Sophia G. Cabral

This portfolio is a compilation of my academic and professional work, observations, and explorations.

Index:

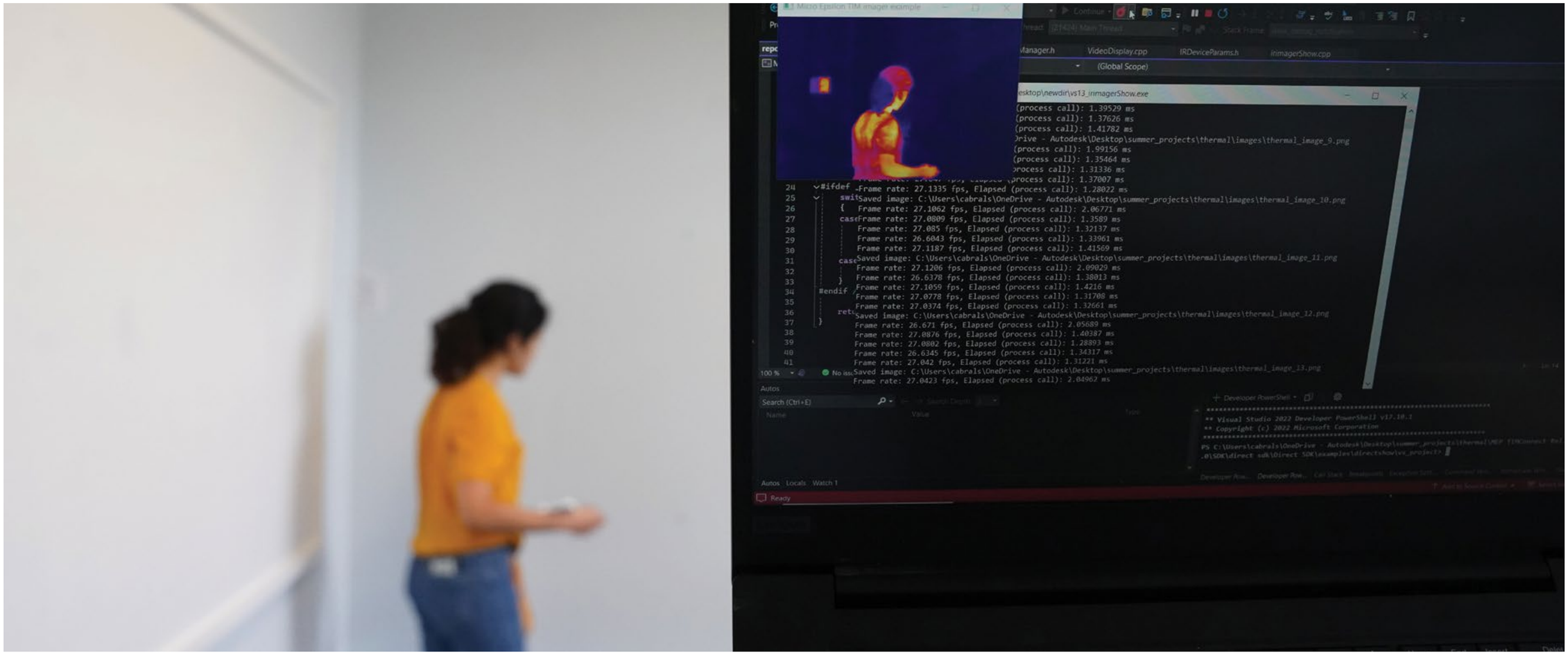
Recent + Ongoing work

Fabrication and tool development

The following three projects are snippets of recent and on-going research projects with labs at Harvard University and under Autodesk Research.

A Contactless Multi-Modal Sensing Approach for Material Assessment and Recovery in Building Deconstruction

This study introduces an innovative system combining multi-modal sensing technologies and machine learning to assess building materials for reuse potential, addressing growing environmental concerns. The system integrates thermal imaging, RGB cameras, and depth sensors to analyze material conditions and hidden geometries within existing buildings, enhancing understanding of materials and assemblies. A drywall deconstruction case study demonstrates the technology's effectiveness in guiding the process through automated feedback and visualization. The research also validates the technical and economic viability of contactless assessment methods, establishing a foundation for sustainable construction practices focused on material reuse.

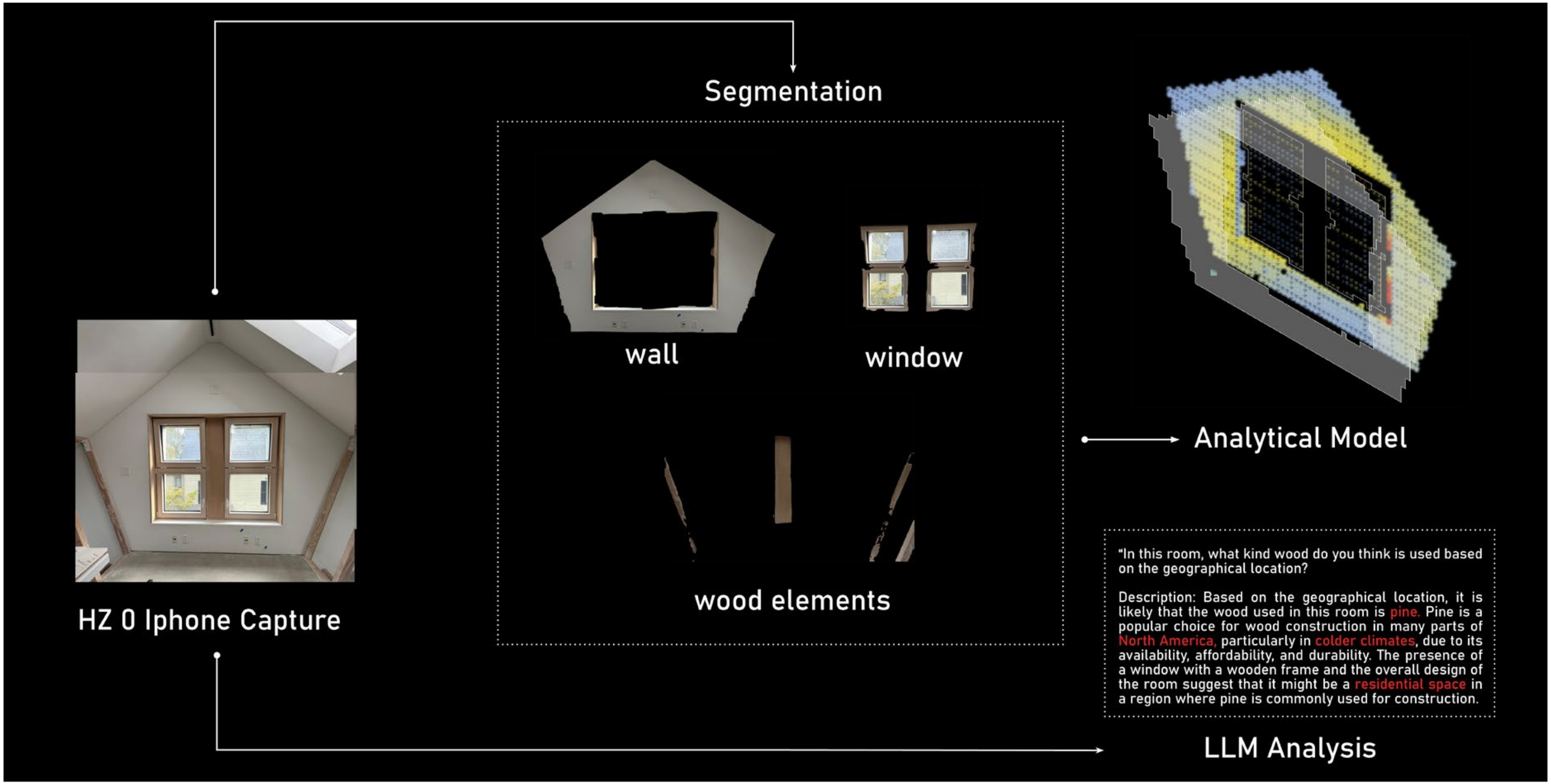


Type: Research paper
Research Collaborators: Mikita Klimenka, Fopefoluwa Bademosi, Damon Lau, Stefanie Pender, Lorenzo Villaggi, James Stoddart, James Donnelly, Peter Storey, and DavidBenjamin
Year: 2024

Awards and Recognition:
Accepted article under MDPI "Sustainability" as part of the Special Issue "A Circular Economy for a Cleaner Built Environment"
Selected to present at the 23rd Annual New York State Green Building Conference.

Project VIS: Image-Based Insights and Predictions for the Built Environment.

Ongoing research at Grinham Research Group, funded by Autodesk, explores LLMs and machine learning for material assessment, spatial analysis, and building science. Currently in the data collection phase of gathering thousands of images with sensor data to train predictive models.



Type: Research paper
Research Collaborators: Jonathan Grinham
Year: 2024 – Present

Localized Biocomposite 3D-Printing with Natural Fibers

A research exploring a framework for the manufacturing of e 3D printable biocomposites made from globally available agricultural fibers, leading to five regionally specific biocomposites. Each biocomposite includes a natural fiber blended
with two universally available additives - a biodegradable binder and cellulose. These biocomposites are experimentally characterized in ways that allow strength and stiffness in bending and compression to be understood relative to the orientation of the print paths.

Type: Research paper
Research Collaborators: Daniel Tish , Amelia Wen Jiun Gan, Martin Bechthold
Year: 2024 - Present

Awards and Recognition: ACADIA Conference Runner-Up for the Vanguard Award.

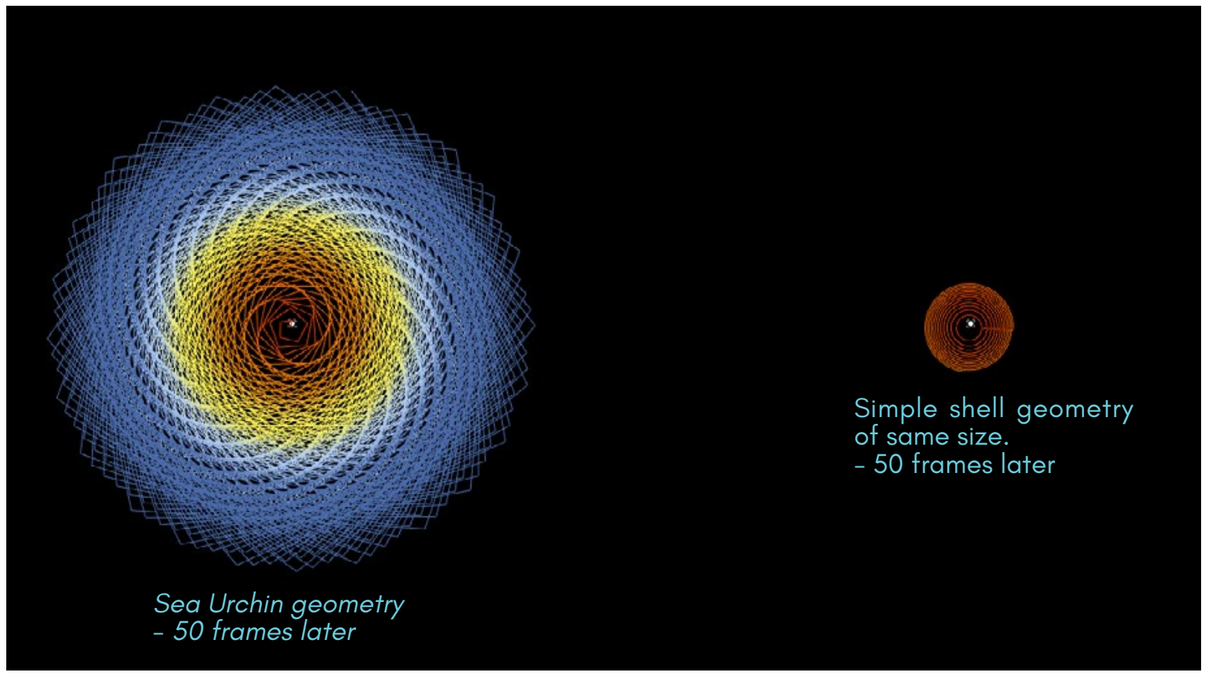
Programming & 3D printing

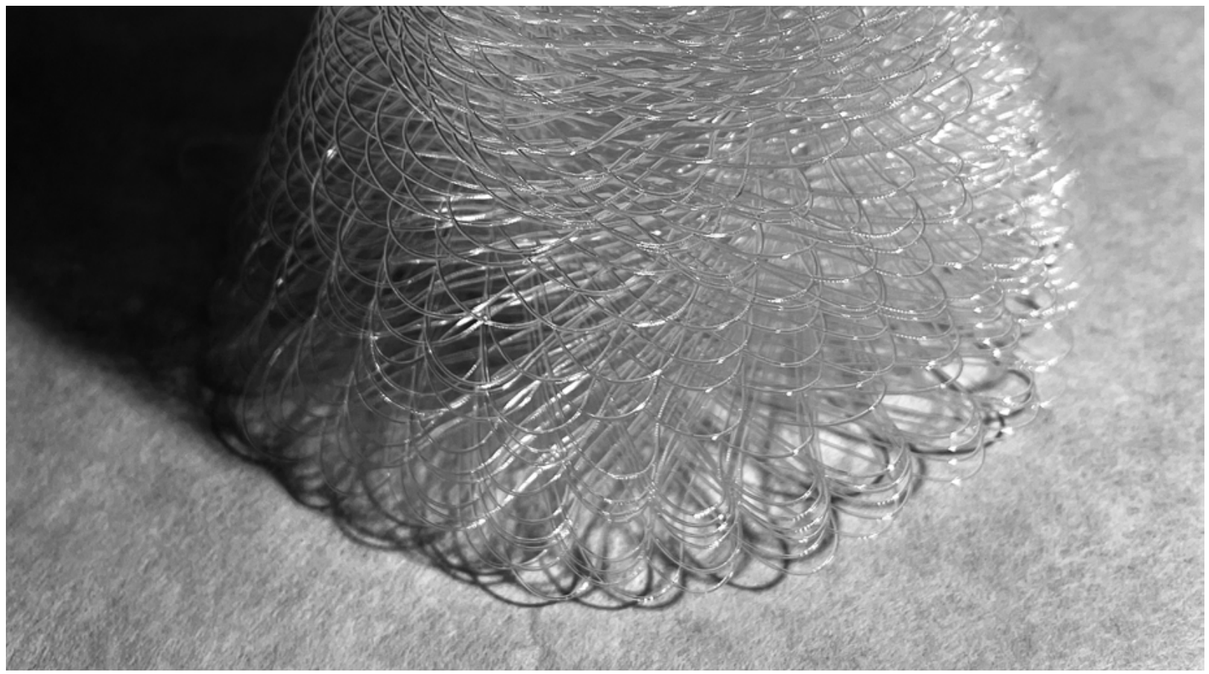
C# + Grasshopper [Rhino3d] + Custom G-code

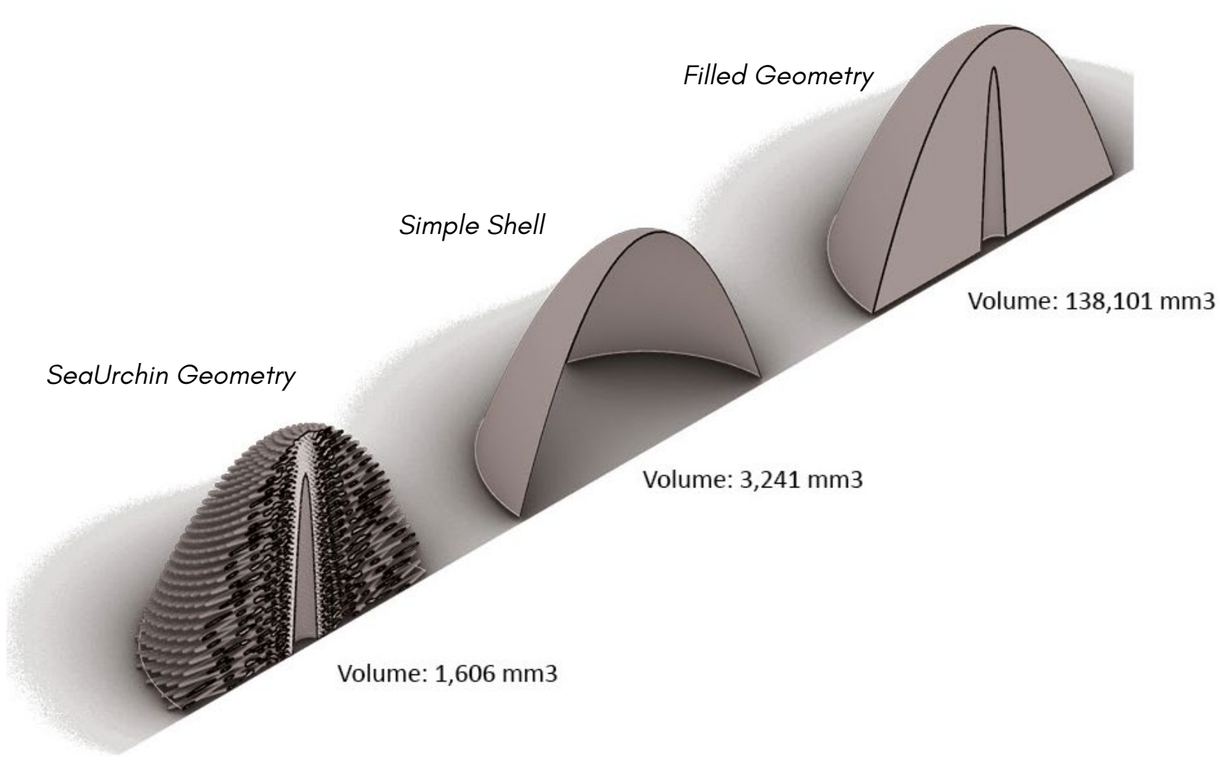
The following shows the development and studies that lead to grasshopper plug-in SeaUrchin. Sea Urchin harnesses the power of simple phyllotaxis algorithms to generate a diverse array of forms. SeaUrchin enables the generation of a continuous and complex polyline, simplifying the translation into G-code for 3D printing purposes.

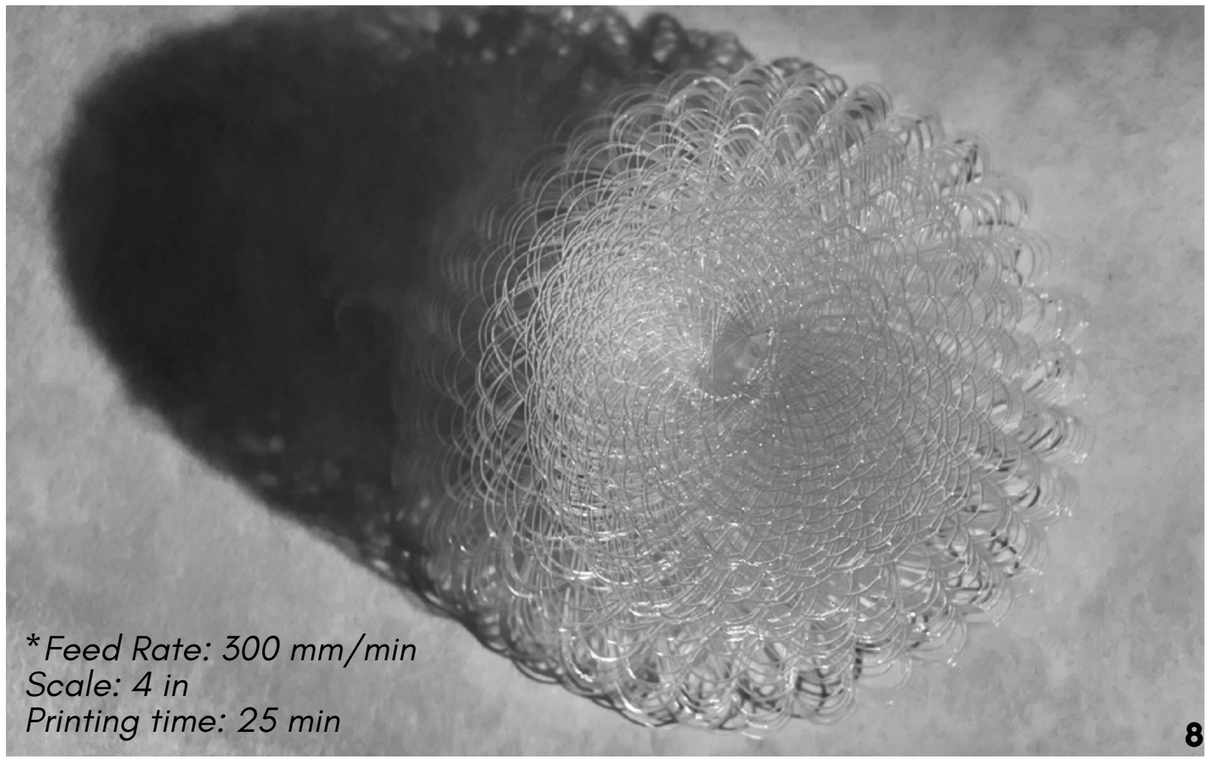
Concept + Introduction:

SeaUrchin explores the numerous possibilities of phyllotaxic algorithms to create intricately detailed forms quickly and with minimal volume. The plug-in ensures proper layer heights for 3D printing purposes, and designers can achieve various shapes depending on how they set their own feed rates and geometry scales.



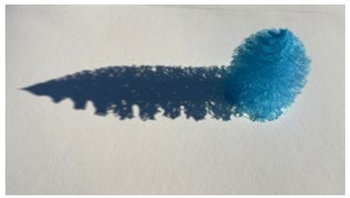


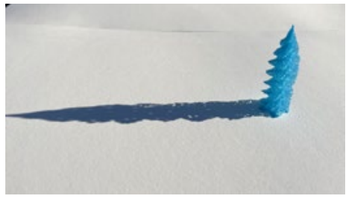




The many iterations

Testing parameters: Angle of divergence, scale, feed rate, and printer.

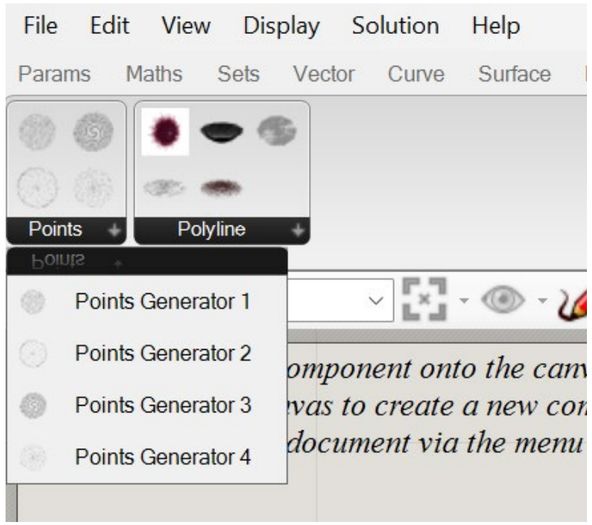


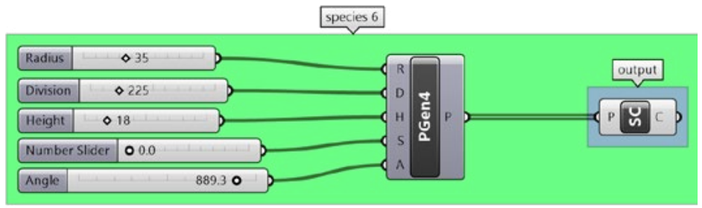


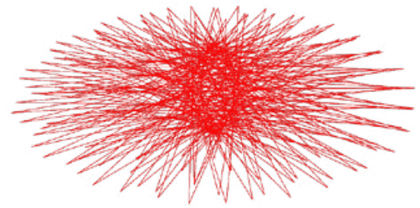
Model Name	Parameter: angle	Parameter: scale	Parameter: feed rate	Printer	Picture
final shell attempt	90	2	250	dremel	
3nd shell attempt	5	1	200	dremel	
2nd shell attempt	137.3	1	300	prusa	
1st shell attempt	137.3	1	300	dremel	
1st pine cone attempt	135.7	1	200	dremel	
2nd pine cone attempt	135.7	1	120	dremel	
final pine cone attempt	135.7	1	120	prusa	
1st icicle attempt	135.7	0.5	300	dremel	
final icicle attempt	135.7	0.5	250	prusa	
mini pine cones attempts	137.6	0.5	500	prusa	
sunflower center	137.5	1	300	prusa	
1st flower attempt	135.7	1	300	dremel	
transparent flower	135.7	1	120	dremel	
stem	n/a	0.5	300	dremel	

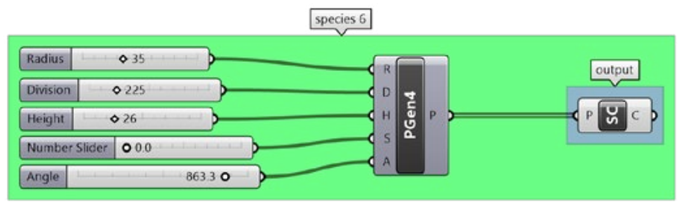
Simple & Beautiful

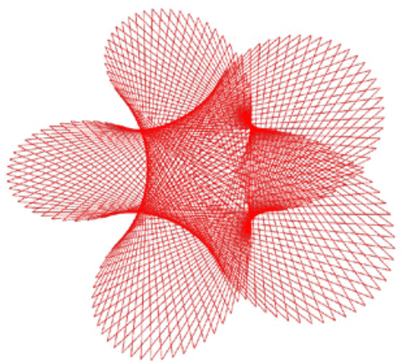
The plug-in includes four types of point generations, each following different angles of divergence, as well as four different species. The richness of shapes that one can achieve with these two configurations is endless.

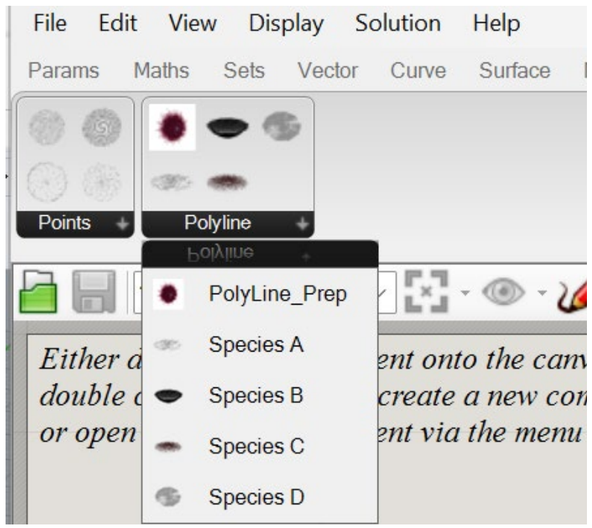


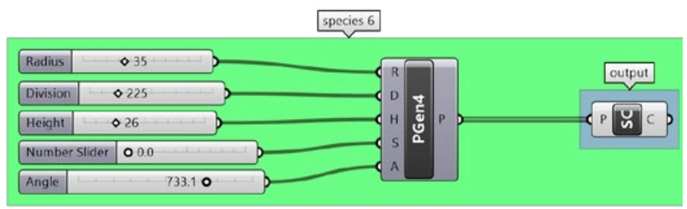


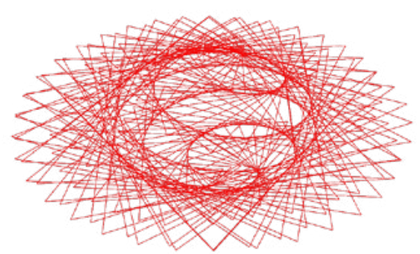










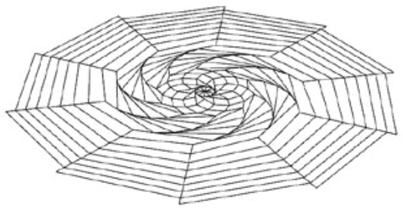


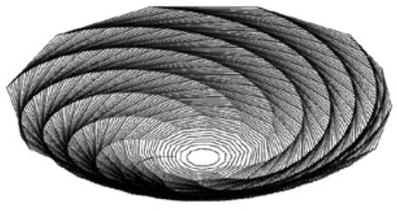
**Possibilities within a single species*

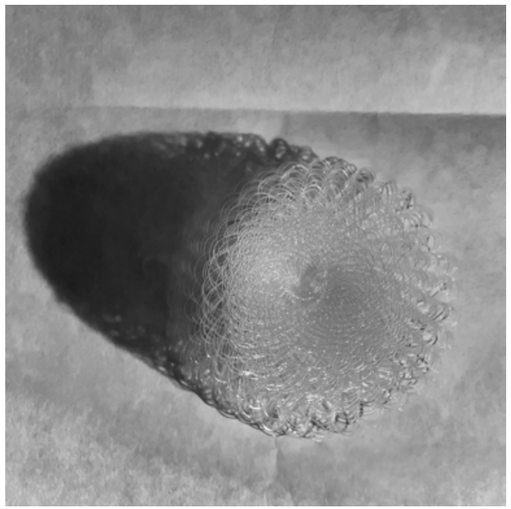
Food4Rhino +
Harvard GSD Documentation

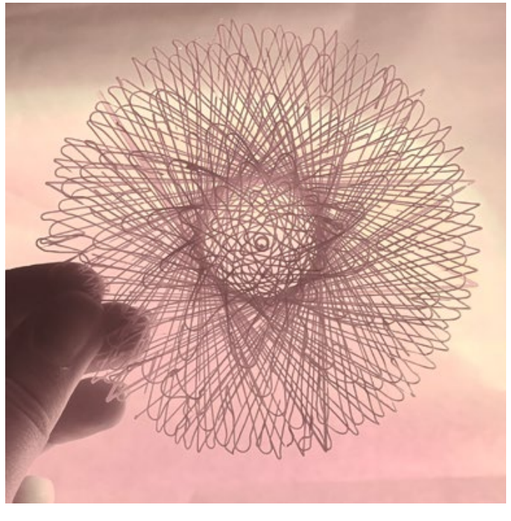
Visit :
https://gsd6338.org/fall2023/projects/seaurchin/index.html
for Harvard GSD documentation

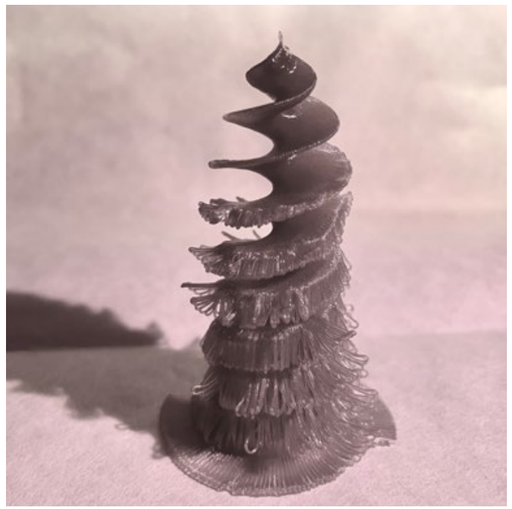
And:
https://www.food4rhino.com/en/app/seaurchin
for Food4Rhino download

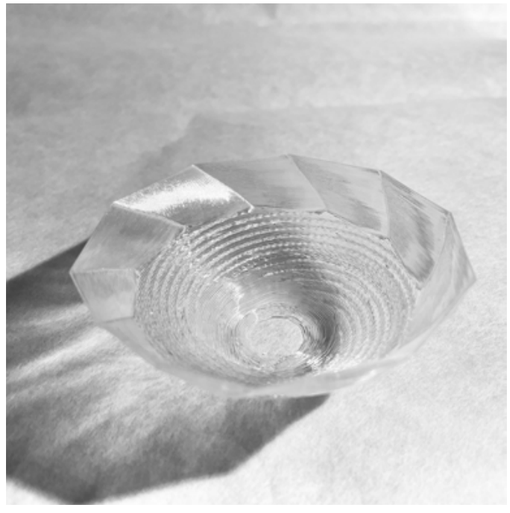


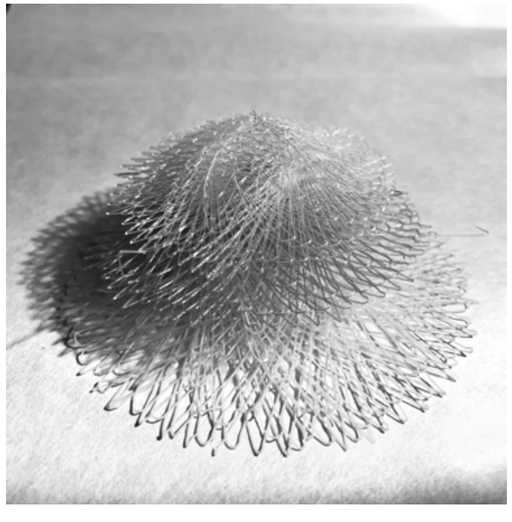












Product + Material Engineering

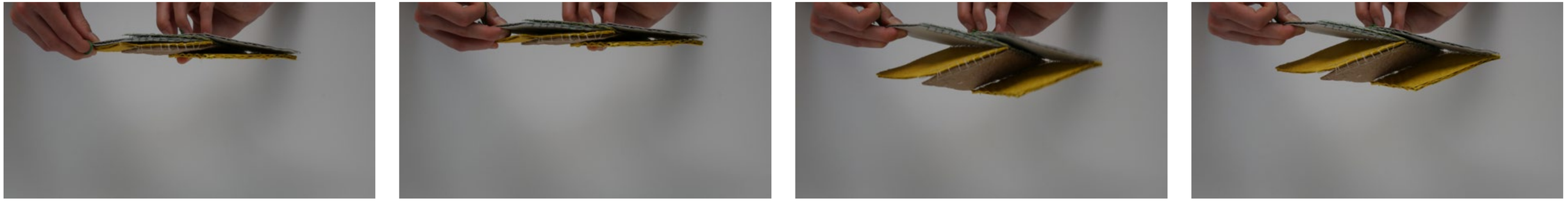
Material Engineering + Market studies + Design Development

The following pages showcase a segment of the development process for the product Pulp Panels*. Pulp Panels are easily deployable sound-absorbing panels designed to offer quick, affordable, and aesthetically pleasing solutions for users seeking to privatize their spaces.

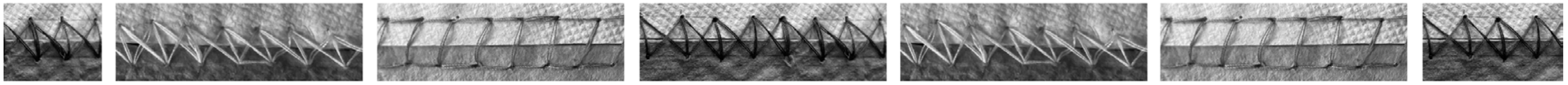
**This product is currently pre-registered and undergoing a copyright process. Please refrain from unauthorized use or reproduction.*

Pulp panels are...

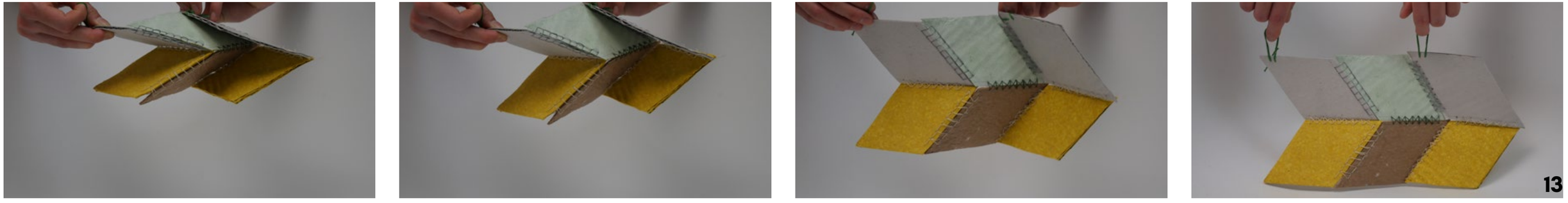
Easily deployable sound-absorbing panels designed for users seeking quick, affordable, and aesthetically pleasing solutions to privatize their spaces.



Highly engineered yet simple, crafted from recycled paper and bound using traditional bookmaking techniques to improve longevity.



Their origami format enables swift and straightforward deployment, ensuring accessibility for individuals of all skill and income levels—only tools required are two pins or nails.



Reverse Engineering

We reverse-engineered the pulp panels, drawing inspiration from the absorbent properties of moth wings, characterized by their porosity and laminations. Our aim was to replicate this natural phenomenon in our design. ---->>

...And we chose paper because:

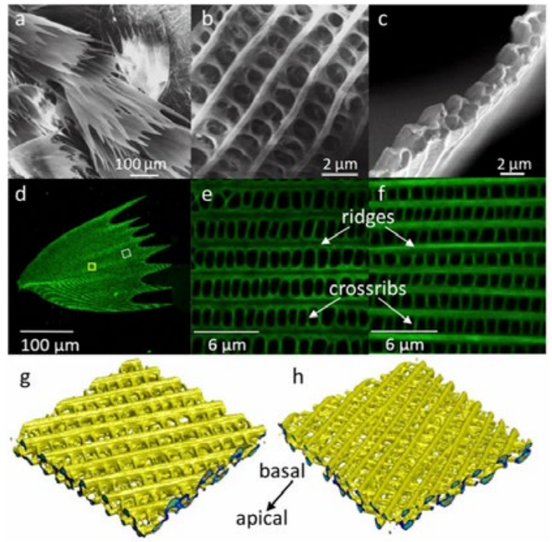
Paper is Bio-Based/ Renewable!

[1]Paper and cardboard make up the largest share (12%) of municipal solid waste! That's 17.2 million tons.

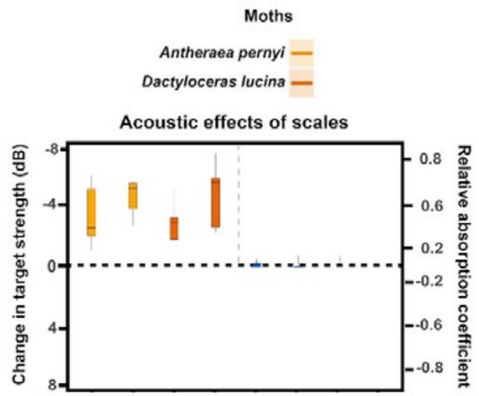
[2]Easy to functionalize! & Sound insulating material.

Its porosity can be manipulated!

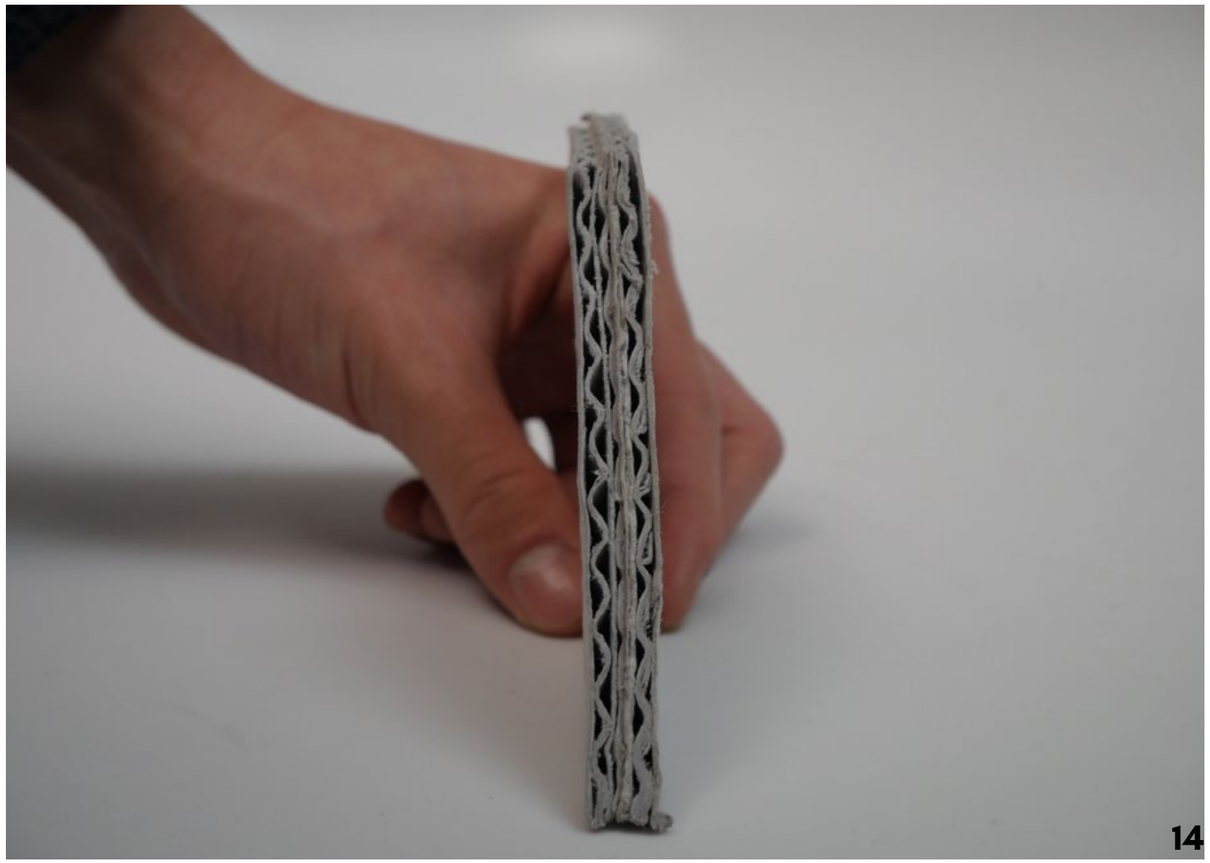
[1]https://www.epa.gov/facts-and-figures-about-materials-waste-and-recycling/paper-and-paperboard-material-specific-data
[2]https://www.mdpi.com/2071-1050/13/10/5546



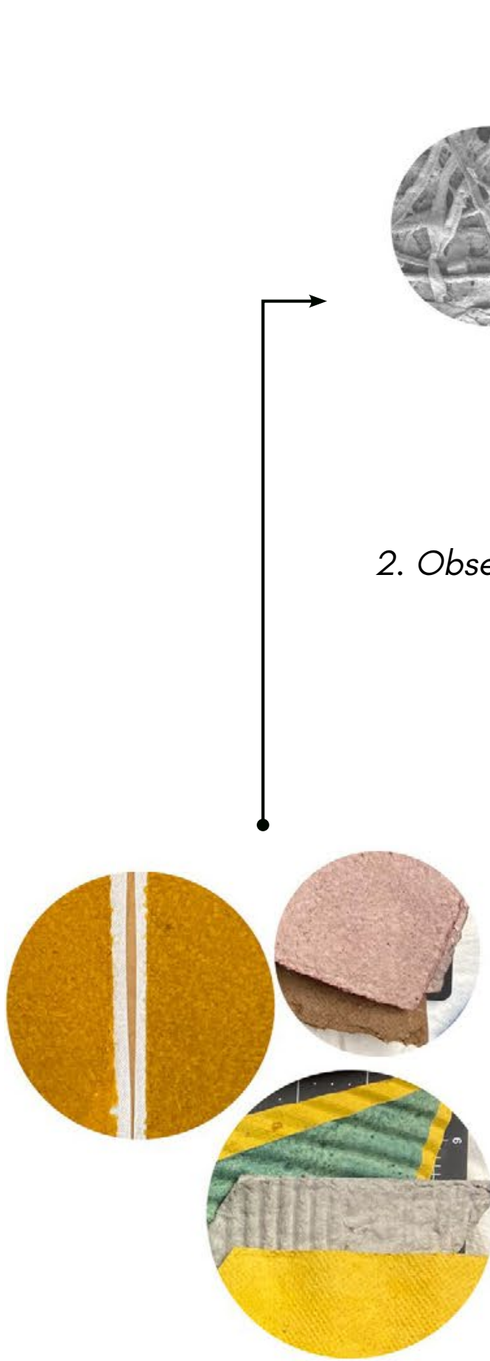
**Porous laminae connect trabecular pillars
**scales layered to create disorder



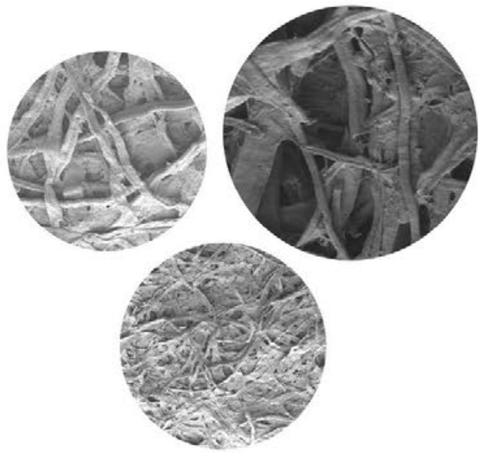
**Wing scales reduce sound by ~5 dB & function like resonant sound absorbers



Our process:



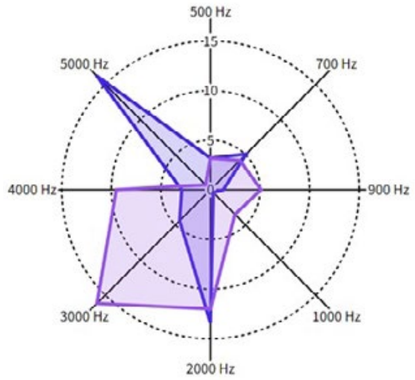
1. We made pulp



2. Observed their micro-structures

3. Molded them

4. Tested their sound absorption

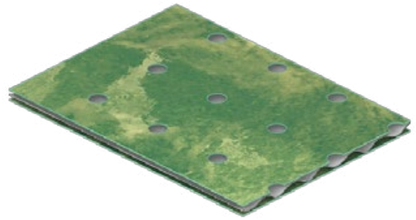


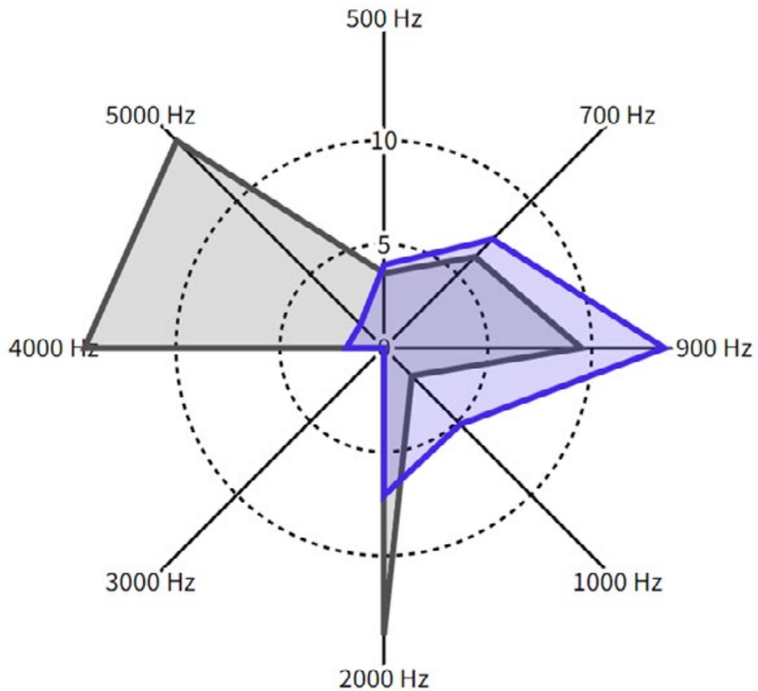
5. Sewed them together

6. Saved our scraps for reuse!

Our findings

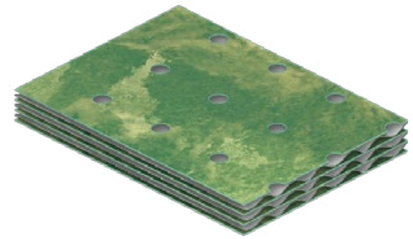
Sound insulation of a single newspaper laminate :

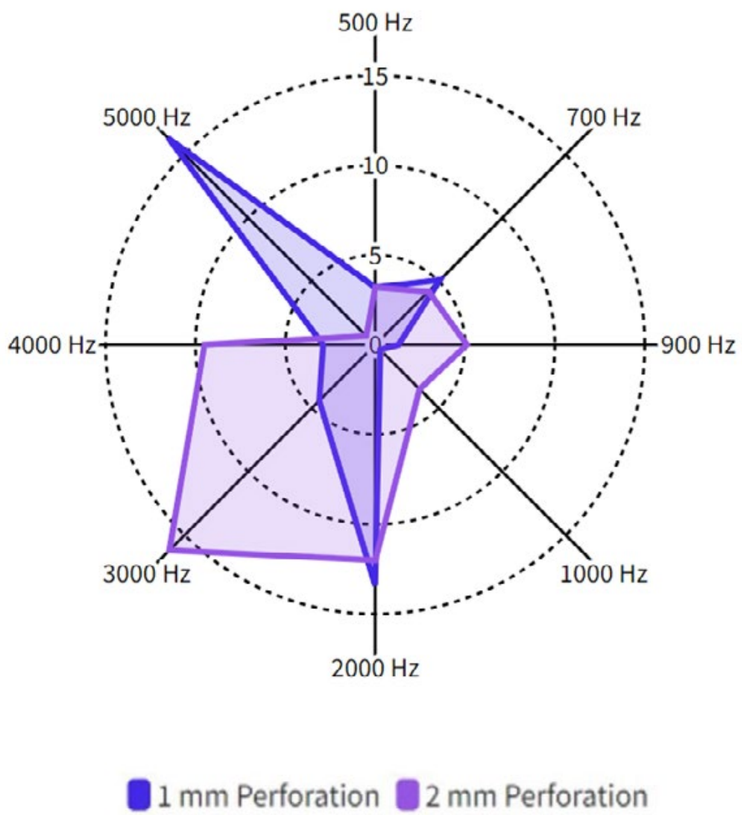




**Perforations increase resonant absorption in mid-frequency range (500 Hz - 2 KHz)*

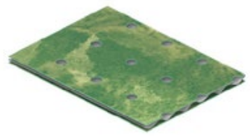
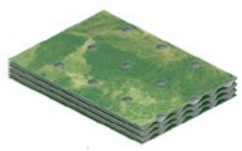
Sound Insulation of a Triple Newspaper Laminate:





***Triple layering increases resonant absorption in upper mid-frequency range (2 kHz - 4 kHz)*

Our findings

Product		Material	Avg. Insulation	Advantages	Recommendation
	Single Sheet	Filter paper	- 9.5 dB	Mid frequency (500 Hz to 2kHZ) Upper Mid Frequency (2 kHz to 4 kHz)	Base material for insulating instruments, voices
	Single Sheet	Paper bag	-10.7 dB	Upper frequency (> 4kHz)	Base material for insulating bird chirps, cymbals
	Single Sheet	Copy paper	-9.3 dB	Mid frequency (500 Hz to 2 kHz) w/peak insulation at 900 Hz and 2 kHz	Base material for insulating voices (extra insulation at upper & lower range)
	Single Sheet	Newspaper	-8.2 dB	Mid frequency (500 Hz to 2 kHz)	Base material for insulating instruments, voices
	Single Laminate	Newspaper (1mm perforation)	-5.0 dB	Mid frequency (500 Hz to 2 kHz)	Insulator for instruments, voice
	Triple Laminate	Newspaper (2 mm perforation)	-6.8 dB	Upper frequency (> 4kHz) Mid frequency at 2 kHz and 4 kHz	Insulator for instruments, voice

***Our technology insulates within maximum sensitivity of human hearing (2 kHz to 5 kHz)*

Micro-Studies

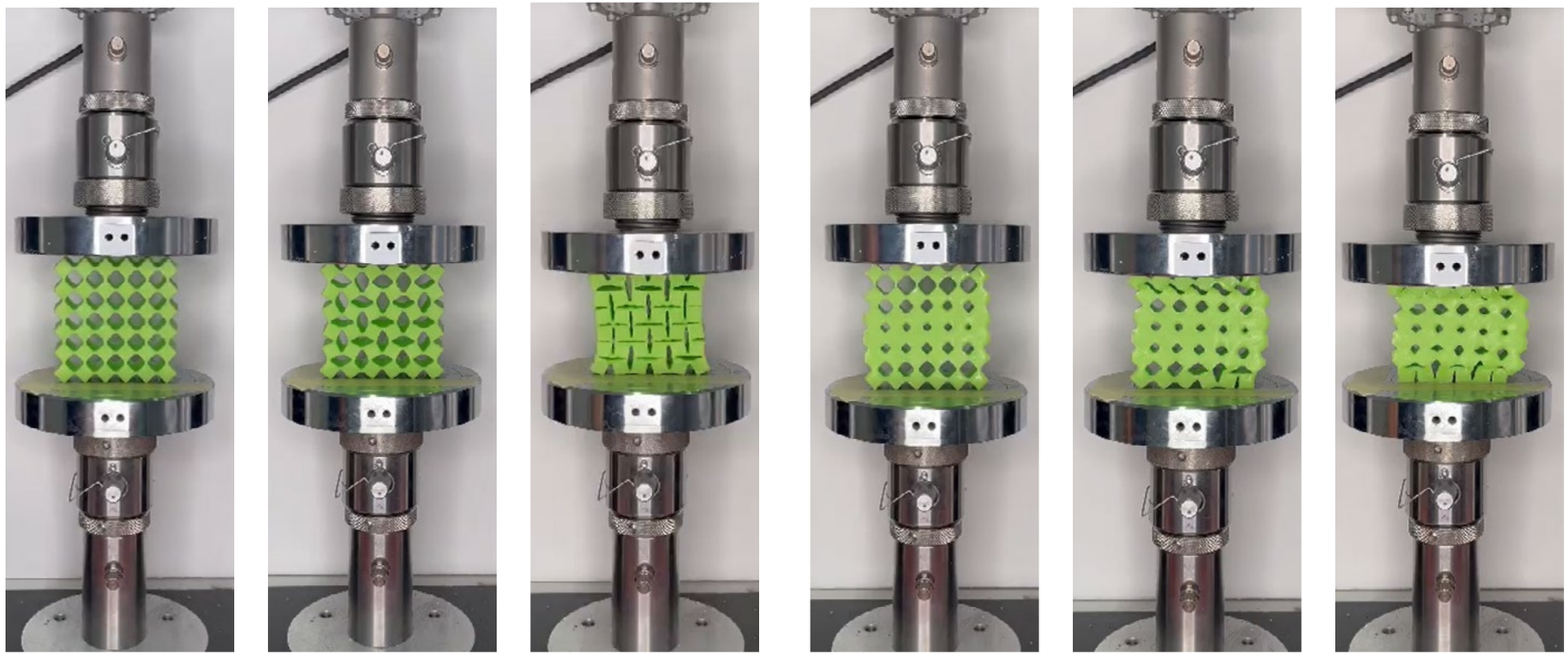
Scientific experimentation + Design Development

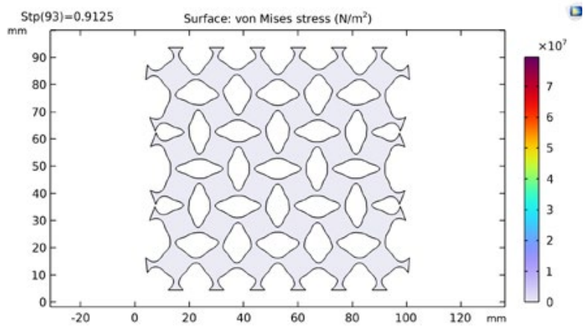
3Depot is a platform designed for the efficient and swift visualization and display of one’s 3D creations, as well as for the efficient transfer and viewing of 3D objects among various users. It facilitates easy sharing and interactive visualization of 3D models, enabling seamless collaboration and exchange of 3D models between individuals.

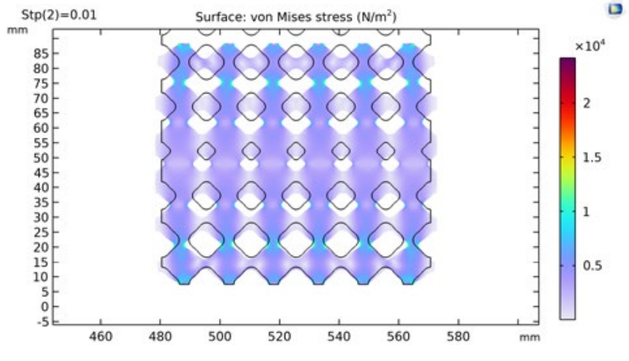
Auxetic Sidewalks to Accomodate Urban Tree Root Growth

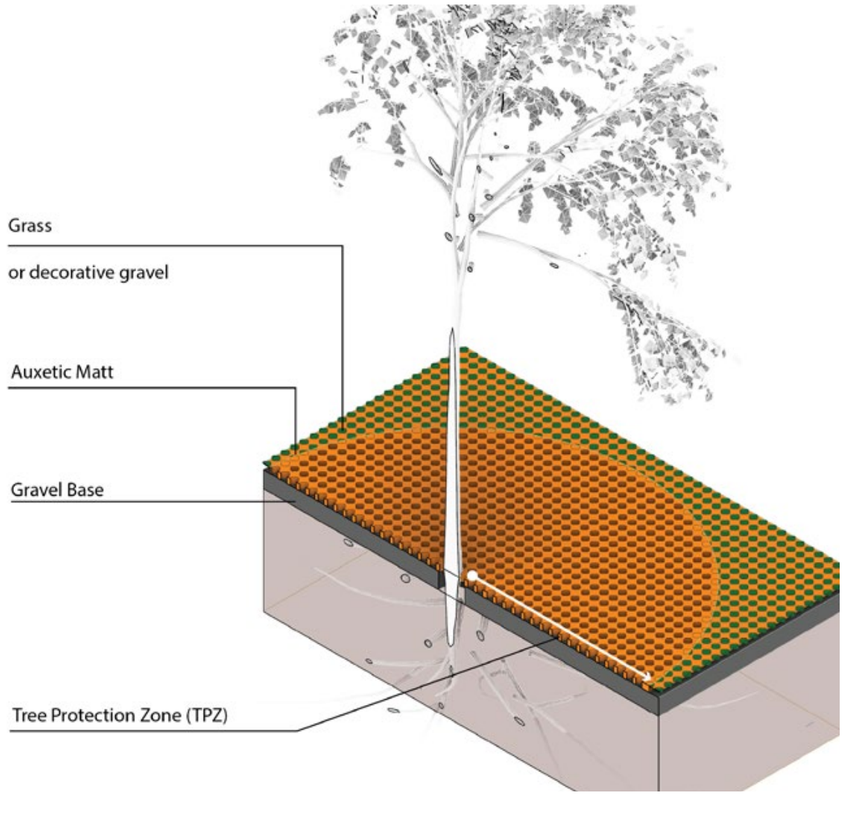
View paper:

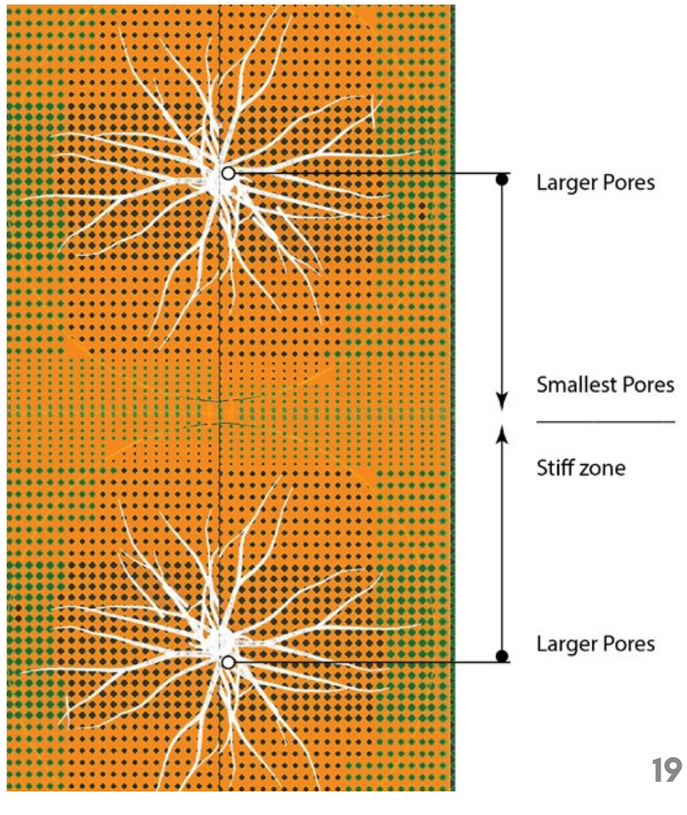
https://www.researchgate.net/publication/378100904_Auxetic_Sidewalks_to_Accomodate_Urban_Tree_Root_Growth







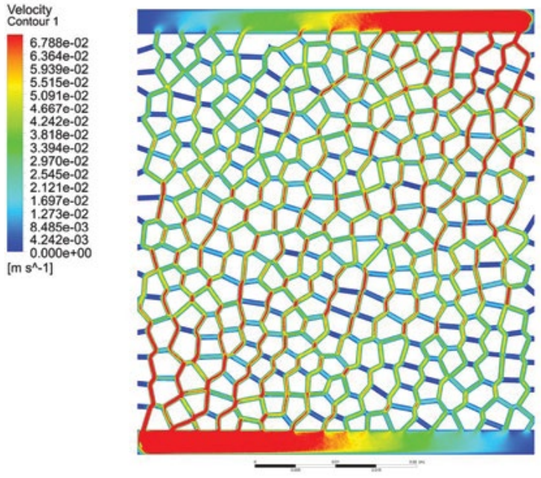


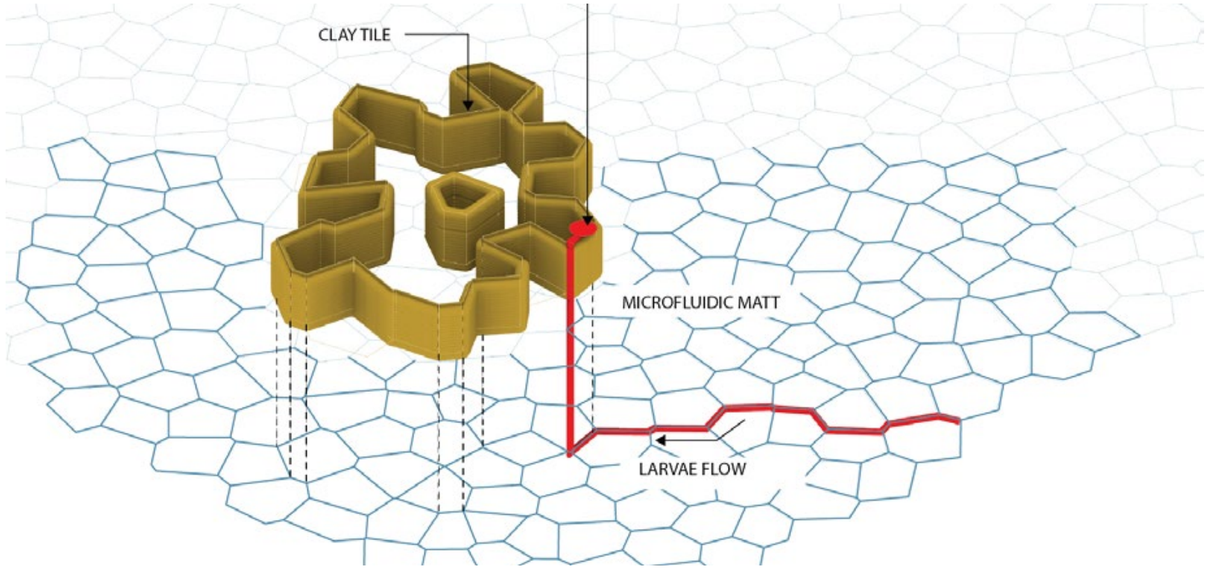


Microfludics for coral larvae propagation

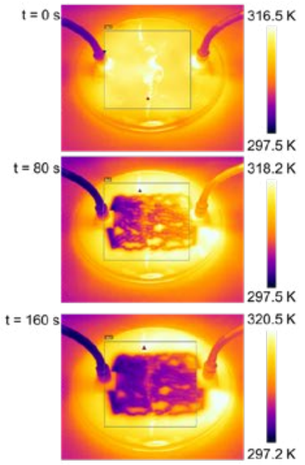
Porposal for a composite device, made of microfluidic PDMS channels for the flow of larvae over large expanses of the ocean floor, and clay tiles following the blueprintof the mat and acting as a substrate for larvae to grow when released from the channels. Coral larvae can be as small as 1mm, making microfluidic channels good vessels of transportation.

View citatation: https://www.researchgate.net/publication/378102189_Microfludics_for_coral_larvae_propagation





a)



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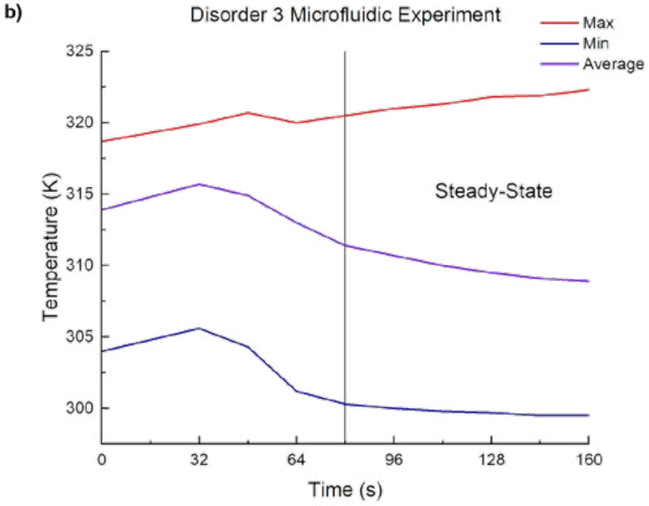

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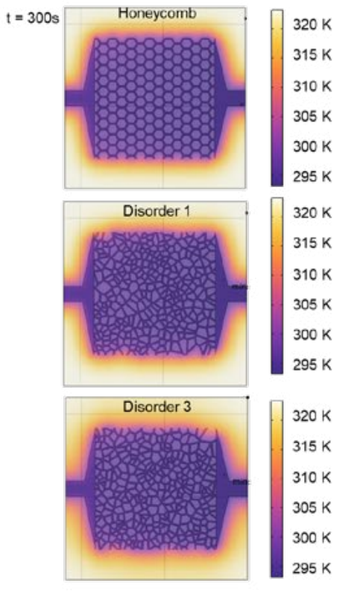

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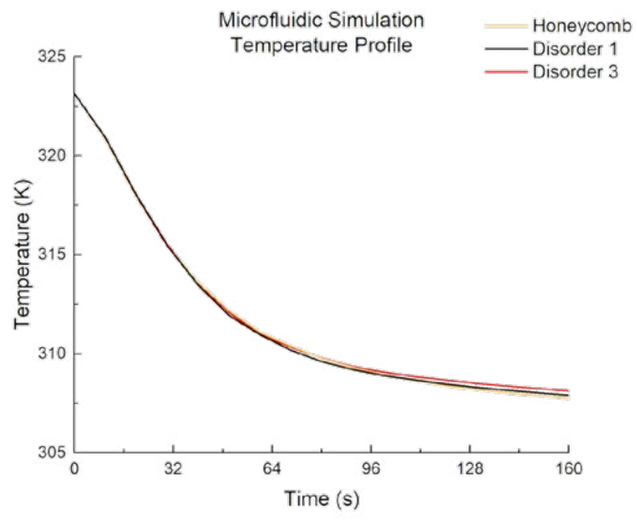

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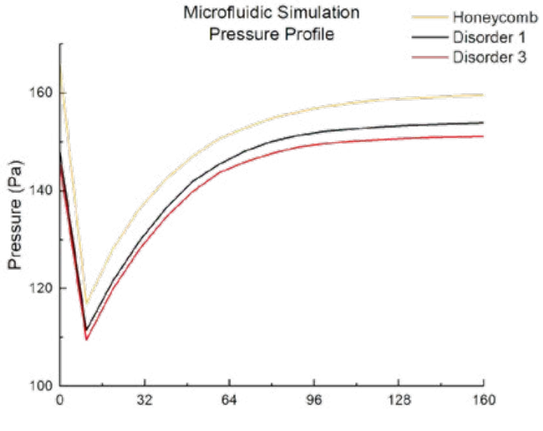

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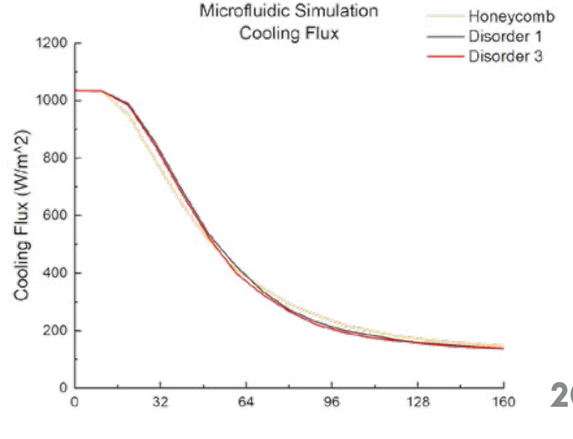
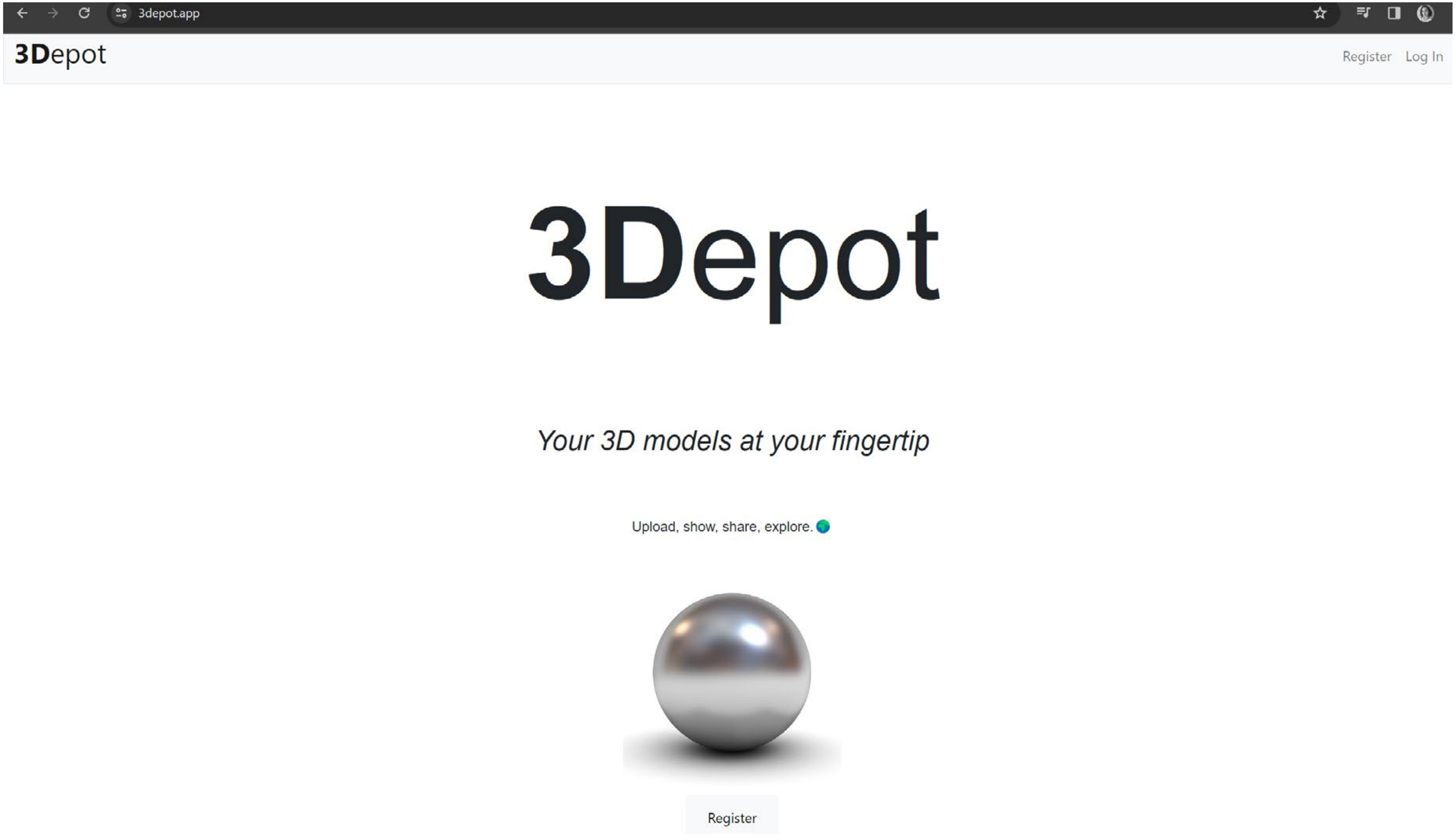


Application Development

Dynamic web-development [Python + Flask + Jinja + SQL + HTML + CSS]

3Depot is a platform designed for the efficient and swift visualization and display of one's 3D creations, as well as for the efficient transfer and viewing of 3D objects among various users. It facilitates easy sharing and interactive visualization of 3D models, enabling seamless collaboration and exchange of 3D models between individuals.

Home Page


3depot.app
3Depot
Register
Log In
3Depot
Your 3D models at your fingertip
Upload, show, share, explore.
Register

Backend develeopment

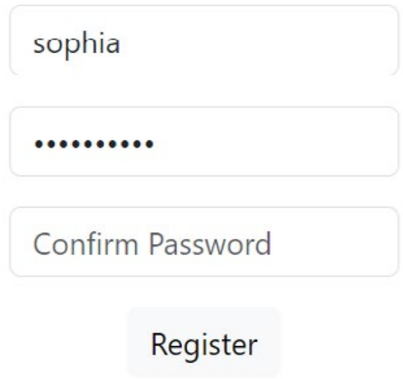
1. Set up the website's backend to store user information.

2.Develop a storage system so people can upload their 3D models and access it later (SQLite3).

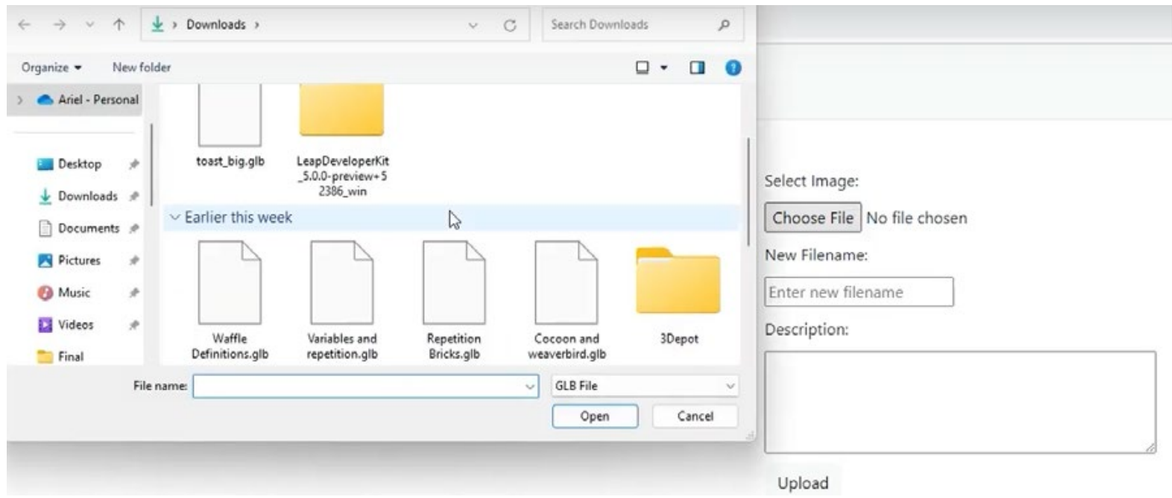
3. Explore Javascript features to interact with the models + 3D Model Converter Integration.

*The project employed Flask, Jinja, Python, HTML, CSS, and JavaScript, harnessing Python's capabilities to handle user data storage efficiently.

1



2



3

Waffle_Definitions

Description: Hello World!

Owner: Ariel

File Size: 2.9 MB

Repetition_Bricks

Description: Hello Harvard!

Owner: Sophia

File Size: 6.3 MB

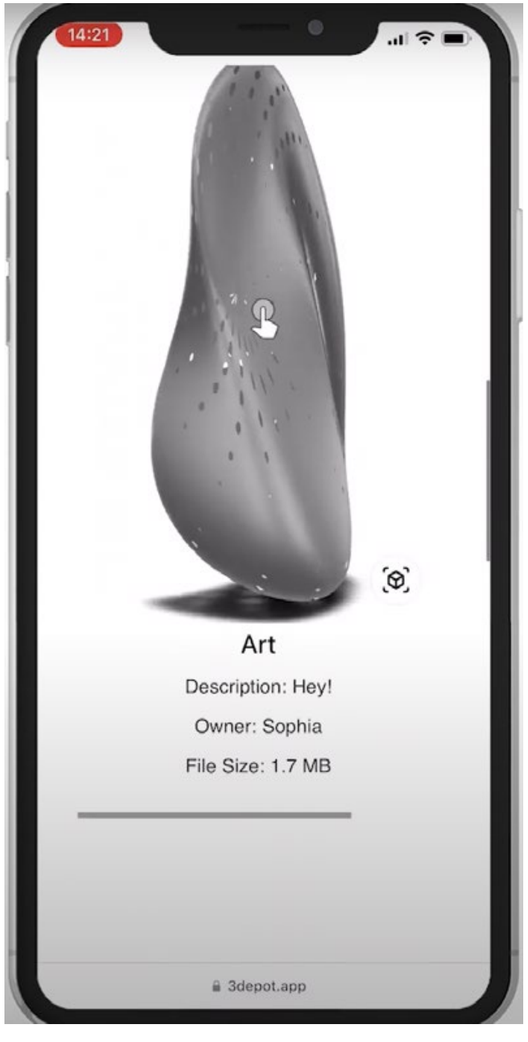
Phone App + AR integration

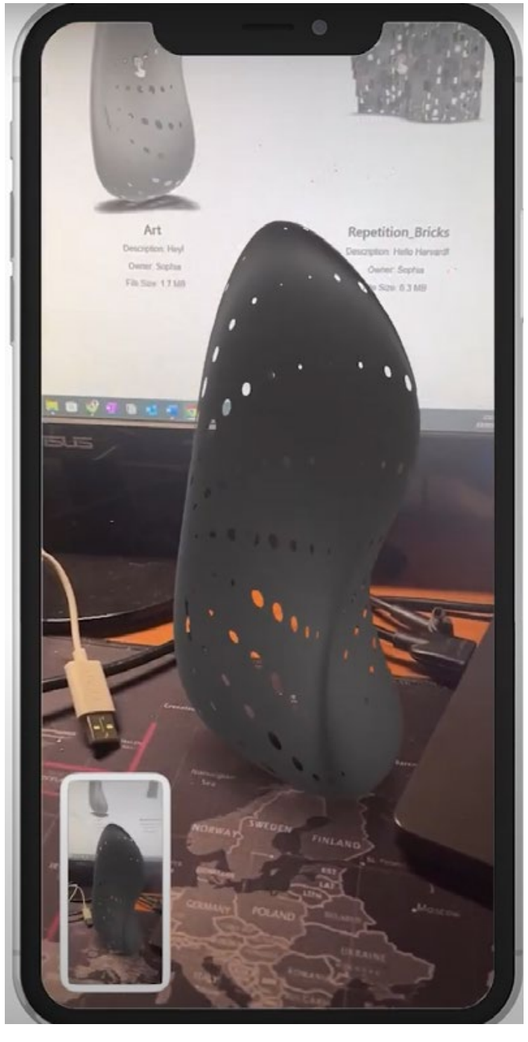
To see how our application works, visit:

https://www.youtube.com/watch?v=67LJnXjonX8 Of 2021

To see my GitHub repository:

https://github.com/soph-cabral/3depot/



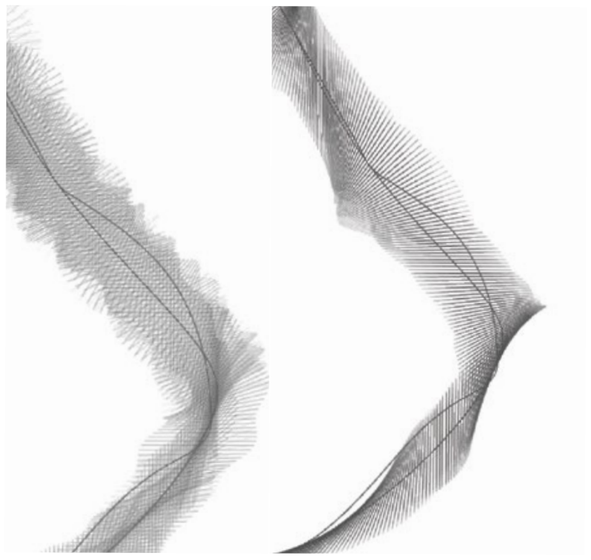


Explorations:

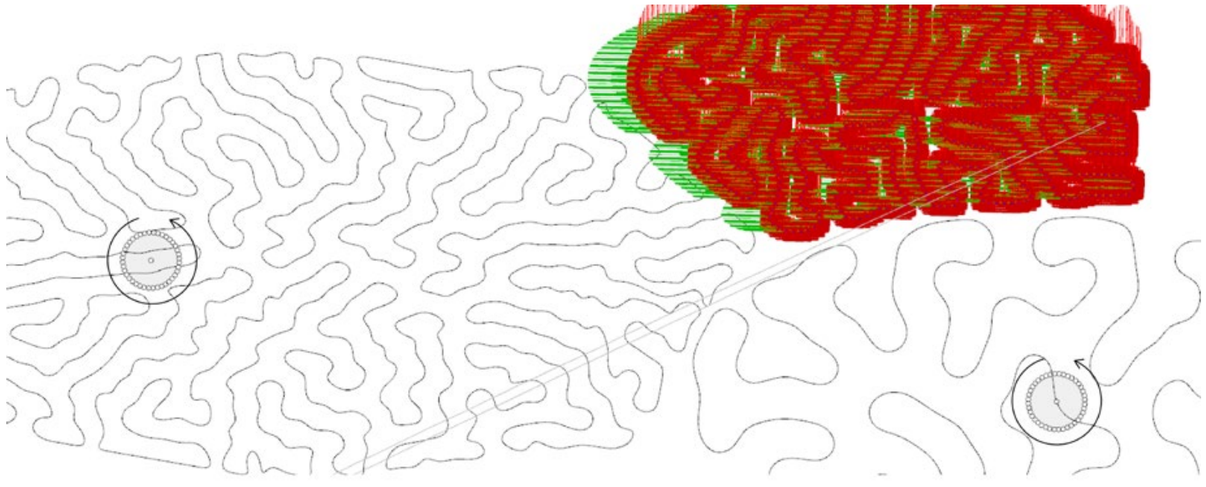
Clay Extrusion: Coral Cross-Sections

Because clay printing works with continuous motions and reaction-diffusion algorithms develop a continuous line, a clay extruder is used to test the production of the cross-sections.

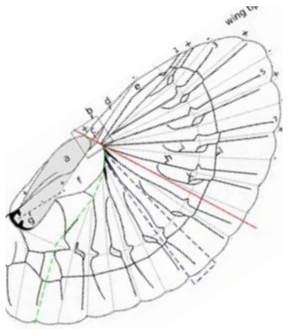
< One cross-section repeated 464 times to create a continuous geometry.

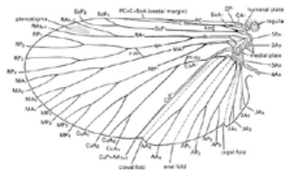


<Create 464 unique cross-sections for a dynamic geometry.



<Testing different grains to print using a reaction diffusion algorithm

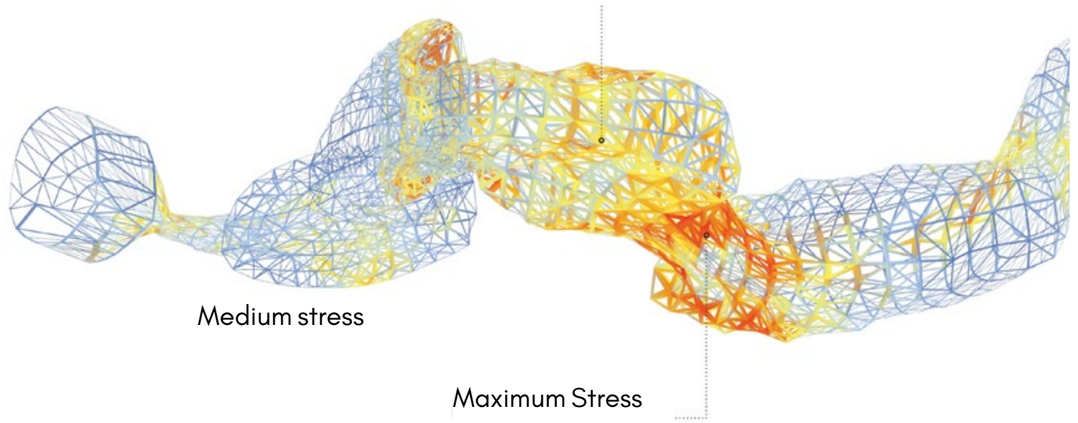




Ref Image - Earwig Labia Minora Wing Venation used as an inspiration for the design of the structure

Growth of Structure on Areas of Stress

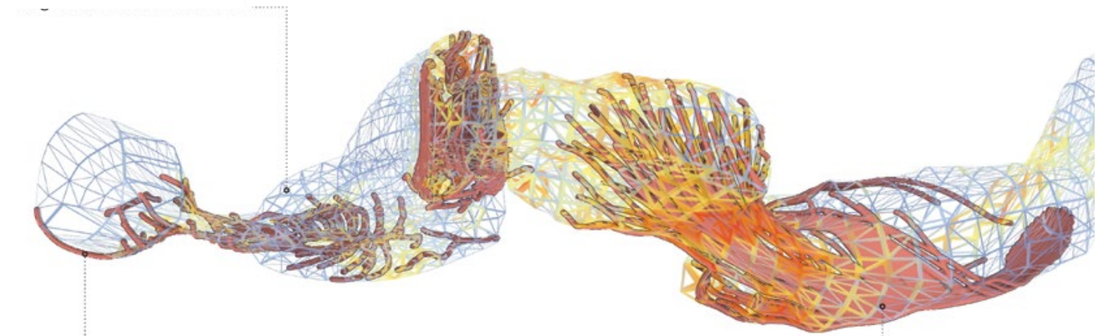
Using Karamba (grasshopper plug-in) to identify stress areas and using those areas as start points for a swarm simulation. The swarm simulation allows for the flow of those points to other parts of a geometry's body; the initial agglomeration diffuses as it moves further away from its start. As a result, support diminishes as it gets closer to stronger areas.



Medium stress

Maximum Stress

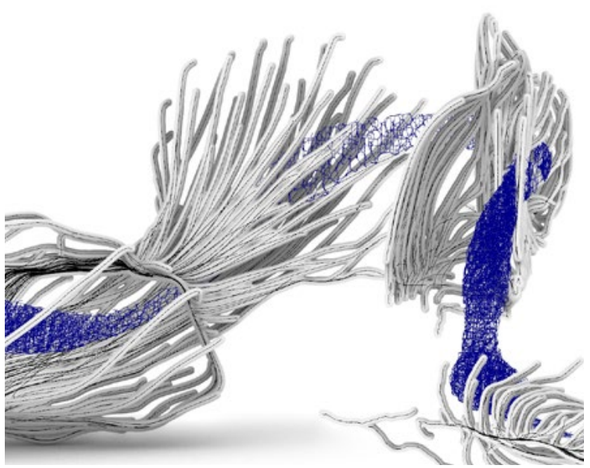
Medium material accumulation



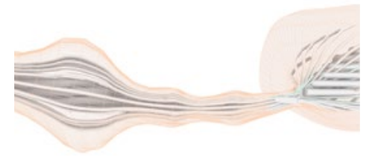
Structural Veins - Placed where additional material support is needed

Maximum Stress

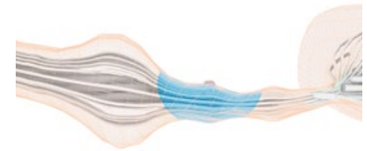
Minimum Stress



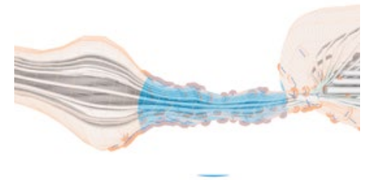
a



b



c



d

Images a-d:
Shows the growth of structural veins required to support compromised areas.

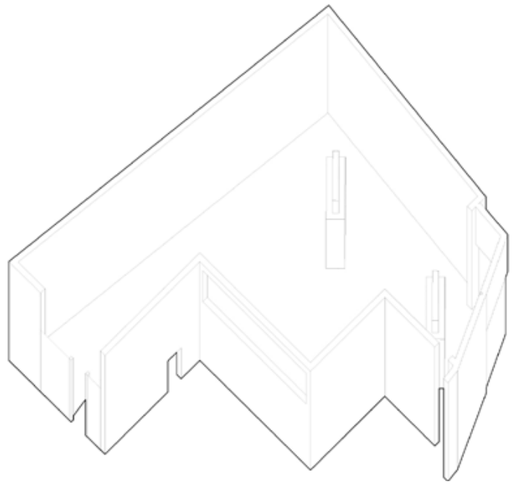
Responsive Surfaces: The New Public Space (Part 1)

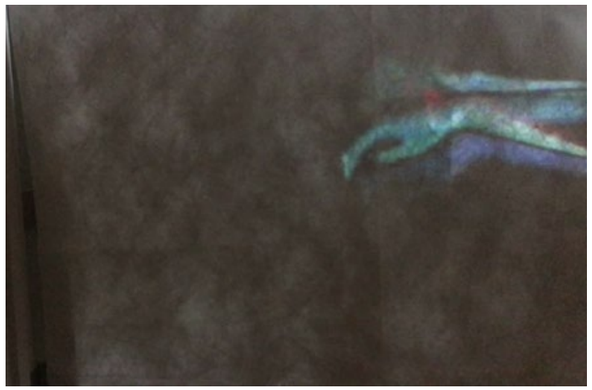
This exploration led to a one-day event at the BEA Gallery at Florida International University. The project studies the possibility of embedding responsive surfaces, either digital or non-digital, or small-scale urban interventions to improve people's engagement with each other and their environment. The additions, or interventions, were designed to stimulate the senses and increase one's awareness of what surrounds them.

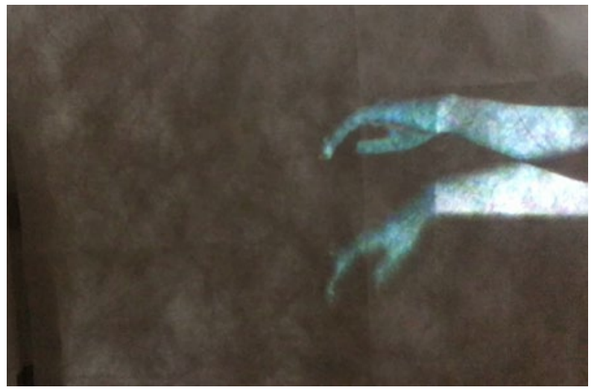
Data was recorded through surveys and recording to discover what surfaces people interacted most with.

https://www.youtube.com/watch?v=67hdZrt7G9E

BEA GALLERY | FIU SCHOOL OF ARCHITECTURE

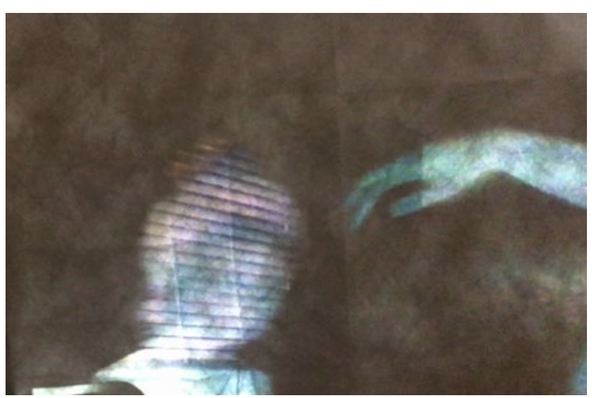


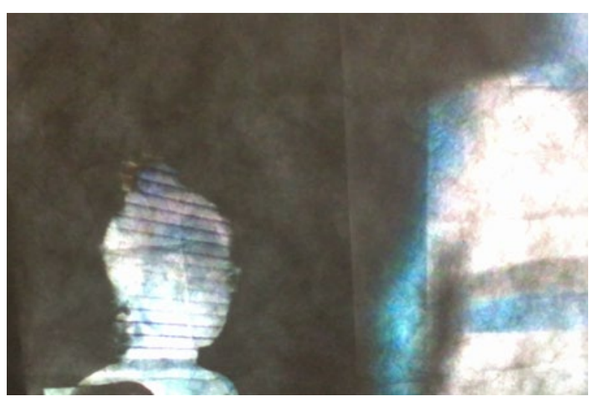


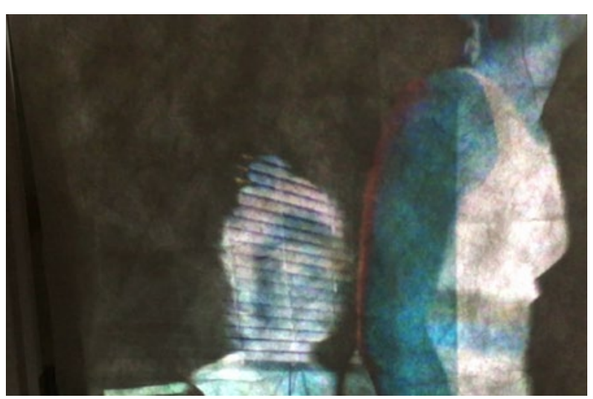


Preliminary Studies: Testing Responsive surfaces.

These photos show a projection that mirrors you and transforms your image into a digitalized self. It responds to your motions as a mirror would, but a lag allows you to view the sequence of your actions.

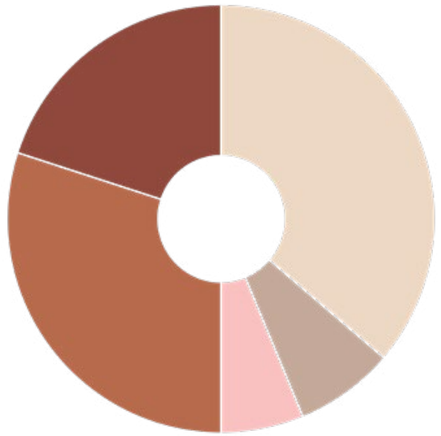




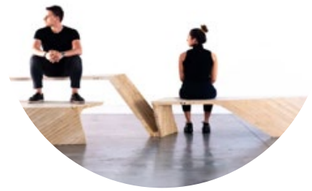


The New Public Space Event: (Part 2)

According to surveys, the most popular areas of the event where:

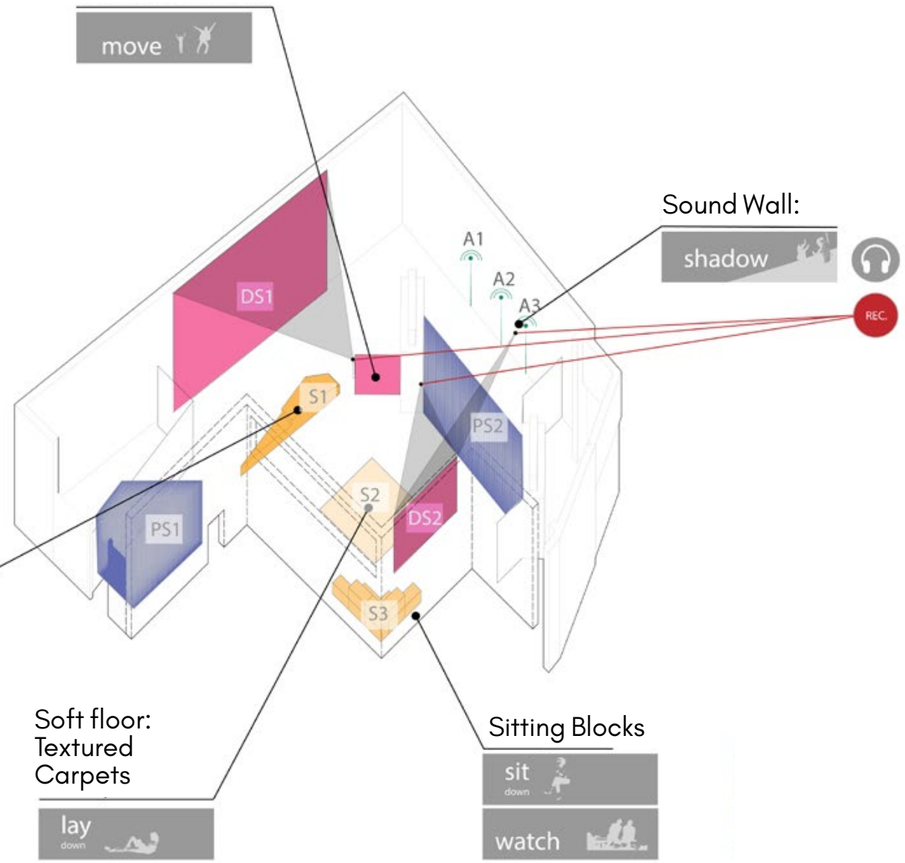


- *Delayed Action on Digital Wall (DS2)*
- *Wooden Bench & Soft Carpets (S1+S2)*
- Sound Wall (A1 + A2 + A3)
- Yarn Walls (PS1+PS2)
- Motion Detection Digital Wall (DS1)



Height Changing Bench

Digital Motion Responsive Wall



Inhabitable Yarn Walls:

Curated, designed and built by myself, Daniela Perez, Elmer Garcia and Hadi Alhaffar

Bench: Fabricated by Elmer Garcia for the event.

Carpets Designed and made by artist Karla Caprali for the event

Carving Ceramic Tiles

Parametrically designed clay bricks carved with the aid of a 6-axis robotic arm. The bricks acquire rich textures and vary according to the end-effector/ carving tool.

Openings in the center of each brick vary to monitor the amount of light coming in. The bricks are arranged in rows [image 1] to create a dynamic light and shadow effect on the surrounding context [Image 2].

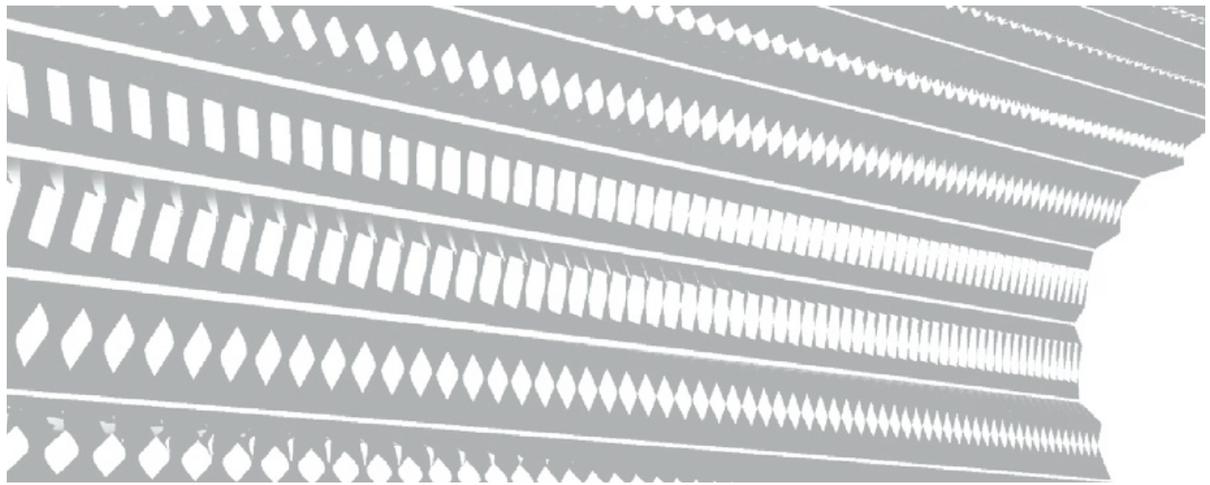
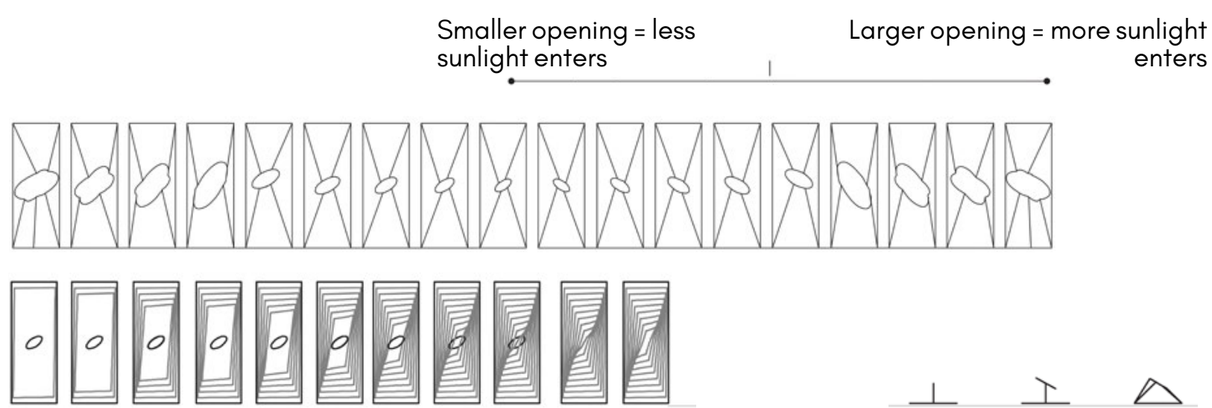


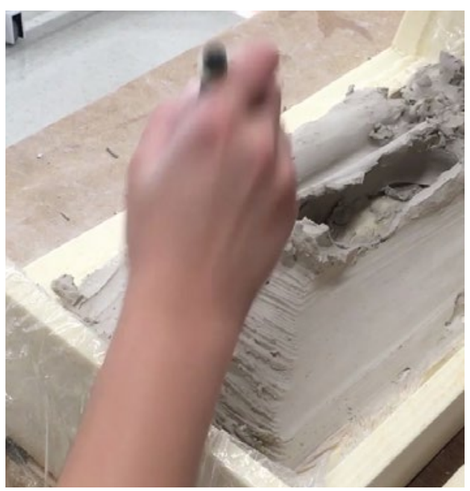
Image 1

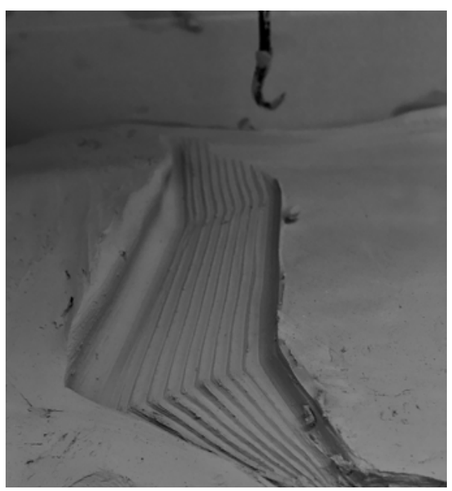
Image 2

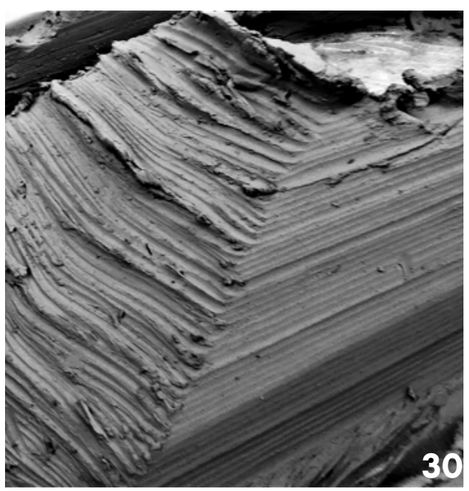


Carving lines

Profile







Biophilic Household Objects

Ref Image - Precedent from my own explorations shown in previous section.

Teaching 3D printing techniques to Architecture Graduate students at Florida International University. Two the right, the student's creation are shown.

The Phases where as follow:

1. Analysis of everyday household objects such as kettles, cups, etc.

2. Learning to use Modo and Grasshopper to design objects.

3. Analysis of plants and their needs and application of this analysis into the design of household objects that sustain them.

4. Making of household objects that sustain plant life.

Lemon Balm Infuser

by: Natalia Castillo

Succulent Teapot

by: Colin Mele

Spanish Moss IKEA Lamp

by: Rafael Cardero

Other Prototypes

End.