Borealis

Borealis | Documentation

Team member: He Zhu, Jiaheng Wu, Xiaojing Li

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1. Overview

1.1 Concept

Sea levels are rising and oceans are becoming warmer. Longer, more intense droughts threaten crops, wildlife and freshwater supplies. From polar bears in the Arctic to marine turtles off the coast of Africa, our planet's diversity of life is at risk from the changing climate.

Borealis is an interactive installation, which is designed to uncover the fact that global warming has hastened the rate at which glaciers melt into the sea. The concept is to reveal how people's thoughtless act can bring destructive impact to the environment. Human need to be aware of the results of their destructive behaviors.

1.2 How does it work

Audiences interact with the installation by approaching and "breaking up" the pieces. The installation presents a "malfunction" after being totally "destroyed". Which leads to a reflection that unrestricted human activities will exceed the tolerating ability of nature and eventually cause an environmental destruction.

There are four stages of the whole process:

Stage 1: The installation glows with Northern lights, which looks like a scene of icebergs.

Stage 2: After the installation detects audience, it goes into stage 2 where the light increases its brightness gradually and presents a color changing pattern. The speed of color changing depends on the number of active sonar sensors.

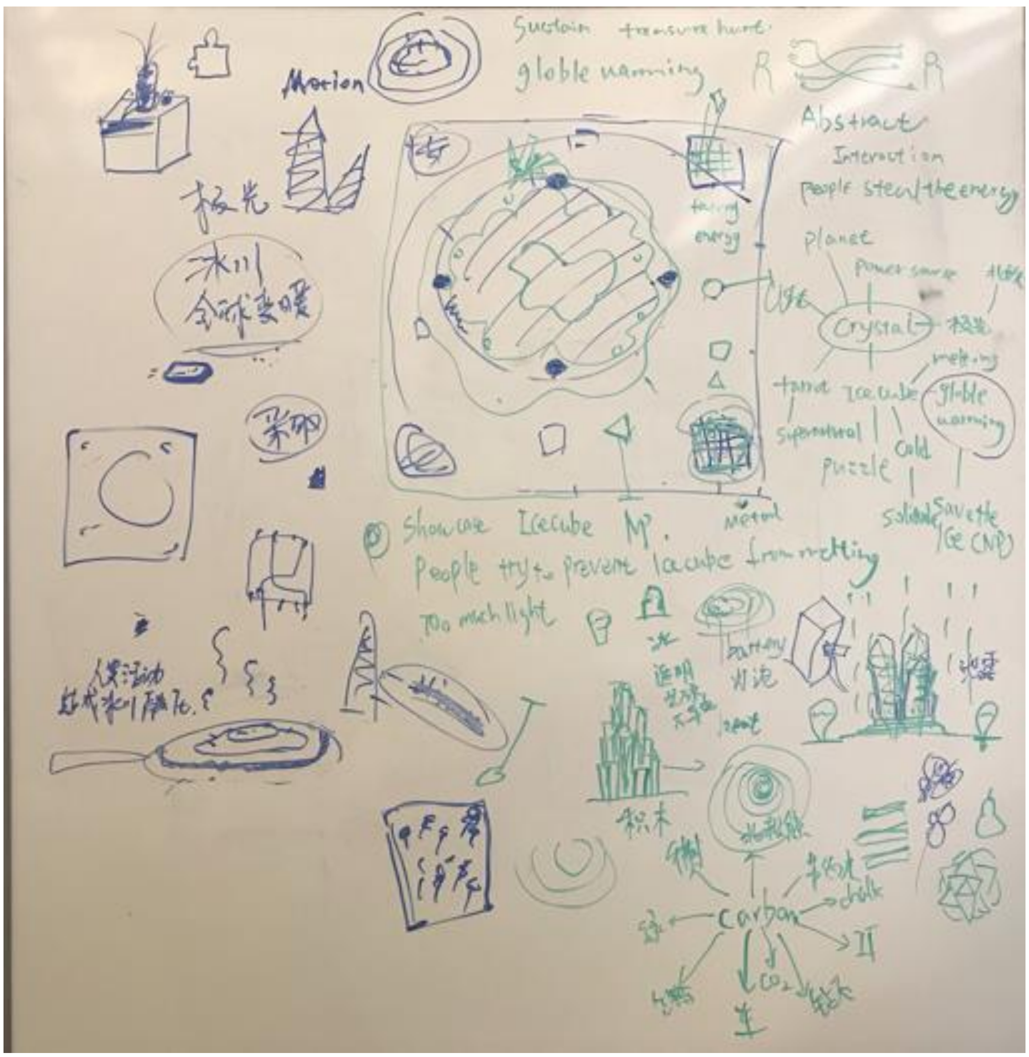
Stage 3: There are 4 polar bears standing on the icebergs with blink LEDs inside that attract users to pick it up. Once they pick up the polar bears, the installation performs a spread light and plays drop animations.
If all the polar bears are picked up, the light gone. The melting motion is displayed and continued with burning motion to urge people return the polar bears.

Stage 4: The model will be reset after all of 4 polar bears being returned to the designated place.

2. Ideation

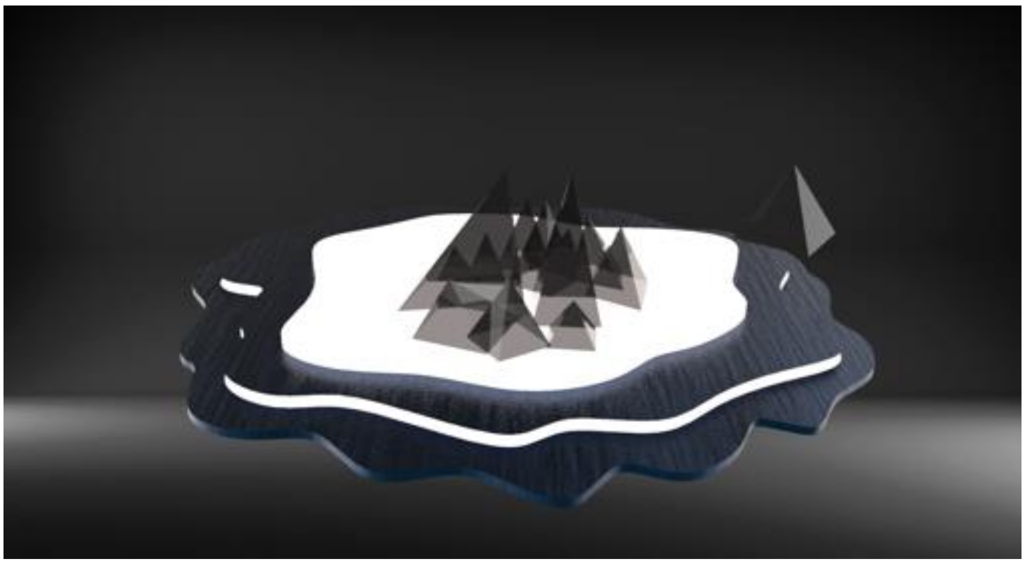
2.1 Brainstorming

After presenting our personal ideas, we decided to merge our three ideas into one. At the very beginning, the three concepts we had were about city, crystals and human interactions. We set up different mood boards that gave us visual references and inspirations. Then we tried to visualize the process of all practical interactions. The analog centered around human behaviors have impacts on certain objects and affect the environment.



2.2 Rough Concept

After mind map based on our initial topic, we formulated our rough concept: how might we promote awareness of environmental issues regarding global warming by using interactive installation. We try to have the interaction to represent that our ecosystem is suffering due to unreasonable human activities. The idea of combining nature and technology was what we thought we could experiment with our concept.



3. Research

3.1 Physical Construction

3.1.1 Material Research

We spent some time exploring Home Depot to look for ideal materials for our construction. We noticed that wood, plastic and foams might be ideal materials for constructions. We bought several acrylic sheets and pink foams.

Pink foams are ideal materials for prototyping because they are firm materials but can also be easily modified. What’s more, the thickness provides more opportunities to place sensors. So we use thick foams for the base of our model.

We took acrylic because the transparency may be ideal for the lights. we were able to use laser to cut the acrylic and produced certain shapes. We had several types of acrylic with different surfaces. We made several prototypes to see how were the light effects and how projections look on them.

3.2 Hardware

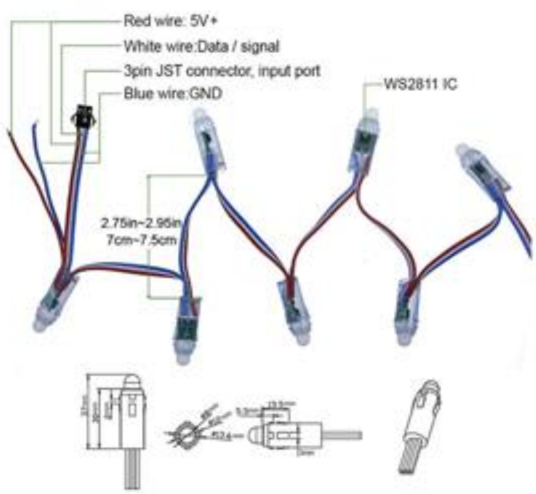
3.2.1 LED Strips

We went through all the projects in the Arduino project hub to see what we can do with Arduino and provided several ideas that may be applied on the project.

Firstly, we came up with the idea that using lights to perform. We found some amazing led strips projects like LED Racing[1], Eye Motion Tracking[2], Fire From Water[3] and Light Dancing with Music[4]. Since LED is the most direct and effective way to present a visual effect. We decide to take led performance as the basis of our project.

There are mainly two types of led strips could be used. One is WS2812B RGB LED Strip,

the other is WS2811 Digital RGB LED Pixel Light strip, which we decided to use because it has better light and fit in our project well.



[1]https://create.arduino.cc/projecthub/xing-hackweek/formula-led-b4cd78?ref=platform&ref_id=424_trending___&offset=3549

[2]https://create.arduino.cc/projecthub/H0meMadeGarbage/eye-motion-tracking-using-infrared-sensor-227467?ref=platform&ref_id=424_trending___&offset=449

[3]https://create.arduino.cc/projecthub/ben-eagan/fire-from-water-9e6ae4?ref=platform&ref_id=424_trending___&offset=1100

[4]https://create.arduino.cc/projecthub/buzzandy/music-reactive-led-strip-5645ed

3.2.2 Ultrasonic Sensor

For interaction method, we choose to use distance sensors like ultrasonic sensors trigger light performance. Ultrasonic sensors are easily detected by audiences and they are more likely to interact with.

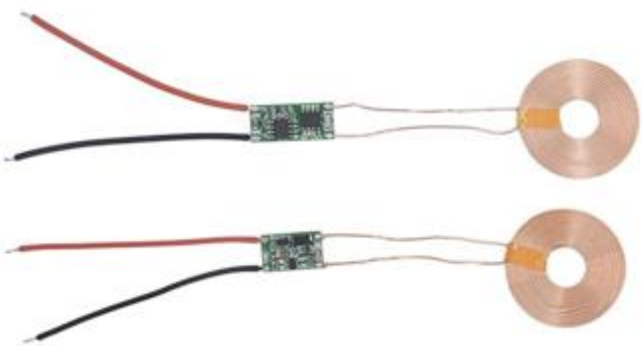
The parameters shows its Induction angle is no more than 15 degrees and detection range is 0.78~196 in/ (2cm~500cm). However, after testing, When the range is within 200cm, Ultrasonic HC-SR04 has stable performance mostly. But even within 200cm, it is easily disturbed and became unstable.

3.2.3 Infrared Sensor

Infrared sensor can be used to detect obstacles in a line within a short distance. And it is very stable.
The instruction shows the module detects the distance 2 -30cm, detection angle 35 °, the distance can detect potential is adjusted can be used for 3-5V DC power supply modules. However, after testing, the infrared sensors can be only used at 5V DC. It didn’t work under that volt.

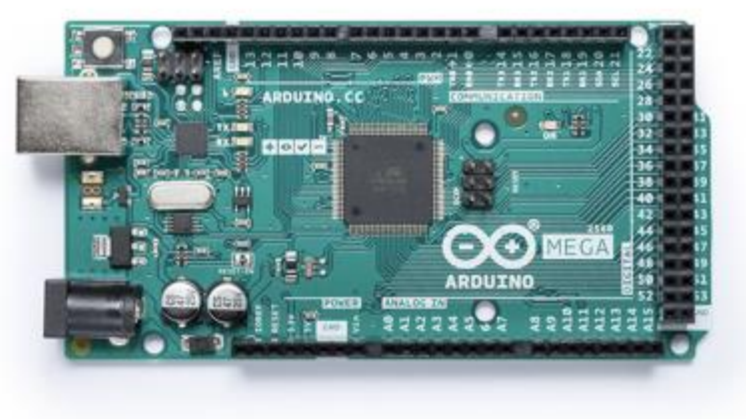
3.2.4 Induction Coil

Also, the most interesting way of interaction should be induction coil. Applied physics theory, the induction coils enable audience to light LEDs without connecting them to any power supplies.



3.2.5 Arduino MEGA Board 2560

The MEGA 2560 is designed for more complex projects. With 54 digital I/O pins, 16 analog inputs and a larger space for the sketch. This gives our projects plenty of room and opportunities.



3.3 Software

Arduino: 1.8.9

Isadora: 3.0

4. Process Implementation

4.1 Proof of Concept

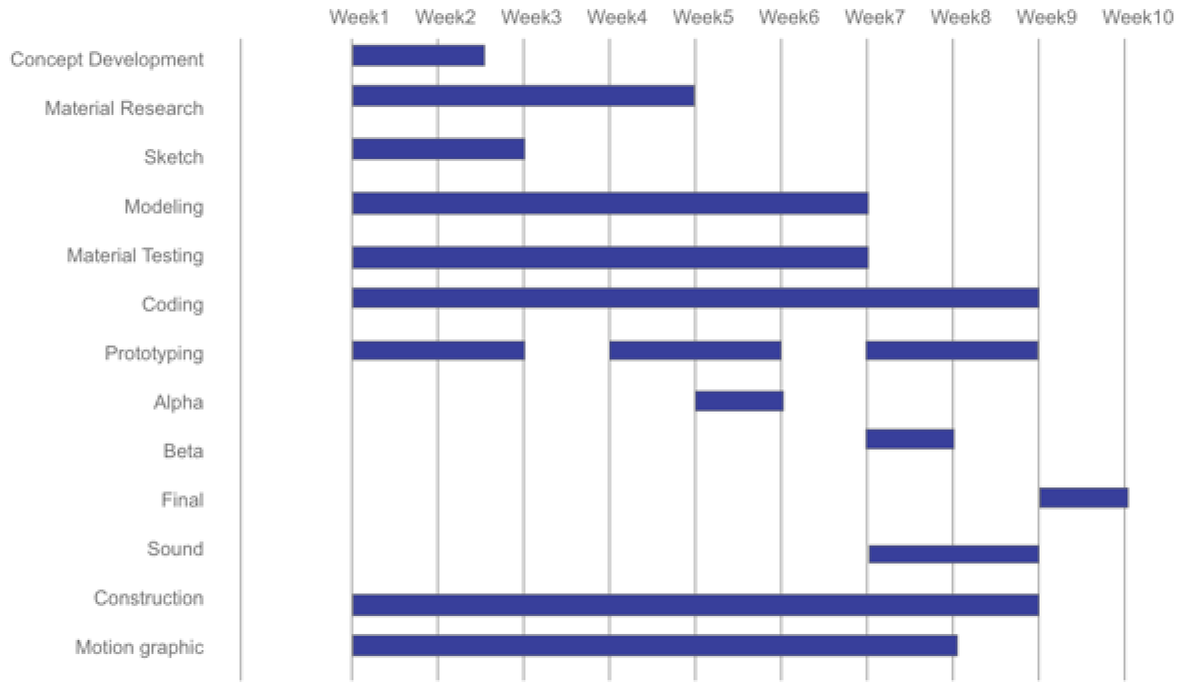
For proof of concept, we were asked to demonstrate the specific features that validate our project is workable within the following timelines. We completed several features and crafted the timeline in order to demonstrate our proposal.

4.1.1 List of Features

For proof of concept, we settled our process and several features that we needed for our project

1. Detect audiences by distance and change lighting patterns.
2. Sense touch in a distance by using bare conductive board and conductive materials and change light pattern.
3. Provide induction coil-based interaction items.
4. Detect sculptures position and trigger projection.
5. Present different motion according to audiences’ interaction with the sculptures.

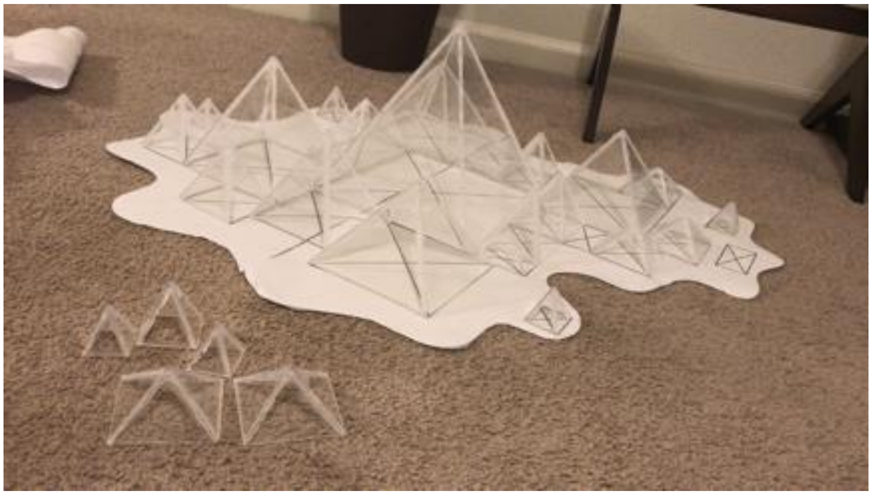
4.1.2 Timeline



4.2 Alpha

For Alpha, we finished the first portion of our model and construct our basic process:

1. If the sonar sensor detects an audience, the LED strip performs blue breath light.
2. If the infrared sensor loses its obstacle (induction coil), the LED strip performs blue rise and fall light. The LED attached to the induction coil goes off.
3. If both infrared sensors lose their obstacles, the LEDs will be turned off and send signals to serial port.
4. Isadora detect certain data and start to project a corresponding animation.
5. If all the obstacles are returned, the animation will be turned off. LEDs perform step 1.



After presenting our current model to the class, we have several feedbacks that we need to work on before beta:

We still need to figure out how to place the installation on the table by adjusting the position of the projector.
We should make sure the circuit would be invisible.
The lagging of the motion is quite visible, which was required to be solved.

4.3 Beta

For Bata, the process has some changes, the whole process is listed below,
1. The performance of LED strip depends on how many sonar sensors detect audiences.
    0 -> Glowing smoothly
    1 -> blue breath light
    2 -> wave and colorful light
2. If the infrared sensor loses its obstacle (induction coil), the LED strip performs a spread light. Isadora play drop animation, depending on which infrared sensor loses its target. The LED attached to the induction coil also goes off.
3. If all the infrared sensors lose obstacles, the light will be turned off and Isadora play melting animation.
4. If all the obstacles are returned, the animation will be turned off LEDs perform step 1.

We managed to put together our installation with circuit and our hand-sanding model. But there’s still a lot of details that we need to work on to get ready for our final.

One suggestion was made by professor Josephine, that we should add more LEDs in our models, the overall model was much better after we sanded them. The texture was organic but couldn't be seen if the LED was not close enough to the surface.

Another issue we were struggling with is the base, It used a white board to cover the foam-core, we decided to use foam core because it's easier to manage the circuit with the foam-core. And is easier to get it cut through hot wire also it's cheaper than other materials.

Issues comes with that is we need a really smart way to cover the foam-core because it's pink and the edges looks very unpolished at that moment. We tried to use acrylic paint to match the white board and the foam-core, but more ideas needed to fill in so that the whole model didn't look inconsistent.

The LED strip present severe lagging in brightness changing. There was a bug in 4 infrared sensors algorithm due to the interconnections with each other. We were still working on those problems.

We start looking for music that will contribute to our exhibition and we start to think how are we going to design the exhibition space, that will also add up to our project and contribute into an immersive experience. Our current idea is to find a black cloth that will block the whole area, so when people come in they will be guided toward the exhibition. And immediately being attracted by the installation.

3.4 Final

For our final, multiple changes had been made. The process was refined as followed:

1. The LED strip performs white breath light at a low brightness when sonar sensors do not detect any audiences. The aurora animation is projected.
2. The LEDs increase their brightness gradually and present a color changing pattern. The speed of color changing depends on the number of active sonar sensors.
3. If the infrared sensor loses its obstacle (induction coil), the LED strip performs a spread light. Isadora plays drop animation, depending on which infrared sensor loses its target. The LED attached to the induction coil also goes off. 4. If all the infrared sensors lost obstacles, the light will be turned off and send signals to serial port. Isadora detect signals and play melting animation along with fire animation.

5. If the audience return the coils, the LEDs at corresponding area will be lightened. If all the coils are returned, the animation will be turned off and LED strip return to step 1 or 2.

We refined our model with three different materials. And our installation was assembled. We concealed the edges with magic model air dry clay and added more motion graphic.

We made a lot of changes to the light effects and made the whole process smooth.

We also conduct several user testing, we got lots of positive feedback on the visual but also several suggestions for the interaction, below are quotes from our users.

Dillon:
I like polar bears, the concept is great.
The instruction process can be refined to be better

Coco:
The visual is very pleasing.
And I can get the idea of protecting the environment.
It took me a while to figure out the interaction.

Ziwei:
I like the idea that you get different results when interacting differently with the system.

Xiyue:
Maybe using storytelling as an introduction to your project can eliminate the confusion.

Insight:
We need to make the entire installation more like a system rather than just a piece of glaciers. The user could use more instruction, so we made a piece of instruction for our user.

Collect the polar bears

The loss of sea ice habitat from climate change is the biggest threat to the survival of polar bears. Other key threats include polar bear-human conflicts, unsustainable hunting and industrial impacts. - World Wild Life

5. Working in Detail

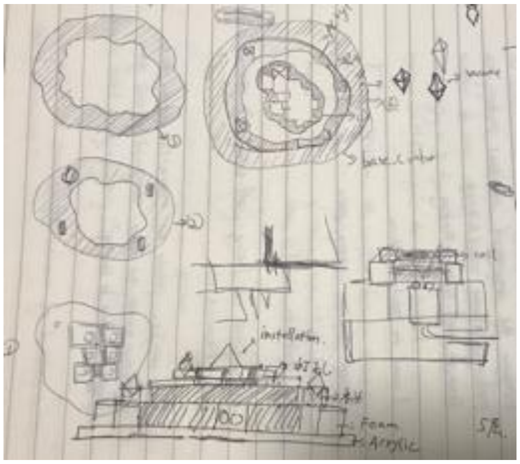
5.1 Construction

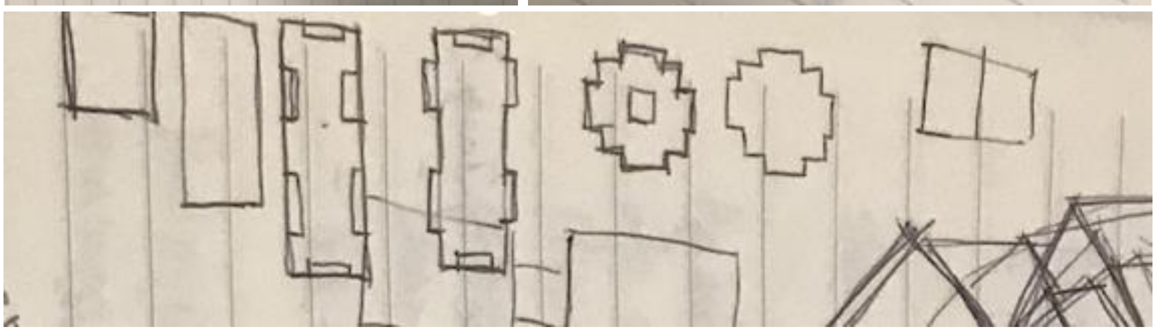
Although the caption is layout as a linear order, the actual process is more like a circular process of ideation evaluation and iteration.

5.1.1 Sketch

Through Ideation, we as a team agree on the concept of building an interactive glacier, so the sketch start from this base understanding.

Through looking for visual reference of our glaciers, I sketch the model on paper.
The problem diverges in two phases. One, to make sure is visually pleasant to look at. Two, to make sure each component can be efficiently assembled.





To find a way to make sure our sculpture is match with the projector, I finalize the model using pyramid shapes and finalize the scale of our model in rhino. I sit with He who is our motion designer, together we decided the outlook of our model and I deliver the front view to him so he can start design the motion of our project.

5.1.2 2D Model

In room 112 there is a great platform for us to settle our model, so we decided to center the scale of our model based on the scale of table which is 48in X 36in.

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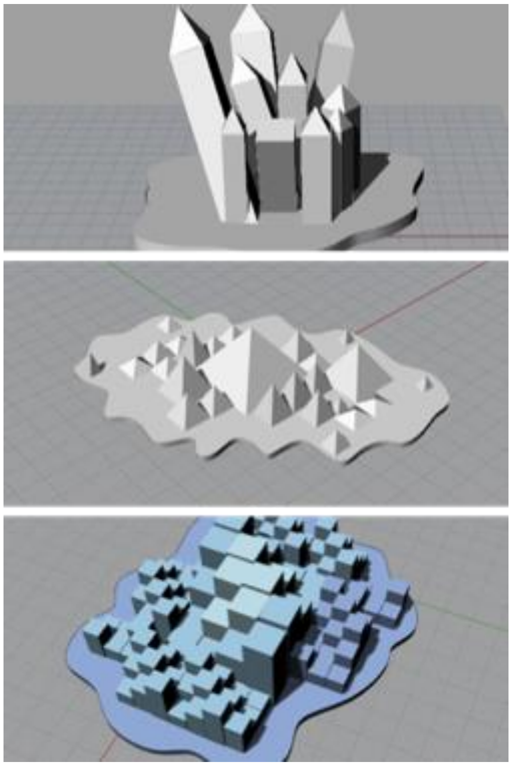

Trying to visualize the outlook of the sculpture. The image in my head is a slowly melting iceberg. But the question is how might we assemble each component together so that we can reduce the construction process another question is, what are the layout for the sculptures.

I look up some reference on Pinterest and sketches the glaciers on my notebook. And then start to build the model in rhino. There are three variations.
The pattern is that the glaciers in the middle is always the highest will the height will continue to decline until it reaches the edges. I built several models in different shapes and layout. And we tried building prototype to see which works best with the projector and turns out the pyramids works best.

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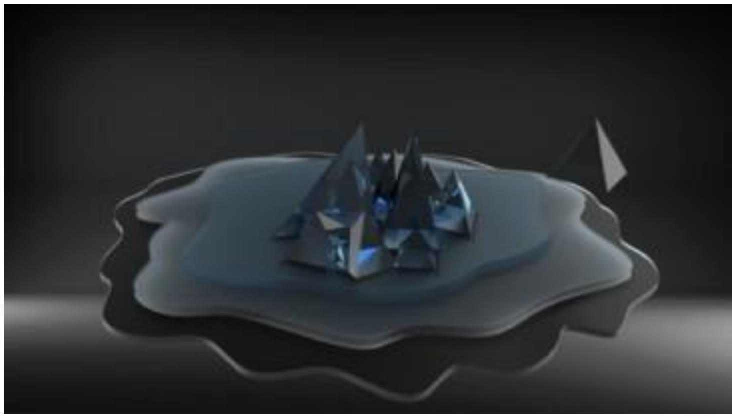

Visual Reference:
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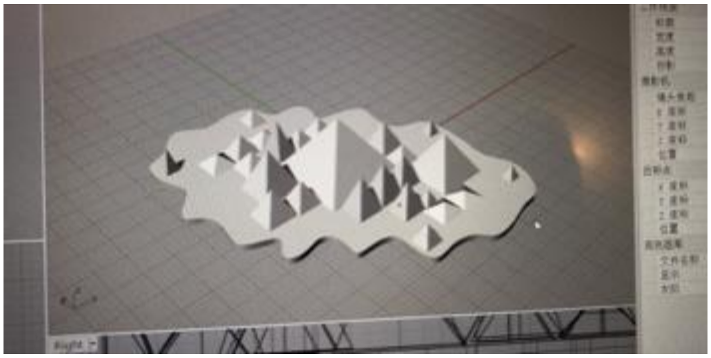
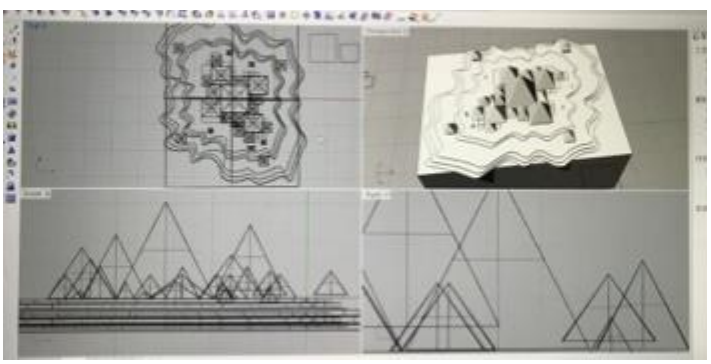


5.1.3 Prototype

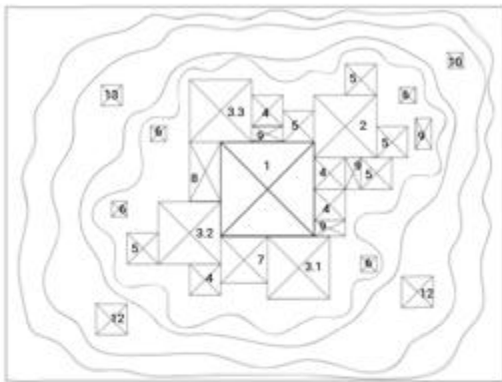
The model has been prototyped for several versions.
During this experiment we figure out we need a more efficient way to construct each component of our model.

Version1:
First version was meant to give a quick iteration, so we use paper and thin acrylic to test out how does the projector work with three dimensional structures.

Version2:
We then find out that the light of the projector will penetrate the transparent acrylic, so we plan to use white paint to reflect the projectors.
It took me quite a long time to imagine how are we going to build every pyramid. Cause when you build a model in rhino, it gives you the freedom to manipulate everything but doesn’t give you the actual scale, while solid works give you the exact scales but limit your ability to adjust the model freely.



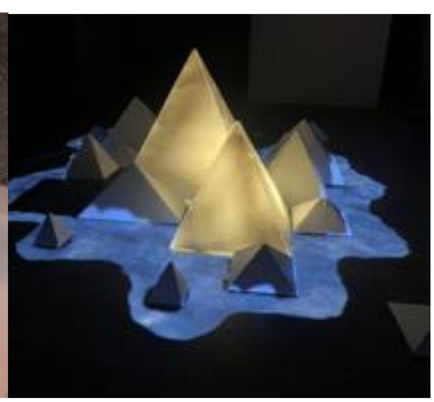
I then create a number system that helps me track all the individual pyramid components of the iceberg. They have to be broken down into four triangle shapes. So, what I need to know is the edge length of the triangle. But calculate the edges takes forever. To save my time of measuring, I set up the height and a ratio for the largest pyramids and use it as number1 and all other pyramids are based on a certain proportion of the largest one.



Next, I built all the pyramids in solid works, based on the number in the front view, cause the algorithm allows me to build the pyramid based on its width and height. What I need is to record the length and height of the triangle generated in solid works after I build the pyramids. Then draw the triangle in illustrator then copy and paste it in rhino. Cause rhino can copy the scale of illustrator.

Since we have a limited space of arranging and we want to utilize our material as much as possible I manage to layout everything in an efficient way, so we only use one acrylic board for the modeling. And then we go laser cut each small component and using hot glue to assemble them together.

We test how does the acrylic looks like when it was painted and when it was transparent. We test white semi-gloss paint and white matt paint. Turn out the paint made the light little uneven and doesn't looks organic.



Version 2.5:

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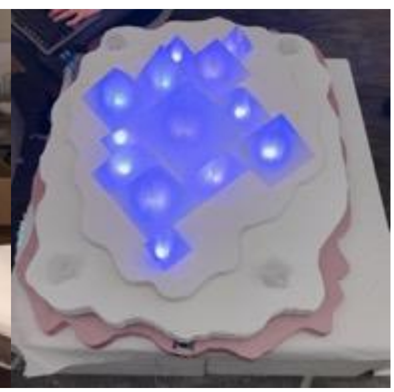
During the following quarter we tried multiple materials we bought semi transparent film and cover it on acrylic models. Then we use chloroform to make sure that the model glues together without extra glues.

The white film has a thin edge that curl up which makes the model looked a little unfinished. So, we continued iterate our model. We cut pink foam with hot wire and use it as the temporary base.

Version 3:
For the final version we decided to sand all our models to give it the icy organic texture. The process is that we use two types of sandpaper, one is 220 and the rougher one is 80. We sand two sides of the triangle component with 80, and then refine the edges with 220.

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To make sure the light looks subtle and organic, we filled our model with fabric materials

We sandblast a new acrylic and cut it based on the exterior of our model, with the same texture between the base and pyramids

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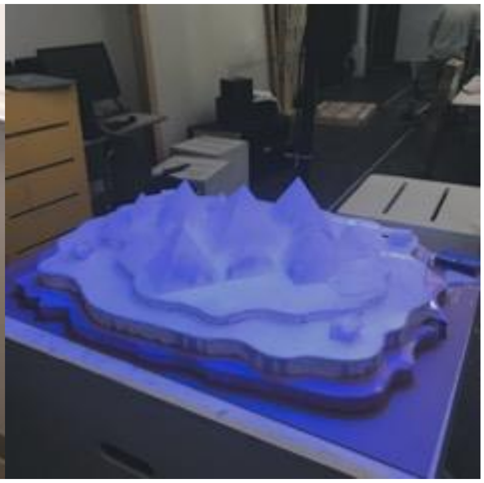
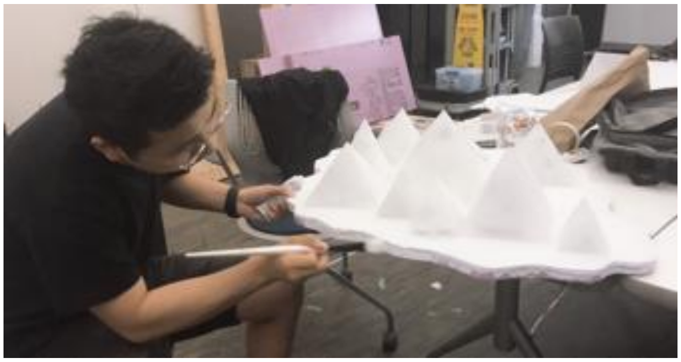
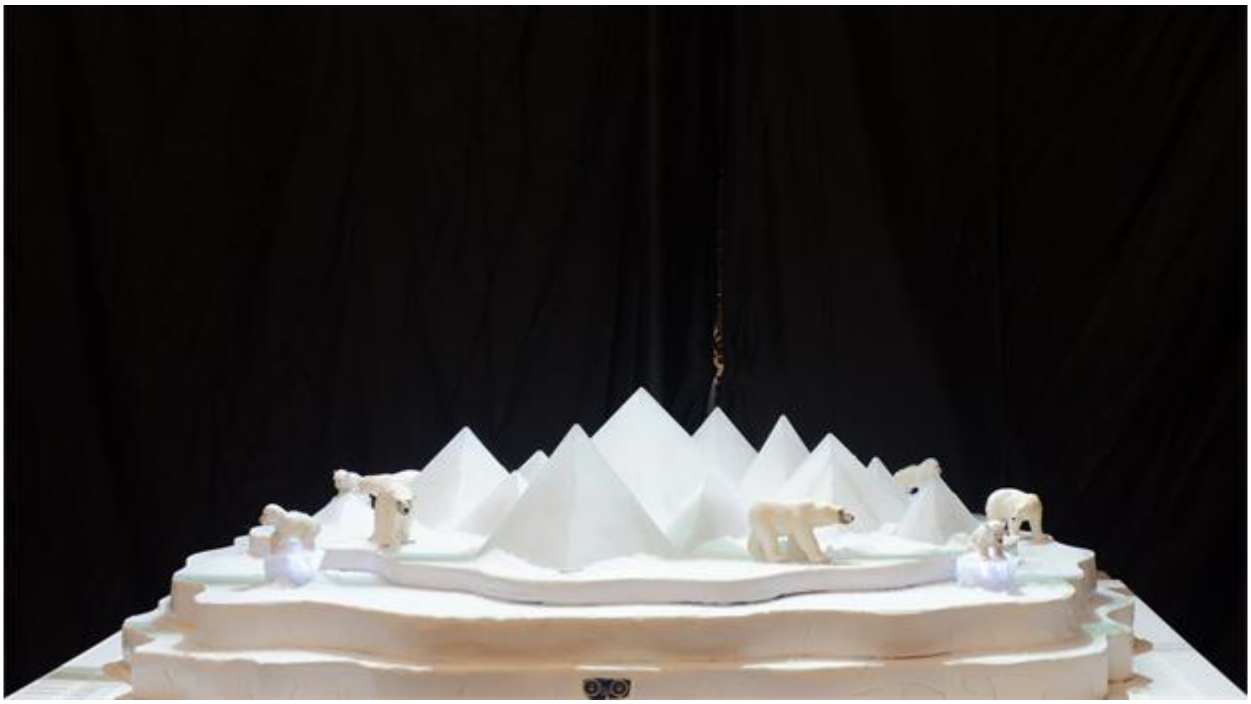


to refine the edges of our base, I try sanding the edges and then seal it with caulking materials.



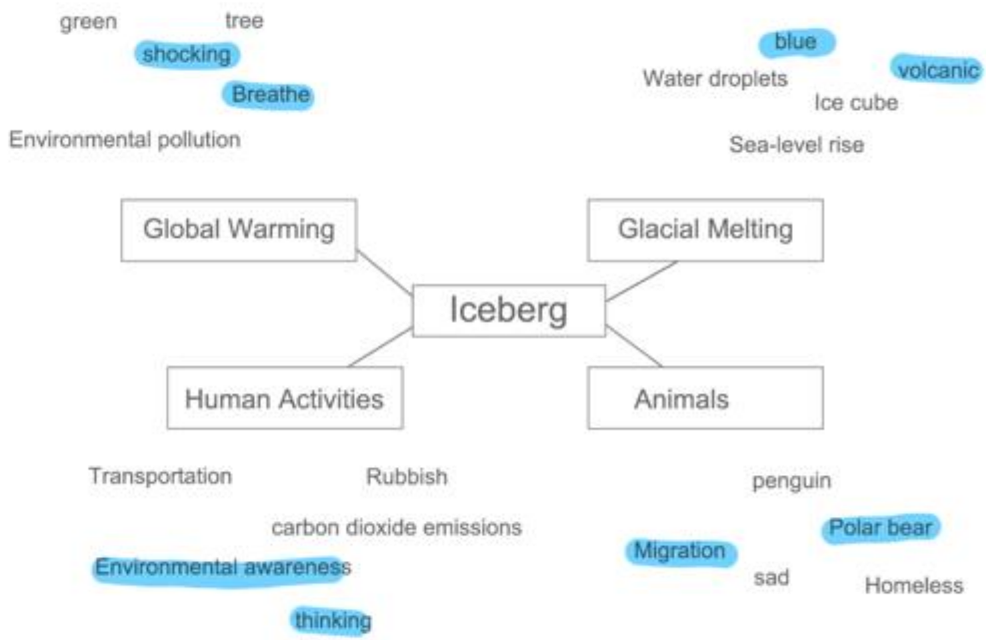
In order to make sure the audience understand how to interact with our model, I look up to Pinterest and find several interesting ideas of the outlier ice cube. I then find out that with the rest of the acrylic board we had we can multiply the small pieces and made it into a different component that looks different from the main installation.
After a quick iteration I came up with the new model for our outliers, the way it works is that it has small storage space for the induction coil and people can hold it up.

5.1.4 Final Outcome

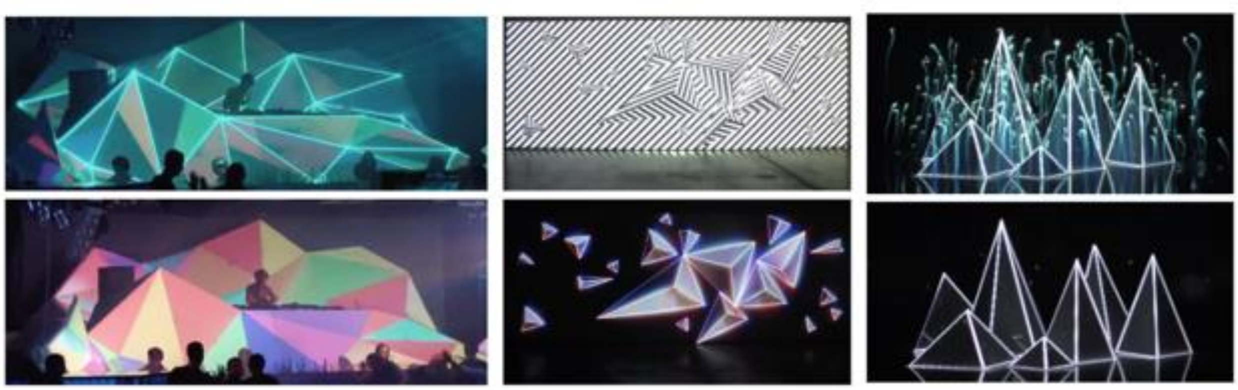


5.2 Motion

5.2.1 Mind Map



5.2.2 Mood Board



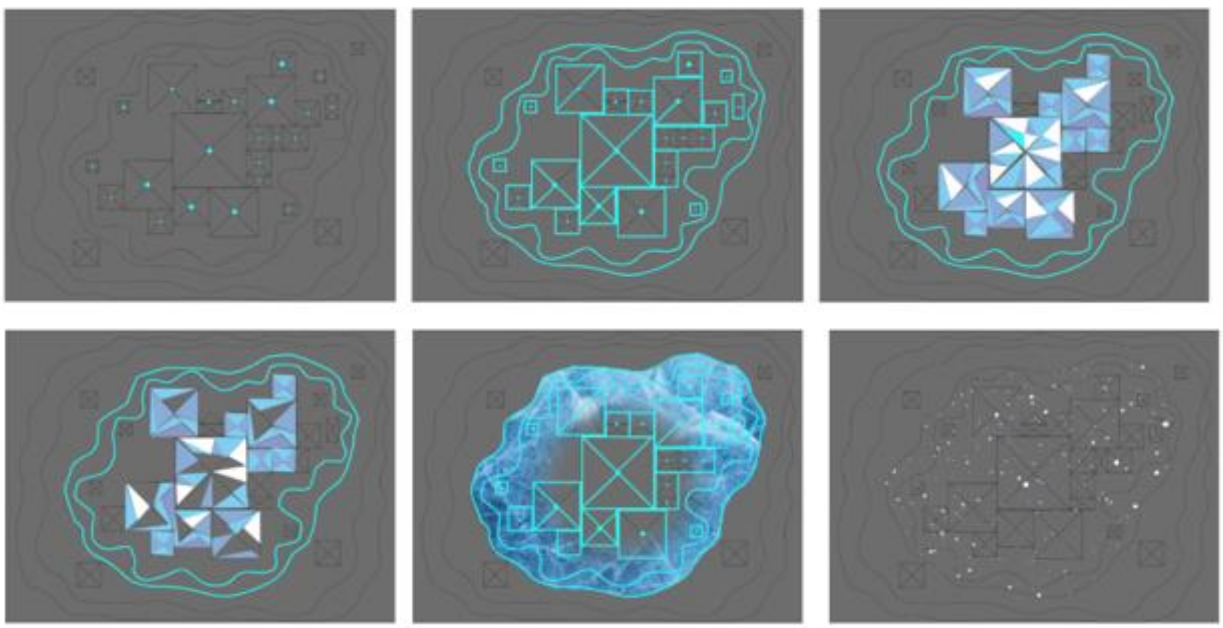
https://vimeo.com/40505337
https://vimeo.com/193103734

5.2.3 Concept

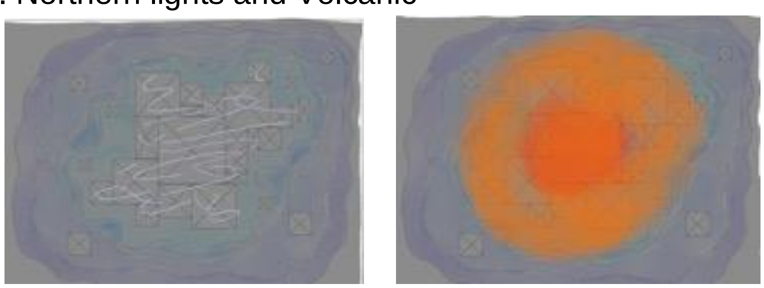
Through realistic methods, we lead the audience into the Ice World. The motion introduces four main aspects of the installation: breathing iceberg, galling ice cubes, melting snowy mountains and volcanic eruption of the iceberg. Thus, the device is divided into four parts, each representing a different theme. To emphasize the notion that how people's activities affect the environment of icebergs and human life.

5.2.4 Style Frame

1.Iceberg breathing and melting.

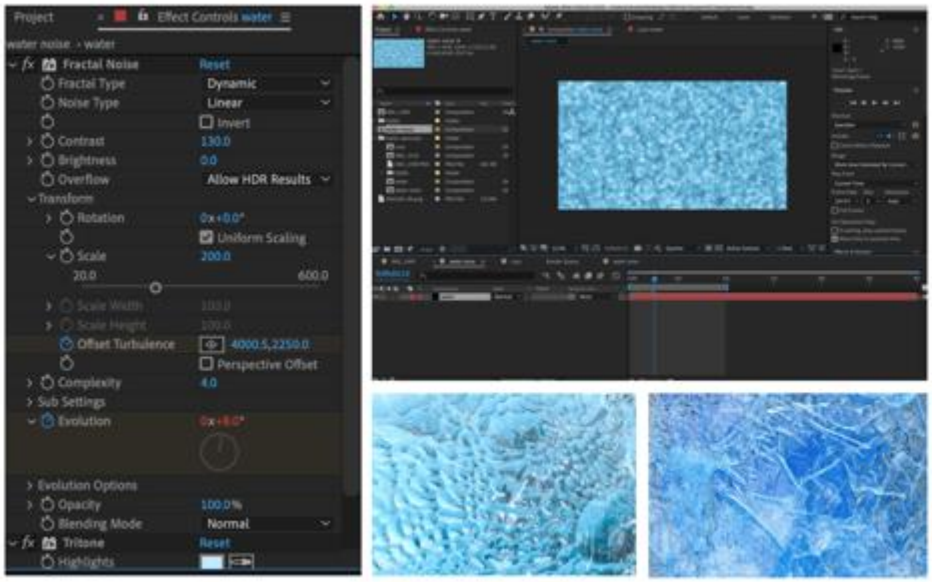


2. Northern lights and Volcanic

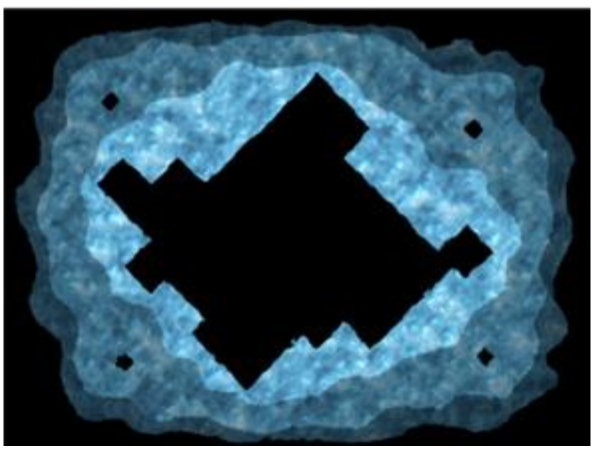


5.2.5 Final Motion

1. This is an animation of the base, simulating a picture of the ice movement. I use the Fractal Noise effect to design the motion.

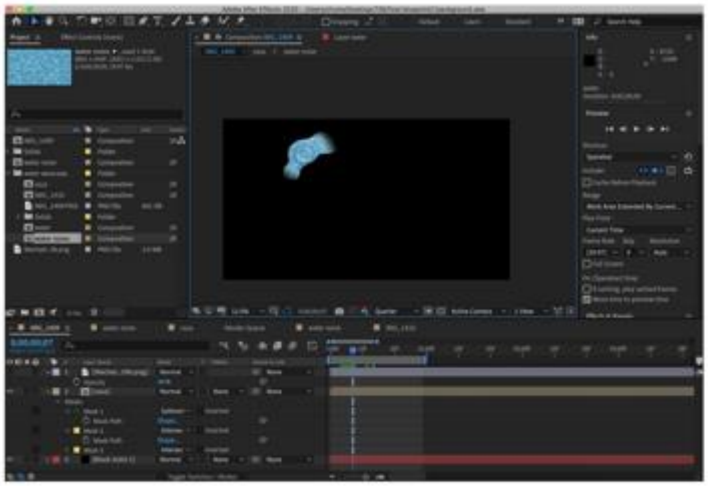
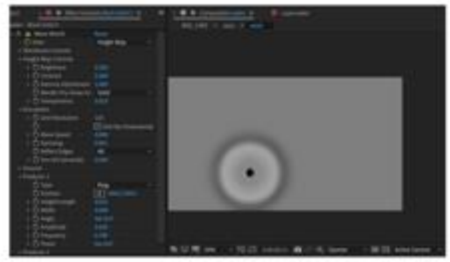
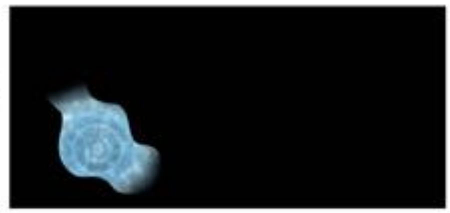


Then use the mask to divide the motion into three pieces in order to the projection can mapping our model.

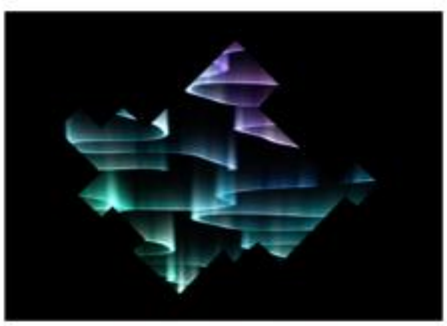
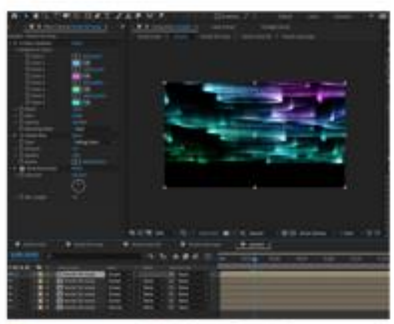


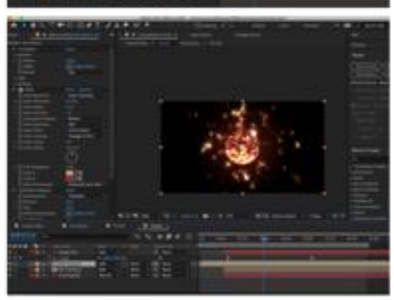
2. Water droplets

The second animated are water droplets. There are four pieces on our device that can be picked up to interact with the user. What we plan is that when the user picks up the ice, an animation of the water droplets appears. This implies that the user removed ice from our iceberg.

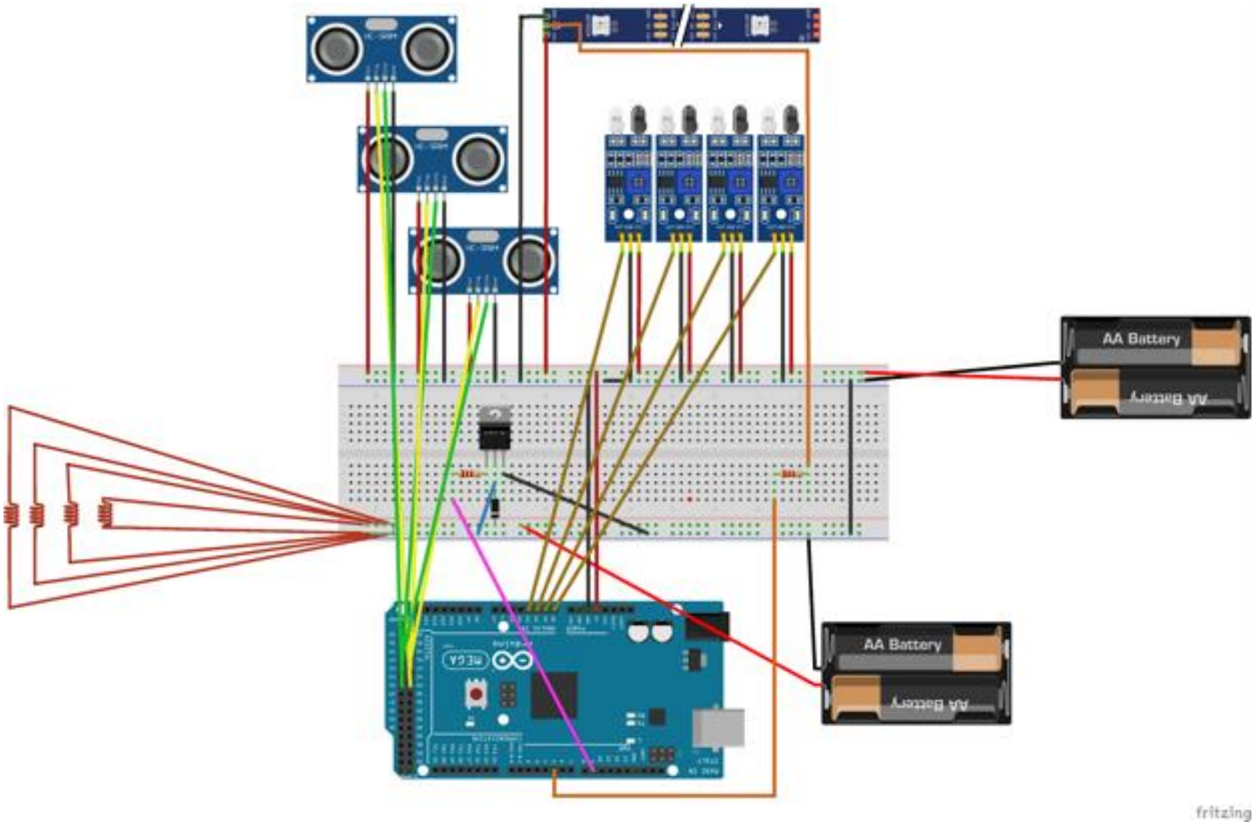
3. Northern Lights and Volcanic.
In order to make the whole effect of the device more abundant, and to give the user a more impact when the iceberg melts, we have added two more motions, northern lights and volcanic.



5.3 Arduino

5.3.1 Circuit



5.3.2 Ultrasonic Sensor

After adding another sonar sensor. A new problem is that the LED strip present severe lagging in brightness changing. There are two main reasons.

1. The sample code of sonar sensor takes time to trigger and echo. More sonar sensors mean it takes more time to obtain distance information. Two sonar sensors already cause incredible lagging.

2. Low brightness always have severe lagging that can be easily perceived by audiences. It is unavoidable.

After conducting some research, I used New Ping Library. It is a sonar sensor library. Unlike the sample code. The sensors do not need much time to process the distance reception. It starts working without additional code since being declared.

During user testing, we found another disadvantage of using sonar sensor. They use ultrasonic waves to detect obstacles. But if the surface of the obstacles is not made of smooth materials like glasses, plastic or wood, the sensors cannot detect any obstacles. For example, sonar sensor did not work well when the obstacles are clothes.

5.3.3 Infrared Sensor and Induction Coils

The feature of Arduino coding is that the whole process is a loop. Which leads to an additional challenge that when multiple elements have some interconnection with each other, the logic of process matters.

To illustrate, When the audience pick up one coil, the infrared sensor loses its obstacles. The LED strip present a spread effect. But what will happen if you pick up another coil before the end of that spread effect?

It took me a couple of times to figure out the logic of four infrared sensors' performance and wrote down the algorithms to make sure all of them work properly and will not conflict with each other.

5.3.4 External Power Supply

After writing all the codes and finishing the circuit construction. The light did not behave as I expected.

After I checked the readings of all the sensors. I found that some sensors did not work right.

At first, I thought it might be the problem of sensors because the reading sometimes worked but sometimes didn't. So, I changed some of them to new ones. I tried to change them to new pins. They still didn't work.

I checked the circuit and code once and once again but did not find any wrong places. My intuition told me it might be the problem of power supply. It proved I was right.
had two possible solutions to solve power problem.

1. Try to use Wire library and additional boards.
2. Use external power supply.

I started by trying first possible solution. The reason is, if succeed, it will not only solve the power problem, but also eliminate the lagging of LED performance. The operating efficiency will be largely improved.

I intended to put LED strip and induction coil in one board (slave board) and the rest of sensors in another (master board).

I attached 12 volts external power supply to the boards. All the sensors worked. But unfortunately. I succeed on UNO board. But the same code never worked on the DUE board.

5.3.5 MEGA Board

Due board is very special. Its TWI communication is very different from other boards. Due to the limitation of time, I stop exploring the requirement to make it work but using external power supply.

The professor provided me instructions to build an external power supply by using transistor and diode.

However, unlike most Arduino boards, the Due board runs at 3.3V. The problem is that the board cannot even provide enough current and volts to trigger the transistor. I decided to use Mega board to avoid more potential problems.

After using Mega board, the external power supply worked well. What's more, the induction coil could be controlled. The LED attached to the coils could perform blink lights.

However, using MEGA board caused another problem which I didn't expect. For Due board, the DC current for 5V Pin is 800mA, which is enough for 3 sonar sensors and 4 infrared sensors. The Mega board's 5V Pin cannot provide enough current for 4 infrared sensors. I need additional power supply for them.

5.3.6 Isadora

Isadora read data from the circuit and play corresponding videos by a projector

6. Construction Instruction

6.1 Physical Component

The model has three components, the glaciers, the base and the outliers.

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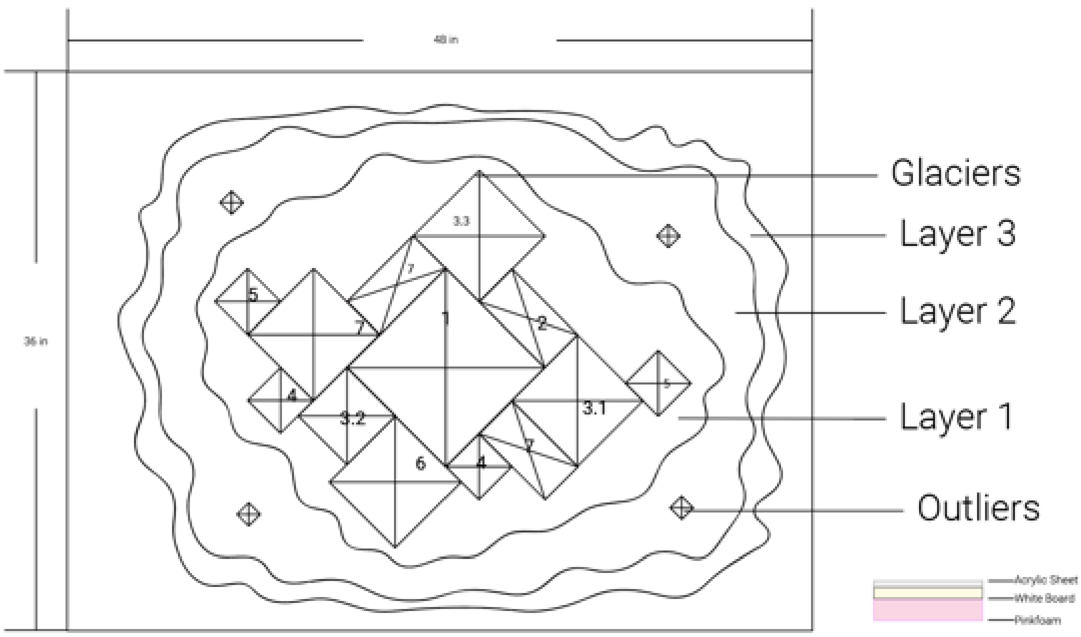
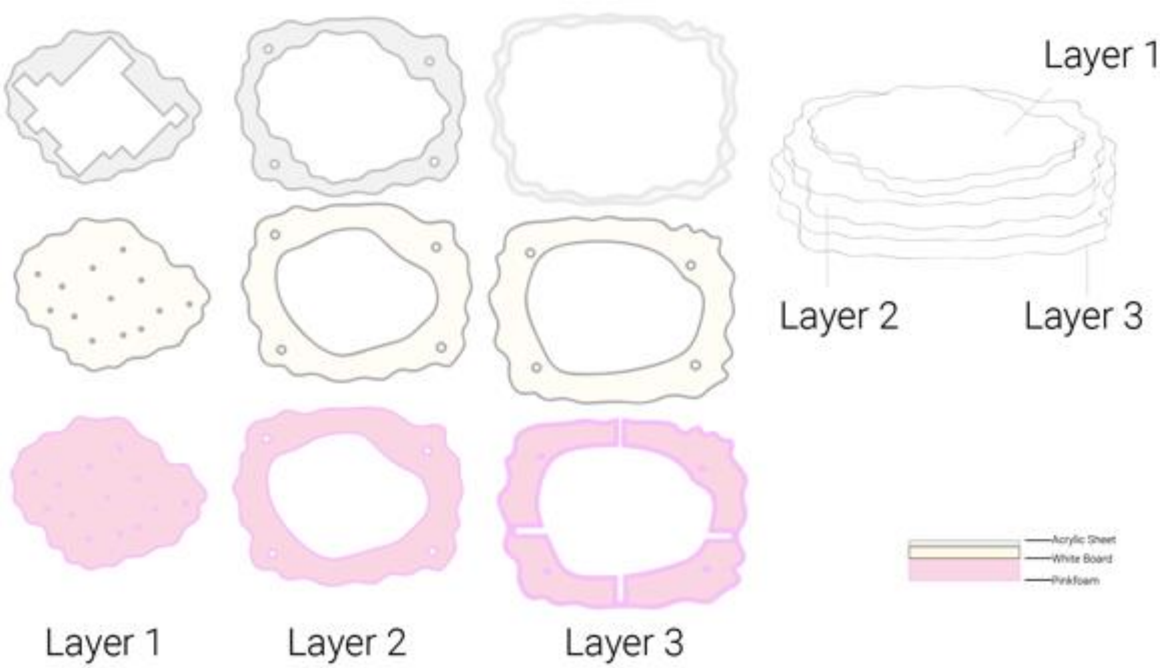


The base is made with three different materials, pink foam, white boards and acrylic.



Each layer is designed to hold different components.

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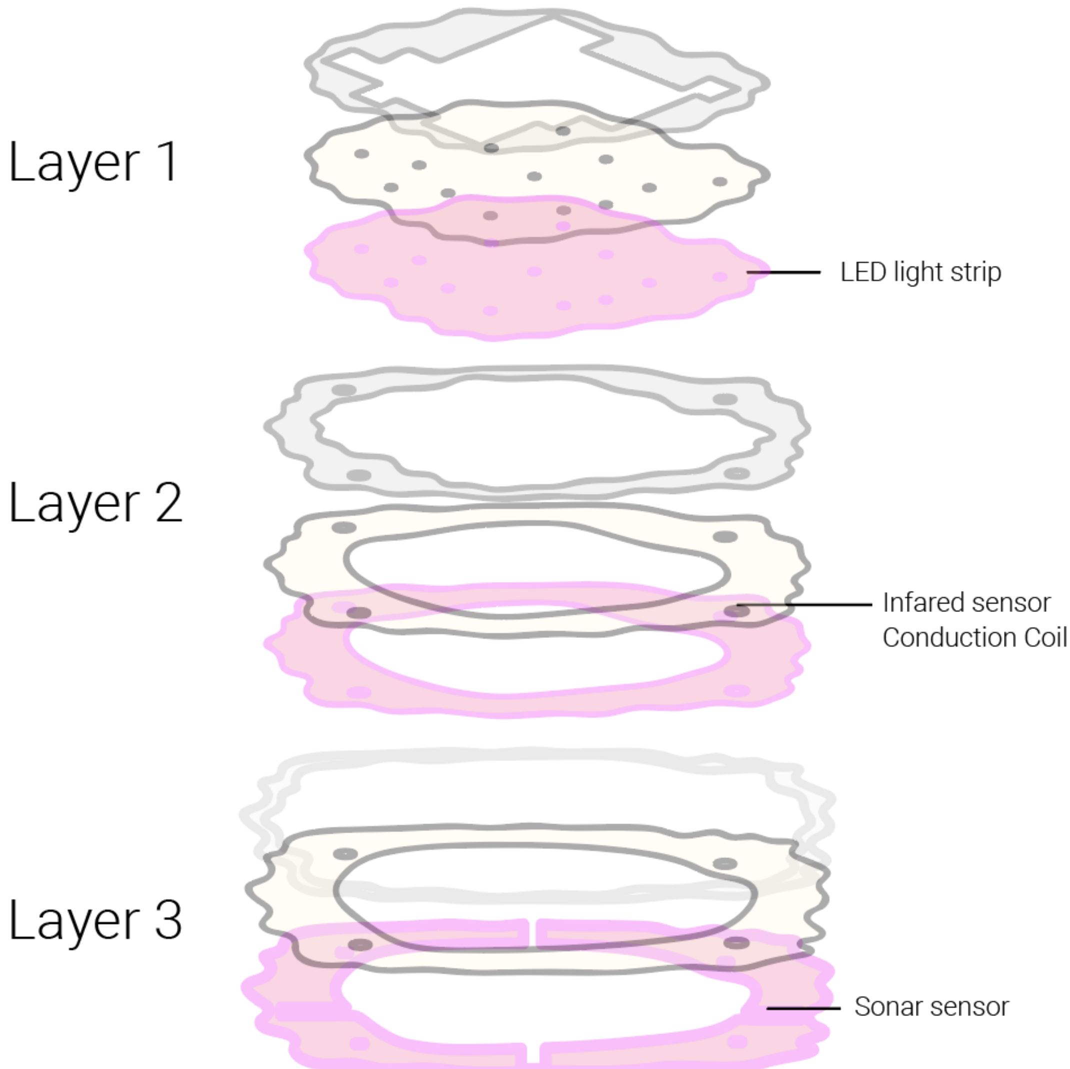

The glaciers is made up by 12 pyramids. Here are the scales of each pyramid.

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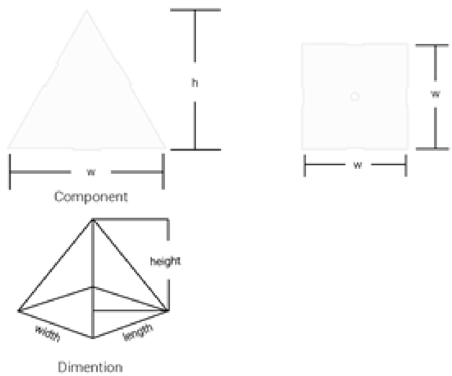
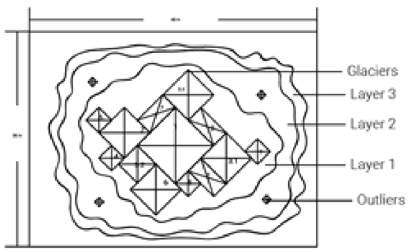
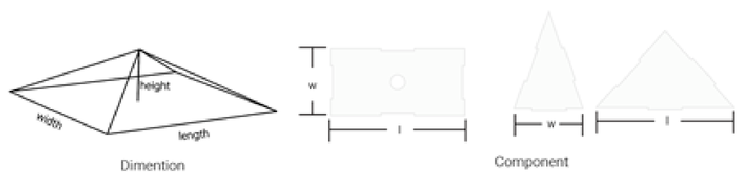
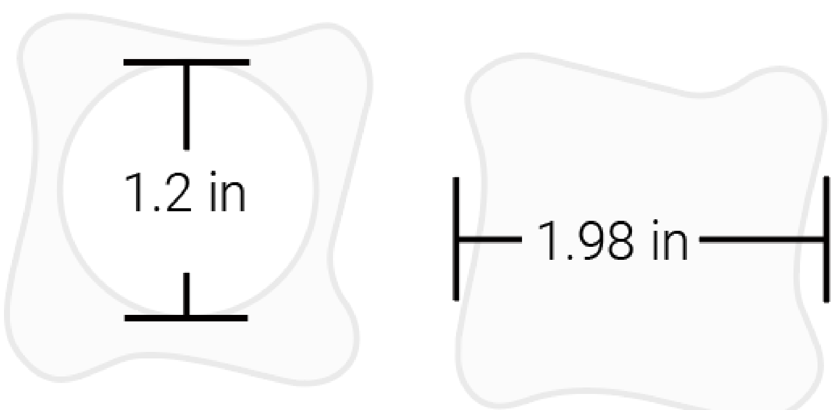


Number	Dimention	Component (WxH)	Copy
1	9 x 9 x 6.5	9 x 7.91	1
2	6 x 6 x 5.5	6 x 6.26	1
2.1	6 x 6 x 4.5	6 x 5.83	1
2.2	6 x 6 x 5.5	6 x 5.41	2
3	4.5 x 4.5 x 4.5	4.5 x 5.03	1
4	3 x 6 x 3	6 x 3.35 + 3 x 4.24	3
5	3 x 3 x 3	3 x 3.35	2
6	3 x 3 x 1.5	3 x 2.12	1





The outliers are layered by the first component and the second component are the caps that seal the conductive coil.



Construction Instruction:

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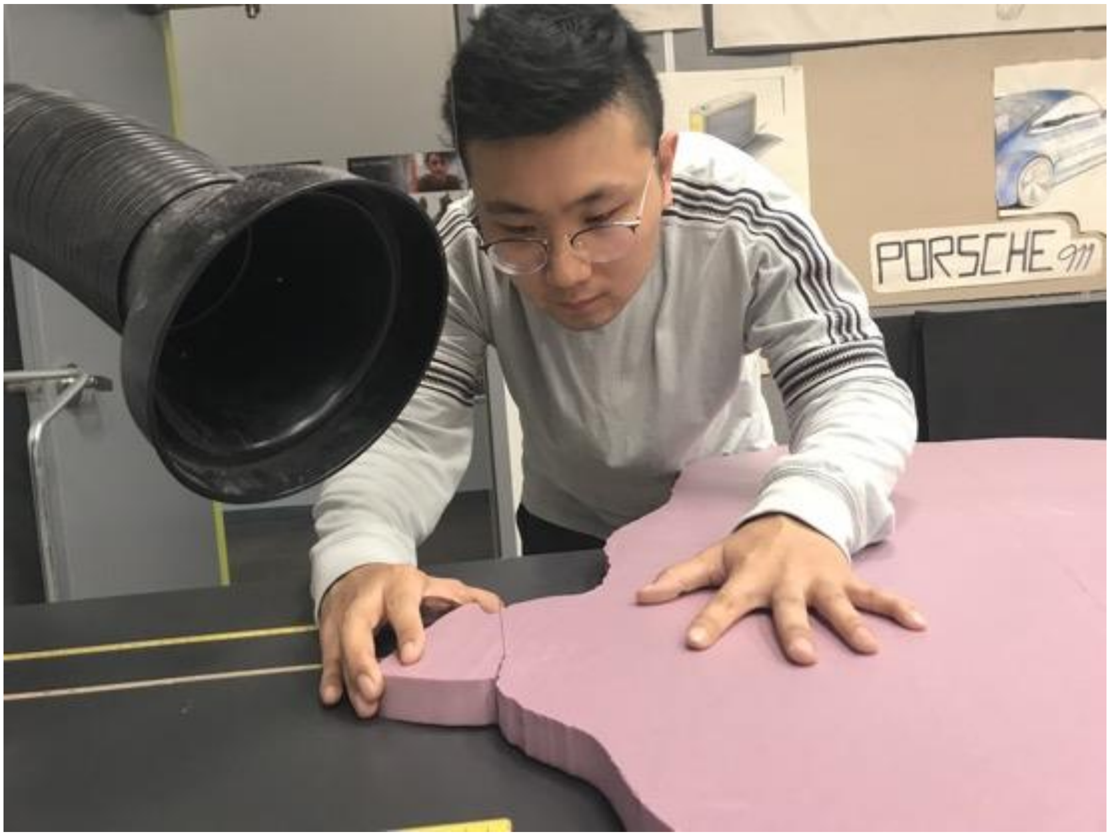
1. First, we laser cut all the acrylic components

2. Then we print out the outline on paper, paste it on the pink foam and use knife curving the outline on the pink foam.
3. Then we use hot wire to cut our pink foam according to the curve.



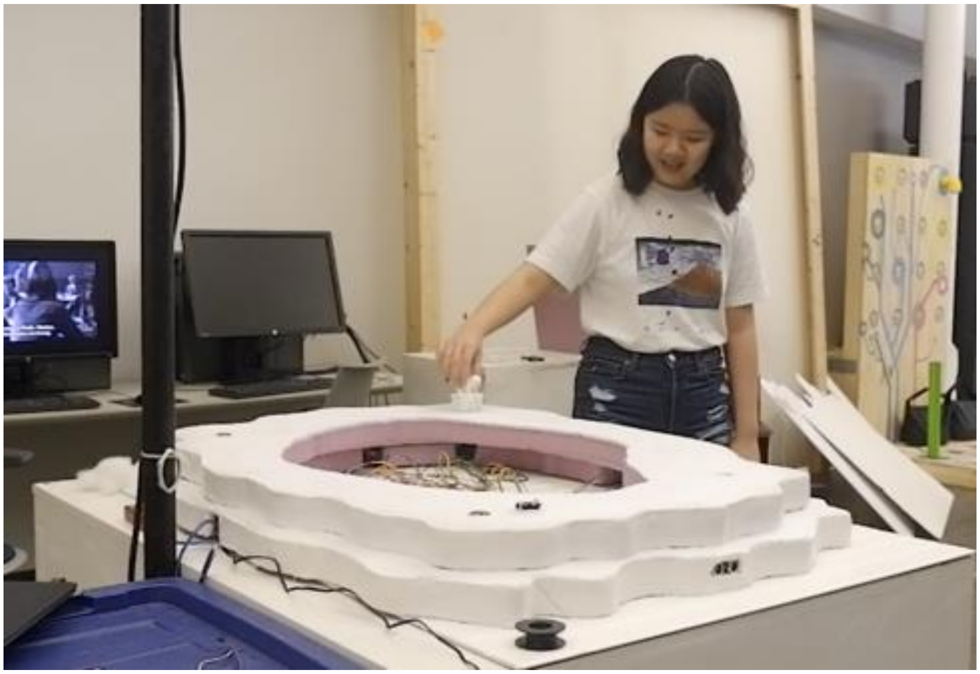
4. We trace the edges on white board and cut it with a knife.

5. We glue together the pink foam and white board.
6. We sand the edges until it’s smooth

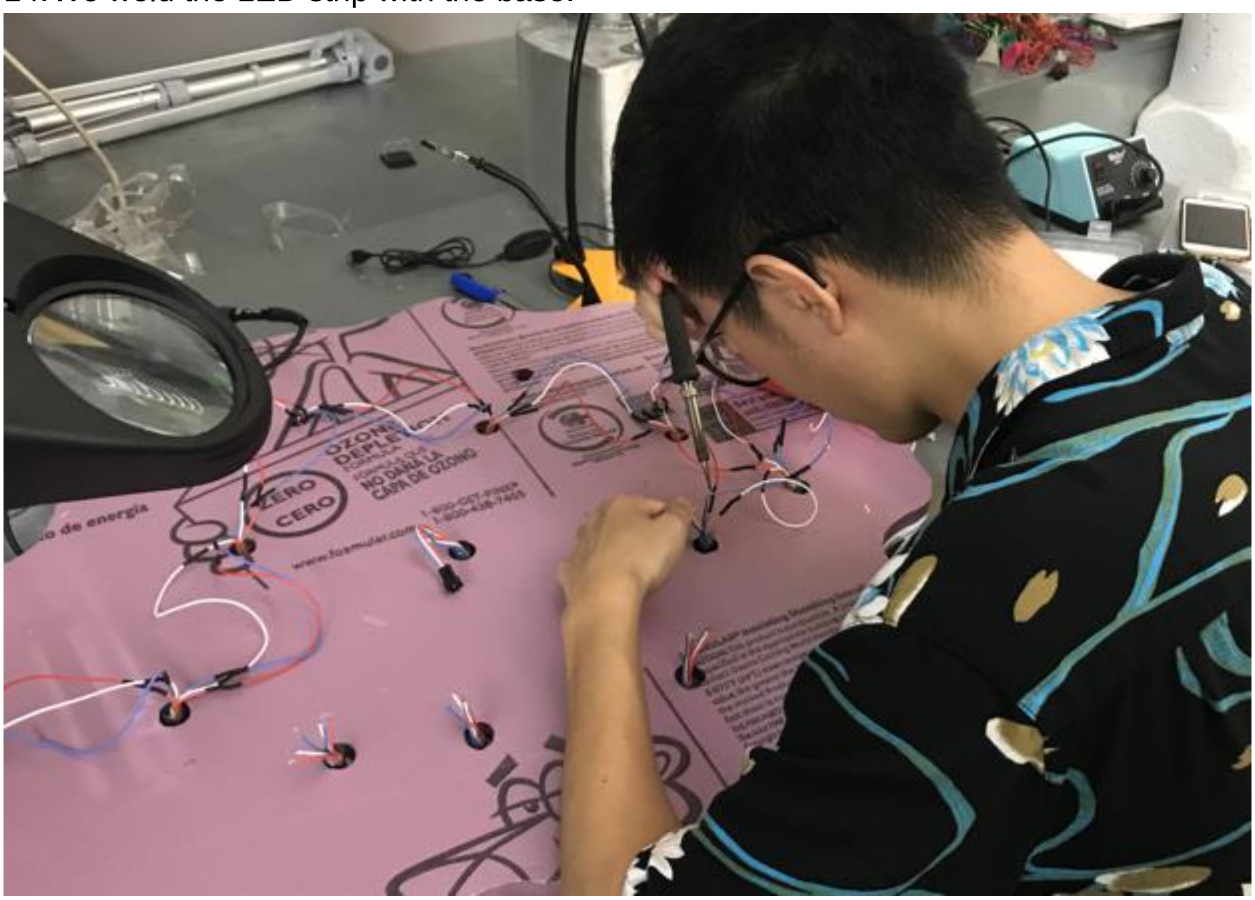
7. We paste the acrylic base on layer3
8. We attach sonar sensor on layer 3
9. We installed infrared sensor on layer2

10. We connect conductive coil on layer2
11. We paste acrylic on layer2
12. We set up layer2 and layer3

13. Install the outlier iceberg

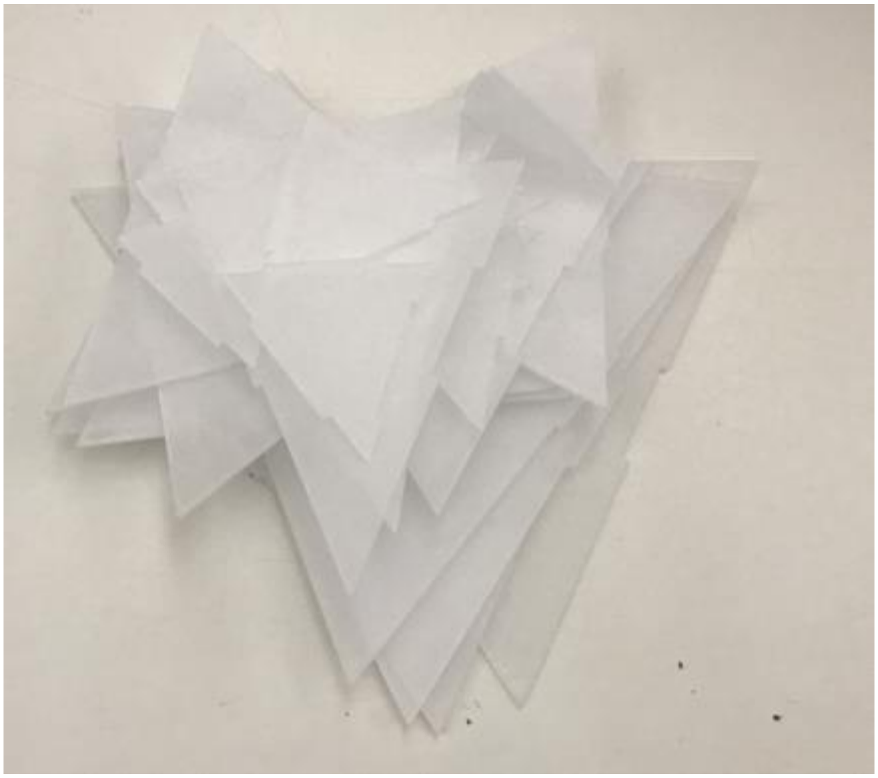


14. We weld the LED strip with the base.



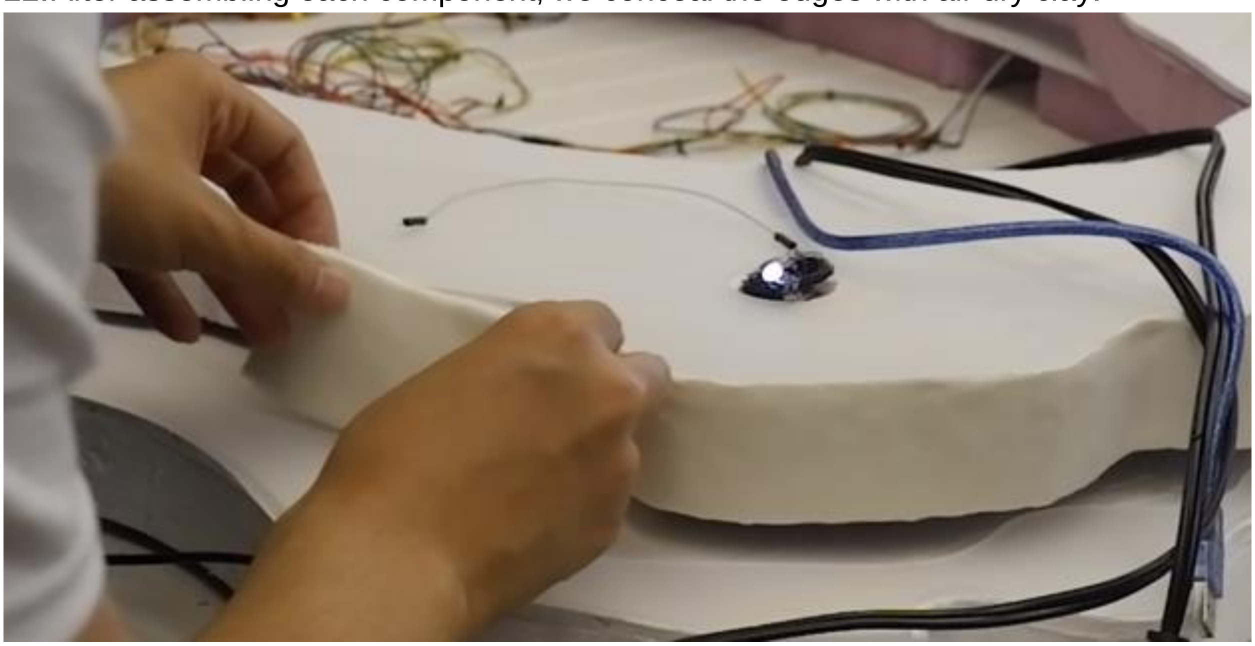
15. We made the light holder for the LED
16. We paste cotton on the LED

17. We pull out the acrylic component



18. We hand sand each component

19. We stick together the pyramid with chloroform.
20. We assemble the pyramid according to the front view.
21. We caulked the model with hot glue.
22. After assembling each component, we conceal the edges with air dry clay.



23. We put some snowflakes on the board.

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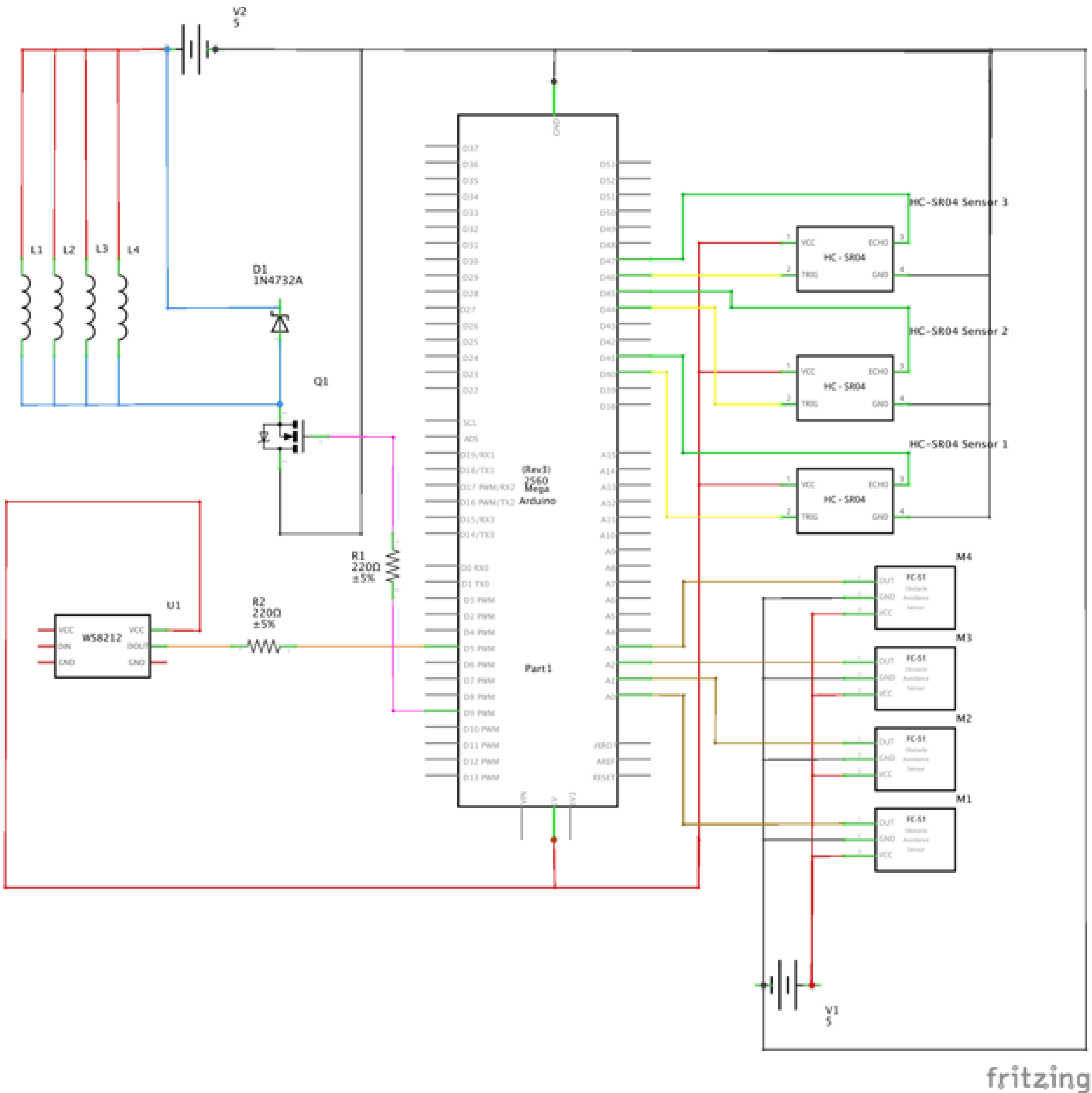
6.2 Electronics Schematics



7. Team

Our team is separated based on each person's expertise, Jiaheng takes care of the coding as a previous electronic engineer, He Zhu is in charge of motion graphic due to his digital media background, as a former industrial designer, Xiaojing is in charge of modeling and mechanical engineering.

Name: Xiaojing Li
Hometown: Beijing, China
Email: xiaojing.ux@gmail.com
Hi, I'm Xiaojing, I am the industrial designer of this project, as a grade students in interactive design who has a background in industrial design. I helped my teams with concept development, sketching, 2d modeling, physical production, and prototyping. As a designer I enjoy the process of creating unique experience through the combination of physical and digital media, and I hope to work on more physical installation in the future.

Name: He Zhu (Harrison)
Email: hezhustudio@gmail.com
Harrison moved to Savannah from Zhengzhou, China to attain his master's degree in Interactive Design at the Savannah College of Art and Design. With a background in Digital Media Art, Harrison specializes in motion and visual design. He is passionate about exploring and creating human-centric designs. He focuses on solving problems to give users an ideal experience. Harrison loves to travel and try new foods.

Name: Jiaheng(Ryan) Wu
Email: jhwuchn@gmail.com
Hello, I am Jiaheng Wu, I obtained my Bachelor of Electronic Engineering from BUPT in China. I have been trained as a classic programmer and equipped with skills like programming languages, machine learning, hardware and advanced communication theories. Design Thinking nowadays has become a more and more important tool in the industries. I decided to pursue a master degree in Interactive Design at the Savannah College of Art and Design. I found making an interactive installation is quite meaningful and interesting.

8. Special Thanks

Professor Josephine Leong