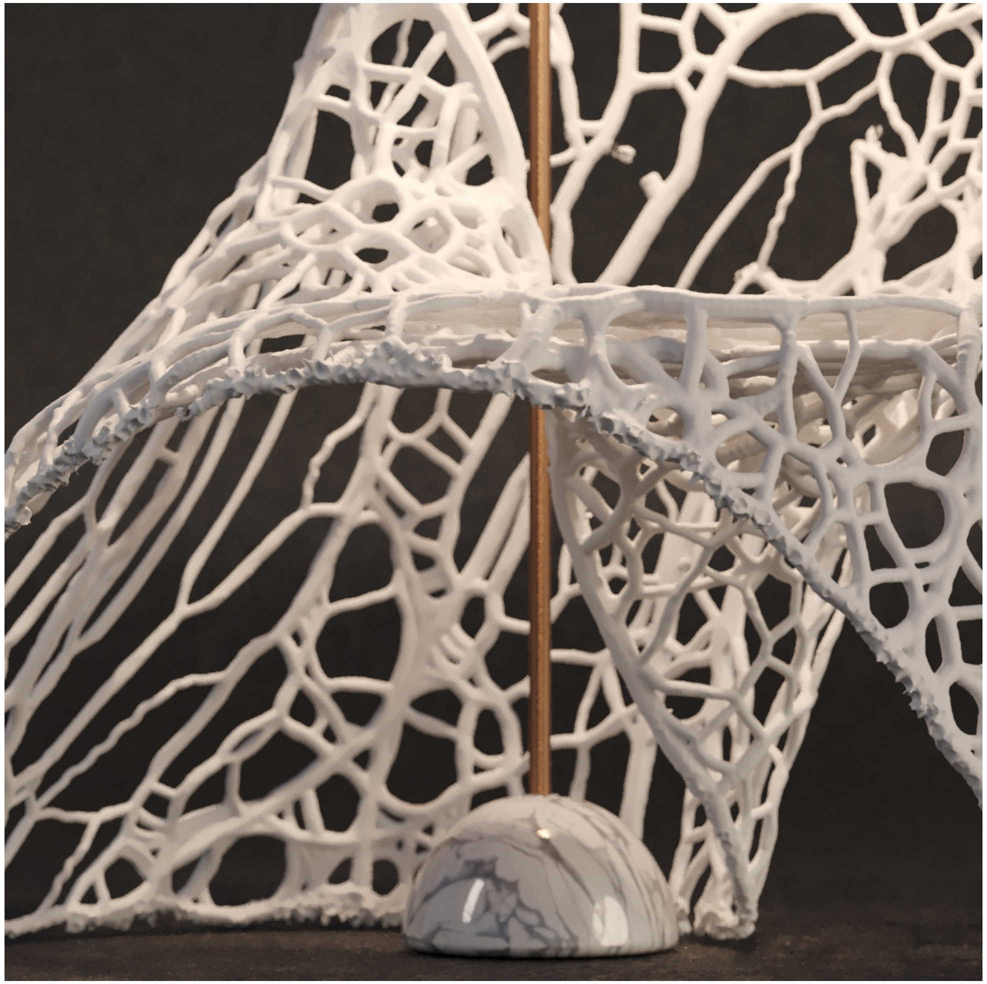
RENDERINGS





RENDERINGS