Boston University EK210

Section A8 - Professor Grace

Final Report

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Executive Summary

The goal of the designed product is to create a touchless, directable overhead light. The product contains features which allow it to move to the left, right, or center itself through the use of a servo motor. In addition, it contains the capability to change its light into various settings, which include: white light, yellow light, and a spotlight. The two color settings are able to change the intensity of the projected light through the use of an ambient light sensor, which has a range of four different brightness settings. This was constructed using a 16x16 LED and each function is operational as a result of the use of a voice sensor. The servo motor, LED sheet, ambient light sensor, and voice sensor were connected to an arduino. The system runs on a 10A 5V AC/DC adapter. The light is capable of fully illuminating a small room, such as a bedroom, and is able to provide an additional 15 inches of maximum range for the illumination distance as a result of the motor tilting the system by 45º in two directions.

Introduction

The goal is to design and implement a directable, touchless, overhead light system that the elderly and those with limited mobility can easily utilize to assist them with their daily tasks. In order to achieve this, a Priority/Constraints Chart, which can be found within Table 1 of the Appendix. was used to highlight the most important features and set the following goals: having at minimum 3 brightness settings, 2 color settings, lightweight, reduced area of concentrated light feature, and being able to turn 90º. Additional objectives and their metrics can be found within Table 2 in the appendix.

Material and Methods

In order to achieve these goals, the following key components were utilized: a MG995 servo motor, a 16x16 RGB LED sheet, a BH1750 light sensor, a voice recognition module V3, and an arduino uno. Additional materials used in the assembly include a small tube of superglue, the mounting plate for the arduino uno, three nylon screws, three nylon washers, six nylon hex nuts, 30 jumper wires, a 10A 5V AC/DC power adapter, four lever wire nuts, and six sets of 15 foot wires. Four additional components were designed. Three of these were 3D printed: a main enclosure to house the internal components with a wiggle infill pattern, a lid for the main enclosure with a wiggle infill pattern, and a plate attachment with a slow honeycomb infill pattern. The CAD designs for these components [Figures 1-3 of the Appendix]. The fourth designed component was a plywood, finger joint box, which was lazer cut and assembled with hot glue. [Figure 4].

To assemble, the arduino was placed in it's mounting plate and secured with a screw, washer, and two nuts through the mounting holes near the DC power jack, the ATMega328P ICSP connector, and near the ATMega16u ICSP connector. The code was uploaded to the arduino. The arduino, voice sensor, and motor were superglued securely into the main enclosure. The LED sheet was securely attached to the plate attachment, and its wires were fed through the plate attachment's shaft. The motor attachment used was superglued to the end of the plate attachment. The power adapter's power and ground screws were soldered to the remaining two 15 foot wires, which were insulated with the heat seal tubing, and twisted to create a larger cable, and were connected to the internal components through the input wire slot of the main enclosure. The speaker module was housed in the plywood box. Four of the 15 foot wires were attached to the speaker module, ran through the plywood box, twisted to create a larger cable, and connected through the input wire slot of the main enclosure. The two were connected via a 15 foot long cable which allowed for the main housing to be placed comfortably in the center of a ceiling, and the speaker module to be moved and/or placed at the most convenient location for the user. A wiring diagram for the system can be found in Figure 5 of the appendix. The voice module was also tested and trained such that a user does not have to speak loudly or directly into the microphone to register commands. The functions that allowed the system to behave were all programmed within the arduino IDE.

The code was developed using a system of boolean variables and if statements which called various functions; each function within the code directly correlated to a designated command given by the user through the voice sensor which can be found in Table 3 within the appendix. For example, if the voice sensor detected the command "power," the code would loop through the potential commands it knows, and once it finds the designated line of code, it would see if a boolean variable "is_on" is true. If the variable is true, that indicates that the lights are already on and thus the lights should be turned off. Opposingly, if the variable is false, that indicates that the lights are off and they should turn on. This series of commands and boolean variables was used for nearly every function the lights have. A representation for how to code works can be found in the appendix in Figure 6.

Results

The construction of the final product allowed for it to be compact and effective. The total cost for this project totaled $110.74 as seen within Table 4 of the Appendix. An image of the final design can be seen in Figures 7 and 8 within the appendix. They were separated so that a client could speak into the microphone from anywhere within their room while also not forcing them to speak too loudly if the sensor had been placed inside the main enclosure. As described, all parts of the product were housed in the main enclosure, connected to the ceiling, while the voice sensor was housed separately. 15 feet of cable were used for both the power adapter and the voice sensor. These lengths were used so that the main housing would be able to be comfortably placed in the center of a room while also being connected to a power outlet, and so that the voice sensor could be moved throughout the room for the user's convenience. The sensor was trained in a relatively loud environment so that a potential user does not have to speak up or directly into the microphone in order for it to register a new command.

The motor was implemented so that the light was able to rotate a total of 90º, being able to turn 45º in each direction which provides an additional 15 inches in either direction, as seen in Figure 9 of the appendix. The light sensor allowed for 4 different brightness settings, which can be seen within Table 5 of the appendix. Additionally, the use of RGB LEDs allowed for the product to have multiple light settings, and its sheet design allowed for a simple implementation of the spotlight feature. Finally, 3D printing allowed for the main enclosure and lid to be lightweight and flexible due to the use of a wiggle infill pattern, and the LED Plate attachment to create a durable design due to the use of a slow honeycomb infill pattern.

Conclusion

Through this project, a number of lessons were learned. The two most important being the value of teamwork and planning. Without teamwork, the project would not have been completed, let alone on time. Each member of the group contributed something to the project which allowed it to be completed and functioning to the successful degree it was. In a similar light, planning was essential to the success of this project. Understanding how each piece of hardware worked and how it could be used in conjunction with others was imperative. Creating a glass box was a great way to visualize the relationships [Figure 10]. On top of this, another aspect of planning that goes hand in hand with teamwork, was the necessity to plan times to build and test materials. An example of the value of testing can be seen when comparing the final build of the project to the team morph chart that was created in week 3. [Table 6]

Overall, this project showcased the versatility of different components and taught valuable lessons in teamwork and ingenuity, which ultimately resulted in the construction of a fully functioning touchless, voice-controlled overhead light.

Appendix

Table 1: Priority/Constraints Chart

	Brightness	Moveability	Safe	Reliable	Accessible	Installation	Total
Brightness	-	1	0	0	0	1	2
Moveability	0	-	0	0	0	1	1
Safe	1	1	-	1	1	1	5
Reliable	1	1	0	-	1	1	4
Accessible	1	1	0	0	-	1	3
Installation	0	0	0	0	0	-	0

Table 2: Objectives/Metrics Table

Objectives	**Metrics**
Safe	- LEDs will not become blinding when looked at directly - Wires are not exposed
Reliable	- Does not require power source replacement - Durable Housing
Touchless	- Voice controlled
Lighting	- 4 brightness settings - Yellow hue setting - Spotlight setting
Directible	- Forwards, backwards, and center tilts for the LED panel
Installation	- Set up once - Overhead

Table 3: Speaker Module Voice Commands

Power	Lights up the LED sheet
Yellow	Changes the LED's hue to yellow
Spotlight	Reduces light to one area, creating a spotlight
Front	Tilts the LED sheet forwards
Back	Tilts the LED sheet backward
Center	Centers the LED sheet along the motor's rotational axis

Table 4: Team Morph Chart

Means Functions	1	2	3	4
Moveable light	Analogue stick	Directional pad	Given presets on remote	Manual motion
Easily turned on/off	Power switch	Wall outlet (plug in/out)	Button on remote	Sound activation
Adjustable lighting	Multiple lights with different brightnesses	potentiometers	Adjustable current output	Placeable light filters
hands-free	Remote control	Motion sensor	Voice activation	App

Table 5: Light Sensor Ranges

Lumens Sensed (ambient light sensor)	Light Setting (LED sheet)
< 100	50
< 200	40
< 279	20
> 280	10

Table 6: Spending Summary

Parts	**Cost (USD)**	**QTY**	**Total**
Arduino uno	28.5	1	28.5
Servo motor	9.99	1	9.99
Voice sensor	10	1	10
Ambient light	4.5	1	4.5
16x16RGB LED	20	1	20
Cables	10	1	10
5V 10A AC/DC adapter	20	1	20
Housing	7.75	1	7.75
			110.74

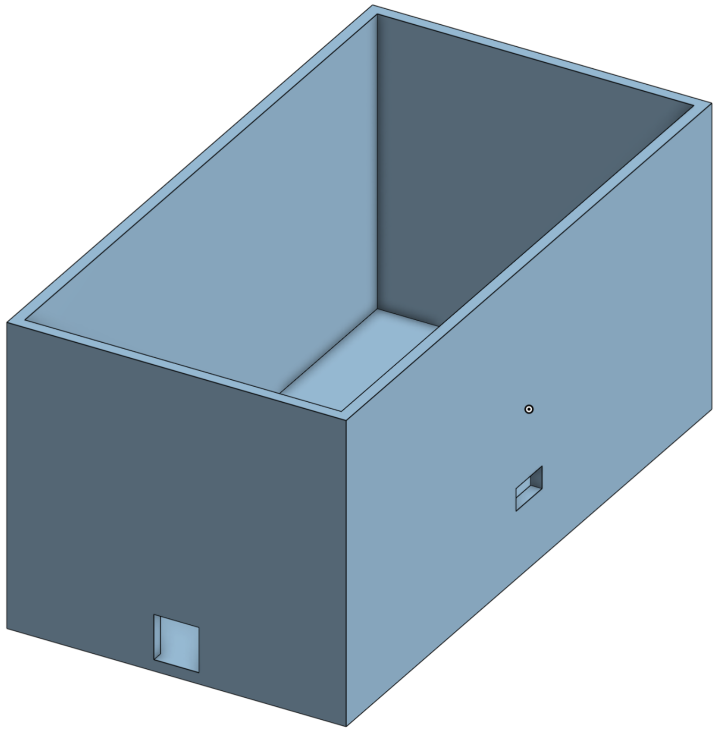


Figure 1: Main Enclosure

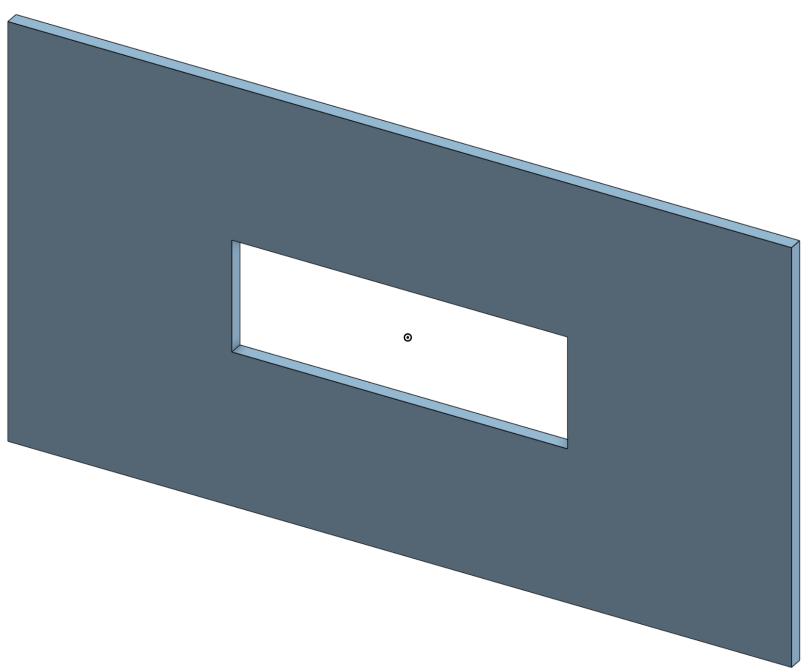


Figure 2: Lid

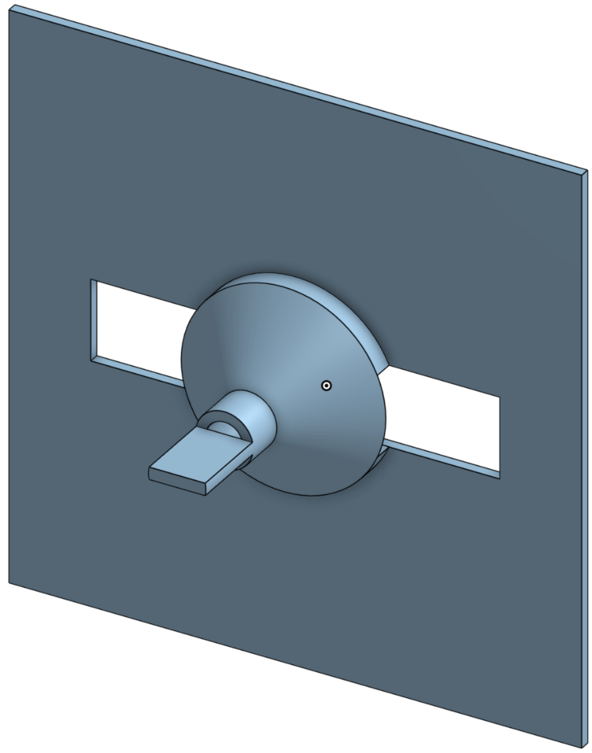


Figure 3: Plate Attachment

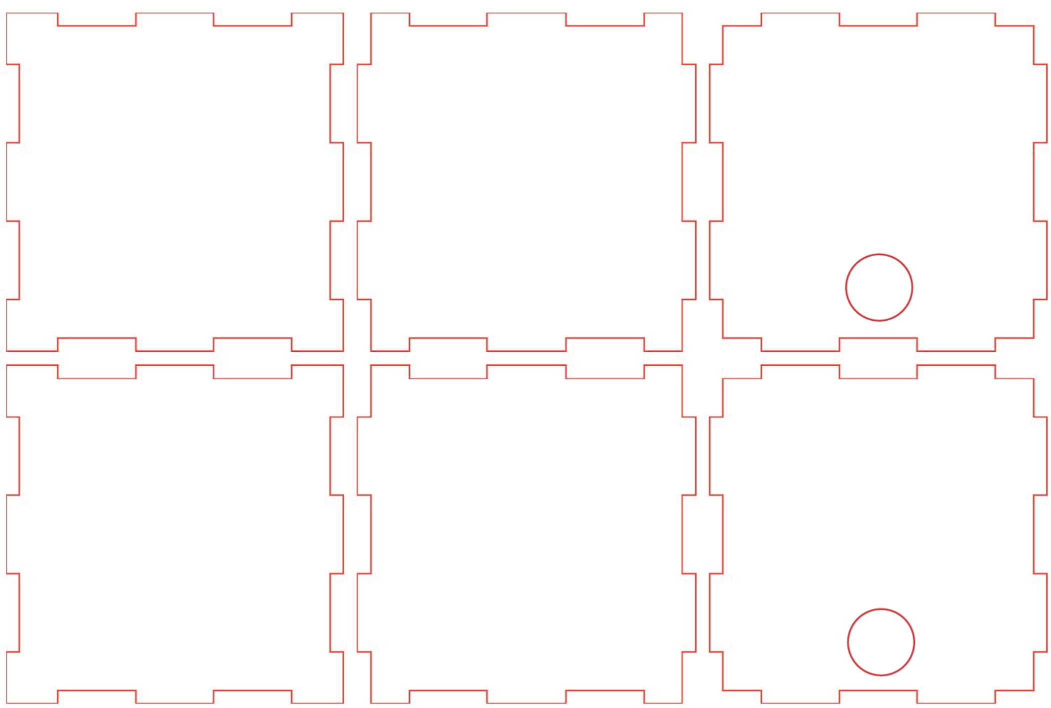


Figure 4: Speaker Module Box

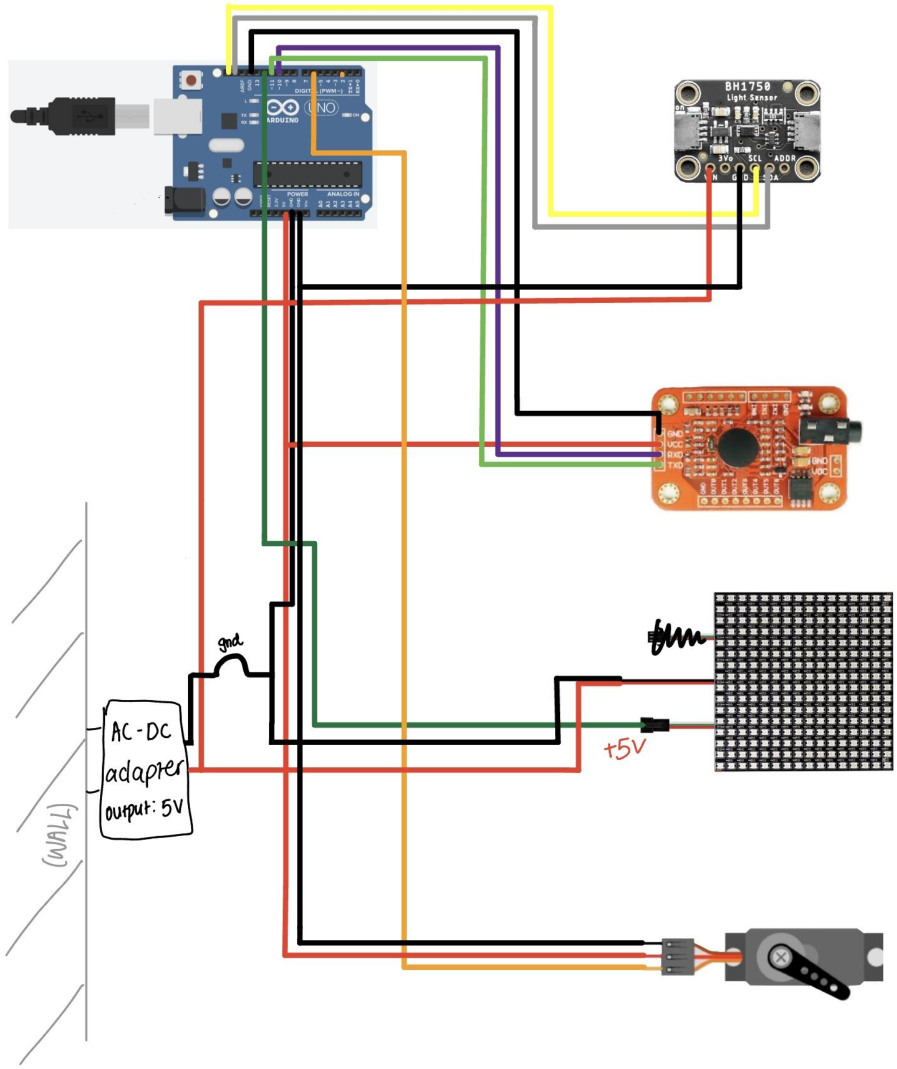


Figure 5: Circuit Diagram

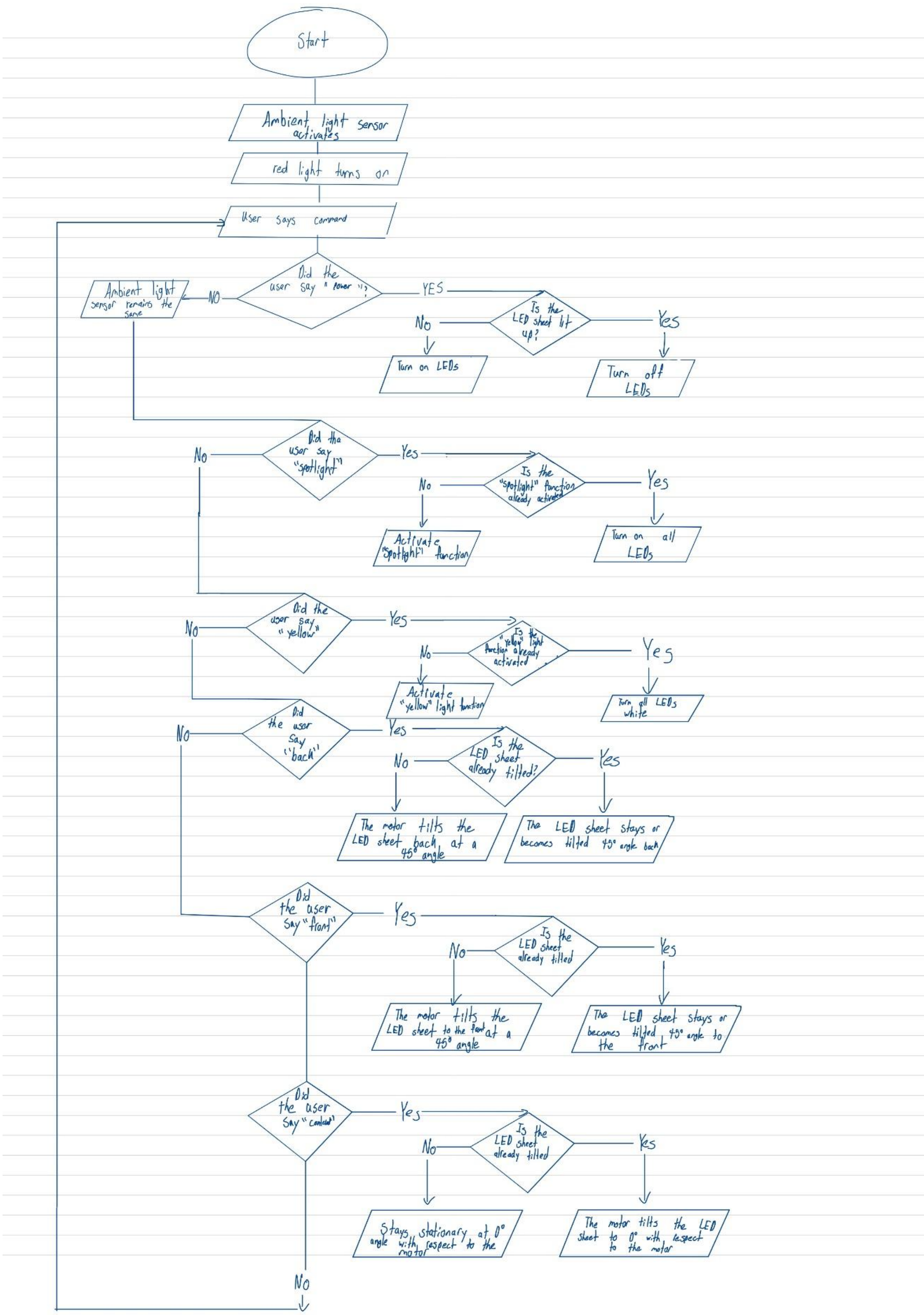


Figure 6: Code Flow Chart

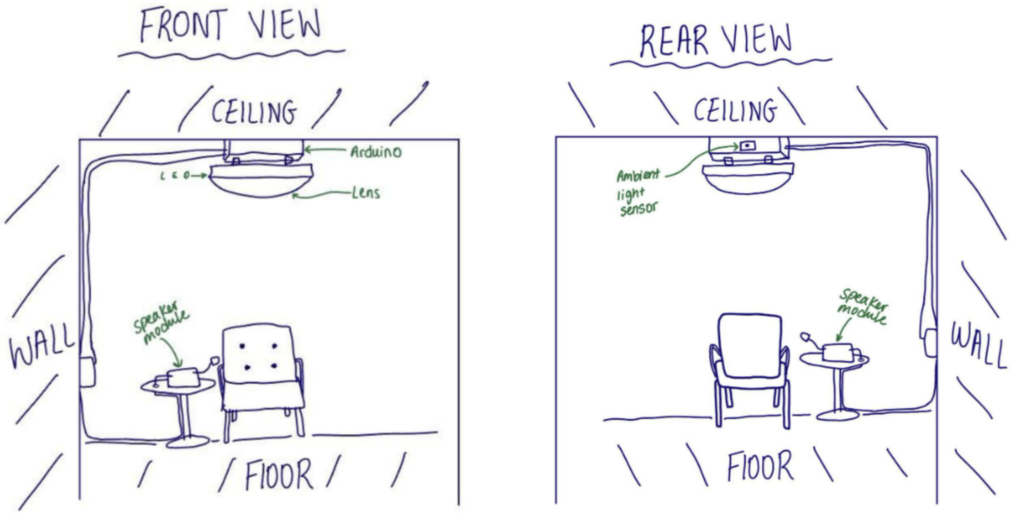
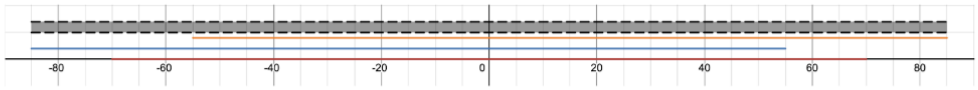


Figure 7: Hand Drawing of Final Product

Figure 8: Digital Drawing of Final Product

Lighting



Commands	Back	Center	Front
Range (in)	{-85, 55}	{-70, 70}	{-55, 85}

Directible

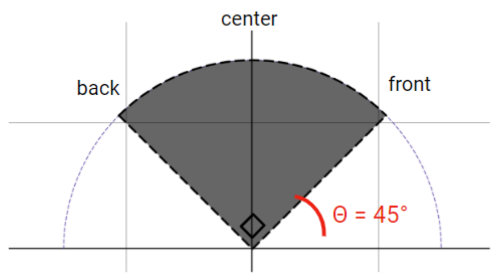


Figure 9: Motor Testing

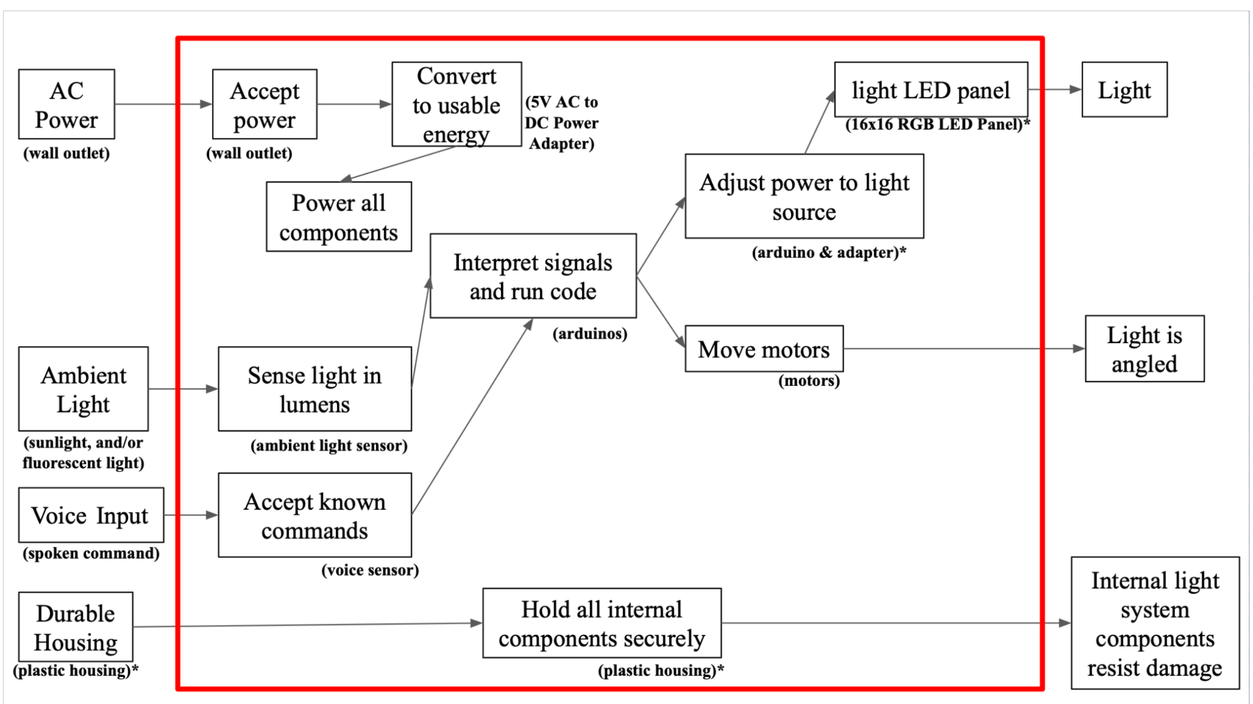


Figure 10: Glass box