FINAL DOCUMENTATION

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CART 360
FALL 2019

RESEARCH PROCESS

Before discussing my research and development process in detail, I'll briefly (re)outline the core intentions and interaction strategies of the project. I'll also weave

The Garden of E-Den (or Another Title That Isn't So Tacky, a.k.a. My Co-Dependent, Dysfunctional Relationship With A Plastic Screw) was conceived as an interactive "garden" of kinetic sculptures. My intention was to create an otherworldly landscape of not-quite-plants, whose ambiguous, liminal nature would prompt us to examine our relationships with the natural and technological environments in which we are enmeshed.

I wanted to subvert the interaction of the *mumisa pudica,* the bashful plant that closes in to protect itself in response to being touched. Instead, my not-quite-plants bloom and grow with human interaction. There's a tongue-in-cheek element here: on a surface level, I'm toying with the cliché that talking or singing to plants helps them grow.

The basic interaction works as follows:

- Proximity sensors around the sculptures act as a gate to further interaction. In other words, no other input or output can occur unless someone is standing near the sculptures. This helps prevent other sensor thresholds from being triggered accidentally by the environment.
- The next axis of interaction is sound. People must talk or sing, or otherwise input sound into mics/sensors attached to each sculpture.
- The sculptures expand and "grow" in response to the sound, as well as lighting up from within thanks to pulsing RGB LEDs
- People need to keep talking or singing until the sculptures are fully expanded, at which point they will continue to pulse with light on their own.
- If people step away and the proximity sensor threshold isn't met, after a time the sculptures will go dark and collapse;
- Once the sculptures are "grown" they will output sound and "sing" back to you.
- When nobody is near the sculptures and the proximity sensors are no longer being triggered, they will go dark and collapse again (after a delay)

I explore these strategies more below, including how they changed and developed, and what kind of research / experimentation process I engaged in. I attempt to frame this process in terms of interaction mode, affordances and materiality.

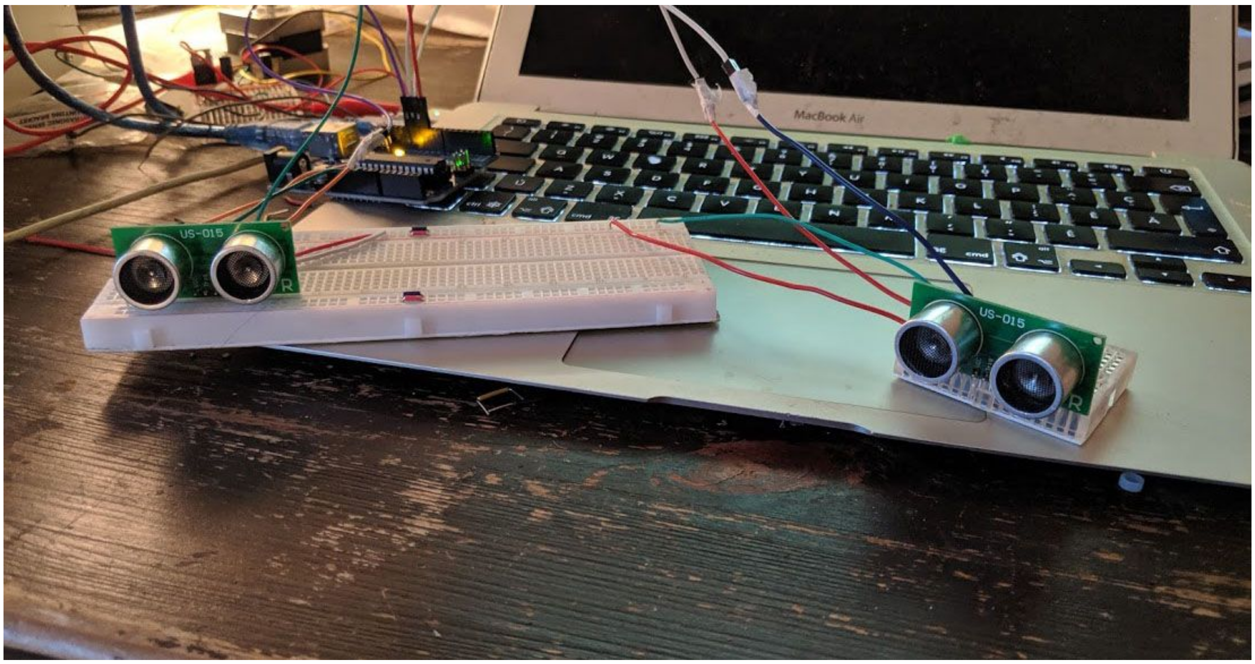
Since this project includes multiple layers of interaction, I tried to work simultaneously (or at least rotationally) on its different components. That said, I did find that certain elements were more fundamental than others, and these drew more of my focus in the end. Specifically, I spent a lot of time working on the movement of the sculptures and experimenting with the overall materiality of the artifact(s).

PROXIMITY (PRESENCE)

I started by researching the different proximity sensors available to me, narrowing down my options to ultrasonic vs infrared. Since my piece is designed to be installed in a dark or low-light environment, and since the sculpture behind the sensor emits periodic light as part of the installations interaction strategy, I determined that the accuracy of infrared sensors would be significantly impeded. Thus, infrared would not produce the desired result.

From there I moved to ultrasonic proximity sensors. Based on reviews and technical specifications, I determined the US-015 ultrasonic sensor was the best option within my price range. The US-015 is the updated and slightly more accurate version of another popular sensors, the HC-SR04 model. The US-015 can realize a range of 2cm - 4m, with a resolution of 0.5mm and detecting precision of 0.1cm+1%. These specifications afford a completely acceptable degree of accuracy and range for the simple task of determining whether or not someone is standing near the sensor / the sculpture behind the sensor.

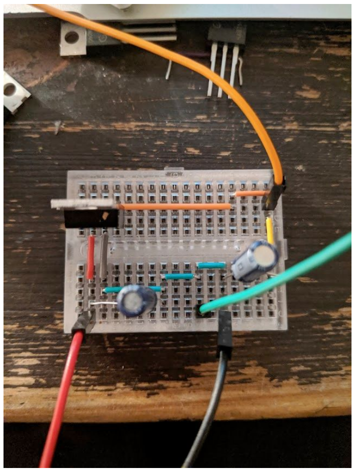
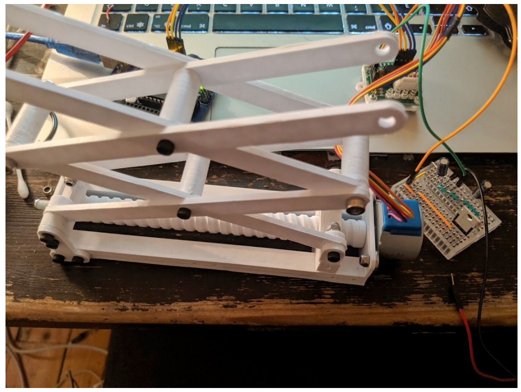
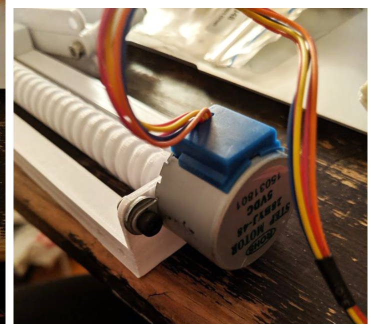
I began by testing one of the sensors, employing the NewPing library for Arduino. I found that the results were not as accurate as I had hoped. When there is no object detected within range, a zero value is logged to the serial monitor. I found that the sensor frequently logged a zero value when it should be detecting my presence. So, I added a second sensor with the hope that between them they would return a more accurate average. The detection angle for the US-015 is less than 15°, so I tried to place the sensors far enough apart that they wouldn't interfere with one another, but close enough that they'd both be triggered by an object the size of a human body. With a few tweaks to the code to further filter out erroneous data, I was able to get a result accurate enough to work with.



MOVEMENT (MOTOR - TECHNICAL)

I'm using a stepper motor to control the movement of the scissor lift and sphere. I started with a 28BYJ-48 5V motor with a ULN2003 driver board. This is an inexpensive, unipolar stepper motor with limited torque, but I wanted to start cheap and small and work from there. This is also the stepper motor that the jack-screw and scissor lift I used was designed to work with, so it made sense as a starting point.

Because the 28BYJ-48 is a 5V motor, I was able to test it with a 9V battery (it shouldn't be powered directly by the Arduino). This was an added advantage for me, as I did a lot of work from home and didn't want to mess around with larger power supplies unless it was necessary. I build a small circuit on a breakout board to regulate the voltage between the 9V battery and the motor.

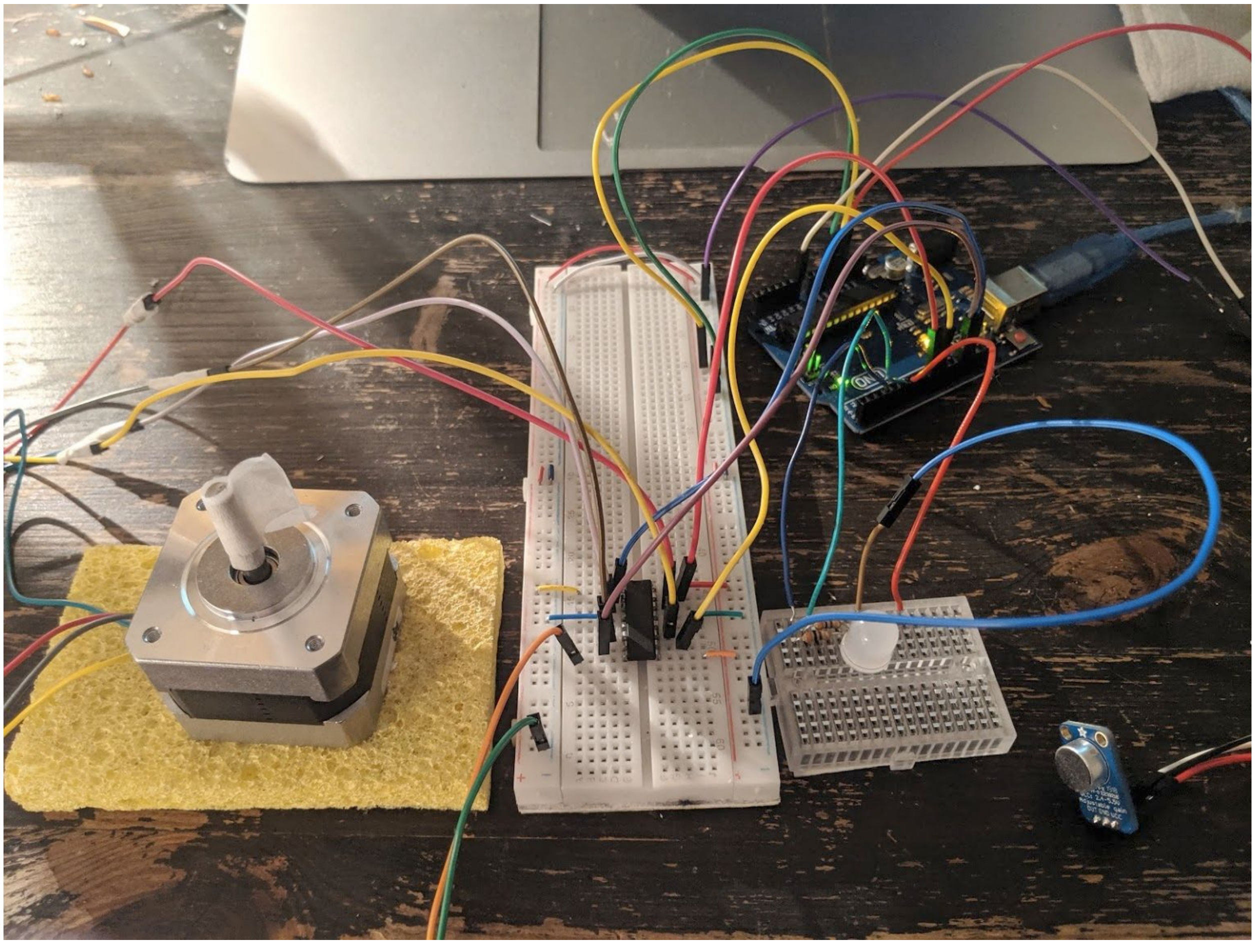




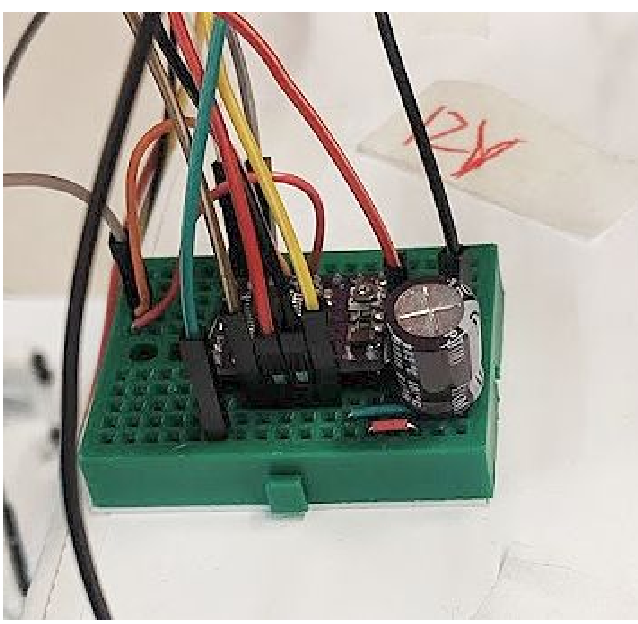
I considered driving the motor from the Arduino directly, but my research suggested it was safer to use an external power source. This experiment was successful, and the motor was able to move the scissor lift.

Unfortunately, I concluded the motor wasn't quite powerful enough for my liking. The motor struggled to start moving the lift when the lift was fully closed, because the collapsed lift offered too much resistance.

I considered coding the movement of the lift so it would never quite fully close. However, around the same time I ran into another issue. I accidentally blew out the motor driver when a wire disconnected while it was communicating with the Arduino. At this point I picked up a 12V Nema 17 size bipolar stepper motor. This fixed the issue with the blown driver and gave me a motor powerful enough to drive the scissor lift with ease.

I now needed a 12V power supply, which I was able to borrow from the Sensor Lab. I used the L293D H-bridge that came with our kits.

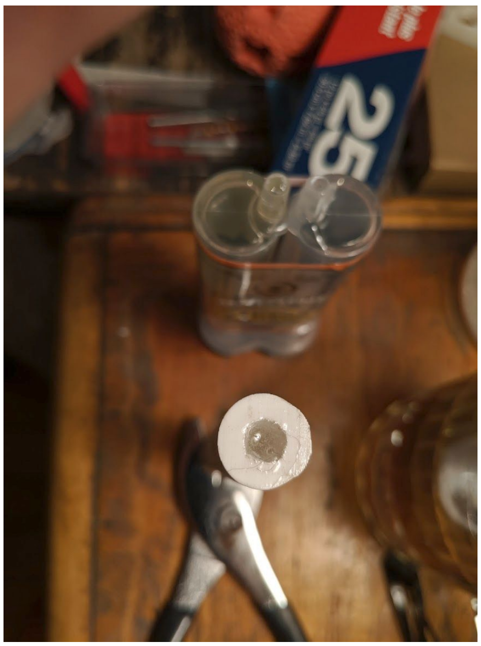




I noticed that the motor was drawing too much current with the H-bridge alone, so switched to using a DR2588 driver board for each motor, which also freed up additional pins on the Arduino.

MOVEMENT (THE LIFT)

After switching to a larger motor, the hole for the motor shaft in the lift was no longer the right size. I expanded the hole manually, but ultimately had to fill it with resin and use a drill press to achieve the correct size and alignment. I was able to get a tight enough fit that adding a piece of duct tape to the motor shaft created the resistance necessary to get decent torque out of the motor and move the screw of the lift.



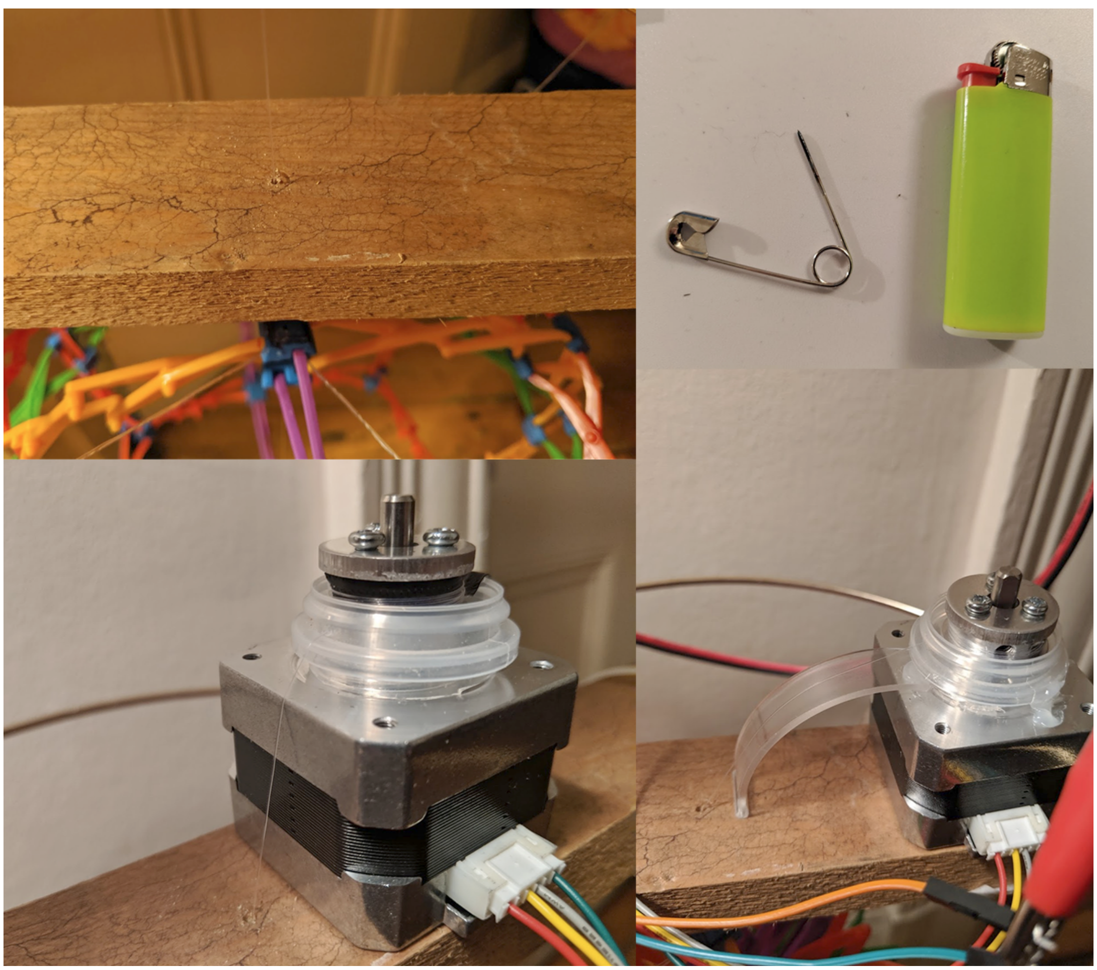
Since my first print and test of the lift was more or less successful, I originally wanted to focus on iterating the lift as opposed to potentially wasting time on the sphere I had envisioned in my proposal as an alternate design. Unfortunately, my initial success with the lift was a red herring, as successive 3D prints failed, wasting over 24 hours each time. So, I iterated towards the sphere late in the game.

Luckily, the one working lift I have is consistent in terms of movement. The way it moves to one side as it raises up is reminiscent of how certain plants crane towards the sun, and I plan to build the sculpture around it in a way that highlights this movement.

MOVEMENT (THE SPHERE)

Ironically, the sphere was much easier to implement than the lift. In the end, I got one of each, which I consider a success, and going forward I can iterate both designs. My strategy for the movement of the sphere was inspired by this project:
https://www.youtube.com/watch?v=E0rEmV49Sro

I considered 3D printing my own Hoberman sphere, but since I had so many issues printing the lift, I thought it was safer to order one online. In order to thread fishing wire through key points in the sphere, I used a lighter and a safety pin to melt holes in the plastic connectors. I attached a hub to one of the stepper motors and spooled the wire around the hub. To make a guide for the wire to unspool I drilled a small hole into the top of a pill bottle I cut off. I repurposed another piece of packaging I found lying around to reduce friction on the wire.



I like the addition of the sphere to the overall installation, since it affords a more delicate kind of movement. I suspended intentionally it so that it would dangle and waft from side to side when it opened. The way it expands and contracts also evokes the feeling of breath, and I'd like to program it so that when it's fully expanded it continues to lightly pulse and breathe (without fully contracting again).

LIGHT

While light is an important part of my project, it's not the primary output. Rather, the light of the RGB LEDs, illuminating the sculptures from within, offers certain affordances that complement the core interaction strategy:

As a responsive output, acting in tandem with movement, and complementing the organic materiality of the sculptures, light signals life, energy and warmth. It helps the sculptures appear to *grow* rather than merely *expand.*

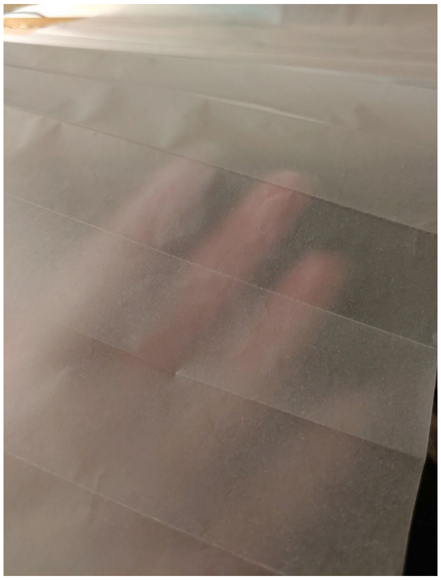
In particular, a light that slowly pulses between colour profiles is more dynamic, fluid, and reminiscent of breath or other rhythms central to biological and ecological systems.

At the same time, the colours of the LEDs are distinctly un-earthly and inorganic. This works with the fact that the light helps to reveal the mechanical guts of each sculpture, furthering the juxtaposition and eerie symbiosis of the 'natural' and technological. It enhances the architectural elements of the folded paper sculptures, further contributing to their qualities as not-quite-plants.

The piece is designed to be installed in a dark room. The light from each sculpture is thrown against the backdrop, which enhances the alien qualities of the installation "landscape" and furthers experiences of liminality, exploration, and disorientation.

PAPER

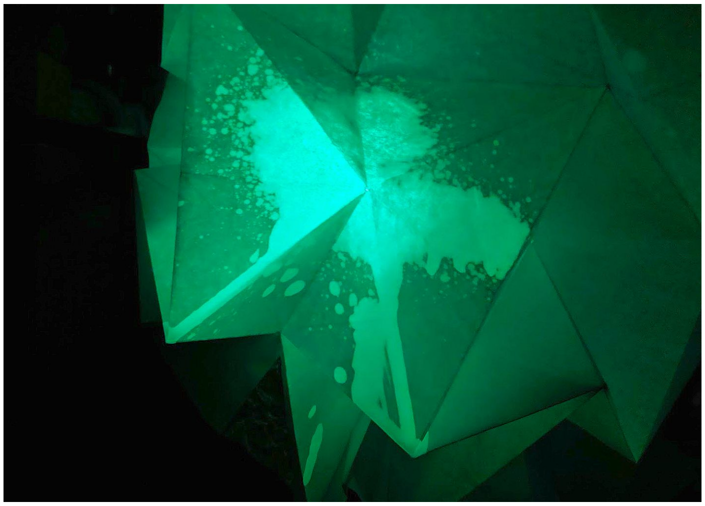
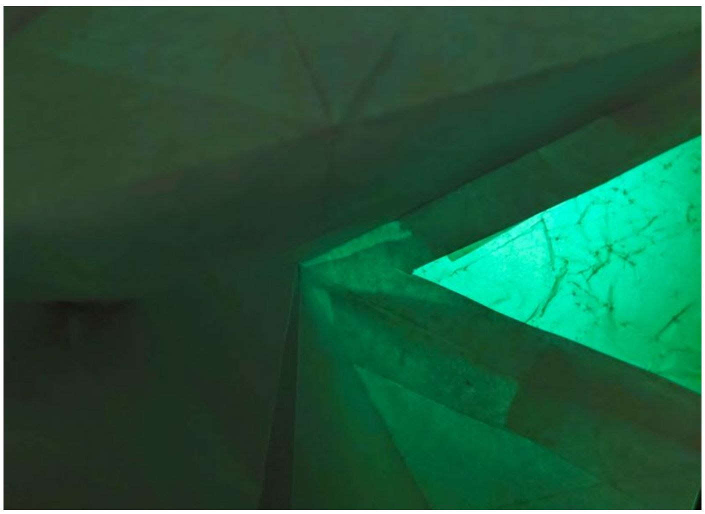
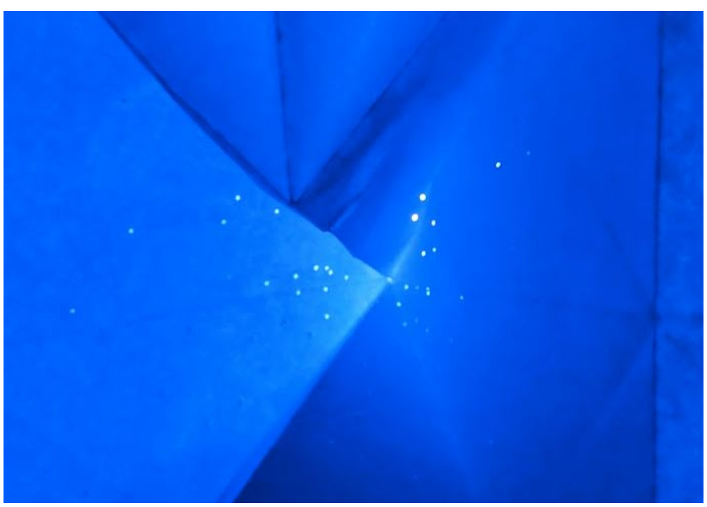
I wanted the outer shell of the sculptures to be organic, delicate and ephemeral, so I focused on working with paper. I started with a semi-translucent vellum, because I wanted the light to shine through, and for the mechanical guts of the not-quite-plants to be rendered visible through the interaction.



While I had used this kind of paper before for an origami project, in this case the designs were too complex and it was too difficult to fold. So were the tracing and rice paper I found as alternatives. At this point I enlisted the help of a friend, Vanessa O'Connor, who's more skilled than me at origami. We experimented with different paper types together and she took over most of the folding, while I gave her direction and focused on the design.

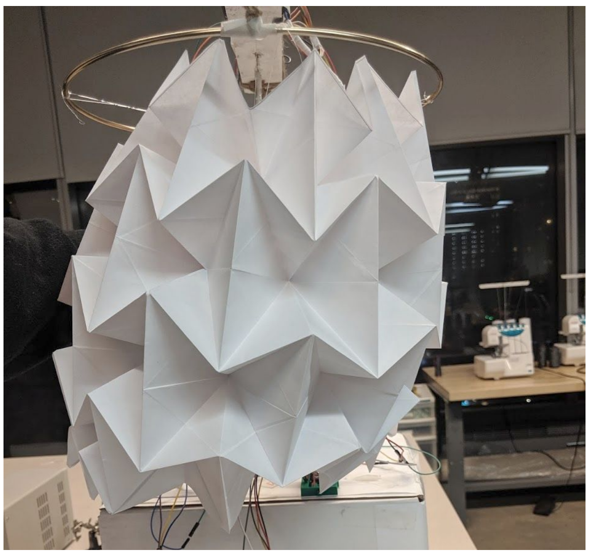
I ended up with several large sheets folded in a *water bomb* pattern. They move well, and my next goal will be to sew them together in an interesting way to fit around the different structures I have, possibly incorporating fabric scraps or other found organic materials.

Since I had to switch to a more opaque paper, I've also been experimenting with different ways to make the light shine through:

	Applying baby oil with a spray bottle. This produces an interesting effect, but I'm concerned about having oily paper near the electronics. I'm still researching better ways to reproduce this that don't involve oil.
	Making cutouts in the folded paper with an exacto knife and taping or gluing pieces of transparent paper between some of the folds. This is time consuming but could work well.
	Using pins to poke patterns of tiny holes in the paper. I think this is a more accessible strategy than the other approaches I considered and could be interesting if applied across the entire sculpture.

TOWARDS THE FINAL SCULPTURES

While I would have liked to have built out the sculptures for the final presentation, I think this should be the last task I complete in terms of implementation. Since the paper will need to be attached to the moving structures, I want to make sure the materiality of those structures is sound and all of the interaction is successful before attaching an outer shell that may impede my ability to make changes to the components within. This is particularly true of the sphere sculpture.



I did experiment with loosley wrapping the paper around the sphere to make sure the components would fit and move together.

While it's only taped to the expanded sphere in two places in this photo and I'm essentially holding it in place, with a little tweaking, I think I can integrate the two well. This will likely involve working with some smaller folds in the paper and attaching it to the sphere at multiple vertices.

While possibly more precise and time-consuming, I believe sewing the paper to the vertices (rather than glueing or taping) will yield the best result. Using thread and sewing through points the paper's folds is more likely to produce a sculpture that is stable and well assembled, yet not too stiff. The final sculpture should be delicate enough in how it's attached that it affords a more subtle and organic movement, like a plant.

SOUND (INPUT)

Sound is my primary input. It's what makes the not-quite-plants "grow" and light up. I had considered using wireless microphones to capture sound, but decided I preferred a wired option.

I ultimately settled on an electret microphone / amp combo from Adafruit to capture sound input.

There are a couple of reasons for this decision:

1. I prefer to use the simplest possible components that are able to rely mostly on the Arduino, without a computer as an intermediary. I also want to use components I can afford to buy myself, rather than needing to rent things from the CDA.

2. I decided that I wanted as much of the installation to be physically wired together as possible. That way I can show the connections between the different structures and highlight the materiality of the wiring in that context (more on this below). I believe the result is more meaningful this way, as the aesthetics stay in line with the discursive intentions of the piece.

To integrate these sensors into the structures I was building, I created smaller origami flowers (with Vanessa's help). These flowers are made in such a way that wires can pass through the bottom, allowing me to hide the electret microphone inside.

The result is a more meaningful interaction experience, where the not-quite-plant sculptures grow in response to someone speaking or singing into a connected lotus flower. This creates a more tangible sense of connection where we can visualize the sound stimulus moving up the wire/vine to the larger not-quite-plant.

WIRING

As mentioned, I wanted the wiring to be part of the aesthetics of the piece, visualizing the literal connections between the different elements.

I experimented with wrapping the wires in different shades of florists tape. This continues the idea of shrouding technological artifacts within something "organic". Mimicking the appearance of vines creates a visual corollary between the electrical connections and the structure of plants.

SOUND (OUTPUT)

In my proposal I originally planned for there to be some sort of sound output when the sculpture(s) were fully expanded. The idea is that the not-quite-plants would sing or communicate back to you if you input enough sound to allow them to grow. The more I worked on the project, the more I became focused on developing some sort of networked, (almost) rhizomatic, relationship.

I like the idea that the not-quite-plants are connected to each other, and that a networked or coordinated input is required to reveal this connection and to trigger their sound output. For example:

- ➢ Each not-quite-plant has its own sound input (lotus flower) and proximity sensor array
- ➢ To make the clustered not-quite-plants grow at the same time, multiple people need to input sound and sing/talk to them in tandem.

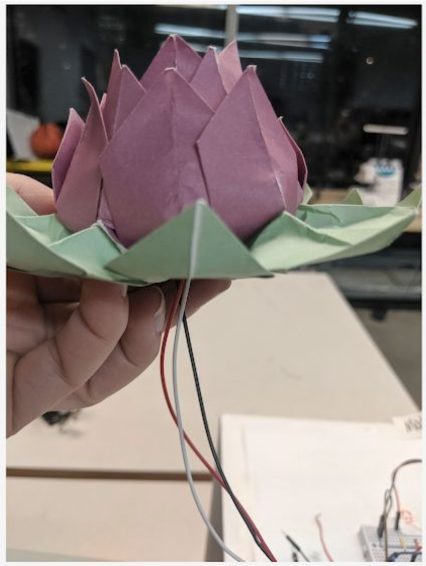
- The networked "community" of not-quite-plants is thus mirrored in the collaboration necessary to discover and access the deepest level of interaction.
- When all of the plants in a cluster reach "growth" together, they will sing a chorus, tell a secret, or otherwise reveal this deeper connection.
- The fact of this deeper interaction should be suggested from the first interaction, but not the methods, so that participants in the installation need to work together to discover and unlock it.
- At this level, perhaps there will be a continuous exchange in sound input and output.

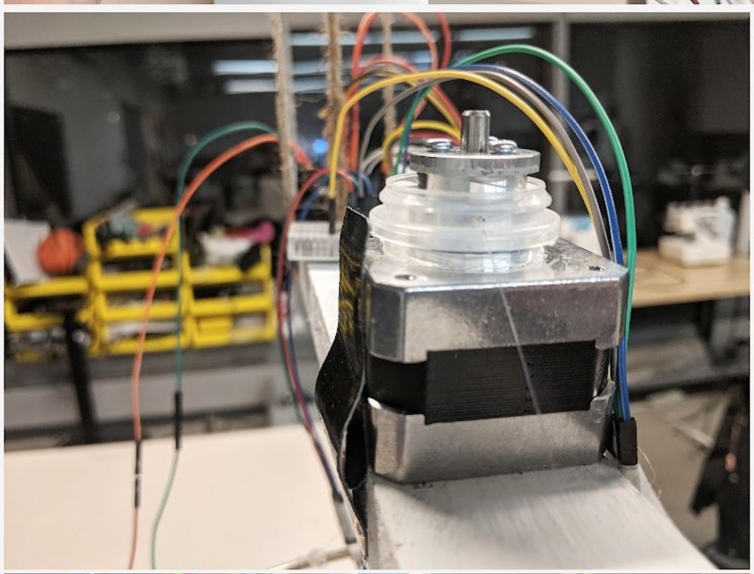
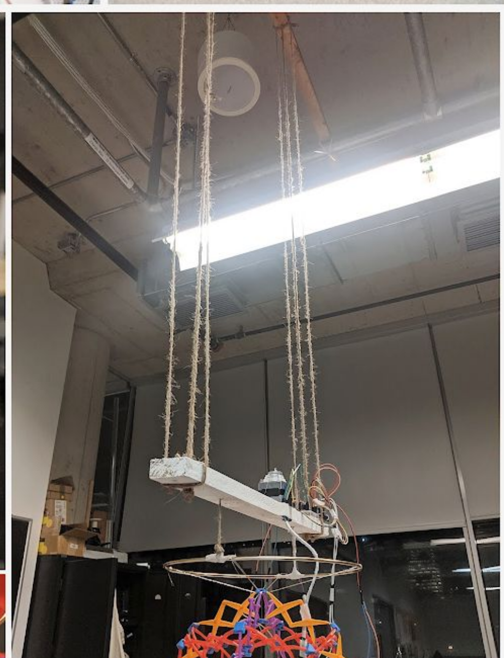
My original intention was to process the sound input into output, so that what you said or sang to the plants was more meaningful and each interactive experience was personal. My plan for the sound processing was to use Max/MSP and do something with granular synthesis. I included an audio file from another project I'm working on to show what direction I was headed in. I'm not claiming the work for this class - it's just an example.

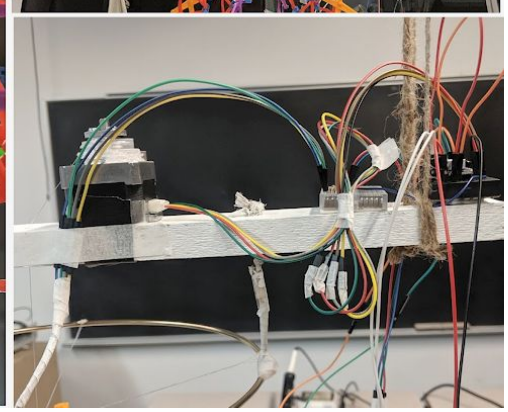
The downside is that I don't really want to use Max, because I don't want to use a computer. Going back to my research process with the electret microphones, I much prefer to use simple components that can be well integrated and that feel as though they are part of the actual material body of the not-quite-plants. In response to this concern, I briefly started researching mathematically significant frequencies and patterns that transcend language, trying to shift through the New Age detritus and look at scientific papers. I didn't get very far, but I'm looking into ways to make the not-quite-plants harmonize with each other or to emit frequencies that are significant in some respect using only Arduino and maybe an FFT library.

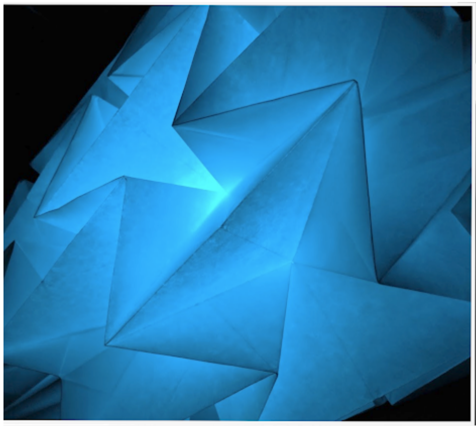
PHOTOS OF FINAL PROJECT

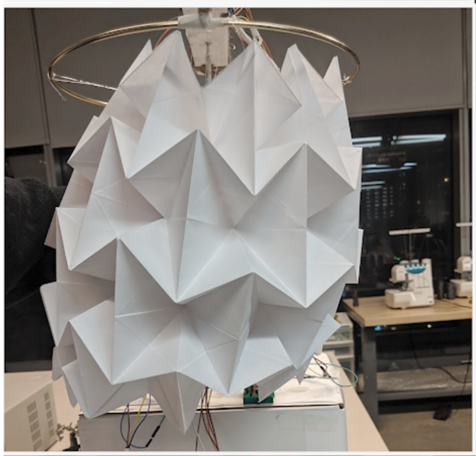
Some of these photos are included above, but I've compiled them for good measure:

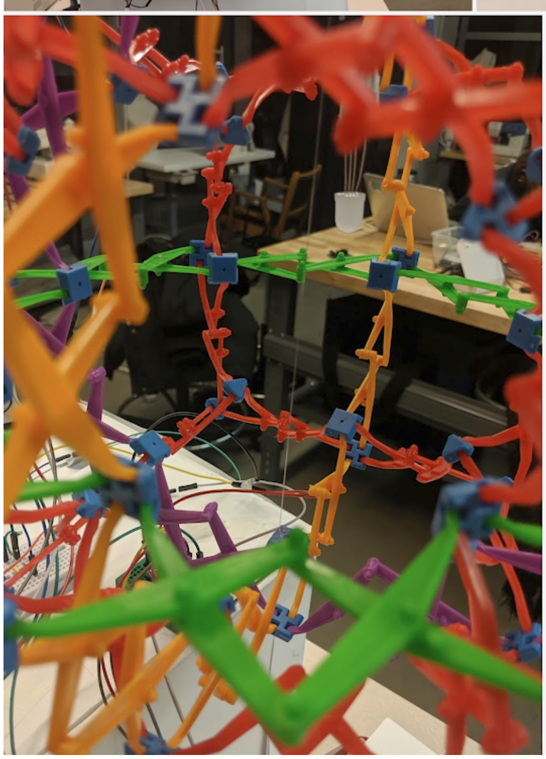



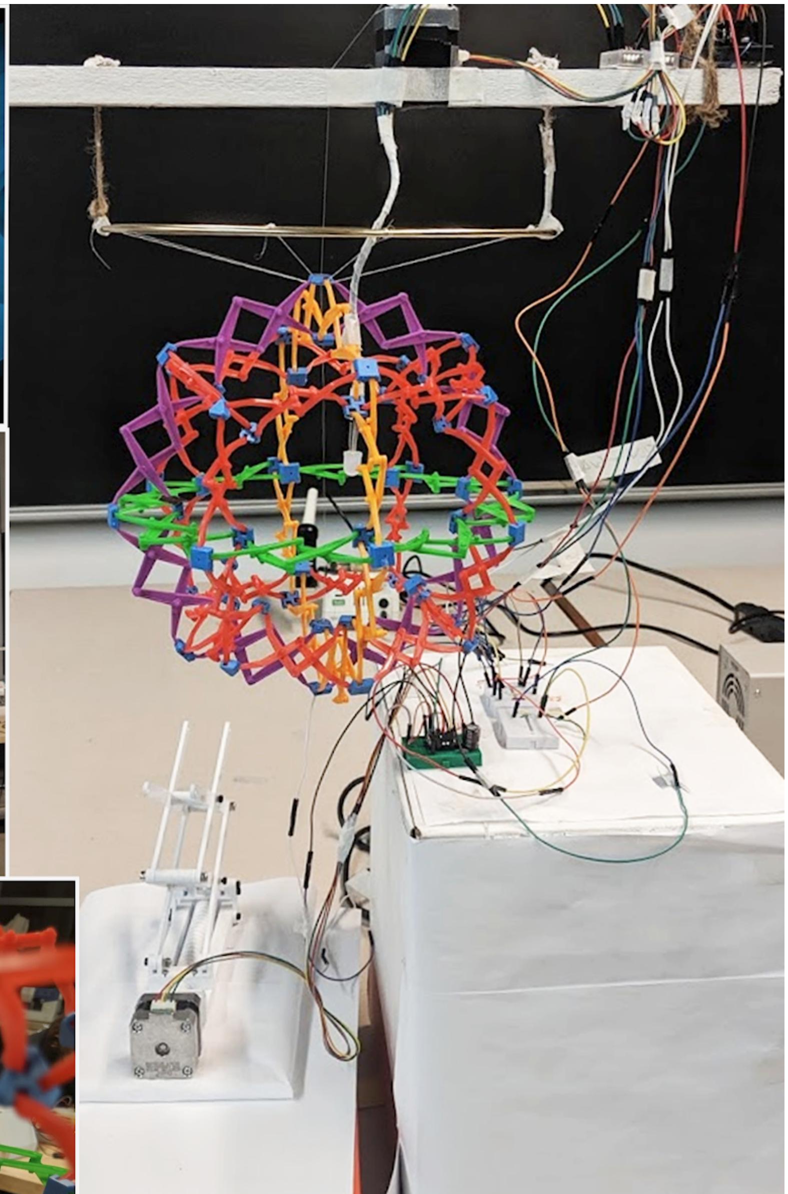













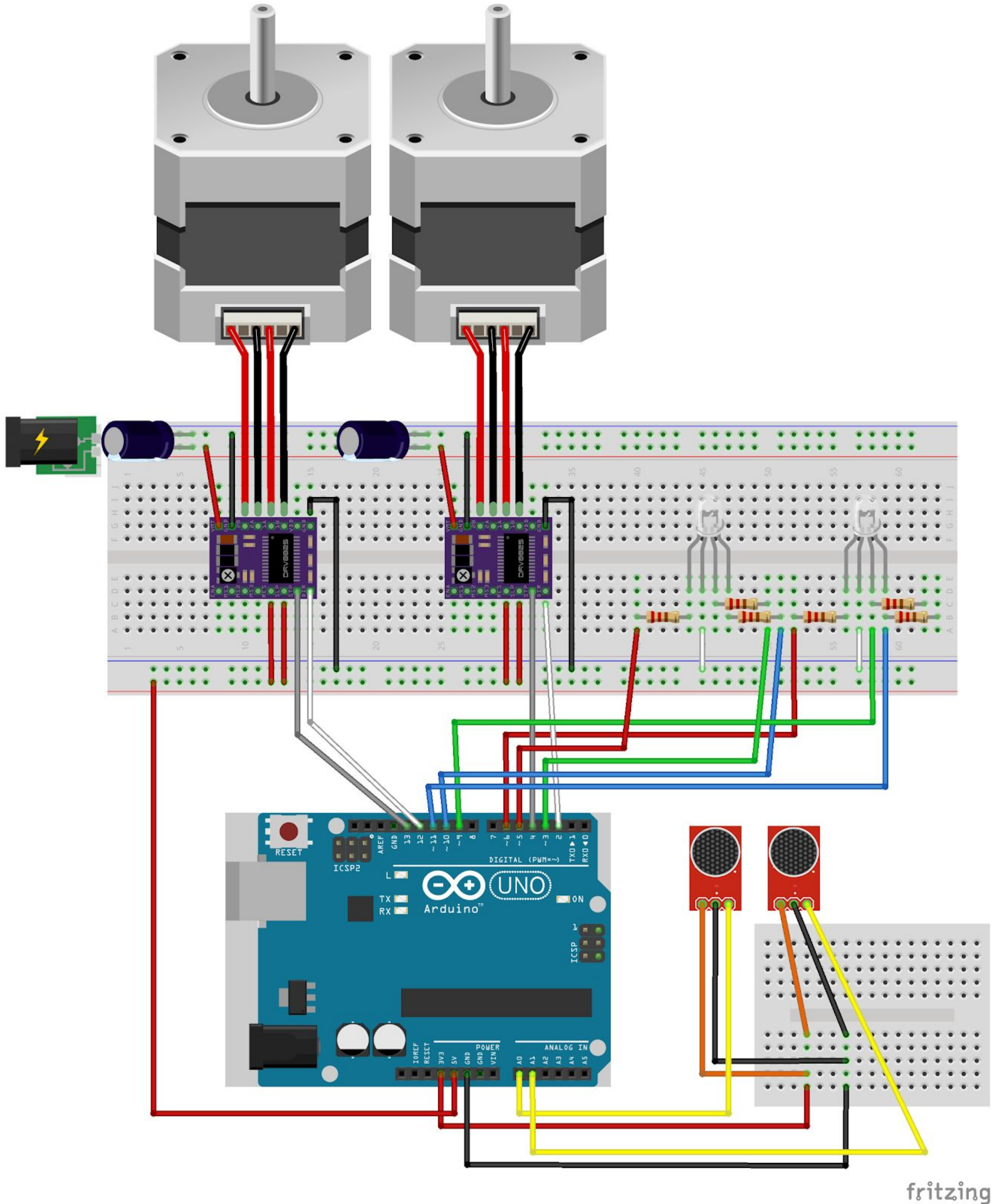
A DESCRIPTION OF THE CODE:

I've included 3 files of code. The first is the code as I had written it for my prototype on November 8th. The second is my closer-to-finalized version that I used for my presentation where I began to adapt the code into a more object-oriented structure using classes. I had started looking into how to write your own library in Arduino. It didn't seem too complicated, but I didn't have time to implement it. I'll definitely do that as a next step. The third file is the preliminary code for the proximity sensors. It works, but uses too many loops. Since I need to integrate it with the rest of the code, I'm going to go back and rewrite it without the loops.

AN OVERVIEW OF FUTURE DEVELOPMENT

Most of my insights and plans for future development were woven into the discussion of my research process. Here I'll briefly summarize:

- Integrate the proximity sensors
- Adjust the LED code to produce more of a slowly pulsing colour change, in tandem with movement
- Finalize the treatment of the paper for the outer sculptures
- Connect the paper sculptures
- Create additional sculptures of each type (sphere and lift)
- Determine sound output and build into code as a networked response
- Hide the motors and wrap any exposed wiring in florists tape
- Use fabric and other materials to create more of a landscape / backdrop for the installation
- Continue to explore meaning through materiality and interconnectedness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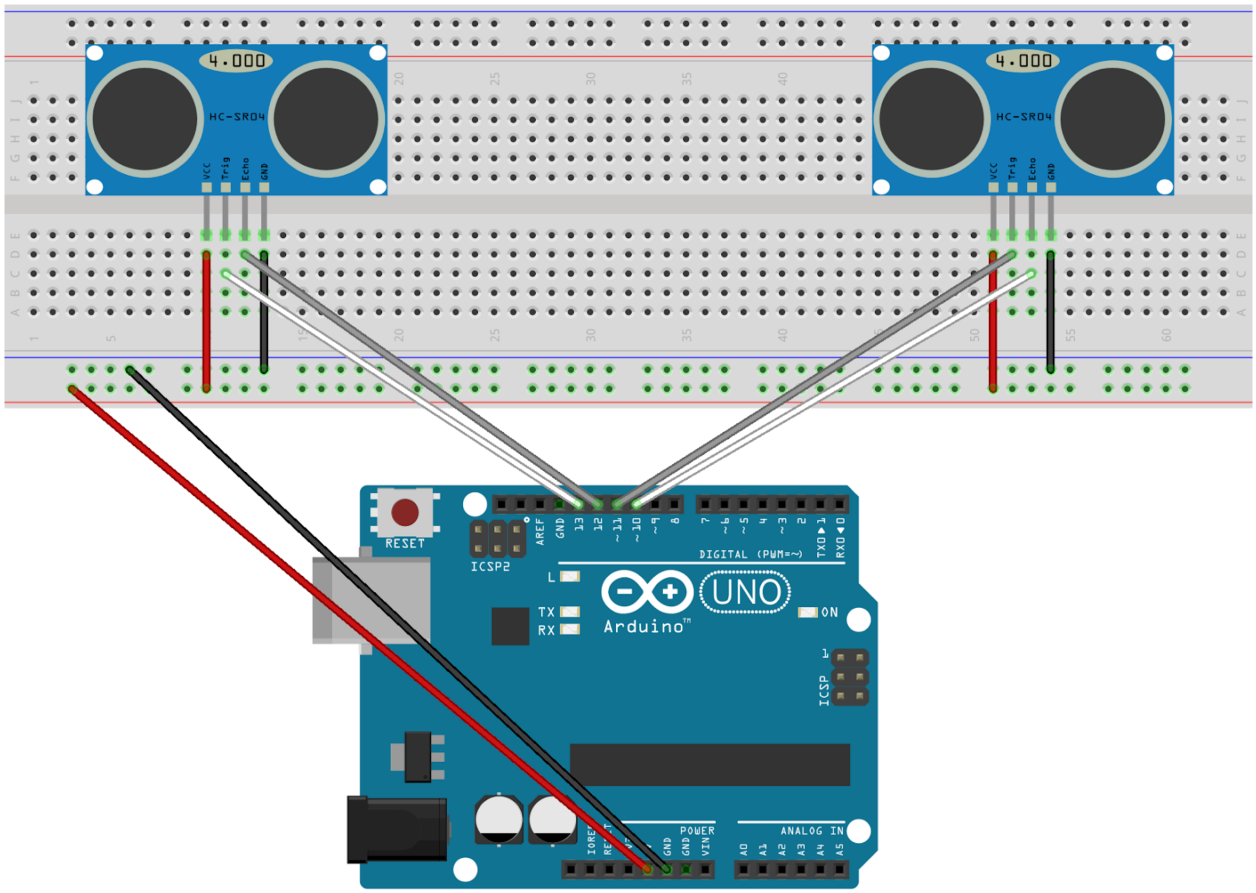
ICSP2
DIGITAL (PWM~)
UNO
Arduino
POWER
ANALOG IN
ICSP
fritzing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HC-SR04
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