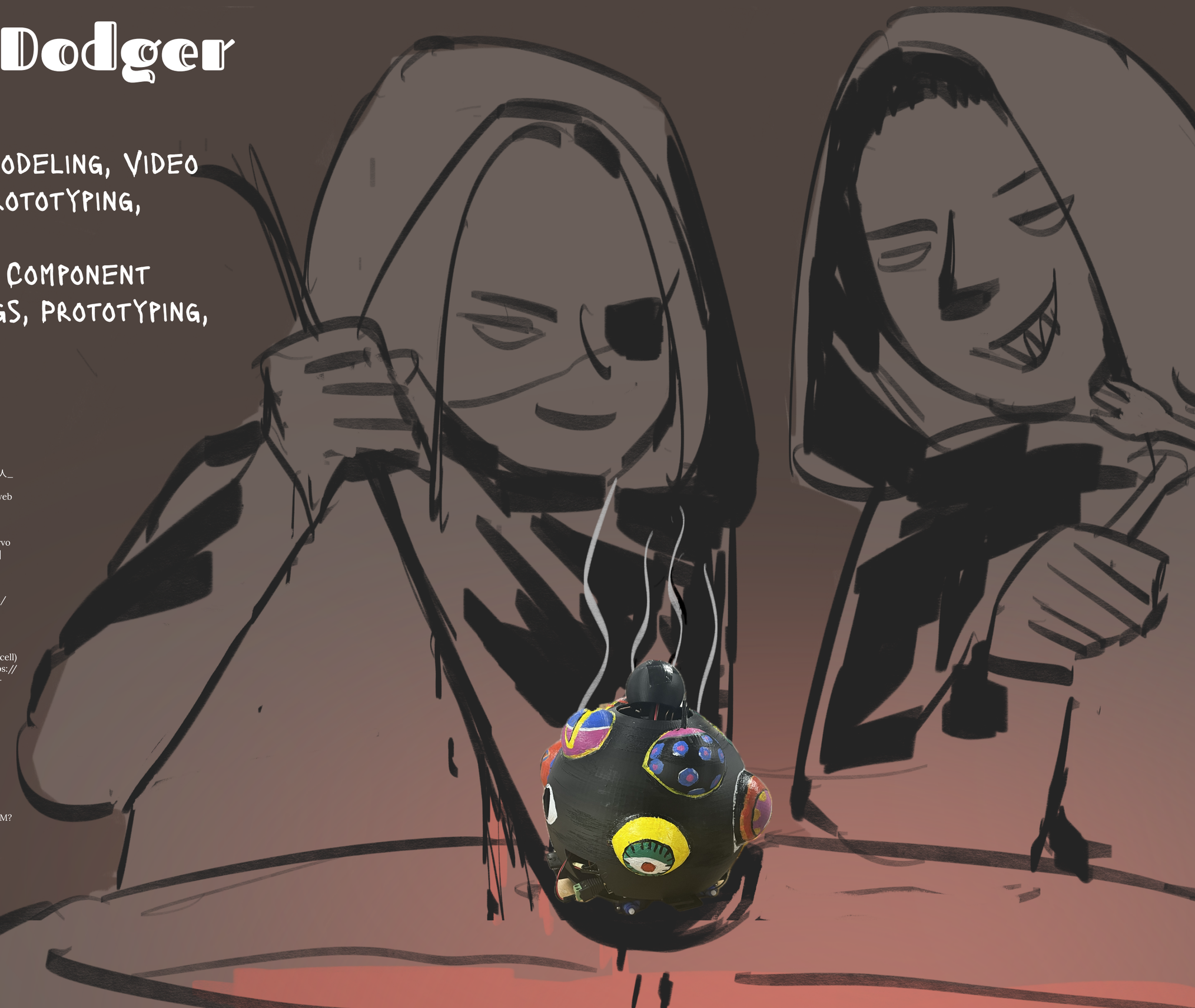
Shadow Dodger

DE2 GROUP 18
MIAOYAN TANG: 3D MODELING, VIDEO MAKING, PAINTING, PROTOTYPING, PORTFOLIO.
QINXUAN LI: CODING, COMPONENT PURCHASING, TESTINGS, PROTOTYPING, PORFOLIO.



REFERENCE:

1. Servomotor Movement mechanism：
石桥北 (2023). 【步态详解】人人都可制作的WiFi遥控迷你四足机器人_哔哩哔哩_bilibili. [online] www.bilibili.com. Available at: https://www.bilibili.com/video/BV1yH4y1U7Zo/?share_source=copy_web [Accessed 7 Dec. 2023].

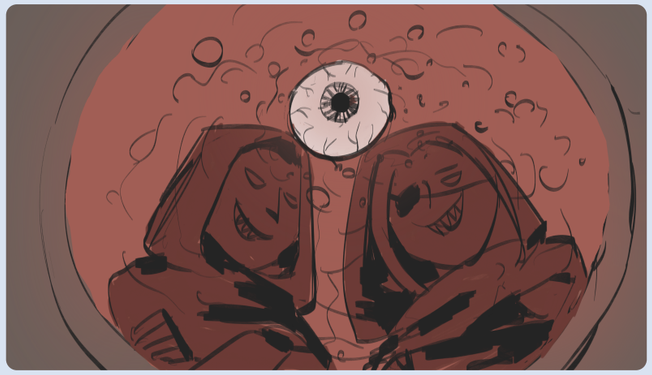
2. Wire graph and code reference (details written in code files):
   a. Robojax (2017). Complete guide to PCA9685 16 channel Servo controller for Arduino with code Version of 5 (V1). [online] www.youtube.com. Available at: https://youtu.be/y8X9X10Tn1k?si=MPvuASfKHgpmy3ow [Accessed 7 Dec. 2023].
   b. McPherson, A. (2020). bela-online-course/code-examples/fft-led/render.cpp at master · BelaPlatform/bela-online-course. [online] GitHub. Available at: https://github.com/BelaPlatform/bela-online-course/blob/master/code-examples/fft-led/render.cpp [Accessed 7 Dec. 2023].
   c. Instructables (2015). How to Use a Photoresistor (or Photocell) - Arduino Tutorial. [online] Instructables. Available at: https://www.instructables.com/How-to-use-a-photoresistor-or-photocell-Arduino-Tu/.
   d. ed (2021). Arduino LED – Complete Tutorial. [online] The Robotics Back-End. Available at: https://roboticsbackend.com/arduino-led-complete-tutorial/.
   e. docs.bela.io. (2023). Bela: Fundamentals/passthrough/render.cpp. [online] Available at: http://docs.bela.io/Fundamentals_2passthrough_2render_8cpp-example.html#a10 [Accessed 7 Dec. 2023].

3. eyeball structure reference:
Hendrix Workshop (2020). DIY Animatronic Eye! [online] www.youtube.com. Available at: https://youtu.be/Lwg8IWPoNwM?si=GfFLa6uChsmPUWVg [Accessed 7 Dec. 2023].

Concept Generation

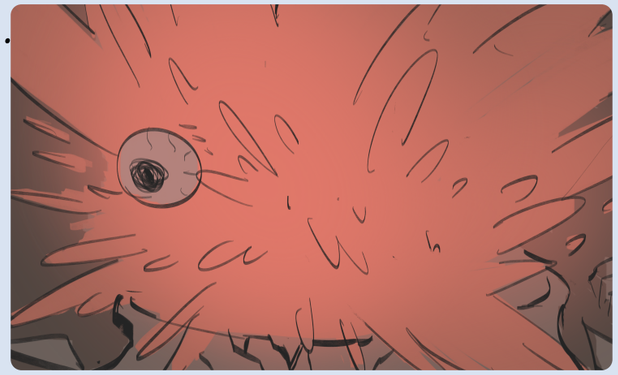
Back Story of Shadow Dodger

1.



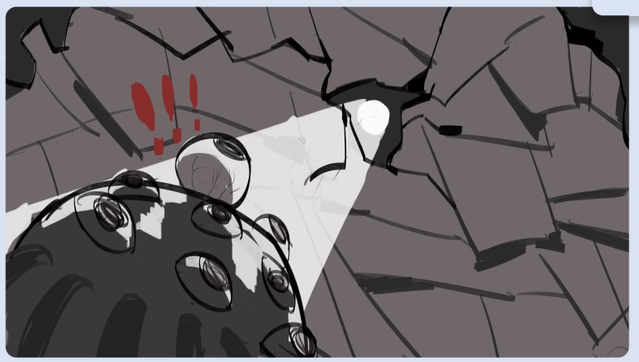
Born amidst simmering cauldrons and whispered spells, the Shadow Dodger emerged not from shadow but light – a singular eyeball, the chance creation of two witches engrossed in their arcane cookery two millennia past.

2.



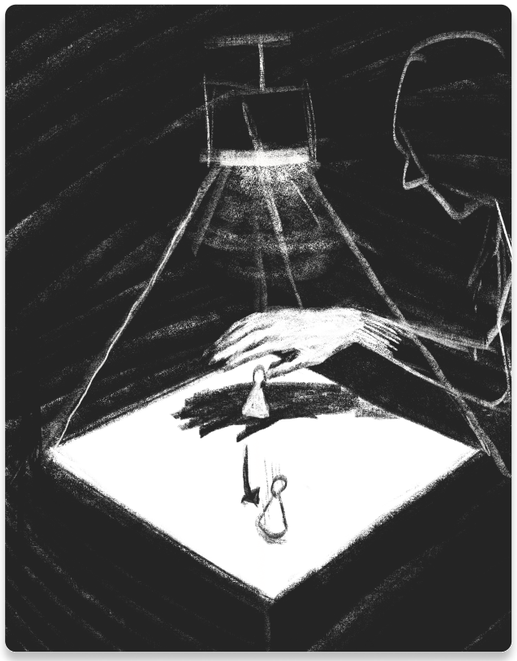
As breaths of enchantment swirled around it, and it teetered on the brink of consumption, a twist of fate unfolded. The witches met their untimely demise; their abode shattered in a mystical eruption, casting the eyeball into the depths of a forgotten ruin for centuries.

3.



In the veil of perpetual darkness, the Shadow Dodger thrived, sprouting additional eyes and spindly legs. Its existence was a whispered legend until fate intervened once more – two intrepid humans unearthed it, bathing it in the very light it craved. Henceforth, it danced with the sunbeams, eternally evading the embrace of shadows.

Initial Idea



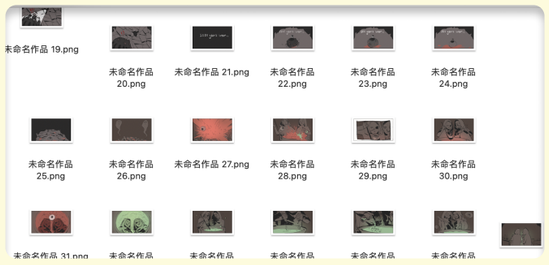
To enhance the realism of our shadow-dodging interactive creature, we integrated story-related interactions, including tapping and blowing.

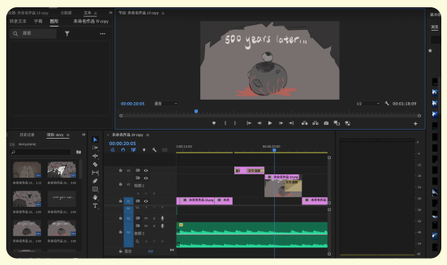
Inspiration

Our inspiration stemmed from an illustration on Miaoyan's iPad case, depicting numerous eyes pursuing the sun, guiding us towards a theme that is both surreal and vivid.

Video Production Process

We produced a video to narrate the story, creating illustrations ourselves and editing the footage in Adobe Premiere.





Storyboard Sketches



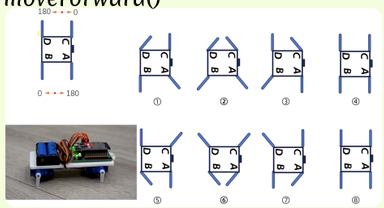
COMPONENTS PREPARATION

Servomotor Movement mechanism ①

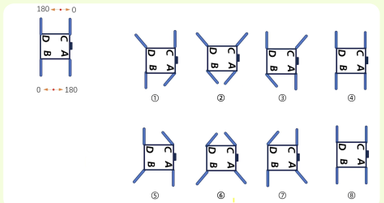
Leg default position



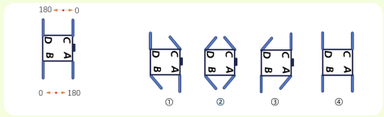
moveForward()



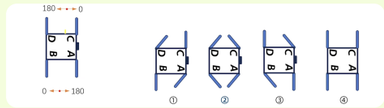
moveBackward()



turnLeft()



turnRight()



```
void goescrazy(){
    for (int g = 0; g < 8; g++){
        pwm.setPWM(0, 0, 300);
        pwm.setPWM(1, 0, 100);
        pwm.setPWM(2, 0, 100);
        pwm.setPWM(3, 0, 100);
        delay(100);

        pwm.setPWM(0, 0, 100);
        pwm.setPWM(1, 0, 300);
        pwm.setPWM(2, 0, 100);
        pwm.setPWM(3, 0, 100);
        delay(100);

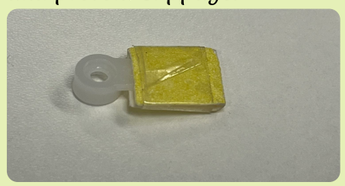
        pwm.setPWM(0, 0, 100);
        pwm.setPWM(1, 0, 100);
        pwm.setPWM(2, 0, 300);
        pwm.setPWM(3, 0, 100);
        delay(100);

        pwm.setPWM(0, 0, 100);
        pwm.setPWM(1, 0, 100);
        pwm.setPWM(2, 0, 100);
        pwm.setPWM(3, 0, 300);
        delay(100);
    }
}
```

We also developed a 'Trembling Gate' walking mechanism for the blowing interactions.

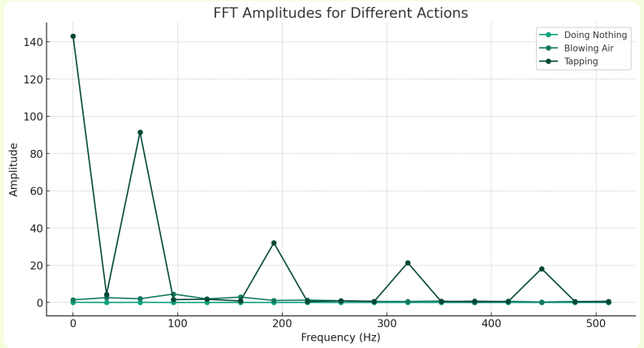
All possible blockings of the four photoresistors were analyzed, resulting in six motion scenarios in the code: forwardSituation, backwardSituation, leftSituation, rightSituation, lightSituation, stopSituation.

Sandpaper was affixed to the servo horn to enhance grip and prevent slippage.



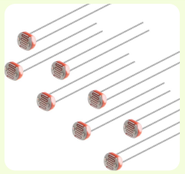
Piezoelectric Sensor

Utilizing the FFT library, we captured amplitudes across different frequencies. Repeated tests involving tapping and blowing on plates allowed us to distinguish these actions by setting amplitude thresholds at frequency 0.



For blowing, the amplitude threshold is set between 1.5 and 40 (fda(0)). For tapping, it's set at fda(0) >=100. To avoid false triggering caused by servomotors, a delay of 3000 milliseconds is implemented at the start and end of the blowing detection sub-loop.

photoresistor



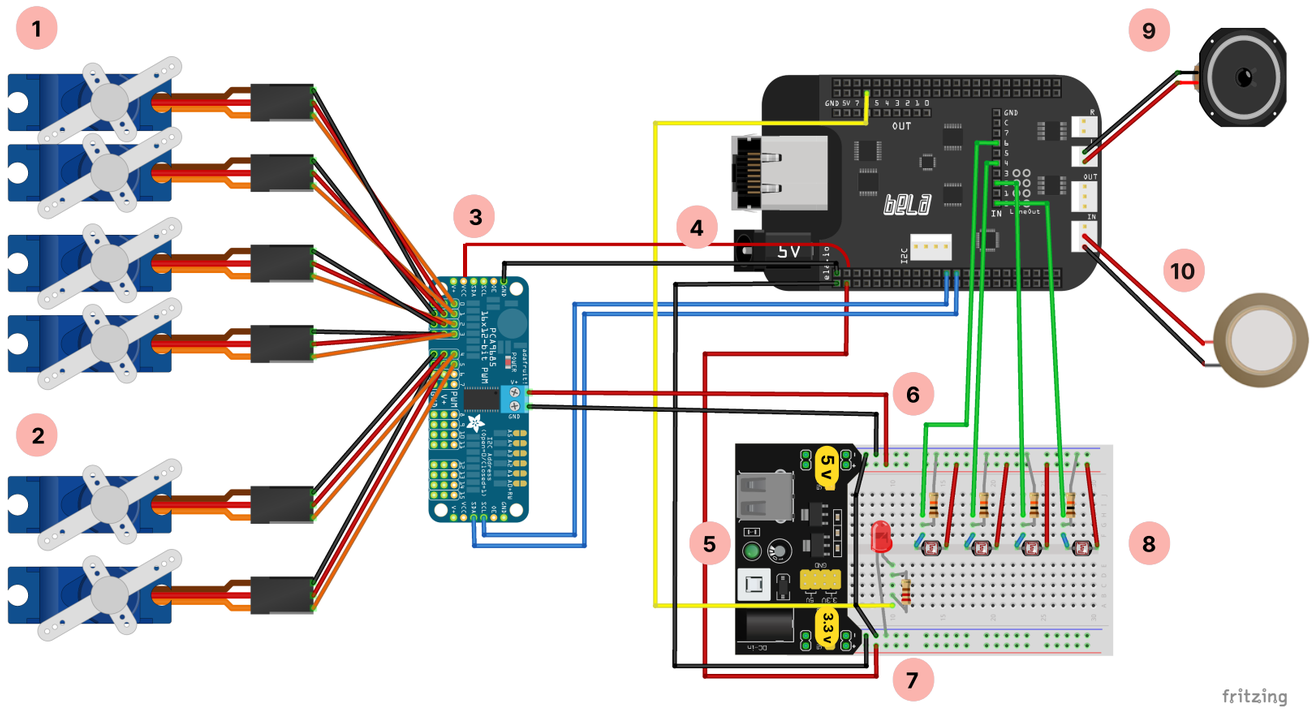
Photoresistor type: GL5506

strategically placed around the creature to detect shadows.

Observations of the photoresistors' responses in varying light conditions led us to implement a calibration session after rebooting the Bela board. Subsequent values are compared with the calibrated value minus an offset to ascertain if the photoresistors are being obstructed.

Detected obstructions are stored in an array for verification against the six predefined scenarios. Detailed annotations are available in the code files.

Wire Graph ②

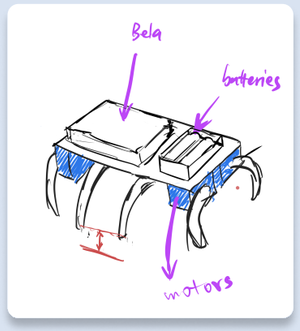


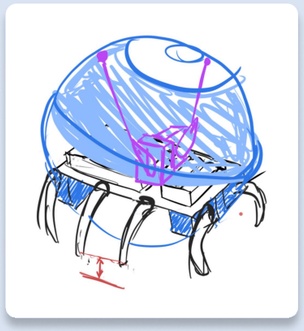
1. Servo Motor SG90 * 4: Act as the creature's legs.
2. Servo Motor SG90 * 2: Control the movement of the eyeball.
3. PCA9685: Utilized to simultaneously power six servo motors, as the Bela board with an external power source can only handle three.
4. Bela board: A microcontroller board powered by a 5V barrel jack using a portable charger.
5. Breadboard Power Supply Module Voltage Regulator: Converts 7.4V from a 2000mAh Li-Po battery to 5V, aligning with Bela's maximum voltage.
6. Breadboard: The 5V upper section is powered externally, while the 3.3V lower section is Bela-powered. Both sections share the same ground, linking back to the Bela.
7. Red LED: Serves as the creature's pupil light. The negative side is grounded; the positive, connected through a 220 Ω resistor, links to a digital input.
8. Photoresistors * 4: Each connected on one side to 5V, and on the other to Bela's Analog Input, with a 10k Ω resistor grounded.
9. Speaker: Linked to the Audio out.
10. Piezoelectric sensor: Detects tapping and blowing.

PROTOTYPING

3D Modeling (shell+bases+internal structure)

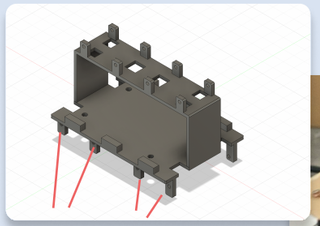
First idea



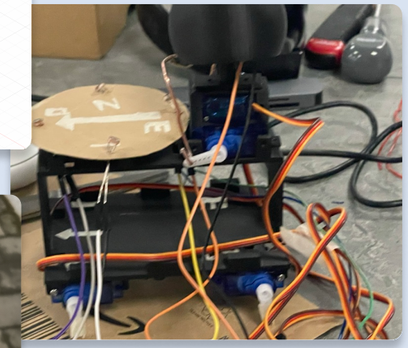


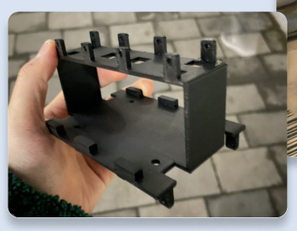
Our initial concept involved creating a large, mobile eyeball with four motors as legs and two motors for rotational control.

We designed a baseboard in CAD to secure the breadboard and Bela board, incorporating motor mounts and apertures for screws and wiring.



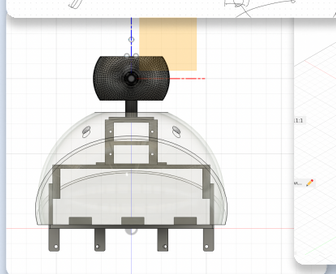
Four motors

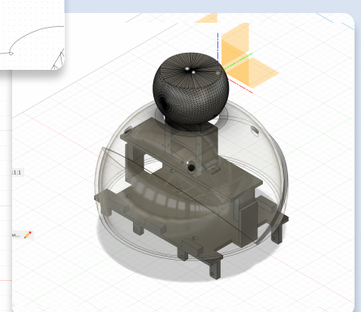




Second idea





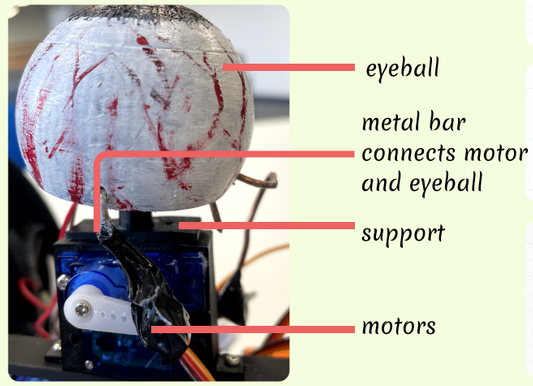


3d modeling for the second idea

We encountered spatial constraints with our first design due to the size of the eyeball, alongside the need to accommodate the breadboard, Bela board, batteries, and wiring. This led us to revise our idea to a creature featuring a smaller, rotatable eyeball.

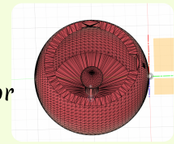
EYEBALL (3)

Through online research, we decided to use two metal bars, manipulated by servo motors, for the x and y axis rotation of the eyeball. We then 3D printed our designed models.

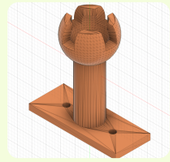




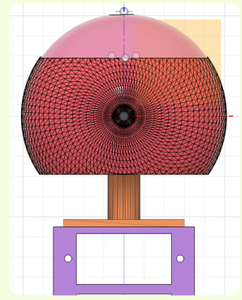
Pupil



Eyeball



support

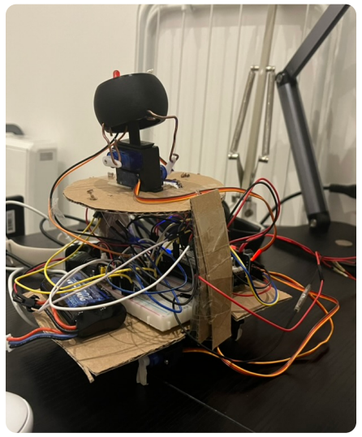


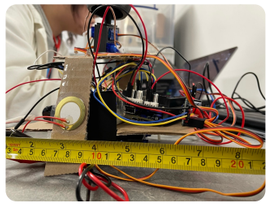
combination

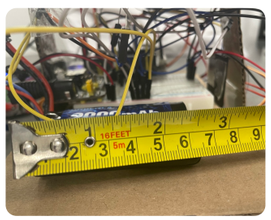
Final design

After assembling the components on the baseboard, we faced a space shortfall. Consequently, we expanded the baseboard using cardboard for our prototype.

To improve the baseboard design, we adopted a different modeling approach. We measured all components, representing them as basic shapes like cuboids and cylinders.

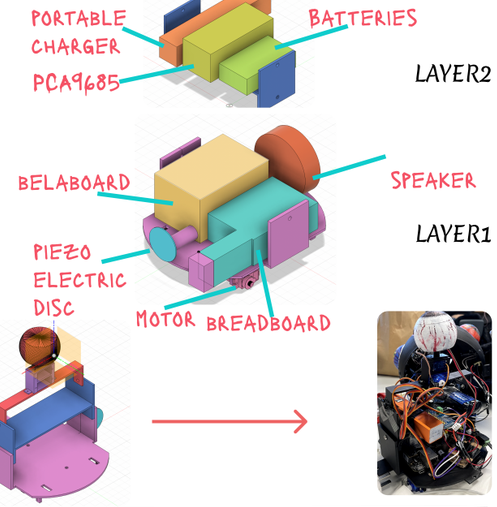






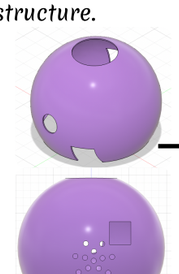
DOING MEASUREMENTS

Next, we organized these simplified shapes into three layers, optimizing space in CAD. We then constructed the three distinct baseboard layers, designed to be interconnected with screws.



The exterior shell was crafted to snugly accommodate this internal structure.

We integrated small openings for the speaker and piezo disc, along with eye-shaped embellishments on the outer surface.

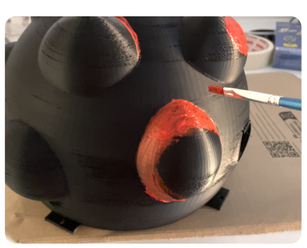


SHELL



SHELL WITH "EYE" DECORATIONS







Operational Logic &Final Result Showcase

loopNormal





When hands cast shadows on the Shadow Dodger, partially blocking its four photoresistors:

- *Eyeball: Rotates towards the movement direction.*
- *Sound: Transitions from curiosity to annoyance as blockage instances increase.*
- *Pupil Light: Activates upon obstruction.*
- *Legs: Move away from the shadow.*

Persistent blockage occurring more than three times. ↓

↑ *Exposure to light for six seconds.*

loopAnnoying







When blocked:

- *Eyeball: Rotates towards the side of obstruction.*
- *Sound: Emits an angry, spiking tone.*
- *Pupil Light: Remains on.*

Complete blockage of all four photoresistors, simulating total darkness. →

loopAfraid



In darkness:

- *Sound: Continues screaming.*
- *Pupil Light: Stays on.*



Blowing at it for 900 milliseconds:

- *Sound: Emits a revengeful, evil laugh (reflecting the backstory of the witches' demise).*
- *Pupil Light: Illuminates.*
- *Legs: Tremble.*



Tapping it four times:

- *Sound: Produces a confused noise (reminiscent of its origin story).*
- *Pupil Light: Blinks.*

Complete blockage of all four photoresistors, simulating total darkness. →

Releasing all photoresistors from blockage. ←

Aerial View

The four photoresistors detect variations in light intensity from four different directions.

