GNG1103

Final Design Report

Fallen

Submitted by

Group F10

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University of Ottawa

Abstract

The purpose of this design project is to create a sculpture that utilizes eighty-percent recycled materials, and that has a human interaction element. The project is carried out through a series of project deliverables, each of which has a specific task assigned to it to ensure that teams were on pace and keeping up with their work. The deliverables included; sculpture design criteria, theoretical designs of the sculpture, budgeting and scheduling for the project, as well as prototype testing and customer feedback that was received at various client meetings. The final prototype is a comprehensive protype that incorporates all the design criteria and requirements that were are outlined in the project, as well as those that were created by the team during the development of the sculpture. The final sculpture is constructed of over eighty-percent recycled materials, as the only components that is not recycled is the Arduino breadboard and the LED strip lighting that is used to light up the sculpture. The sculpture is also portable. It can be easily transported from the one side of the University of Ottawa campus to the other and in-fact , portability was tested on multiple occasions in order to present the sculpture at the various presentations that were required throughout the semester. The overall reception of the sculpture was that it was visually appealing, and it conveys the message of disruption in the environment very well. Overall, the sculpture meets all requirements, is under budget and transportable. The next steps for the sculpture, would be to develop a full-scale model of the prototype that people could interact with and relate to on an emotional level, in the hopes that it could propel people to act and do their part to helping the struggling environment.

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List of Acronyms:

Acronym	Definition
LED	Light-emitting diode

Table 1: List of Acronyms

1 Introduction

1.1 Project Relevance

The purpose of this project was to use recycled materials to create a sculpture that would be interactive for the user and convey a theme to the user. The project had some requirements that were to be followed, the sculpture had to be made over at least 80 percent recycled materials, it had to easily transported, the sculpture must be able to be shown outside, therefore it had to be weatherproof, and it had to be safe for the users that will be interacting with the sculpture. The theme of the sculpture that the team created, was that it was a disruption in nature to have trees growing on a mushroom, because mushrooms usually grow on trees. Therefore, this represents a reversal in the natural processes of the environment, and this speaks to the damage that humans have been doing to the environment, and if we keep harming it, perhaps we could have these weird formations in nature that look very abstract. The state the environment is currently in, is a hot topic issue that is talked about and debated regularly between people of all backgrounds. This makes the theme of the sculpture very relevant and relatable to the average user that will be interacting with the sculpture when it is displayed. The idea behind the theme is that it will hopefully inspire people viewing the sculpture to act and do their part to recycle and help the environment as much as possible. There is only one earth and preserving it in the best condition possible should be the priority of everyone on earth.

1.2 User Requirements and Key Aspects

The sculpture the team created is a mushroom on its side with trees growing out the top of the mushroom. The interactive element is that there are motion sensors placed in three strategic positions around the base of the sculpture (one at the mushroom top, and two placed around the central base). Each sensor is mapped to a certain color that can be displayed by the LED strip lighting (red, green, or blue). If one sensor is activated (a person is standing in front of the sensor) then the sculpture will light up a solid color, however, if two sensors are activated then the sculpture will cycle through two different colors. The same process holds if all three sensors are activated. The rate at which the colors are cycled through, if more than one sensor is activated, is determined by how close the people are to the sculpture; the closer the user is to the sculpture, the quicker the colors will cycle through, and the farther away they are, the slower the colors will cycle through. Therefore, the user requirements for the sculpture are only that people are standing around viewing the sculpture. The more people viewing the sculpture, the more colors that will be showcased; moreover, the closer to the sculpture the users are, the quicker the lights will cycle through the various colors produced by the LED strip lighting.

The differentiation in design that makes our sculpture stand out compared to other groups, is that our design was visually striking, structurally stable, and the user could easily interact with the sculpture. The sculpture we created is quite visually appealing with he LED strip lighting, lighting the sculpture up, as well as the overall design and execution of that design was translated very well into the final prototype. From prototype I, to prototype II, and finally prototype III, the design of the sculpture changed, but it did not change dramatically, and the team believes this was one reason why the final sculpture turned out well. Since the design did not change radically, everyone had a

very focused vision for the sculpture, and this allowed us to easily execute that vision. This is also a key aspect of the sculpture that allowed it to be developed into an aesthetically appealing sculpture that was executed well. The second key aspect of the sculpture that differentiates it, is that it is structurally stable allowing it to survive the harsh Ottawa weather when displayed outside. The sculpture has multiple anchor points that allow it to be fastened to the ground so that the wind cannot knock it over, as well so that it could not move if a person were to accidentally com in contact with the sculpture. There are also hole sin the top of the mushroom that allow air to flow the sculpture. This is essential because a mushroom is not designed well to withstand intense winds, the mushroom top could act as a sail and move it a considerable distance. Therefore, holes in the mushroom top were used to alleviate that issue so that air could pass through the sculpture and have no effect. The last key aspect of the sculpture is the ease at which the user can interact with the sculpture. The user interacts with the sculpture by standing in front of various motion sensors placed around the base of the sculpture. All the user must do to interact with the sculpture, is to stand in front of one of the sensors and the sculpture will light up; moreover, depending on the amount of people around the sculpture, the interaction with the users will be different. The ease at which a single user, or multiple users, can interact with the sculpture, differentiates it from other sculptures and makes a key aspect as well.

2 Need Identification and Product Specification Process

Problem Statement:

Develop an art installation incorporating the element of recycled materials for Recycl'Art/ TRACES, integrate the chosen theme of the art exhibitions, and follow the agreed restraints (e.g. simple transportation, weather resistant, safe, 80% recycled materials, etc.).

Needs Identification:

Customer Needs:

- Event dates (June-September and Sept. 13-15)
- Installation created from 80% recycled materials
- Sculpture needs to be secure (is not in danger of falling over, etc., and injuring someone)
- Portable installation as the exhibit travels frequently (easy to dismantle/transport)
- Installation conforms to themes (recycled materials and a word or quote)
- Must follow a budget of $100 CAD or less

Installation Restraints:

- 80% recycled materials
- Minimum 2'×2'×2' complete prototype
- Frequently moved to different locations, easy transportation is key
- Weather resistant (Recycl'Art is outdoors, TRACES has the option to be)
- Events take place in Quebec, installation elements should be available in both French and English (if applicable)

Design Criteria:

Functional Requirements:

- Transportation
    - Requirement: the weight of the sculpture.
- Bottom-heavy materials
    - Requirement: inspection of each component to determine its ability to endure windy conditions.
- Lighting
    - Requirement: review best lighting prospects for the best match for the sculpture that is within reasonable price range ($100) and will work with Arduino microcontroller.
- Wiring
    - Requirement: 22-gauge wiring that matches the intended appearance and length of sculpture (2'- 4') and is within reasonable price range ($100).
- Sensors

- Requirement: reliable ultrasonic sensors that will activate when interacted with by an individual. Must be within reasonable price range ($100).

Non-functional Requirements:

- The design for mushroom shape
- Weather resistance
- Materials: textiles, metal, plastic, foam, etc.
- 80% recycled materials
- Safety of the sculpture and users
- Product lifespan
- The theme of the sculpture

Constraints:

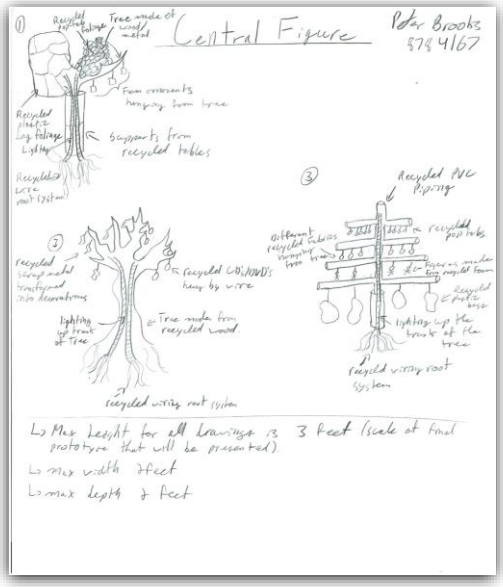
- Weight of the sculpture must be reasonable to be carried by team members
- Cost of materials for the sculpture can not exceed $100 CAD
- Project must be complete before design day (March 29, 2019)
- Weather conditions (must be able to endure weather in all conditions)
- Minimum size of a sculpture that is 2'×2'×2'
- Electrical materials must interact with Arduino Microcontroller

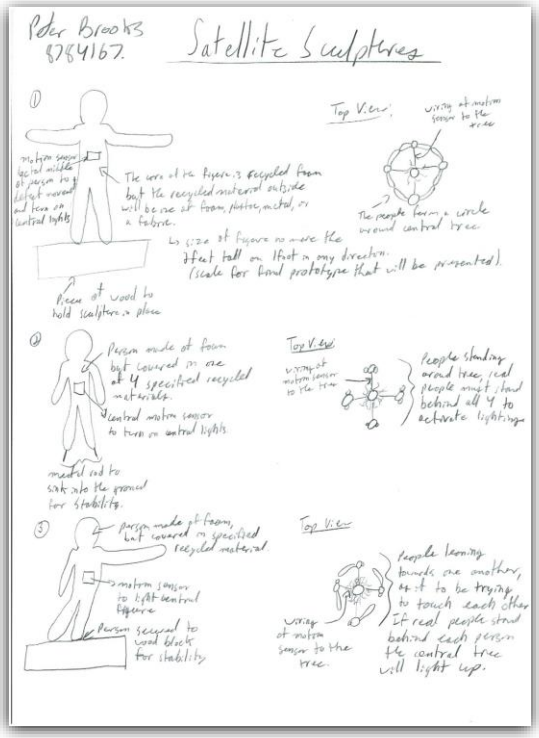
Benchmarking Strategy:

Researching sculptures made from similar materials as to what our group will be working with is our first step to benchmarking our required outcome. It was discovered that sculptures can be made to look quite beautiful and functional with one hundred percent recycled materials. The size of these sculptures varies depending on time, location, and budget constraint of each project. When budget is considered, the sculptures that were identified seemed attainable compared to the constraints provided by the customers. When time constraint is considered, the size of the sculptures that were researched were of comparable size to the size constraints that we have been provided with. In terms of lighting and wiring for our sculpture, we have abundant access to reasonably priced supplies and equipment thanks to the new University Makerspace, as well as local suppliers such as Active Tech and online stores such as Amazon. In closing, benchmarking for a recycled sculpture is challenging; comparing our desired outcome with other completed products was the best strategy for getting an idea of necessary input to get the required result.

3 Conceptual Designs

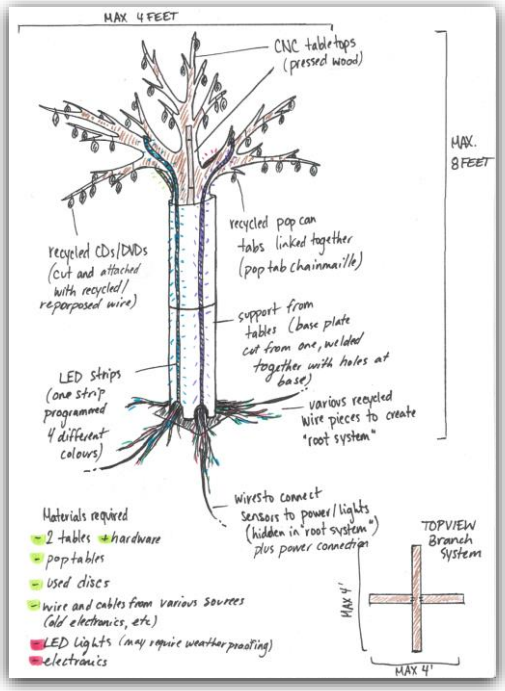
Peter's Conceptual Designs:

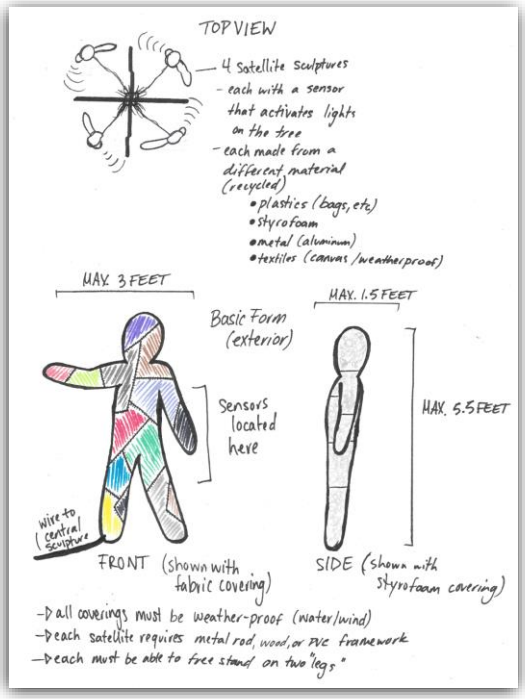




Figures 1 & 2: Peter's conceptual designs

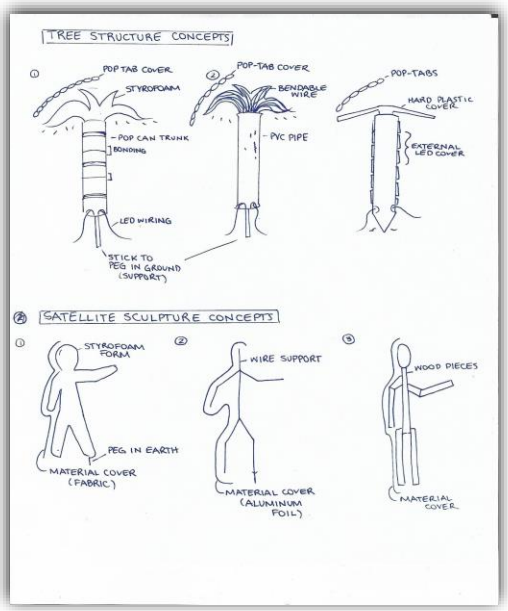
Mimi's Conceptual Designs:

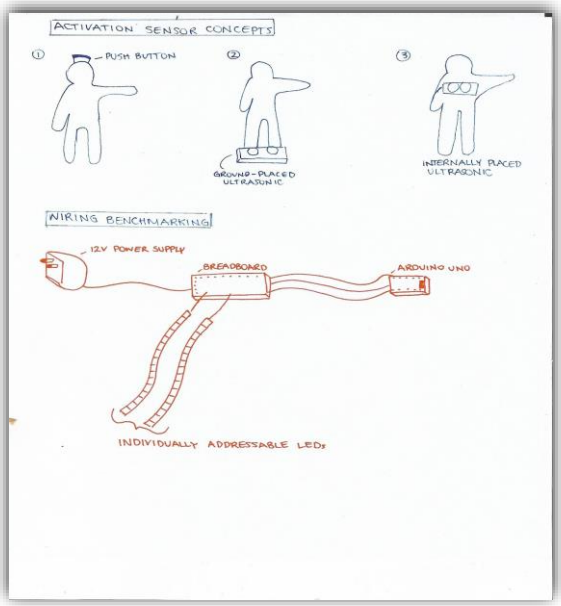




Figures 3 & 4: Mimi's conceptual designs

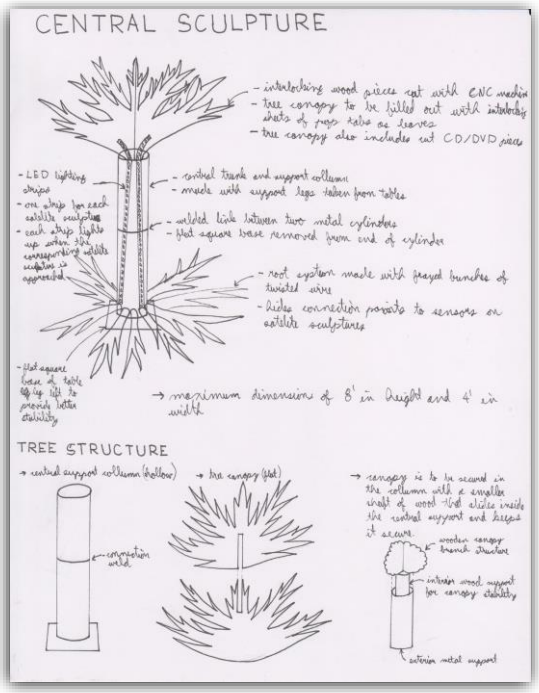
Sam's Conceptual Designs:

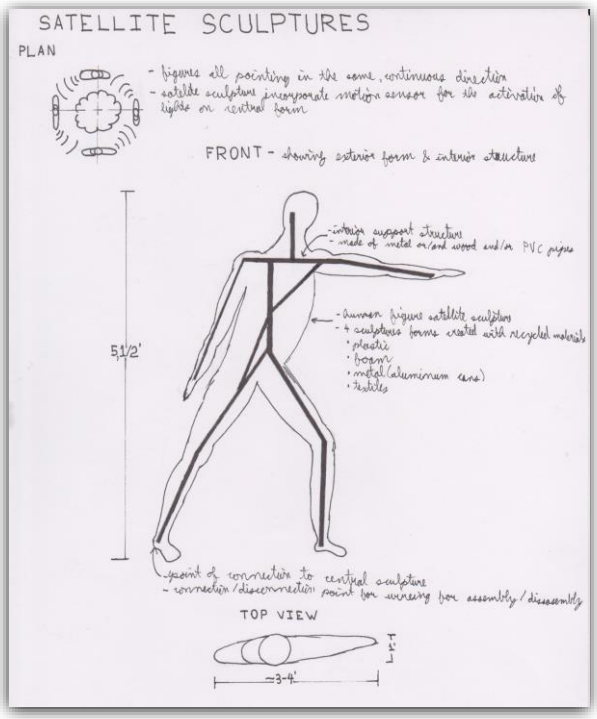




Figures 5 & 6: Sam's conceptual designs

Diane's Conceptual Designs:





Figures 7 & 8: Diane's conceptual designs

4 Project Plan, Execution, Tracking & Bill of Materials

Project Plan:

Prototype I:

Schedule

Task	Brief Description	Duration	Responsible Team Member
Collect materials	Gather materials to be used for current and future prototypes	Jan 28 - Feb 4, 2019 (6 days)	all
Assemble forms	Cut out and put together a simple mock-up of the proposed sculpture	Feb 18, 2019 (1 day)	all
Purchase lighting	Find the best place to purchase lighting and place an order	Feb 19, 2019 (1 day)	Sam & Mimi

Table 2: Prototype I schedule

Significant Prototype Risks

Task	Project Risk	Contingency Plan(s)
Assemblage	Fragility	Have extra materials in case something breaks or is damaged
Lighting	Unavailability, delivery delays, wrong order, etc.	Have a backup plan for purchasing lights locally or making our own (even if more expensive)

Table 3: Prototype I risks

Materials and Cost Estimate

Materials	Cost Estimate
Cardboard	n/a
Styrofoam	n/a
Disks	n/a
White Glue/Masking Tape	n/a
Wire	n/a
Total	**n/a**

Table 4: Prototype I materials and cost estimate

Prototype II:

Schedule:

Task	**Brief Description**	**Duration**	**Responsible Team Member**
Assemblage	Disassemble tables, cut columns to desired height and weld or otherwise attach together	March 4, 2019 (1 day)	Mimi & Diane
Assemblage	Piece together styrofoam chunks to create the mushroom top, glue together	March 4, 2019 (1 day)	all
Manufacturing and Assemblage	Cut tree forms from plywood/MDF, assemble and glue together, apply weatherproofing (stain, clear coat, or acrylic paint)	March 4, 2019 (1 day)	Mimi & Diane (possibly all)
Carving	Carve out the final form from the assembled styrofoam	March 5, 2019 (1 day)	Diane & Mimi (possibly all)
Lighting test	Organize and place the lighting in the mushroom-top and test functioning	March 6, 2019 (1 day)	all
Material Cohesiveness	Test various paint and material coverings (plastic bags, etc) for mushroom top	March 4, 2019 (1 day)	Mimi
Sensors	Decide placement of sensors, build nest system for base if applicable	March 6, 2019 (1 day)	all

Table 5: Prototype II schedule

Prototype Risks

Task	**Project Risk**	**Contingency Plan(s)**
Stability	The mushroom top may be unstable atop the metal column	If the sculpture is unstable, we will put supports on the bottom of the metal column and underneath the mushroom top to increase stability, increase weight at base of sculpture, and/or widen footprint

Lighting Test	The lighting may not turn on when people are near the motion sensors	Allow adequate time to get motion sensors and lighting to work in unison

Table 6: Prototype II risks

Materials and Cost Estimate

Materials	**Cost Estimate**
LED lighting strips	$20-$30
Motion sensors	$15
Plywood or MDF	$5-$20
Wood glue	n/a
Paint	$0-$10
Stain or clear coat	$0-$10
Plastic bags	n/a
White glue/Weldbond	$0-$15
Total	**~ $40-$100**

Table 7: Prototype II materials and cost estimate

Prototype III:
Schedule

Task	**Brief Description**	**Duration**	**Responsible Team Member**
Welding	Cut and assemble the metal pieces for the mushroom stem	March 11, 2019 (1 day)	Diane & Mimi
Tree form design	Draw out the two-dimensional forms of the trees	March 11, 2019 (1 day)	Mimi and/or Peter
3D modelling	Model out the tree forms in 3D and export to file compatible with CNC machine	March 18, 2019 (1 day)	Diane and/or Sam

Electronic system design	Integrate motion sensors into metal stem & connect lighting to sensors	March 18, 2019 (1 day)	all
Final assemblage	Connect all disparate pieces together and test all systems	March 22, 2019 (1 day)	all

Table 8: Prototype III schedule

Significant Prototype Risks

Task	**Project Risk**	**Contingency Plan(s)**
Assembly	Making sure all components of the sculpture work and fit together	Allow several days to figure out how the components of the sculpture work and fit best together, and make changes if necessary
Stability	The sculpture must be free standing, and able to remain standing in outside weather	Design elements from previous prototypes will be used, and enhanced upon if the stability of the sculpture is still in question
Lighting	Motion sensors and lighting must work together to light up the sculpture	Iron out any issues observed from previous prototypes, and if not easily solvable, look into potentially new sensors and lighting that could be more easily worked with

Table 9: Prototype III risks

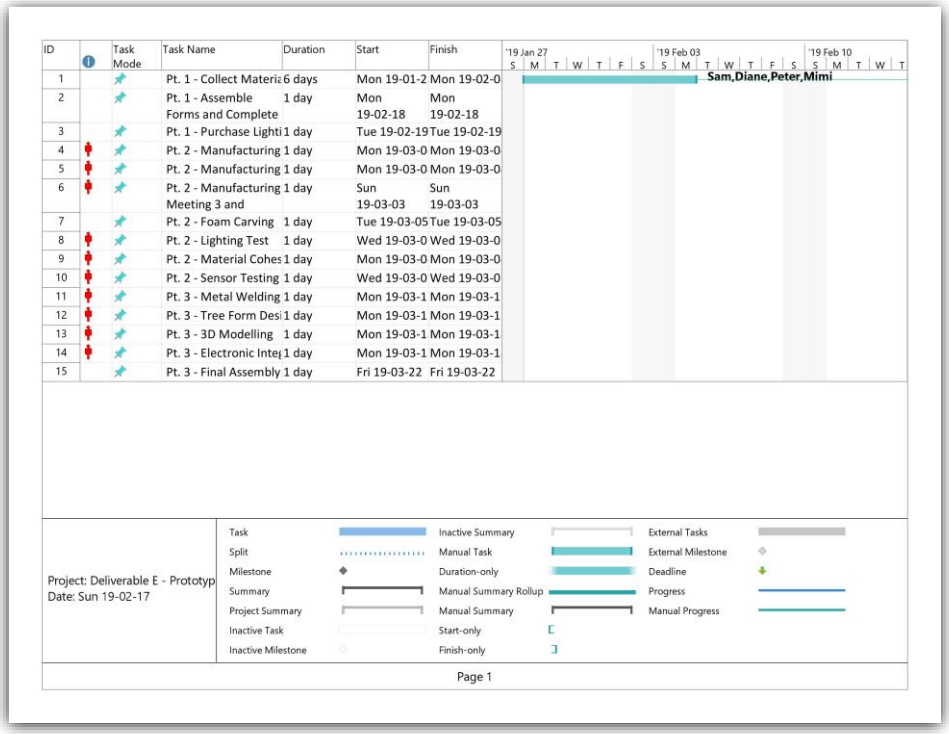
Materials and Cost Estimate:

Materials	**Cost Estimate**
Arduino Ultrasonic Sensors x5	$ 11.66
16ft Waterproof RGB LED Strip	$ 26.99
Arduino Uno	n/a
22 Gauge Wire Kit	$ 22.88
Recycled Materials	n/a
Paint and Stain/clear coat	~ $ 10
Plywood or MDF	~ $ 20

Total	**~ $ 91.53**

Table 10: Prototype III materials and cost estimate

Gantt Chart:



ID	Task Mode	Task Name	Duration	Start	Finish
1		Pt. 1 - Collect Materi	6 days	Mon 19-01-2	Mon 19-02-0
2		Pt. 1 - Assemble Forms and Complete	1 day	Mon 19-02-18	Mon 19-02-18
3		Pt. 1 - Purchase Lighti	1 day	Tue 19-02-19	Tue 19-02-19
4		Pt. 2 - Manufacturing	1 day	Mon 19-03-0	Mon 19-03-0
5		Pt. 2 - Manufacturing	1 day	Mon 19-03-0	Mon 19-03-0
6		Pt. 2 - Manufacturing Meeting 3 and	1 day	Sun 19-03-03	Sun 19-03-03
7		Pt. 2 - Foam Carving	1 day	Tue 19-03-05	Tue 19-03-05
8		Pt. 2 - Lighting Test	1 day	Wed 19-03-0	Wed 19-03-0
9		Pt. 2 - Material Cohes	1 day	Mon 19-03-0	Mon 19-03-0
10		Pt. 2 - Sensor Testing	1 day	Wed 19-03-0	Wed 19-03-0
11		Pt. 3 - Metal Welding	1 day	Mon 19-03-1	Mon 19-03-1
12		Pt. 3 - Tree Form Desi	1 day	Mon 19-03-1	Mon 19-03-1
13		Pt. 3 - 3D Modelling	1 day	Mon 19-03-1	Mon 19-03-1
14		Pt. 3 - Electronic Inte	1 day	Mon 19-03-1	Mon 19-03-1
15		Pt. 3 - Final Assembly	1 day	Fri 19-03-22	Fri 19-03-22

'19 Jan 27 | '19 Feb 03 | '19 Feb 10

Sam,Diane,Peter,Mimi

Project: Deliverable E - Prototyp
Date: Sun 19-02-17

Task, Split, Milestone, Summary, Project Summary, Inactive Task, Inactive Milestone, Inactive Summary, Manual Task, Duration-only, Manual Summary Rollup, Manual Summary, Start-only, Finish-only, External Tasks, External Milestone, Deadline, Progress, Manual Progress

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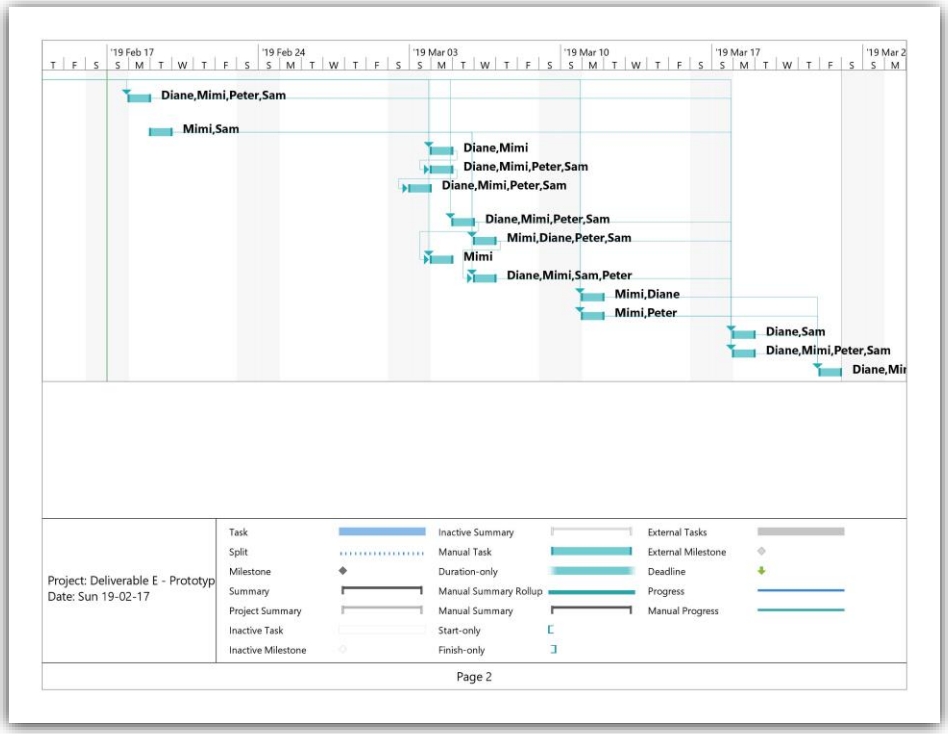

'19 Feb 17 | '19 Feb 24 | '19 Mar 03 | '19 Mar 10 | '19 Mar 17 | '19 Mar 2

Diane,Mimi,Peter,Sam
Mimi,Sam
Diane,Mimi
Diane,Mimi,Peter,Sam
Diane,Mimi,Peter,Sam
Diane,Mimi,Peter,Sam
Mimi,Diane,Peter,Sam
Mimi
Diane,Mimi,Sam,Peter
Mimi,Diane
Mimi,Peter
Diane,Sam
Diane,Mimi,Peter,Sam
Diane,Mi

Project: Deliverable E - Prototyp
Date: Sun 19-02-17

Task, Split, Milestone, Summary, Project Summary, Inactive Task, Inactive Milestone, Inactive Summary, Manual Task, Duration-only, Manual Summary Rollup, Manual Summary, Start-only, Finish-only, External Tasks, External Milestone, Deadline, Progress, Manual Progress

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Figures 9 & 10: F-10 Gantt chart

5 Analysis:

The analysis that was performed on the final prototype was that of its weight and performance outside facing the elements. The weight of the sculpture was calculated by weighing the overall sculpture once it was completed. It was found that the most effective way to weigh the sculpture would be to acquire a measuring scale, and have a team member hold the sculpture while they were on the scale, and then take the difference between the overall weight of the person and sculpture and the weight of the team member. This analysis was performed, and it was found that the overall weight was 235 pounds, the team member weighed 180 pounds when on the scale alone, therefore it was concluded that the sculpture itself weighed around 55 pounds. The weight of the sculpture is critical since the sculpture must be easily transports and must withstand wind when displayed outside. The weight of the sculpture was deemed acceptable as 55 pounds is easily transported by two people and is quite manageable by a single person as well.

The second portion of analysis that was performed was the sculptures performance in windy conditions outside. Due to the nature of the sculptures shape, it is very likely that without proper ventilation the mushroom top could act as a sail and catch the wind, moving the sculpture in wanted motions. The analysis that was performed was part of the prototype testing, and this was placing the sculpture outside on a windy day and observing how well the sculpture faired in the wind. It was observed that the sculpture could easily handle winds of up to 60 Km/h, as this was the wind speed on the day of the testing. The sculpture showed no signs of movement, nor did any component of the sculpture show any signs of being torn off due to the ind. Therefore, it was concluded that the sculpture could withstand an adequate amount of wind and the analysis/testing was considered a success.

Prototyping, Testing and Customer Validation.

Prototype Test Objectives:

Prototype I:

The specific test objectives that the team has set out to answer are stability, proof of design, and whether the current design conveys our message/theme effectively. These objectives are essential for prototype one, as this will lay the foundation for the following prototypes. The main purpose of this prototype was to convey the overall design and theme that the team is striving for on the final model. The stability and overall design concept for the final sculpture is also being learned through this prototype, as it was suggested by the customers, that perhaps the sculpture should be horizontal rather than vertical. The results of the prototype were that stability may be an issue in windy conditions and that a slight design concept change may occur, as mentioned previously regarding the orientation of the sculpture. Taking these results under consideration, the team will discuss what should be done in terms of sculpture orientation and stability of the sculpture. The feedback that was given to the team about these specific topics will be discussed and a decision will be reached about how to further develop later prototypes. The criteria for success and failure would be achieving a sculpture that is not hindered in any way by the elements (especially wind), and by having a design concept that is clearly conveyed by the sculpture. These attributes of the sculpture will be tested prior to the second customer meeting, and then tested again for the final sculpture before design day.

Figure 11: Physical prototype I

Prototype II:

The most basic stopping criteria for prototype II is that the testing is completed when the form can stand on its own without any additional outside supports. This is a critical component to the sculpture as it is meant to be free-standing, therefore it must not require supports that have not been incorporated into the design of the sculpture. Another component to this stopping criterion is that it is able to withstand moderate wind conditions, as the sculpture may be presented outside, so it must be weather resistant. To test this criterion, the team will bring the sculpture outside on a windy day and observe how the sculpture performs under the conditions. Moreover, if the test outside is deemed inconclusive, the team will try to obtain an industrial fan

and test the wind resistance of the sculpture that way. The stopping criteria for this testing would be, that the sculpture does not shift in any way in wind approaching 60 Km/h, if this is the case, then the sculpture will be deemed suitable in windy conditions. The second stopping criteria is for the sculpture to be easily disassembled and transported. This is a critical component of the sculpture as it may be integrated into various art shows the clients put on which travel frequently. Therefore, easy assembly and disassembly is critical. The testing for this would be simply to time how quick the sculpture is to be taken down and put back up. If the time is less than 15 minutes, then the sculpture will be deemed transportable and the testing will be stopped.



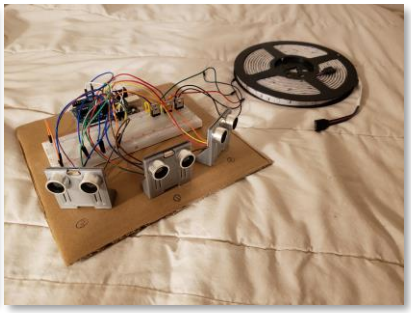


Figure 12, 13 & 14: Physical prototype II

Prototype III:

The first step in the prototype testing plan is to complete the weatherproofing of the mushroom top by covering it in repurposed canvas banners. The next step would be to test if the parasitic tree forms can be secured properly in the mushroom top through the exterior canvas shell, and that the holes through the mushroom top do not become blocked by the canvas. At this stage another test will be performed to see how well the sculpture performs in the wind, ensuring stability in exterior conditions. The stopping criteria for this test, will be if the sculpture can survive in up to 60 km/h winds, as this represents a moderately windy day and is sufficient for the duration of the project's life. Once this testing stage is complete, the next stage is to construct and test the lighting and interactive elements of the final prototype. The stopping criteria for this test will be if the motion sensors can pick up multiple people around the sculpture and change the light pattern accordingly. If the motion sensors and lights work together and produce the required colour patterns, then the test will be deemed a success. The underside of the mushroom top will be decorated with fins or ribbing similar to those found on real mushrooms. These fins will be made of recycled coroplast poster boards and will have notches cut on the underside of them to thread the LED lighting strip through. The fins will both provide visual interest and act as a securing point for the lights. The introduction of the fins will allow for the testing of the ease of assembly and disassembly of the sculpture, since they will be positioned at a major connection point. With the fins in place, the stability of the lightings system can be tested to ensure its proper functioning throughout the extent of installations of the sculpture. The final stage of the testing plan for the prototype revolves around the integration of the sculpture with its surroundings through a root-like system coming off the base of the mushroom stem. The roots will be made of coiled power cords and other cables scavenged from end-of-lifespan electronics prior to being recycled or discarded. The root system will serve to hide portions of the support

structure of the form and add visual interest to the stem. They will also allow for a more acute integration with the environment that, in the case of outdoor installations, could be extended to link with surrounding trees and other features, furthering the theological backing of the sculpture.

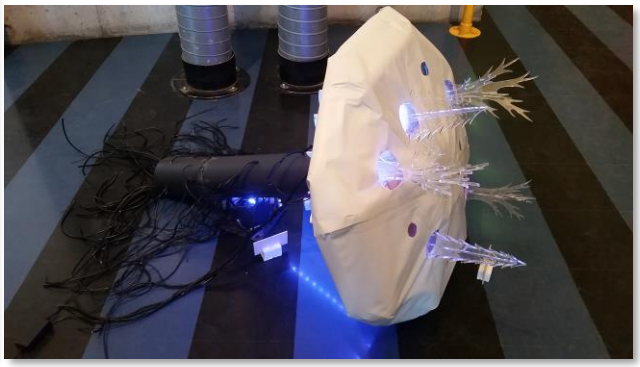



Figure 15 & 16: Comprehensive prototype II

Customer Feedback and Comments on the Prototypes:

Prototype I: Comments from client meeting #1:

- Explore alternative materials (and/or be able to defend why we chose certain materials rather than others)
- Explore other designs for the mushroom cap to account for windy conditions ("roots", more holes, support systems, etc.)
- Consider further weatherproofing (specifically relating to the styrofoam top and wind, but also MDF/unfinished wood in raining conditions)
- Consider displaying it horizontally rather than vertically (increases stability, can be anchored easier, makes the elements under the cap visible, etc.)
- Consider a "root system" that connects the sculpture to the exhibition space (network of "roots" extending outwards and into the ground and/or extending the lights from the sculpture and onto a nearby natural tree, incorporating the natural environment of the outdoor exhibition space into the sculpture in some way)
- Overall theme and concept were well-received and strong

Prototype II: Comments from client meeting #2/ in-class presentation:

- Both well thought out
- Very structurally stable prototype
- Large prototype, good to see from far away
- Advanced to final structure
- Prototype echoes the problem
- Prototype present, great visual

- Well built

Prototype III: Comments from design day/ second in-class presentation:

- Prototype would hold up well outside, except for the Arduino components that were exposed
- Nice to see the overall idea of the protype not change too much from the first client meeting
- The visual appeal of the prototype was excellent, the prototype is striking in a dark setting
- Theme of the prototype was evident, and it was conveyed well by the sculpture
- It would be interesting to see the next phase of the prototype if it were to be developed to a full-scale model
- An abstract sculpture that was very striking and interesting to look at
- Good integration of technology with the motion sensors and laser cut acrylic glass
- The prototype can be interpreted in many ways

6 Final Solution

The final prototype that was created for this project represented a fallen tree, except that it was a mushroom that had trees growing out the top of the mushroom. To make the final prototype more convincing to the user as to what it was, the team added fins to the underside of the mushroom top, to replicate the fin like structures that actual mushrooms have on the underside of their tops. The stem of the mushroom was also integrated with 'roots', that were made from various electrical cords from different electronic devices. These roots not only represent the roots a tree would have, but also that in this electronic age, if people were as rooted to the environment as they are to their own electronic devices, perhaps the environment would be in better condition than it is currently in. The LED strip lighting was inserted underneath the fins on the underside of the mushroom top. This was done by cutting notches in the fins to allow the lights to slide through them and wrap around the entire underside of the sculpture while being held in place by the fins. These lights were then connected to an Arduino breadboard that was fastened to the sculpture at the central support of the sculpture. This Arduino was also connected to three ultra-sonic sensors that were placed around the sculpture. Two of the sensors were placed on the central support of the sculpture facing the mushroom top (at a slight angle), while the third was placed at the mushroom top facing out to the general area around the top of the sculpture. For this prototype, the placement of these sensors was deemed sufficient.

The feature of the sculpture is that it lights up according to the number of people around the sculpture, and that it cycles through various colors depending on how far away people are from the sculpture. Each one of the sensors is mapped to a different color, therefore if one sensor is activated then the sculpture will light up one color, but if more than one is activated then it will cycle through the various colors. As well, if the people interacting with the sculpture are close, the colors will cycle quickly, while if the people are viewing the sculpture from further away, the colors will cycle slower. Another feature of the sculpture would be the acrylic glass tree figures that are seen on the top of the mushroom. These were created by first hand drawing the trees on paper, and then from those models, make a digital render of these trees and then using the digital renders of the trees, the laser cutter was programmed to cut out the tree forms from a piece of acrylic glass. The trees were then inserted into the holes in the top of the mushroom (that are used for air flow) and the trees were lit up by running some of the LED lighting into the holes so that the trees would light up when the sensors were activated.

The final testing results were that the sculpture's lighting did work. The sculpture would light up the correct color depending on what sensor was covered, as well as cycle through various colors if more than one sensor was covered. The sculpture also performed well under the stability tests. The sculpture was capable of being free standing, as well withstanding up to 60 Km/h winds. This test was conducted outside on a windy day that the winds were recorded at being up to 60 Km/h. The sculpture was in the wind for several minutes and showed no signs of moving, and no components were showing signs of coming off the sculpture. Due to these results, it was deemed that the test was a success and the team was convinced that the sculpture could be outside for a long period of time without any side affects.

The final protype on display at Design Day March 29, 2019:

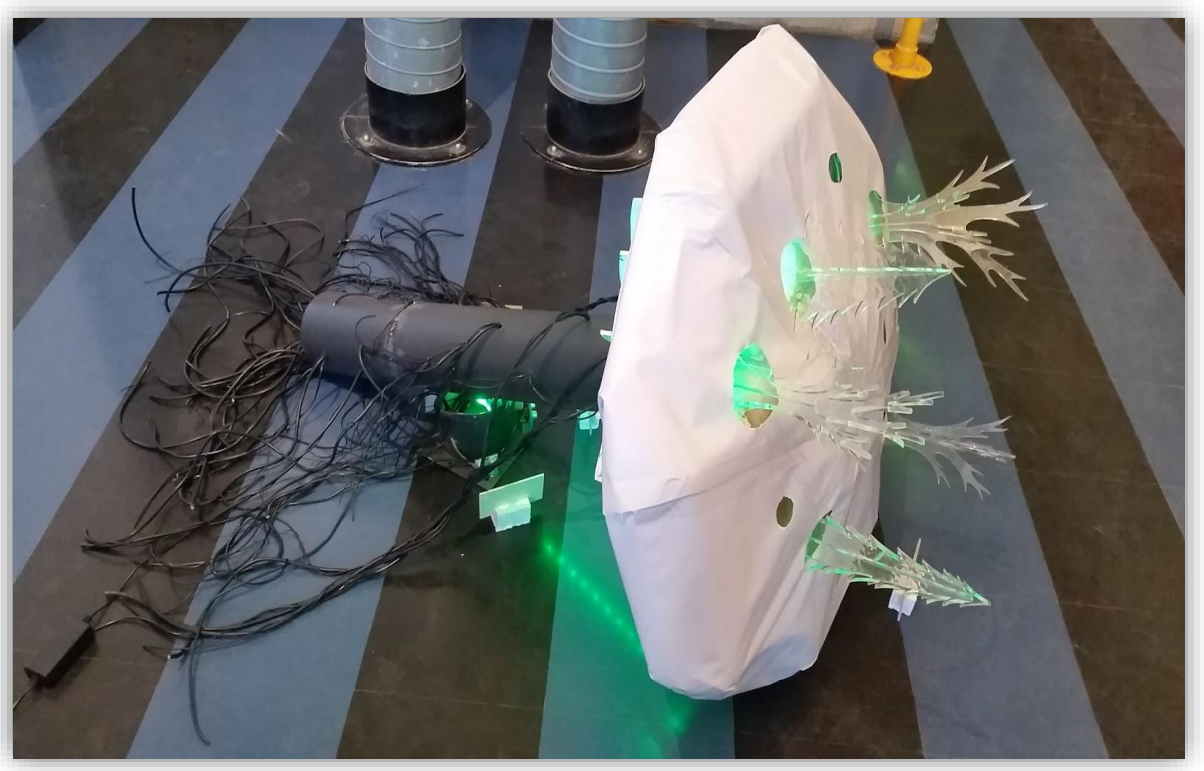


Figure 17: Final prototype on display

7 Conclusions and Recommendations for Future Work

In summary, the final prototype turned out very well and the team was very happy with the outcome. There were many lessons learned when developing the design of the sculpture, and while the building of the sculpture was taking place. Some of these lessons were to not procrastinate any aspect of the process as this will not allow you to keep up with all the deliverables that are due, and you will be rushing to finish the prototype before design day as well. Another lesson learned is that changing aspects of the design is not necessarily a bad thing. Perhaps the design has to change because components of the sculpture do not fit together, or because new ideas arise while building the sculpture; moreover, these ideas should be discussed in the group, and a decision should be reached to determine whether or not that idea will make it into the final product or not. The integration of engineers and artists was an interesting collaboration that taught everyone a lot about communication and how to resolve conflict within a group. The engineers learned that to consider the aesthetic of a piece while building it, and that if it is visually appealing, then more people will be attracted to the piece and they will interact with it. The artists learned that not every idea is necessarily possible due to either time/budget constraints, or because the sculpture would not be structurally stable enough to withstand the weather when the sculpture is outside for long periods of time. The team also learned how to deal with conflict within the group. When conflict arises, it is best to listen to both sides and have a respectful discussion about each point of view, and most of the time a compromise between the two sides is an effective strategy at settling the difference in opinions.

The future work that could be done on the prototype would be to fully weather proof the sculpture as well make it to full scale. Right now, the Arduino components are out in the open and could not withstand any form of weather, however, the future work that could be done would to compartmentalize the electronics into the either the base of the sculpture, or the stem of the sculpture so that they are not exposed to any form of weather, thus being able to last long periods of time outside. Another step that could be taken in the future is to incorporate more sensors around the sculpture. The prototype currently only has three sensors situated around it, a full-scale model of this would be perhaps up to ten sensors situated in the base and around the top of the sculpture to detect people approaching and leaving the sculpture in any direction. Lastly, building the sculpture to full scale would be the final future step. When doing this, better lighting would also be bought to ensure none of the connections within the lighting breaks so that all the colors are available to be used at any point around the sculpture. Developing the sculpture to full scale would also entail better motion sensors that could detect people up to four meters away from the sculpture and as close as a couple centimeters from the sculpture as well.

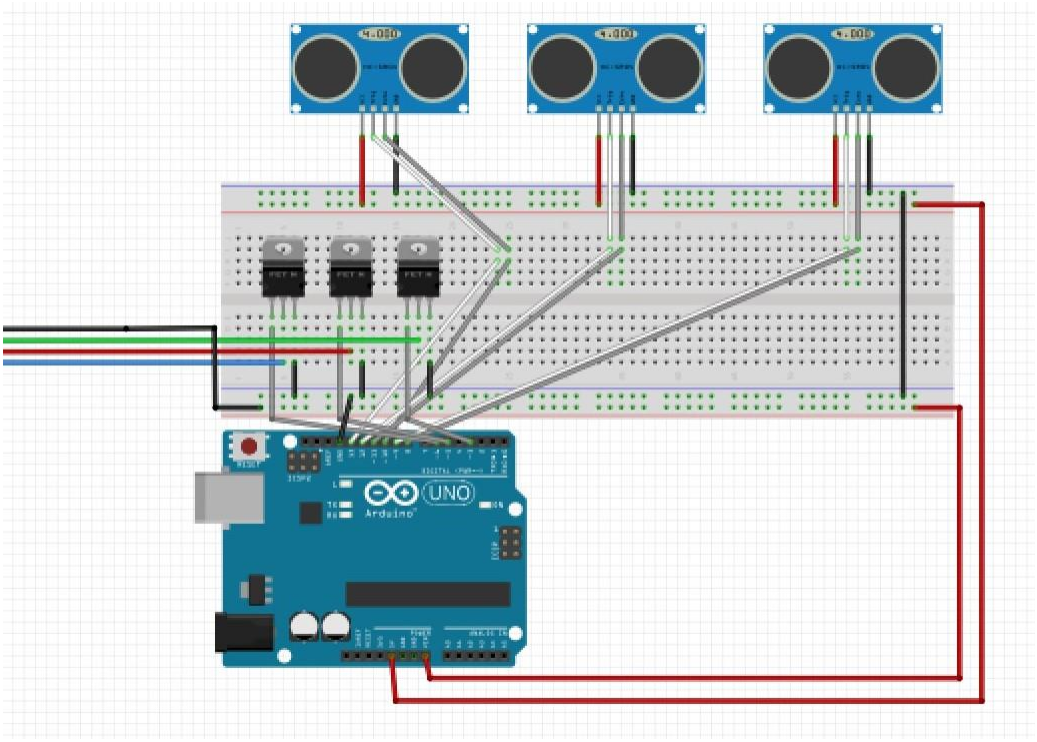
8 Bibliography

No sources were cited in the creation of this document.

APPENDICES

APPENDIX I: User Manual

Wiring Schematic:



Components:

- Arduino Microcontroller
- Solderless Breadboard
- NPN transistors (IRLB8721) × 3
- RGB LED strip (5m)
- Ultrasonic sensors (HC-SR04) × 3
- 3D-printed sensor supports
- 22 awg wiring

Links to components:

1. **uOttawa MakerSpace:** Arduino, Breadboard, NPN transistors, 3D-printed support, 22-awg wiring
2. **RGB Lights:** https://www.amazon.ca/gp/product/B07B5Z2Y34/ref=ppx_yo_dt_b_asin_title_o01_s00?ie=UTF8&psc=1
3. **Ultrasonic Sensors:** https://www.amazon.ca/gp/product/B071P91YDS/ref=ppx_yo_dt_b_asin_title_o01_s00?ie=UTF8&psc=1

APPENDIX II: Design Files

Included Design Files:

Arduino Programming Code:

Provided on MakerRepo: GNG1103 – F10 – Fallen

APPENDIX III: Other Appendices

No other appendices were needed for explanation of the sculpture.