OPTO-SMART PET FEEDER

JACOB HAAS (EE)

TYLER KNIGHT (CREOL)

CASSIDY COLL (CREOL)

RICKY EGAWA (CPE)

GROUP 9

What is the Opto-Smart Pet Feeder?

An autonomous feeding device for pets that utilizes optical and photonic technology to ensure that the user’s pets are being routinely fed without needing the owner of the pet to be physically present with them

Project Motivation

- Routines are good for pets
  - Pets thrive getting their food at the same time each day
  - Chance of pets getting stressed waiting for food
  - Other pets can steal food from other dog bowls
- Pets going hungry
  - People have busy lifestyles and can sometimes forget to feed their pets
  - Overfeeding can occur when pets are fed manually
- Room in the Market
  - No other pet feeder on the market incorporates optics and electronics similar to our design

Project Goals

- Minimize the users time with easy to use software allowing for simple and routine pet feeding
  - Simple to use app with programmable dates and times
  - Automatic pet identification
- Safe for pets to use
  - Quickly dispenses food
  - keep other pets from stealing other pets food using an automatic lid

PROJECT OBJECTIVES

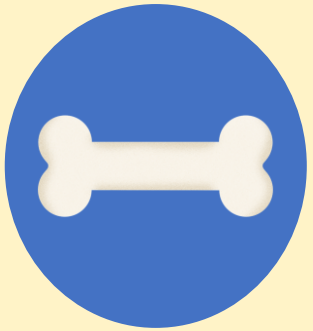
TAKE THE STRESS OUT OF FEEDING YOUR PET

RECOGNIZES IF A PET IS AT ITS BOWL

THIS DEVICE CAN TELL THE DIFFERENCE BETWEEN PETS

ENSURE PETS ARE FED EVEN WHEN THE OWNER IS NOT HOME

DISPENSE FOOD AT THE CORRECT TIME



PREVENTS OVEREATING

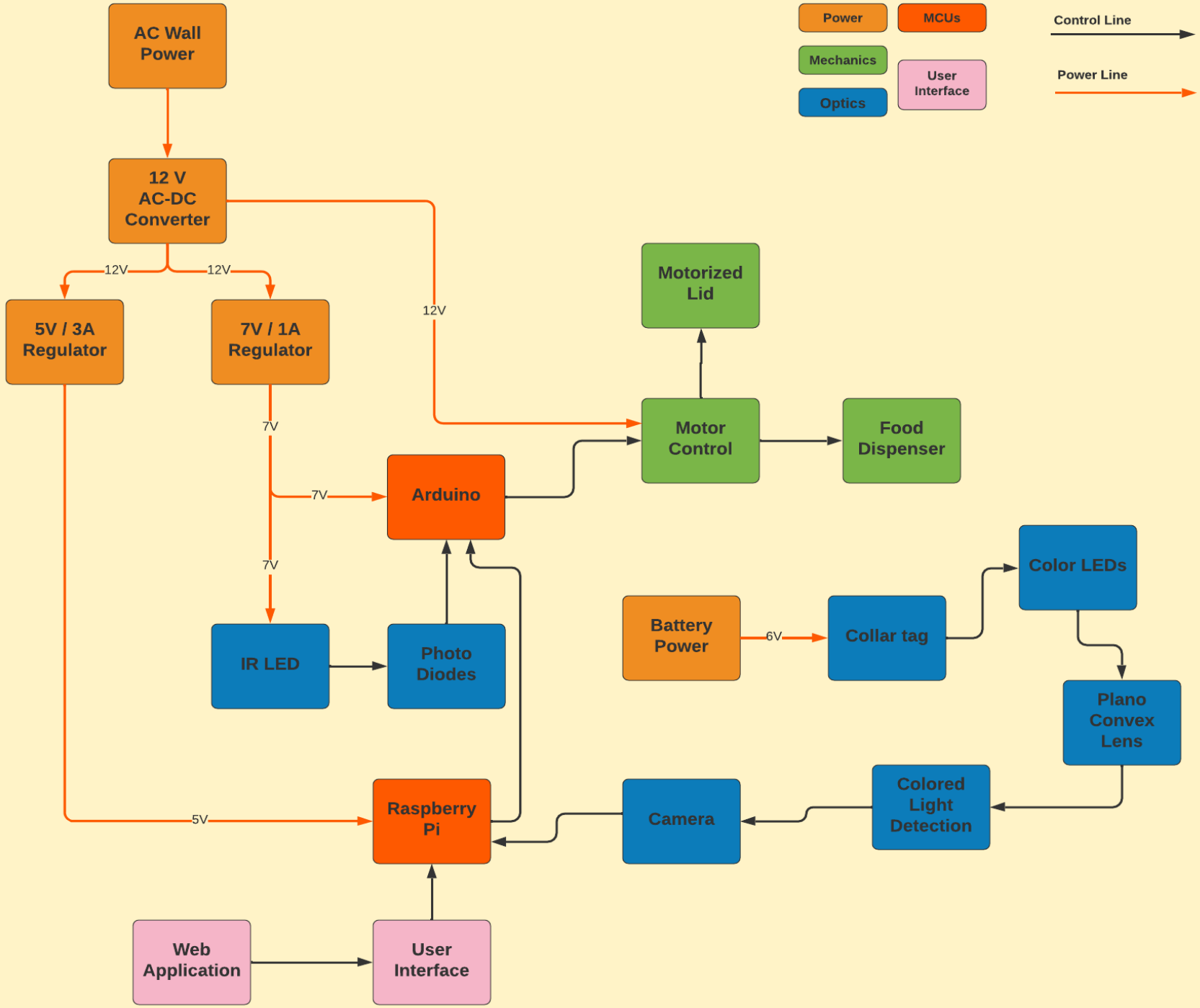
DISPENSE APPROPRIATE AMOUNT OF FOOD

CREATE A FEEDING ROUTINE FOR THE PET

Engineering Requirements

Engineering Requirement	Specification
Camera detection range	≥ 5 feet
Motor power	< 100 watts
Photodiode response time	< 10 seconds
Food Dispensing time	< 60 seconds
Collar tag battery life	≥ 2 hours
Dispenser lid closing time	30 seconds ± 10 seconds
Pet food dispensed	± 10% of designated amount
Demonstratable Specifications	

Overall Block Diagram



Member assigned to block

Tyler Knight -
IR Detection

Cassidy Coll -
Camera/ Collar Tag

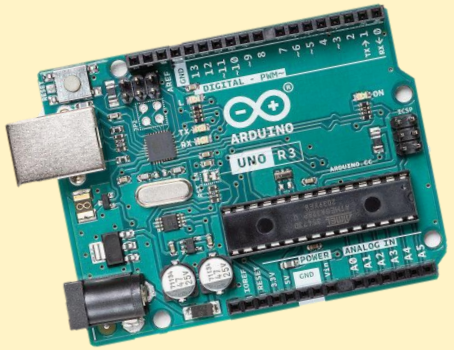
Ricky Egawa -
software / Web App Development

Jacob Haas -
Power/ MCU

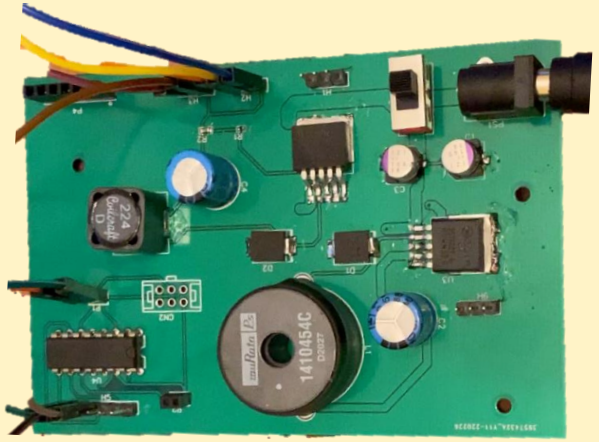
PET FEEDER FEATURES

- Food is delivered to bowl using gravity and a motor spinning a 3D printed dispenser
- Different pets are identified using an onboard camera built into the feeder. Camera will detect what color LED is on the pet collar and detect the right pet
- Once the pet is Identified the device will respond by dispensing a specific amount of food tailored to that pet.
- Photodiodes will detect if the animal is at the bowl and will close once it walks away.

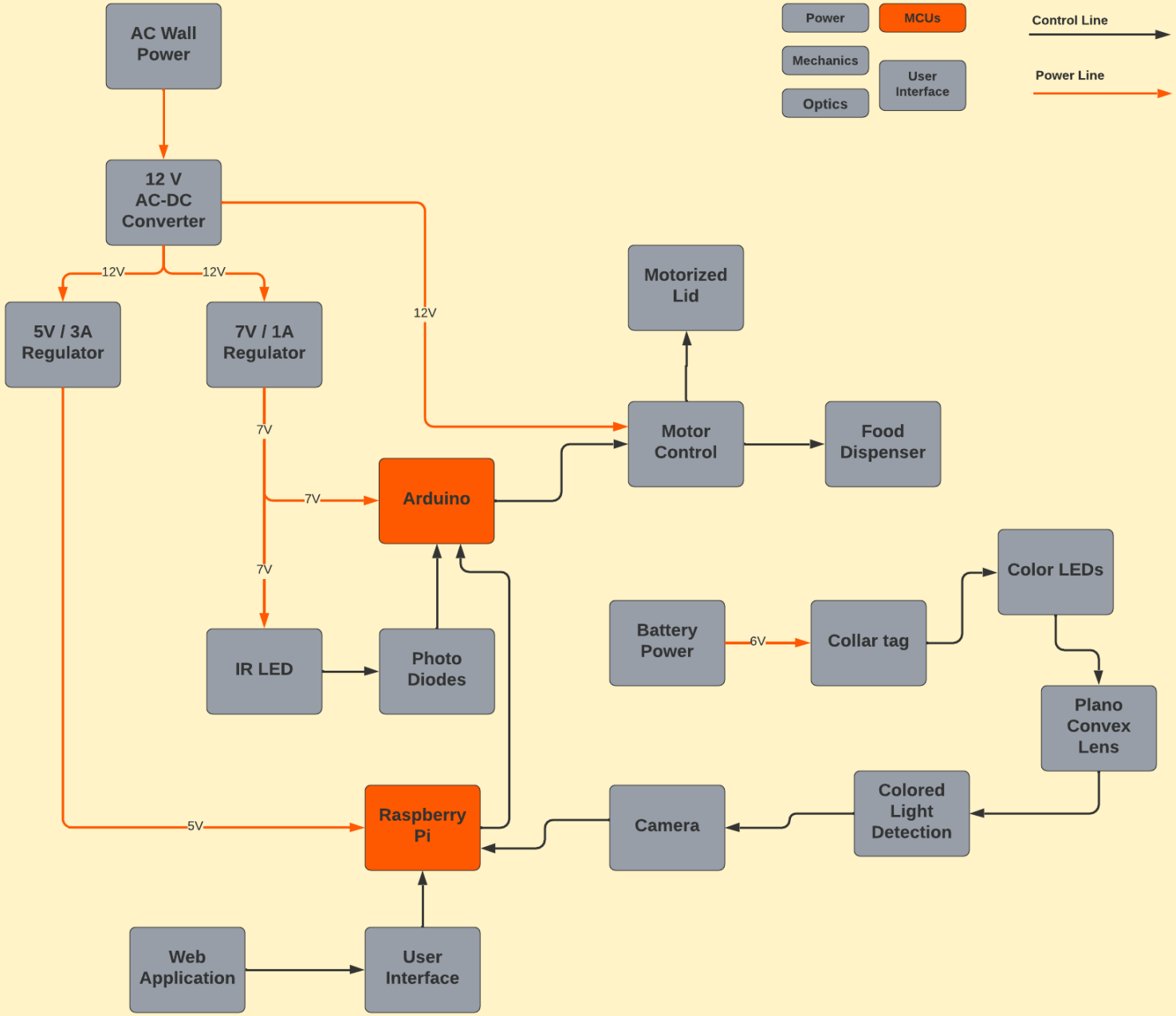
PET FEEDER DESIGN



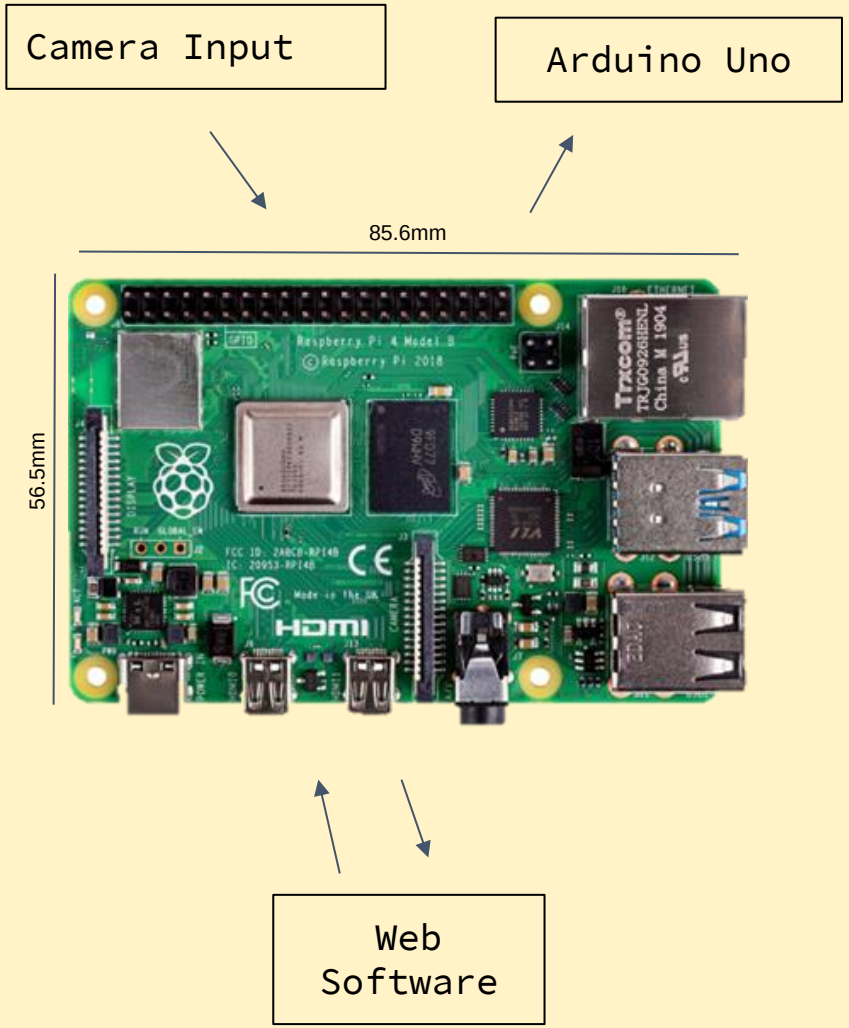
Main Electrical Components



Microcontroller/Microprocessor



Microprocessor (Raspberry Pi 4)



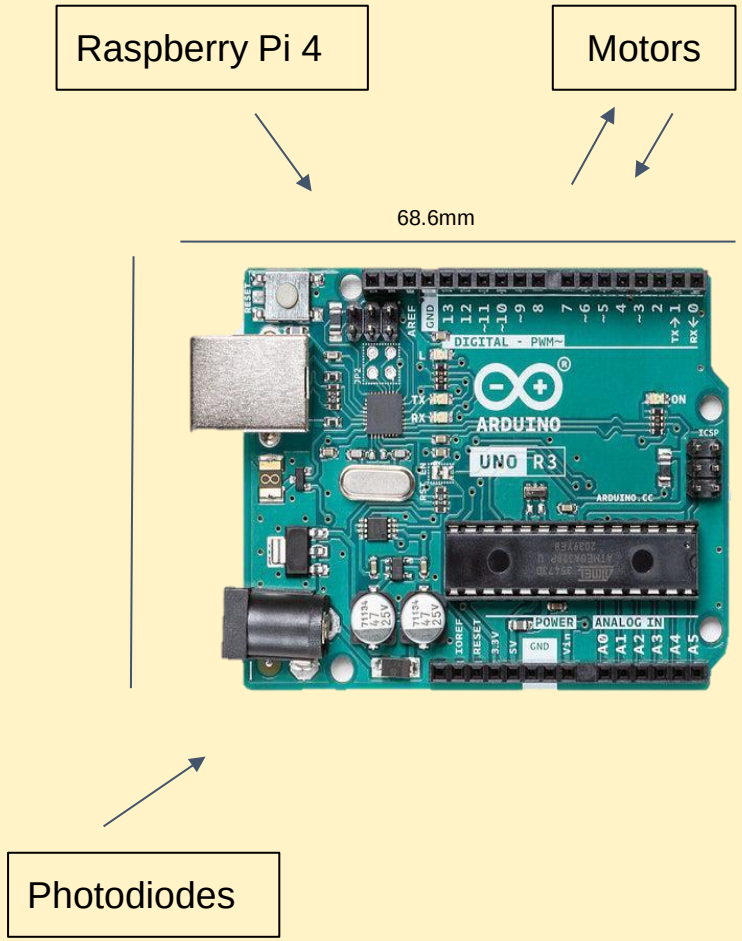
Purpose:

To process the image data presented from the pet collar LEDs and deliver the data to the Arduino for motor control. Additionally, provide the processing power necessary for the web application.

Model	Raspberry Pi 4 (Model B)	Nvidia Jetson Nano	BeagleBone Black
Price (for kit)	≈$70.00 (for standalone) $127.79 (for kit)	≈$99.99 (Extremely Low stock)	≈$70.00
Cores	4	4	1
Clock Speed	1.5 GHz	1.43 GHz	1 GHz
GPIO	40 Pins	40 Pins	Max of 69 Pins
Memory	4 GB	4 GB	4 GB
Chosen Component			

- Ease of interfacing with camera module (made for Raspberry Pi)
- Can communicate serially with microcontroller
- CPU can process image data as well as run the developed web application

Microcontroller Board (Arduino Uno Rev3)



Purpose:

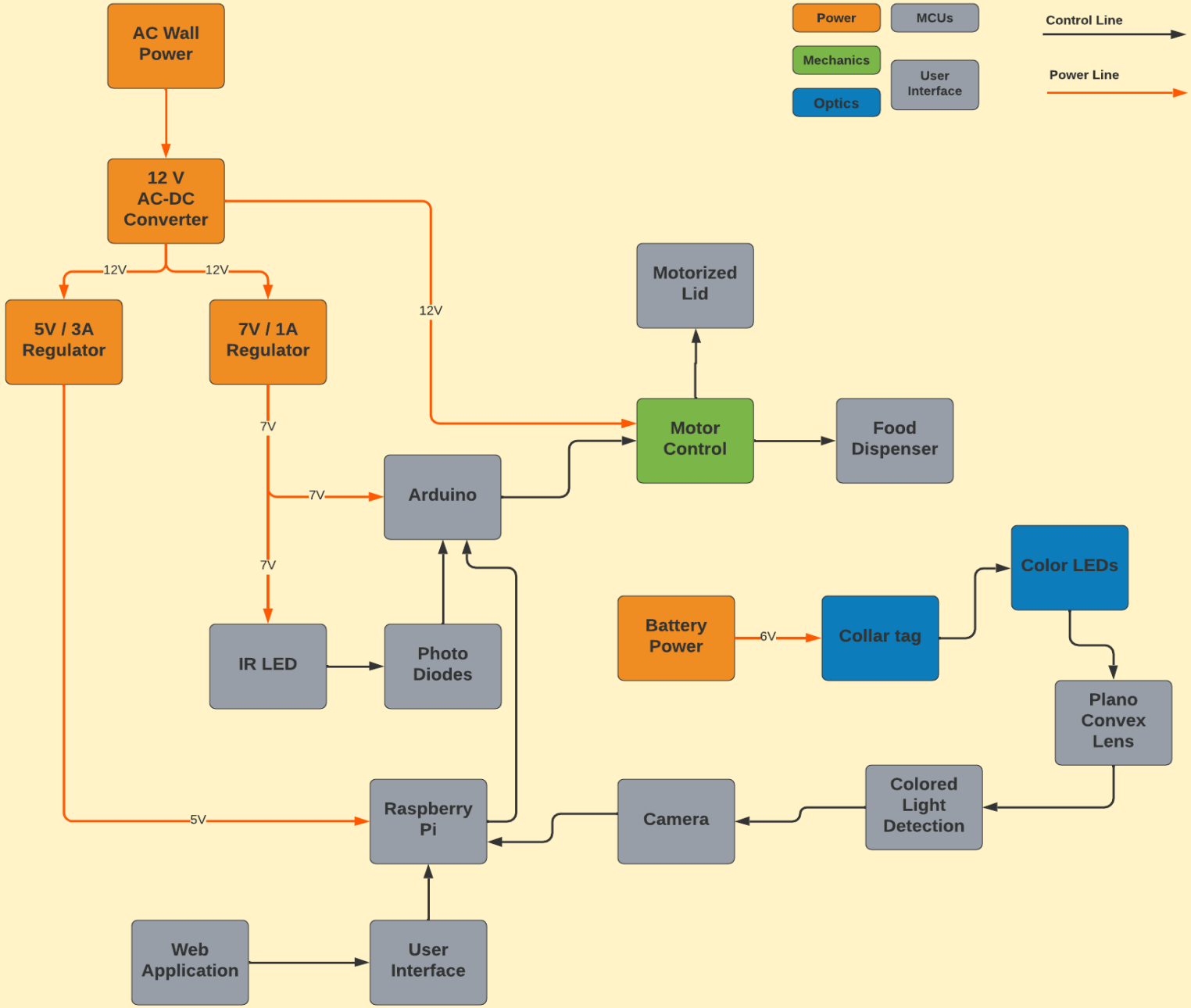
Read input data from Raspberry Pi and Photodiodes to control when each of the lid or dispenser motors should be activated.

Selection Criteria:

- Ease of communication with Raspberry Pi
- ADC with 10 bit resolution to convert analog voltages to digital signals
- Ease of programming motor control in response to data from Raspberry Pi/photodiode voltages
- No need for extra power from the TI or ESP chips

Microcontroller	Arduino Uno (ATmega328P)	TI(MSP430FR6989)	ESP32-S3-WROOM-1
Price	$23.00 (Previously obtained)	$20.00 (Previously obtained)	$15.00
Clock Speed	16 MHz	16 MHz	240 MHz
Memory	32 KB	128 KB	8 MB
Digital I/O	14 Lines	40 Lines	45 Lines
Analog Inputs	6 Inputs	16 Inputs	18 Inputs
Chosen Component			

Power and Motor Control



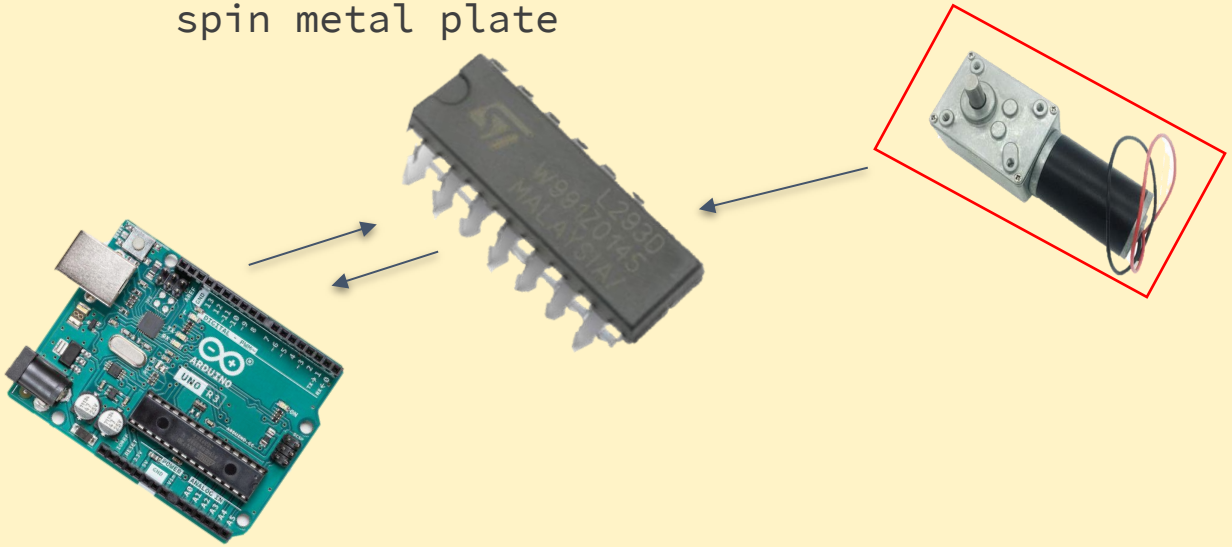
DC Motors(Hugwit 12V 40rpm)

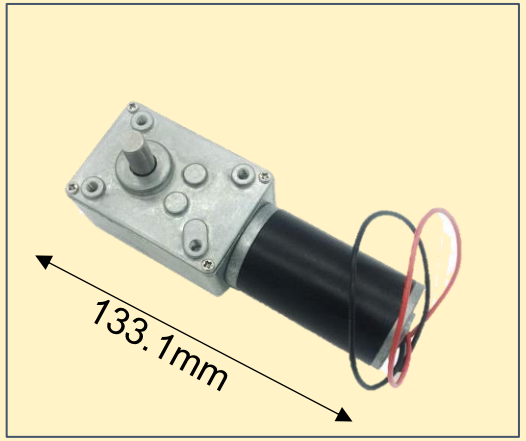
Purpose:

To open and close the lid of the bowl as well as allow food to be dispensed by spinning the metal disk with cutouts

Selection Criteria:

- DC motors chosen due to simplicity and no need for precise increments of movement
- Works with a 12 V power source
- Has enough torque to be able to lift the lid and spin metal plate





Manufacturer	Hugwit	Greartisan DC
Part Number	A58SW31ZY	B071XCX1LH
Price	$29.99	$14.99
Torque	3.92 Nm	0.706 Nm
Motor Voltage	12V DC	12V DC
No load speed	40 rpm	50 rpm
Chosen Component		

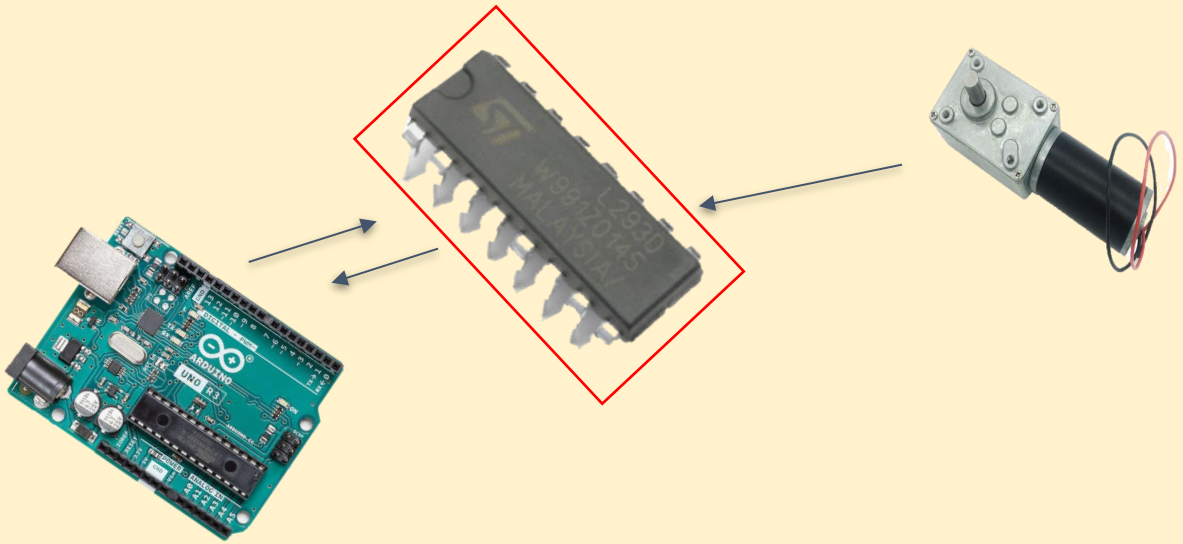
Motor Driver

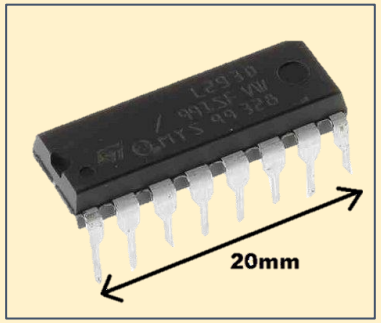
Purpose:

Allow for separate control of the lid opening motor and the food dispensing motor.

Selection Criteria:

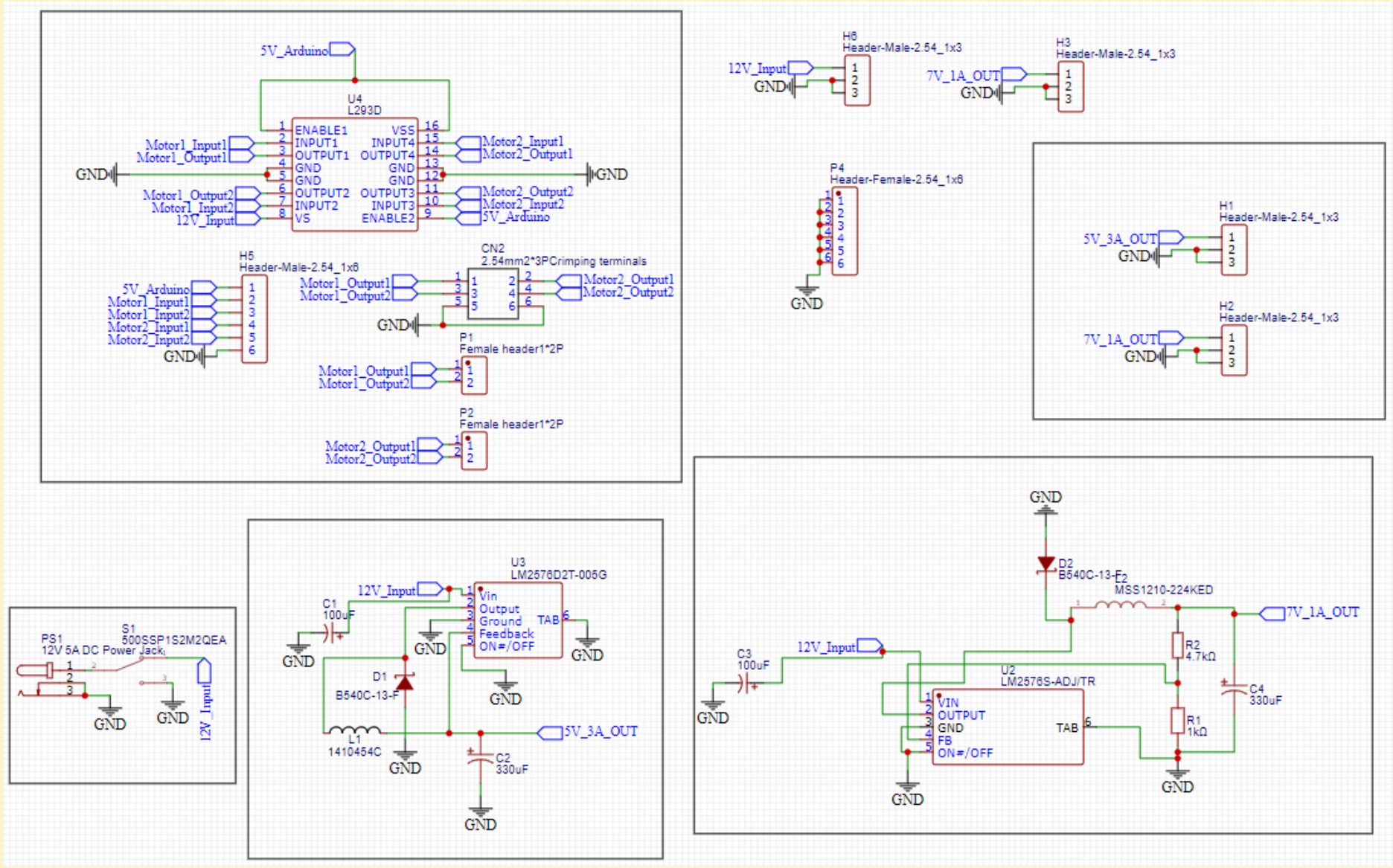
- Ease of interfacing with Arduino digital IO
- Controls two motors with a single IC
- Can interface with both DC and stepper motors
- Form factor is able to be mounted easily to PCB





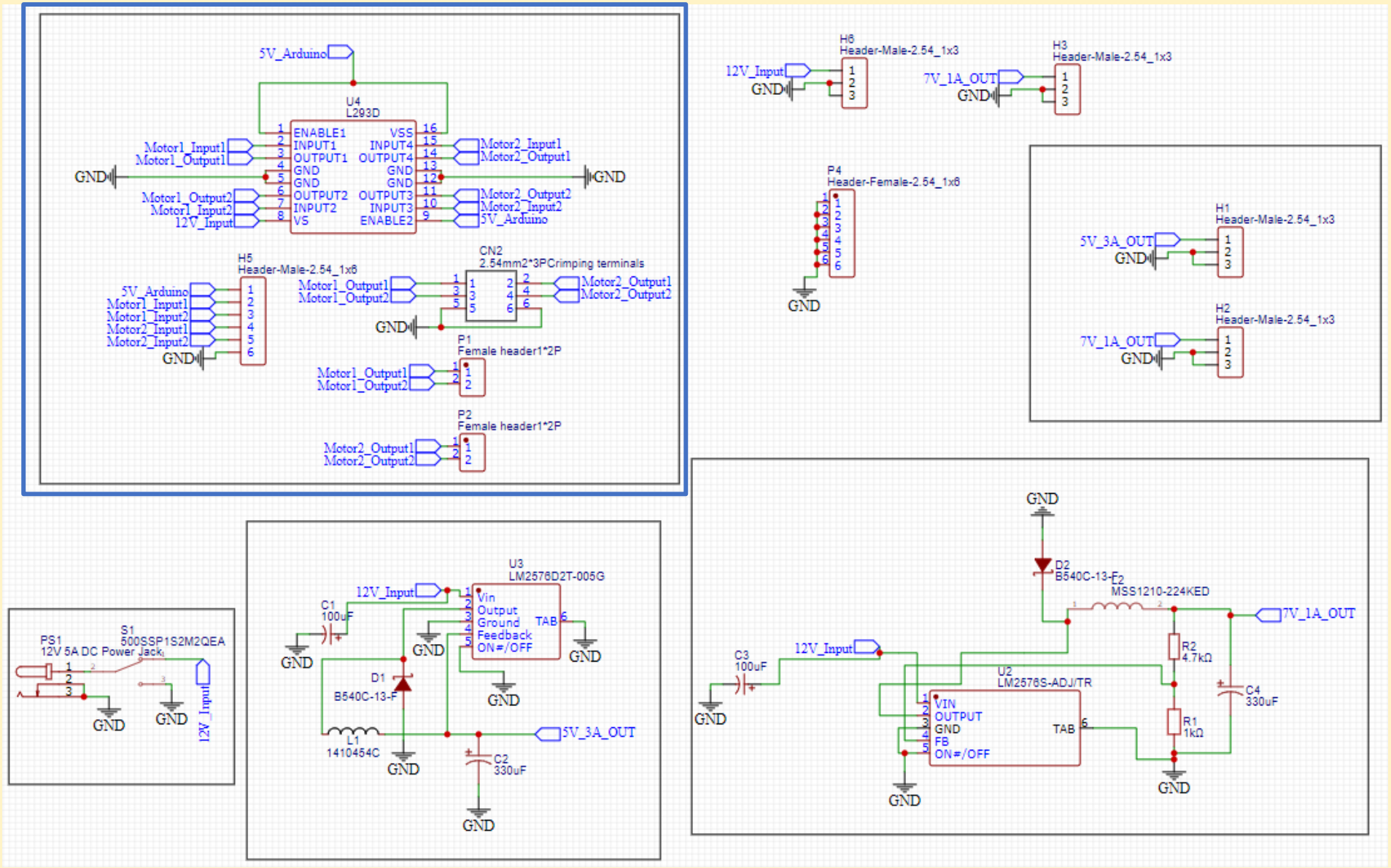
Motor Driver IC	L293D	L298N	TB6612FNG
Manufacturer	TI	STM	Toshiba
Price	$4.50 (previously obtained)	$8.58	$9.95
Logic Voltage	5V	4.5-7V	2.7V-5.5V
Motor Voltage	4.5V-36V	2.5V-46V	2.5V-13.5V
Peak Output Current	1.2A	3A	3A
Chosen Component			

Main PCB Schematic



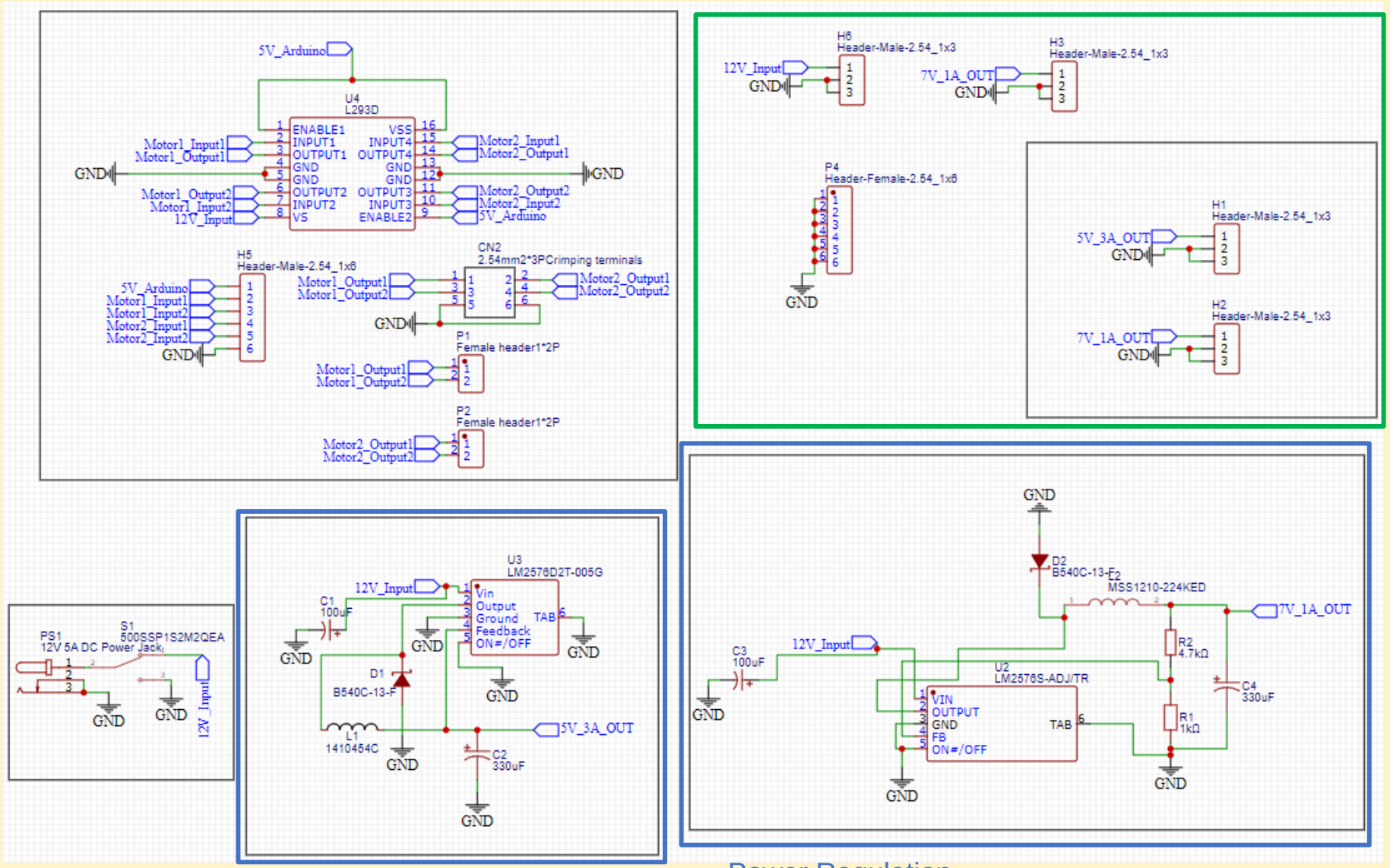
Main PCB Schematic

Motor Control



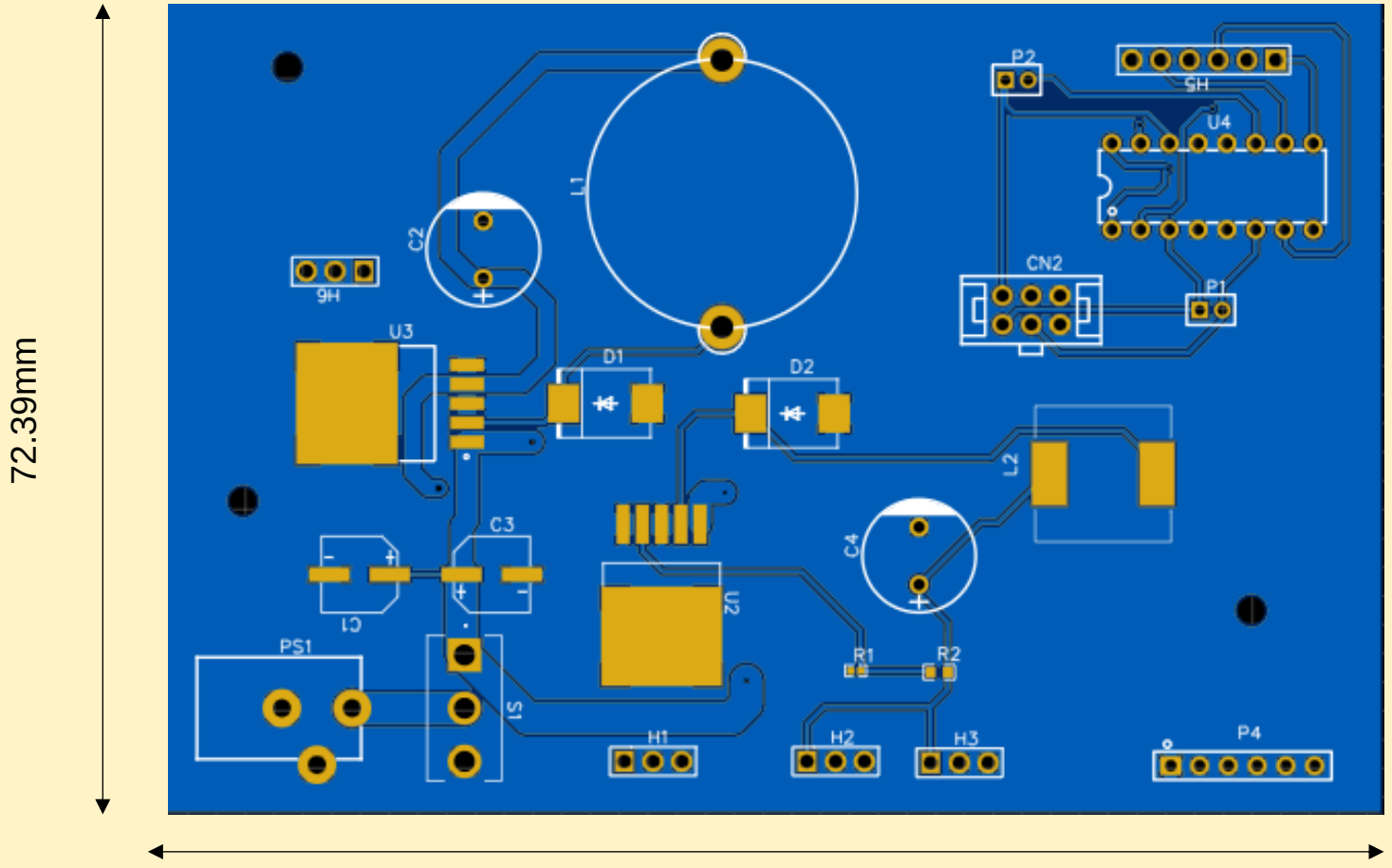
Main PCB Schematic

Power Delivery

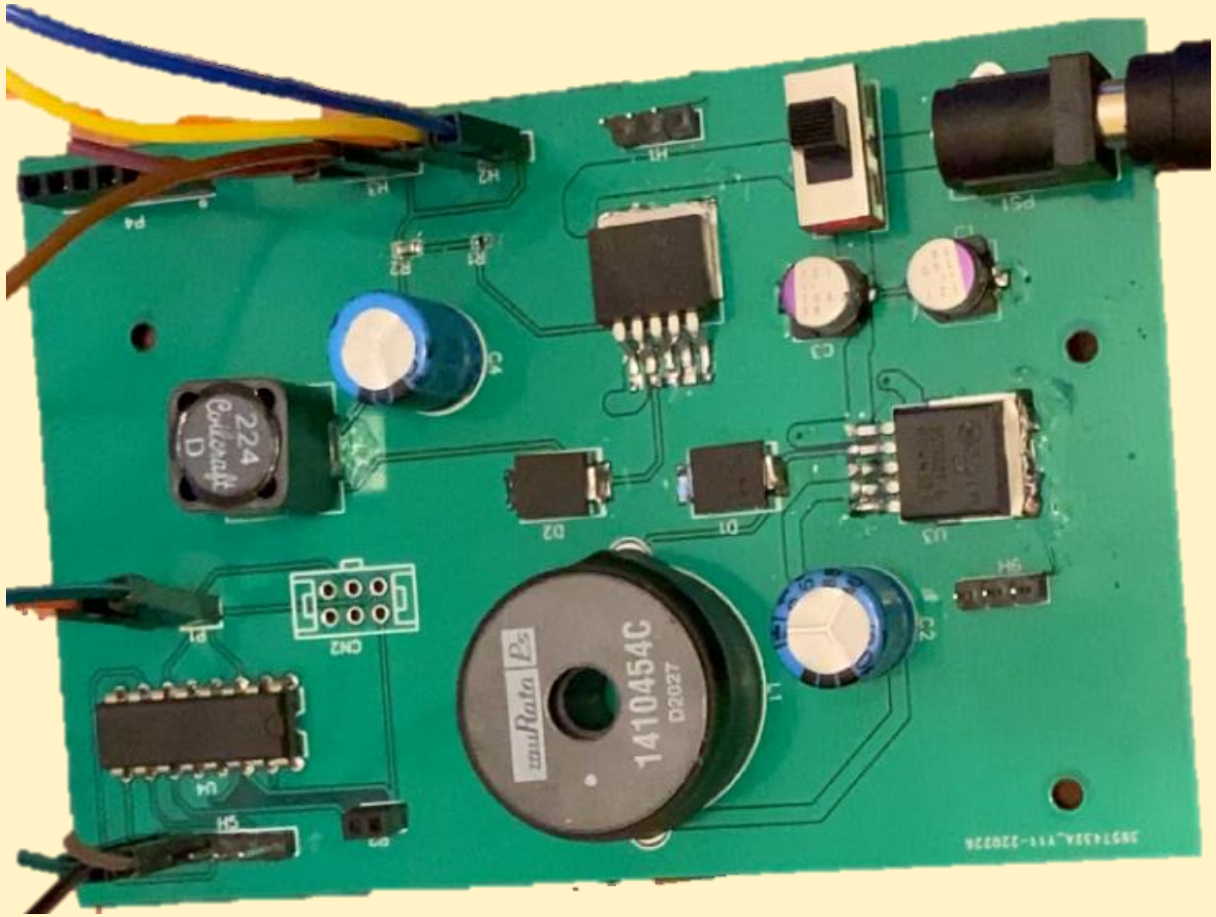


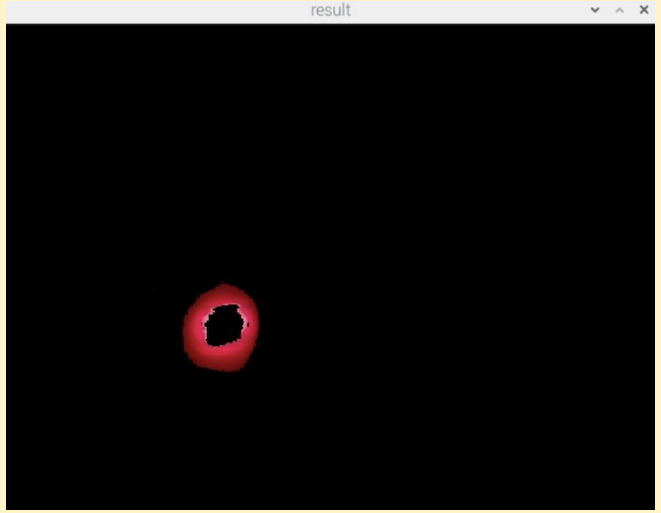
Power Regulation

Main PCB Layout

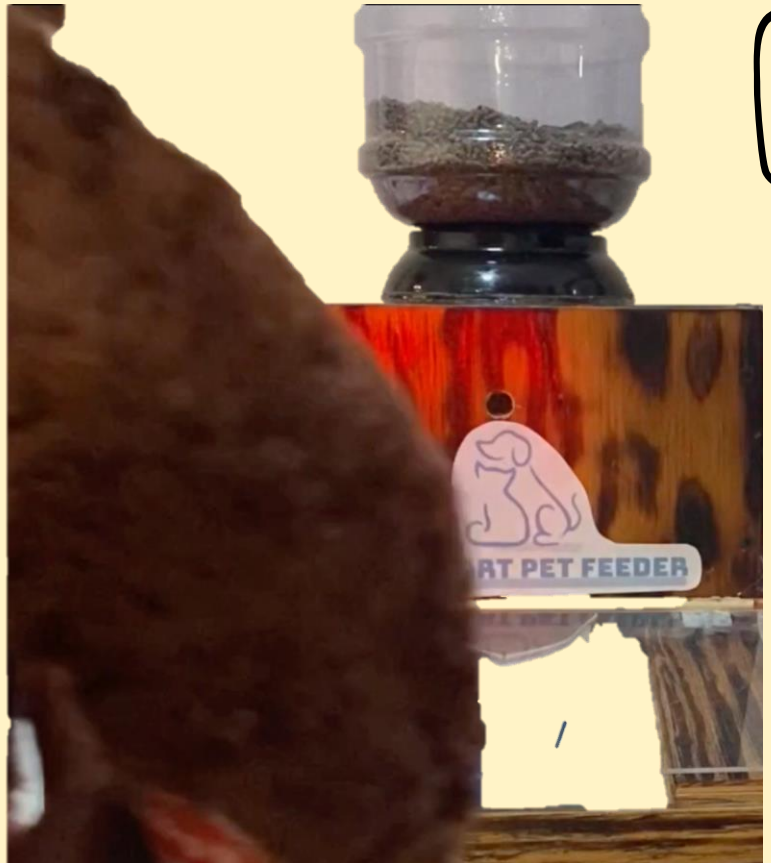


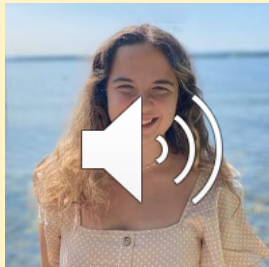
Main PCB Layout





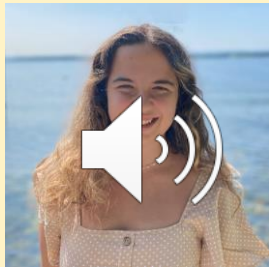
Color Detection





Color Detection

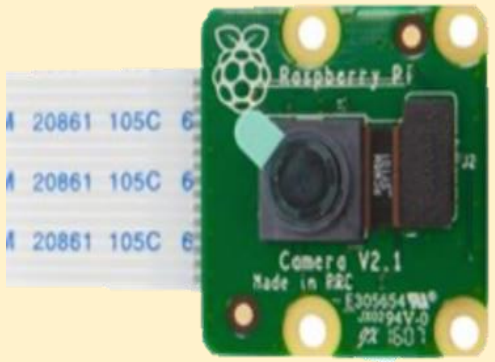
- Each collar will be equipped with either a Red, Blue, or Green LED
- The camera interfaced in the dog bowl will see the color
- Our system will be able to interpret which pet collar color the camera sees
- If the color detected is the one programmed into that feeder, it will open the lid



Color Detection technology comparisons

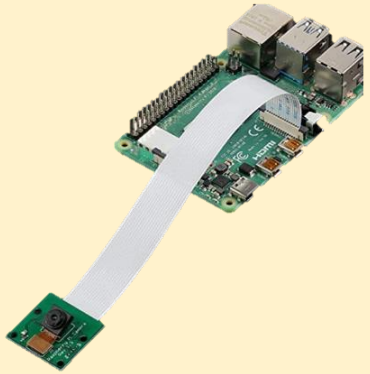
What we need:
- A camera system that will be constantly monitoring in front of the pet feeder
- Ability to detect RGB values
- Able to interface with a raspberry pi

Options Under Consideration



Raspberry Pi Camera v2

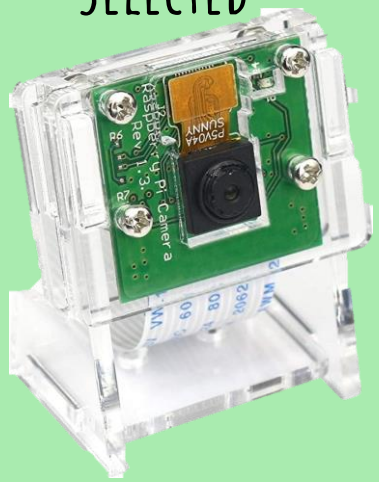
- First device considered
- Made by the company that makes the Raspberry pi
- 8 megapixels with a resolution of 3280 x 2464 ppi
- Small, only 25mm x 23mm x 9mm



BBTO OV5647 Mini Camera Module

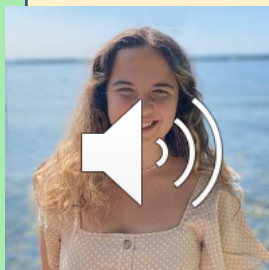
- 2 pack sold on Amazon
- Compatible with Raspberry Pi
- 5 megapixels 2592 x 1944 ppi
- Compact size of 25mm x 24mm x 9 mm

Selected



Jun-Electron 5 MP, 1080P Video Camera Module

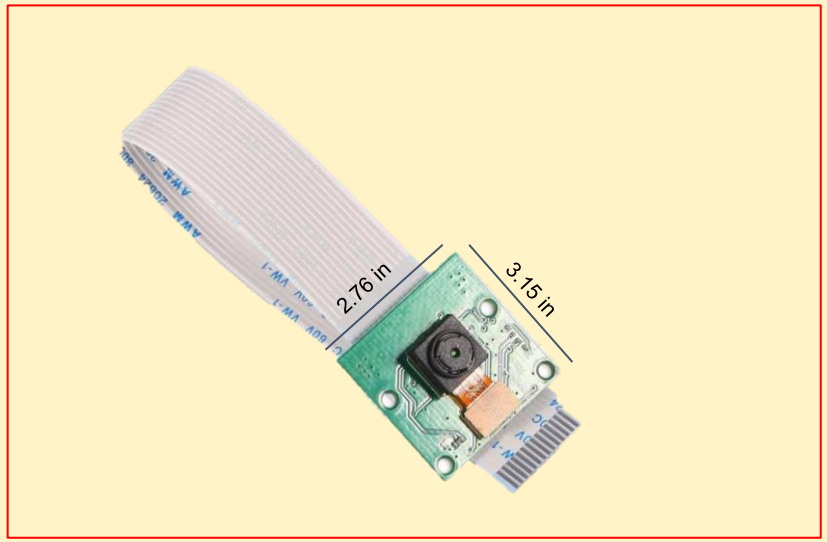
- Comes with a case
- Compatible with Raspberry Pi 4 Model B
- 5 Megapixels sensor with OV5647 webcam sensor in a fixed-focus lens
- Compact size of 3.15 x 2.76 x 1.1 inches



Selected Color Detection Camera (Jun-Electron 5 MP)

High resolution Image

Raspberry Pi 4

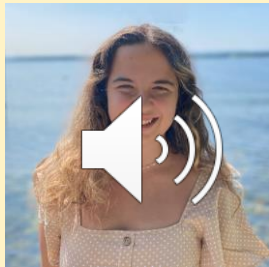


Purpose:

To take high-resolution photographs, along with full HD 1080p video, and can be fully controlled programmatically through the raspberry pi 4.

Model	8541612991
Price	$12.99
Port Type	CSI
Resolution	1080p

- Compatible with Raspberry Pi 4 Model B
- 5 Megapixels sensor with OV5647 webcam sensor in a fixed-focus lens



Color Detection technology comparisons

Lens for LED Collar tags

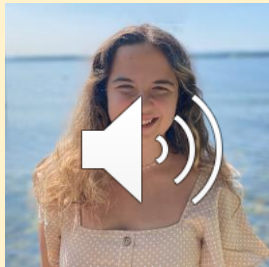
Selected

LA 1951 - N-BK7 Planoconvex Lens

- 25mm focal length 1” diameter
- $25.14 / lens - we require 3
- Great light dispersion at the wavelengths we are using

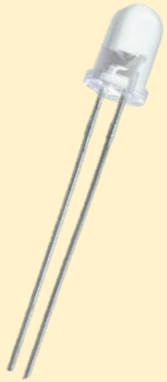
FRP125 - Fresnel Lens

- 25mm focal length 1” diameter
- $23.85 / lens - we require 3
- Great light dispersion with blue and green, very poor with red



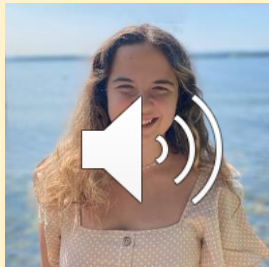
Color Detection technology comparisons

Single Color LED vs multi color led



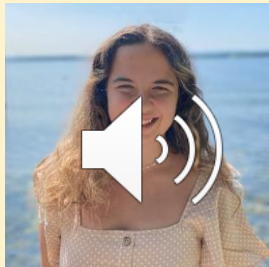
	RL5 - R8030	ALMD-CM3E-Y1002	C503B-BCS-CV0Z0461	NTE30159		
Type	Single	Single	Single	Multi		
Wavelength (nm)	630	525	470	625	525	465
Intensity (mcd)	8000	9300	4800	9000	7000	6500
Viewing Angle (deg)	30	30	30	30	30	30
Forward Voltage	2.2	3.2	3.2	2.1	3	3
Operating Current (mA)	20	30	20	20	20	20
Cost ($)	$0.28	$1.47	$0.21	$0.80		

Selected



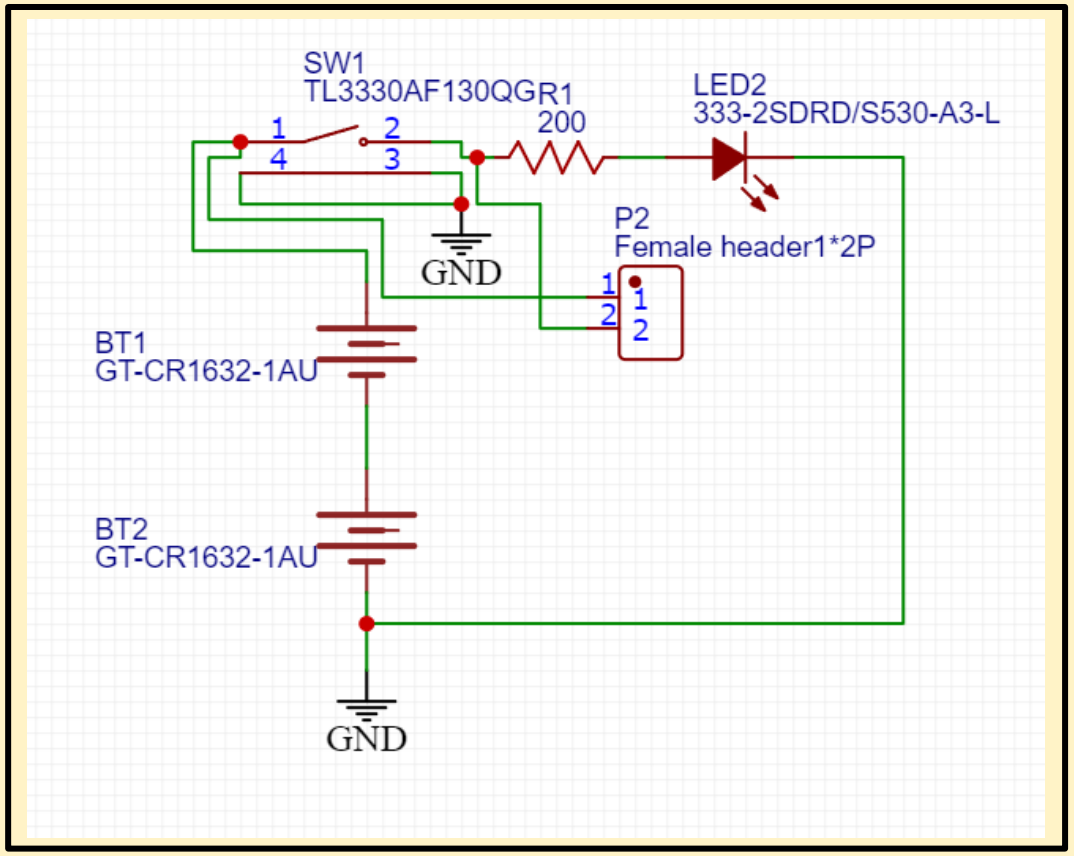
LED Safety

IEC62471 recommends that detailed measurements are not required for sources having a luminance of less than $10^4 cd/m^2$ Our light sources are dispersed using a lens and the viewer is never in direct line of sight of the LEDs.

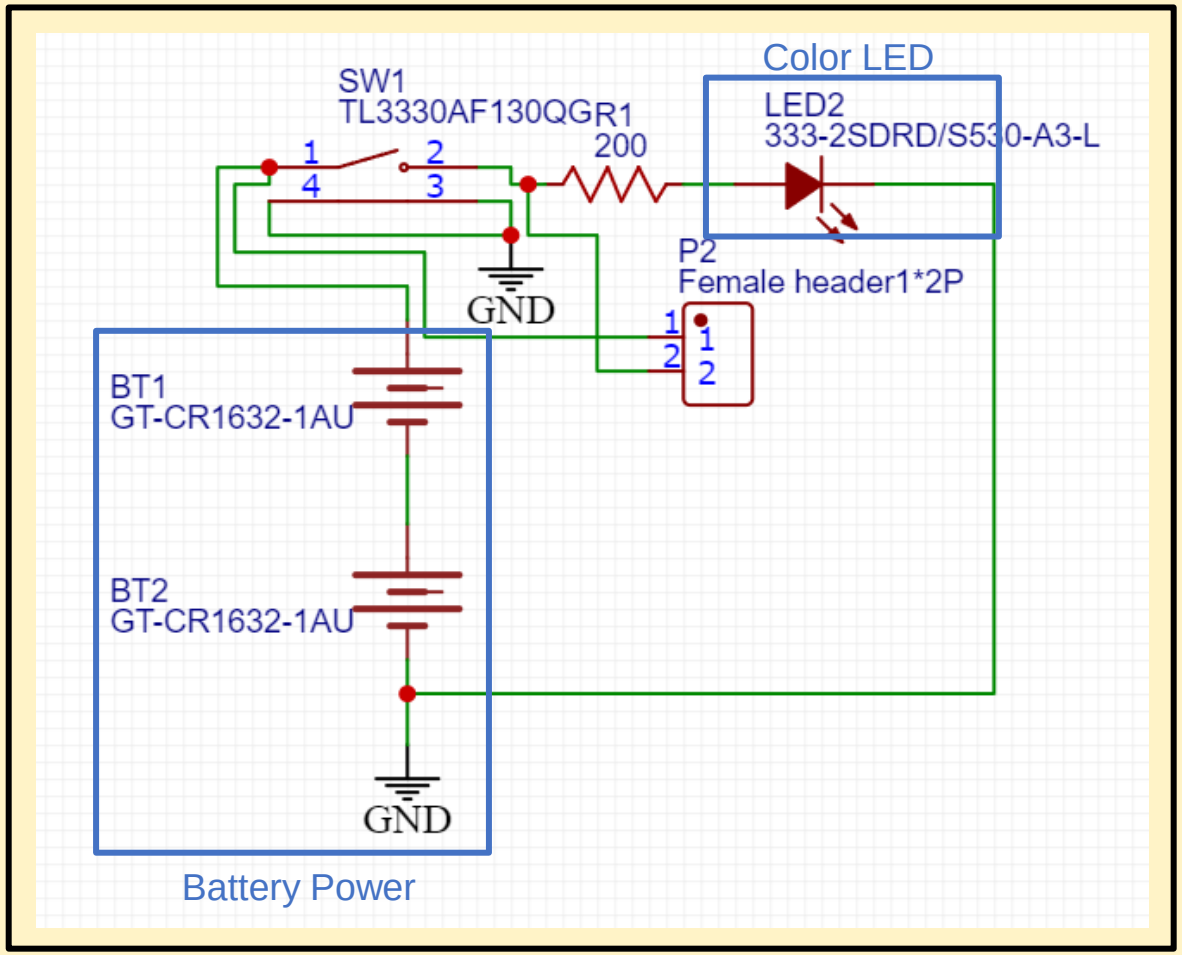


Collar PCB Schematic

- PCB inside the collar tag housing that will power a colored LED.
- Can be turned on and off with a switch.
- Three variations of this circuit will be used with a different LED color for each one.

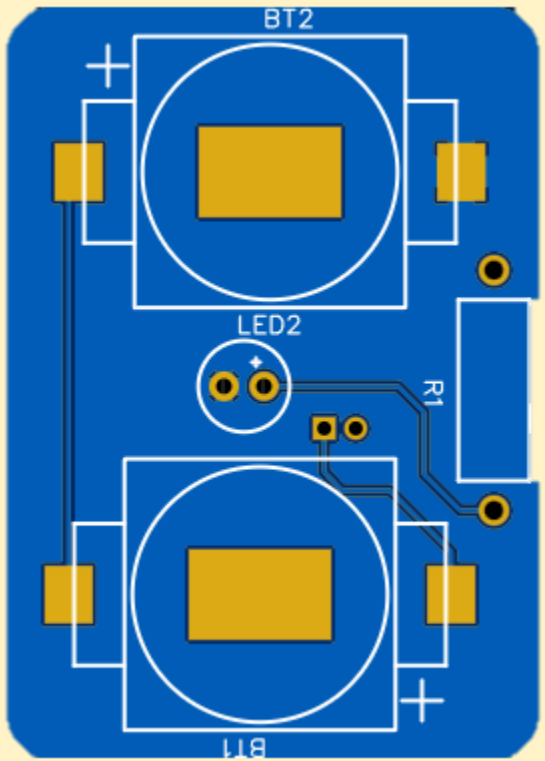


Collar PCB Schematic



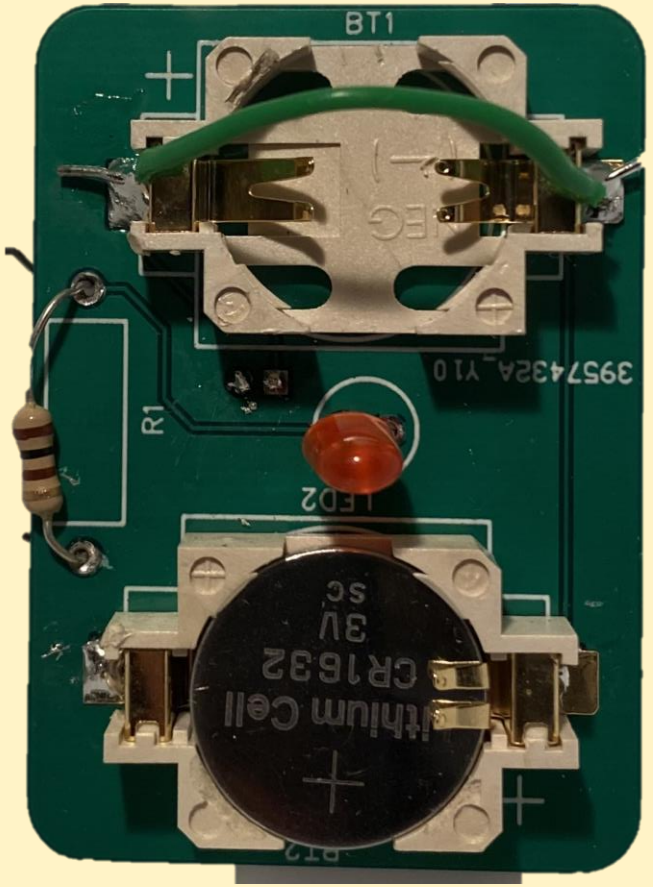
Collar PCB Layout

- Slight changes had to be made to physical PCB design for proper function.



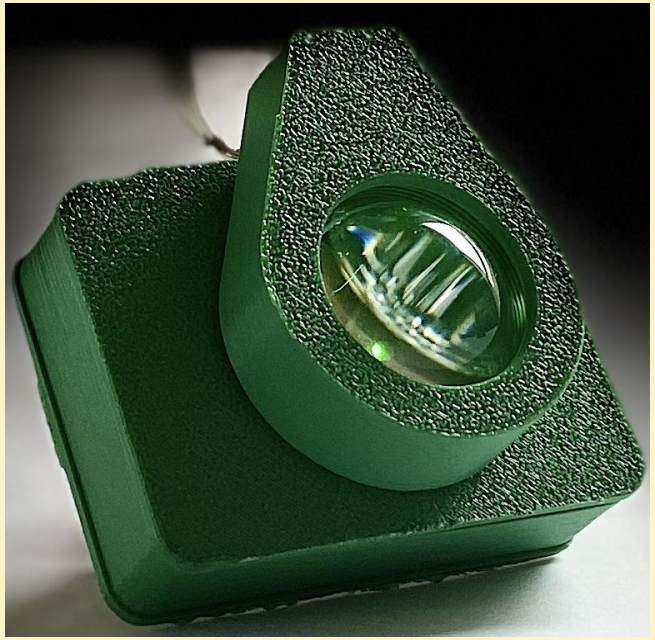
48.26mm

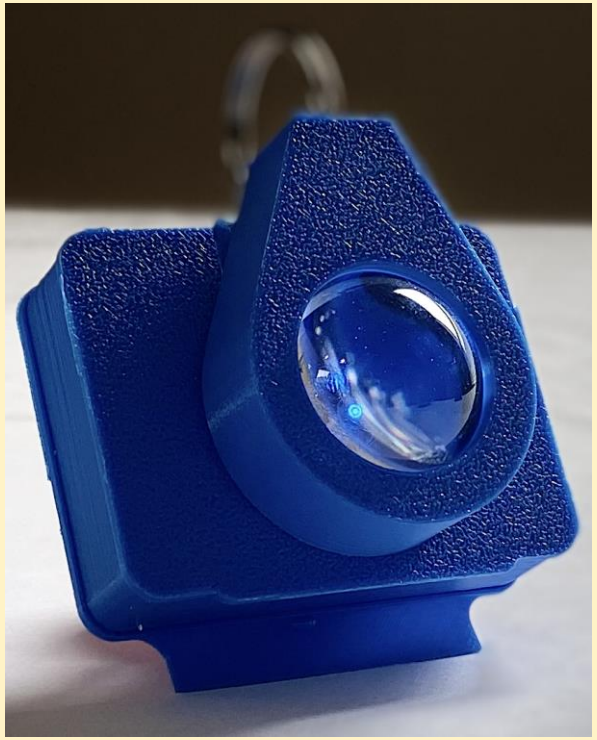
34.42mm

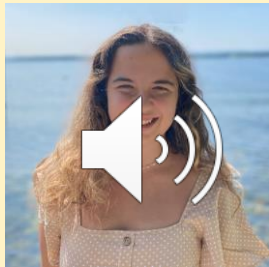


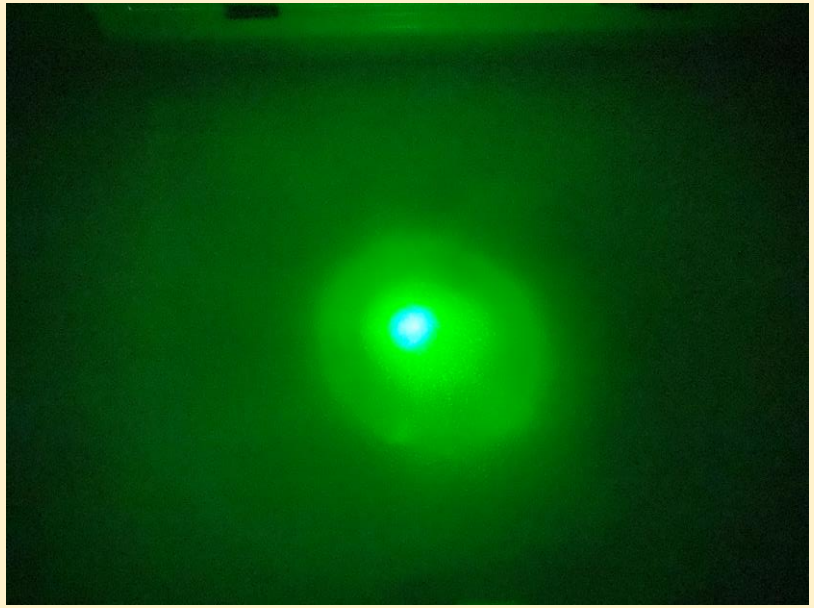
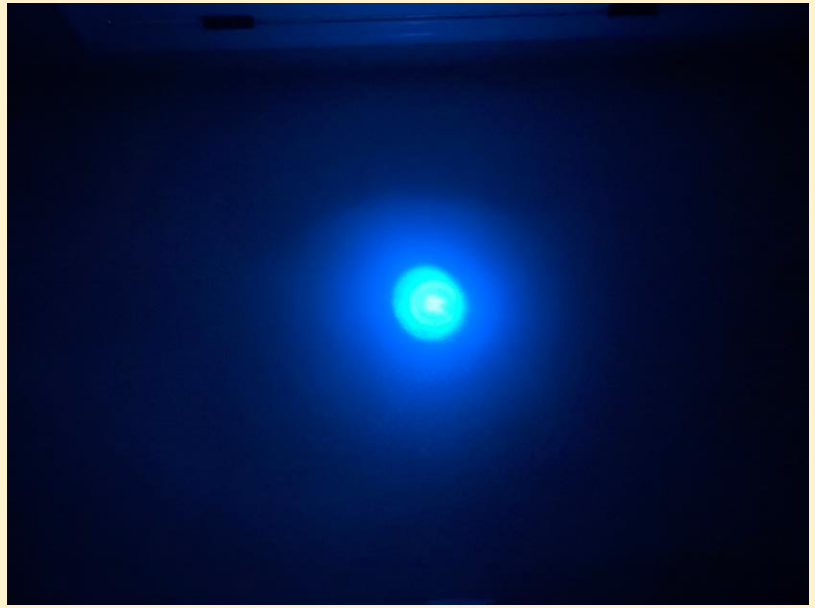
Pet Collar Tag Structural Design

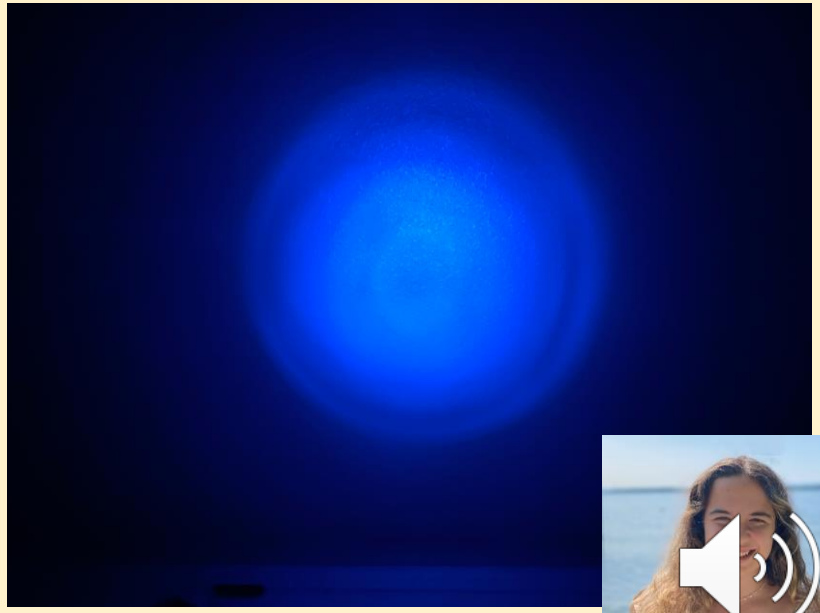
- Collar tag enclosures were printed using the Lockheed Martin Innovation Lab 3-D Printers
- Lens holder fixed onto PCB housing and then can be attached to pet's collar
- Molded plastic allows for a sturdy lightweight design







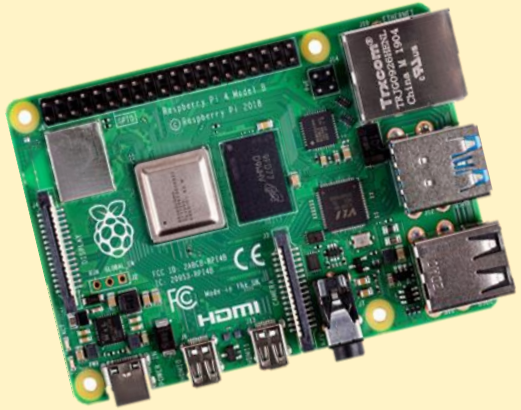



Color Detection Software Overview

- The color detection software will be run on the Raspberry Pi 4
- The color detection software was developed using the Visual Studio Code.
- Python was used for the writing of the software programs for the Raspberry Pi 4 device

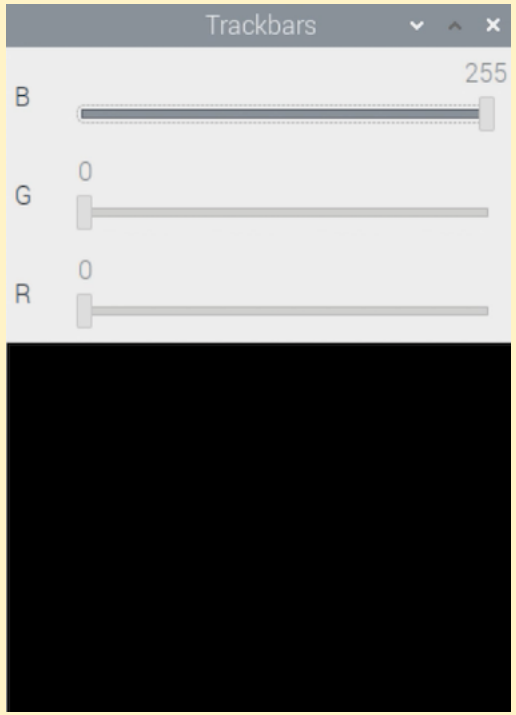
Description

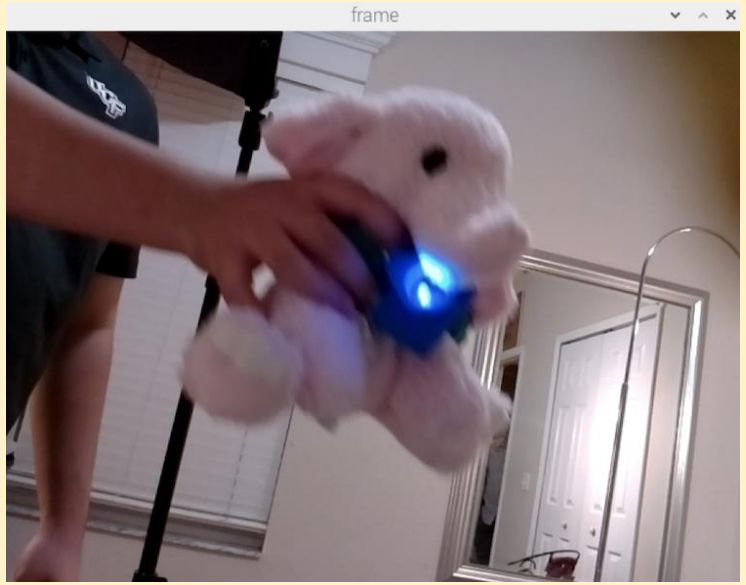
- The color detection software allows for the camera to detect the LED light attached to the collar of the pet to further determine whether the color of the LED light attached to the pet is correct. Once the correct LED color has been detected, the code will activate the Arduino microcontroller and its uploaded code to power the attached motors to ultimately open the lid for the pet to eat the food.

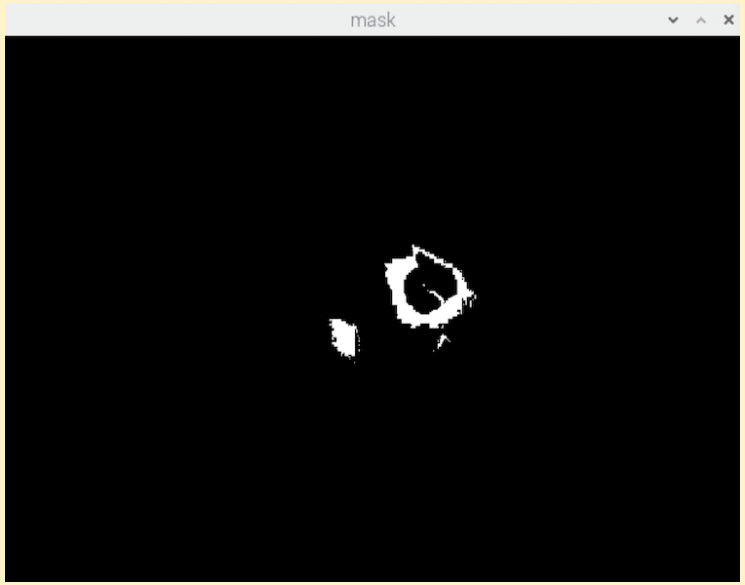


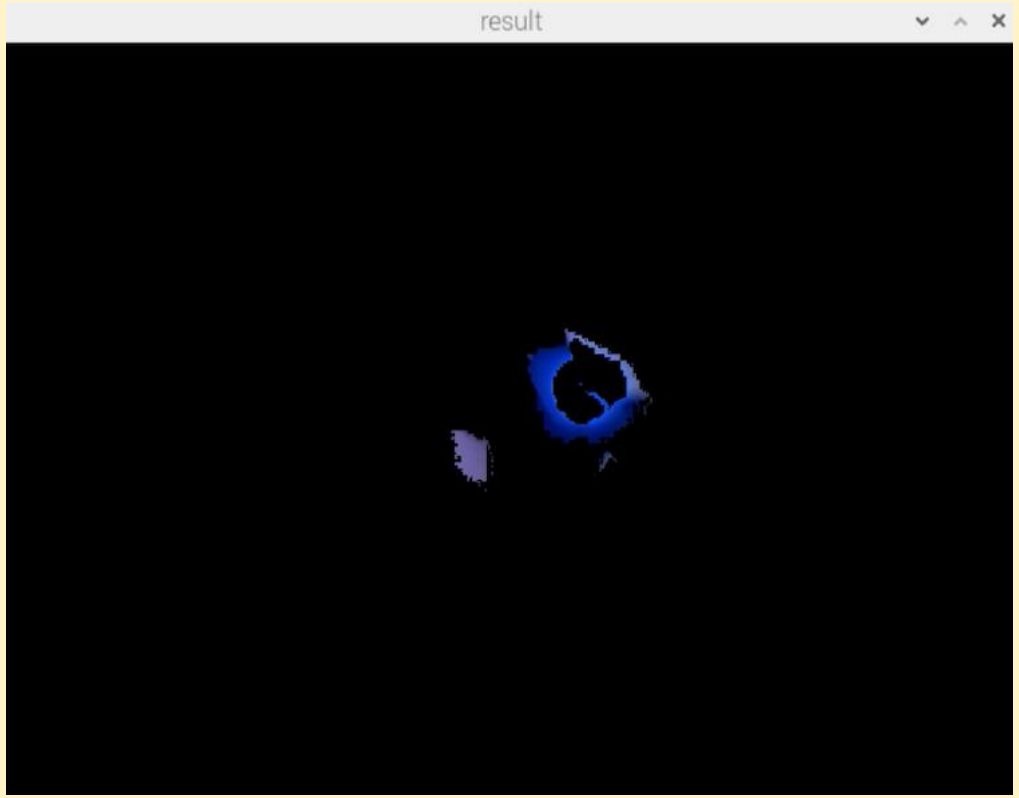
python

Color Detection Software Demo : Blue LED Detection

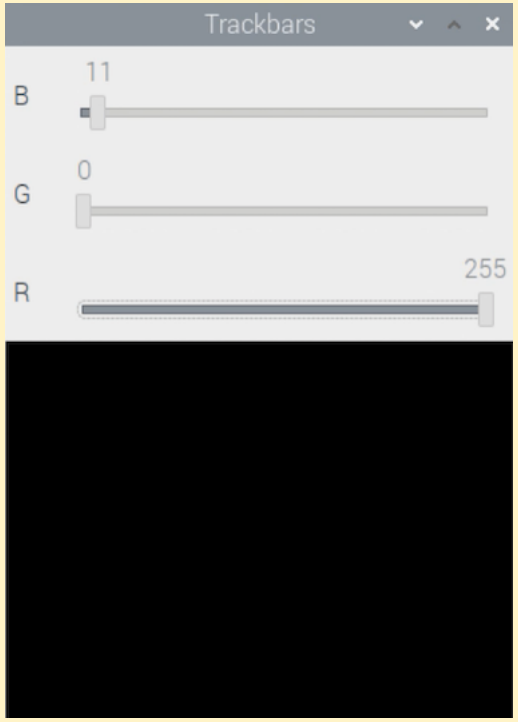


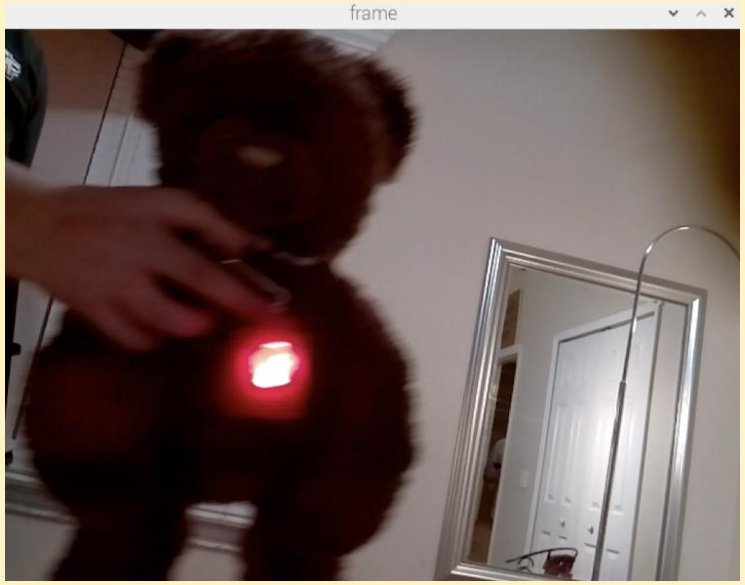


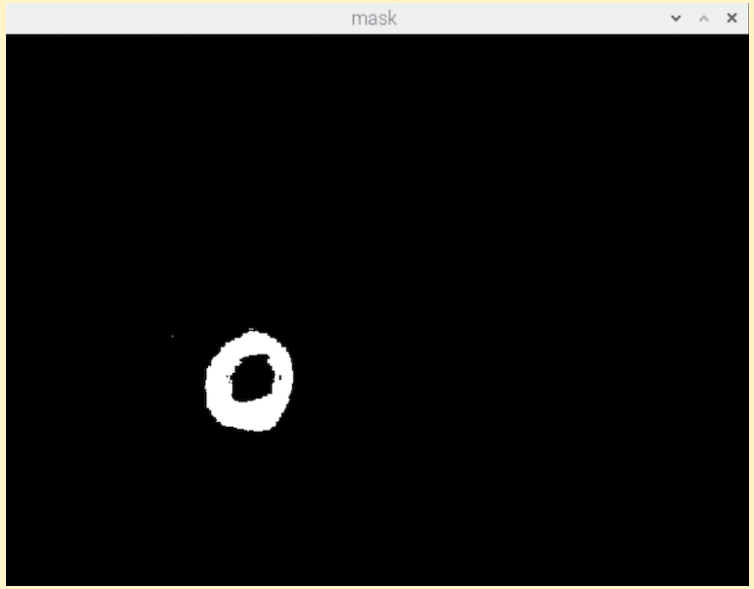


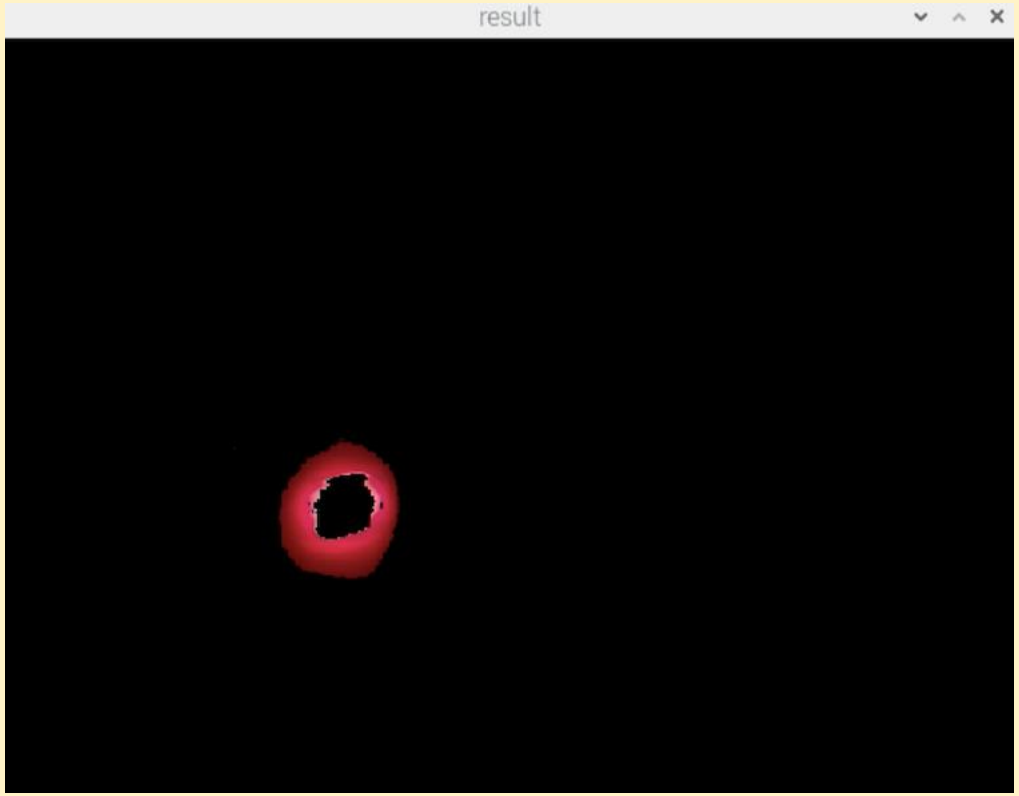


Color Detection Software Demo : Red LED Detection

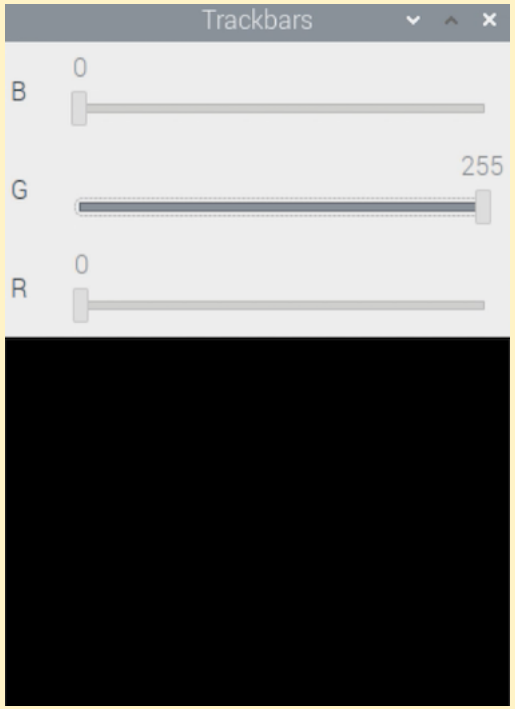


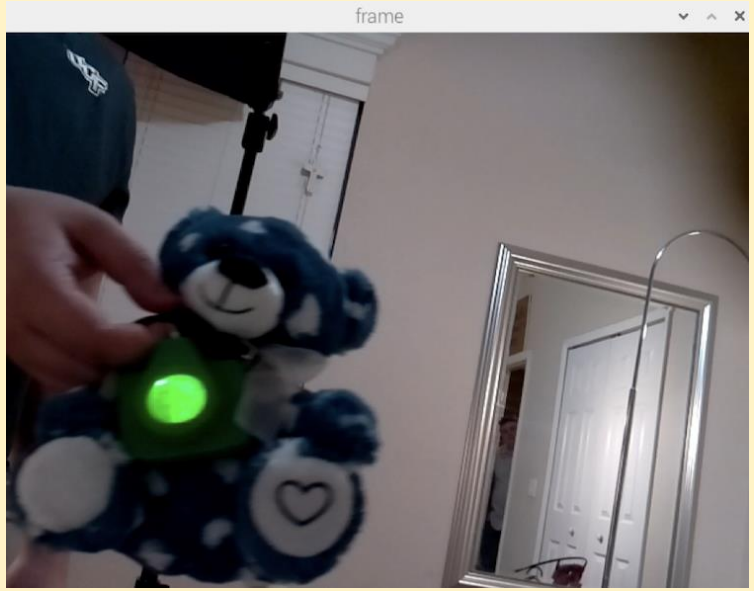


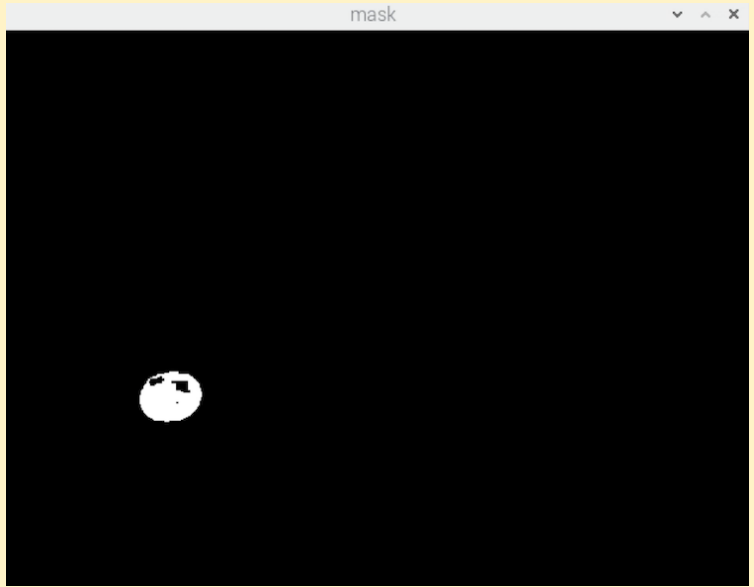


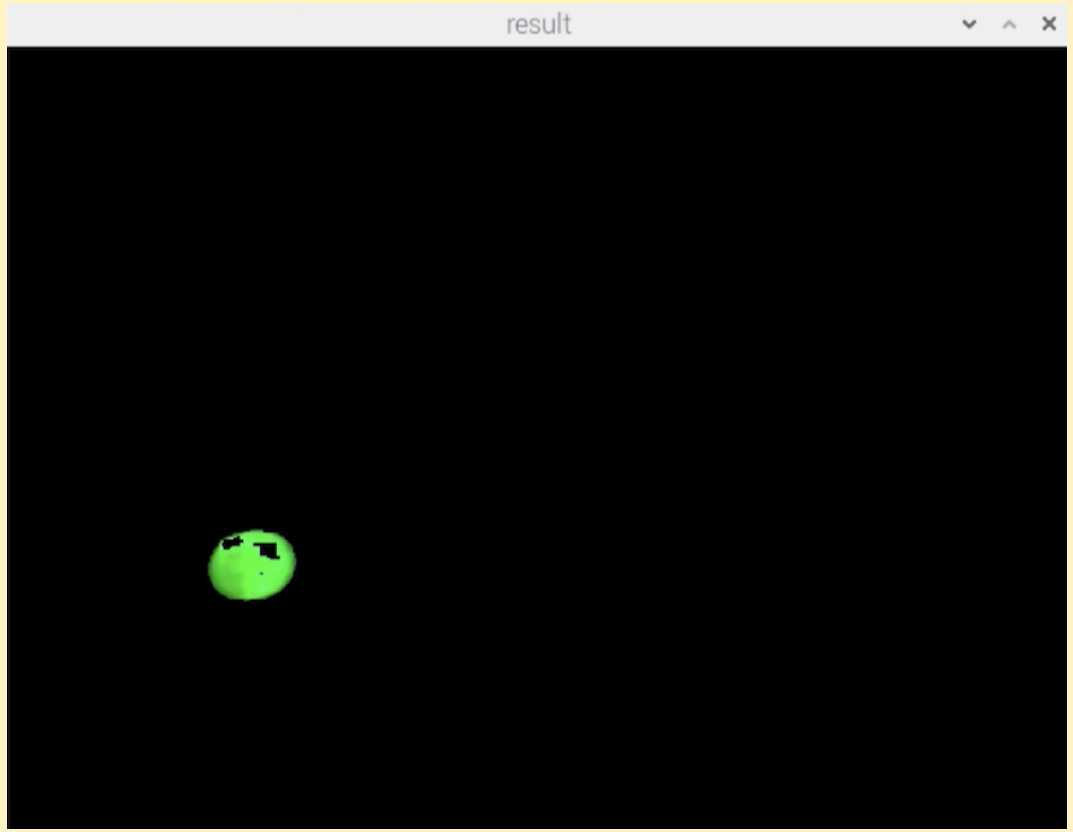


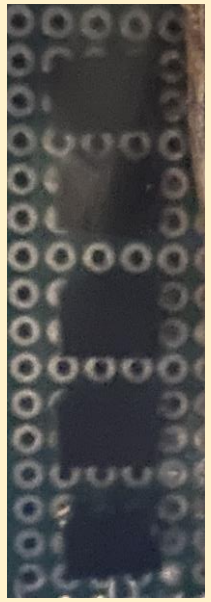
Color Detection Software Demo : Green LED Detection



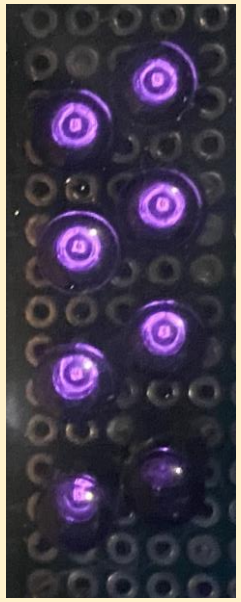








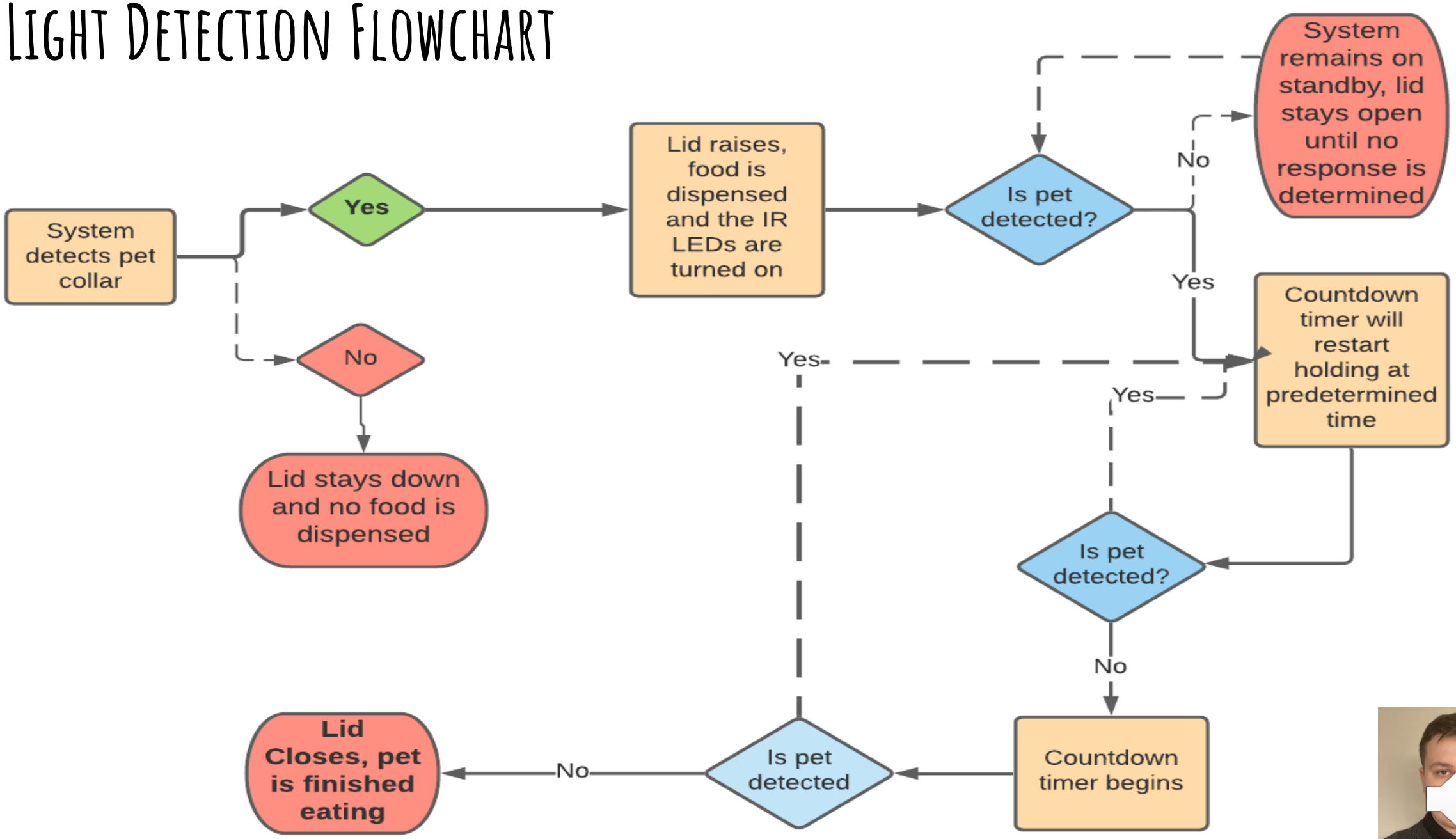
IR LED Detection



IR Light Detection

- IR LEDs are positioned above the bowl to detect the presence of the pet
- When the camera system detects the pet the lid will rise, and the IR LEDS will turn on
- Photodiodes peak detection wavelength matching the wavelength of the LEDs, reducing system noise
- Photodiode voltage is measured by the Arduino
- When a voltage drop is detected, the system knows that the pet is present
- When voltage rises the pet is no longer present and a countdown is triggered
- If no voltage drop is detected, then the lid is lowered.

IR Light Detection Flowchart



IR Detection technology comparisons

LED Comparison

	NTE30048	SFH 4546 -AWBW	MTE9460N5
Wavelength (nm)	950	950	950
Operating Current (mA)	50	100	100
Forward Voltage (V)	1.4	1.4	1.3
Viewing Angle (deg)	40	40	20
Cost	$0.71	$0.87	$6.21
Chosen Component			

Photodiode Detection

- Photodiodes must be operated with a reversed bias
  - Improves quantum efficiency
  - Improves response time (better response = safer device)

Equations used when determining the perfect photodiode

$$I_{ph} = \eta_{overall} \frac{Q\, P_{opt}}{h\, f}$$

(Photocurrent – higher the better)

$$R = \frac{I_{ph}}{P_{opt}} \text{ (A/W)}$$

(Responsivity – higher the better)

IR Detection technology comparisons

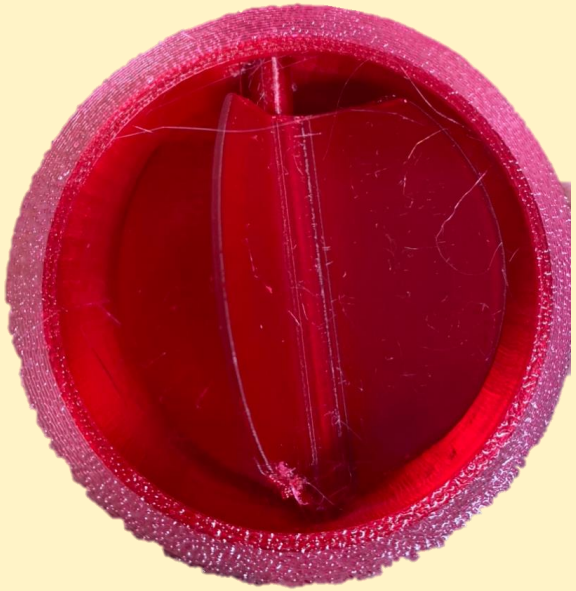
Photodiode Detection

	S2386-5K	BPV23FL	BPW82
Peak Wavelength Sensitivity (nm)	960	950	950
Dark Current (nA)	0.005	2	2
Reverse Voltage (V)	30	60	60
Rise Time (ns)	1.8	70	100
Fall Time (ns)	-	70	100
Photo current (uA)	4.4	63	45
Responsivity (A/W)	0.6	0.6	0.000209
Cost ($)	$13.98	$1.03	$1.07
Chosen Component			

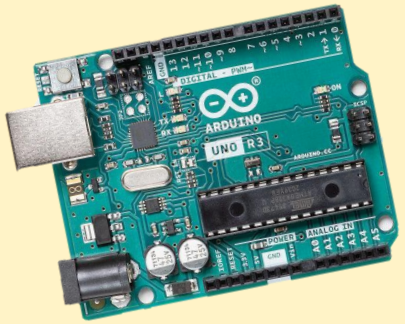
Optical Design Demo : IR Light Detection

		Average
LED/Photodiode	Voltage Drop (per LED/Photodiode)	0.103 V
Photodiodes	Response time	1.588 seconds
Lid Motor	Activation Time	30.714 seconds

Lid / Dispenser



Lid System Software Overview



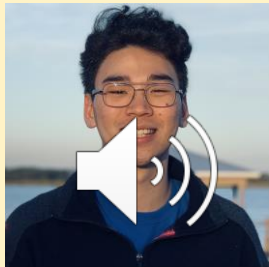
- The lid system software will be run on the Arduino Uno Rev 3
- The software to control the lid system was developed using the Arduino IDE.
- C/C++ languages were all integrally used for the writing of the software programs for the Arduino device

Description

- The software first opens the lid once the Raspberry Pi sends a communication to the Arduino that indicates the correct color LED was detected. While the lid is open, the Arduino will continually check if there is a pet blocking the IR LED signal from reaching the photodiodes. When a blockage is sensed, the lid motor will wait 30 seconds after the pet leaves the bowl to turn the lid closed. If the system does not have a pet interrupt the IR LED signal during the 30 seconds, the lid motor will activate and close.

Lid System Software implementing Safety

In order to protect the pet's head from being injured by the lid's closing action, If the lid system does detect a pet interrupting the IR LED signal during the 30 second feeding period, the lid motor will not close until the blockage that was previously detected has disappeared. Once the blockage has completely disappeared, the system will activate and close the lid.



Food Dispenser

- The Food Dispenser tube and rotating plate were both printed using the Lockheed Martin Innovation Lab 3-D Printers
- Outputs the correct amount of food in at most 60 seconds as the plastic blades on the rotating plate allowing the food to flow from the container down a tube and into the bowl with the help of gravity.
- The exact amount of food released per wheel rotation can be determined to calculate and program the time it takes to fully dispense a complete meal (using the wheel rpm)

Web Application

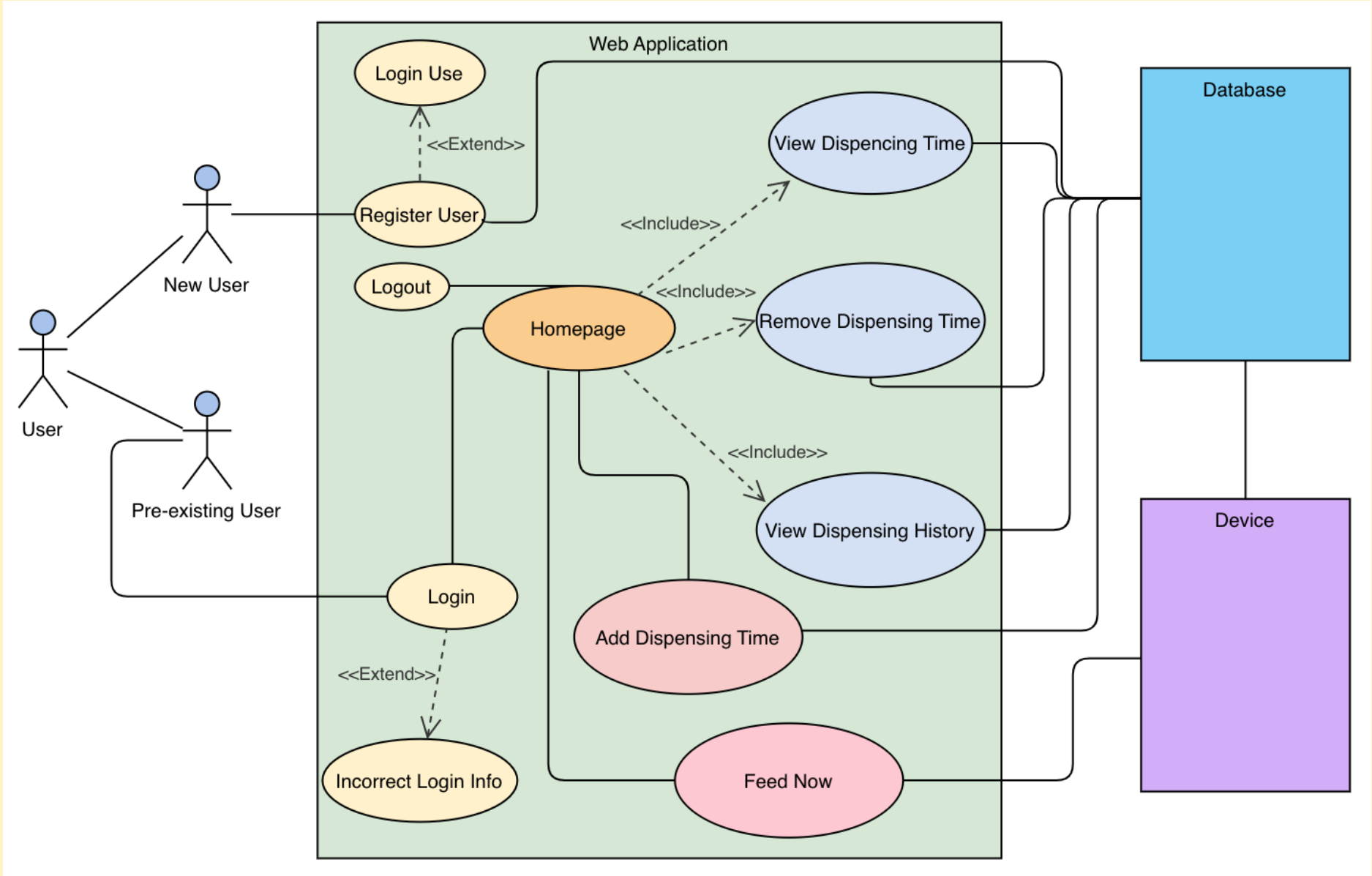
Web Application Development Overview

- This Web application is hosted by the raspberry pi 4 system
- Python, HTML, CSS, and database files was all used in creating the web application

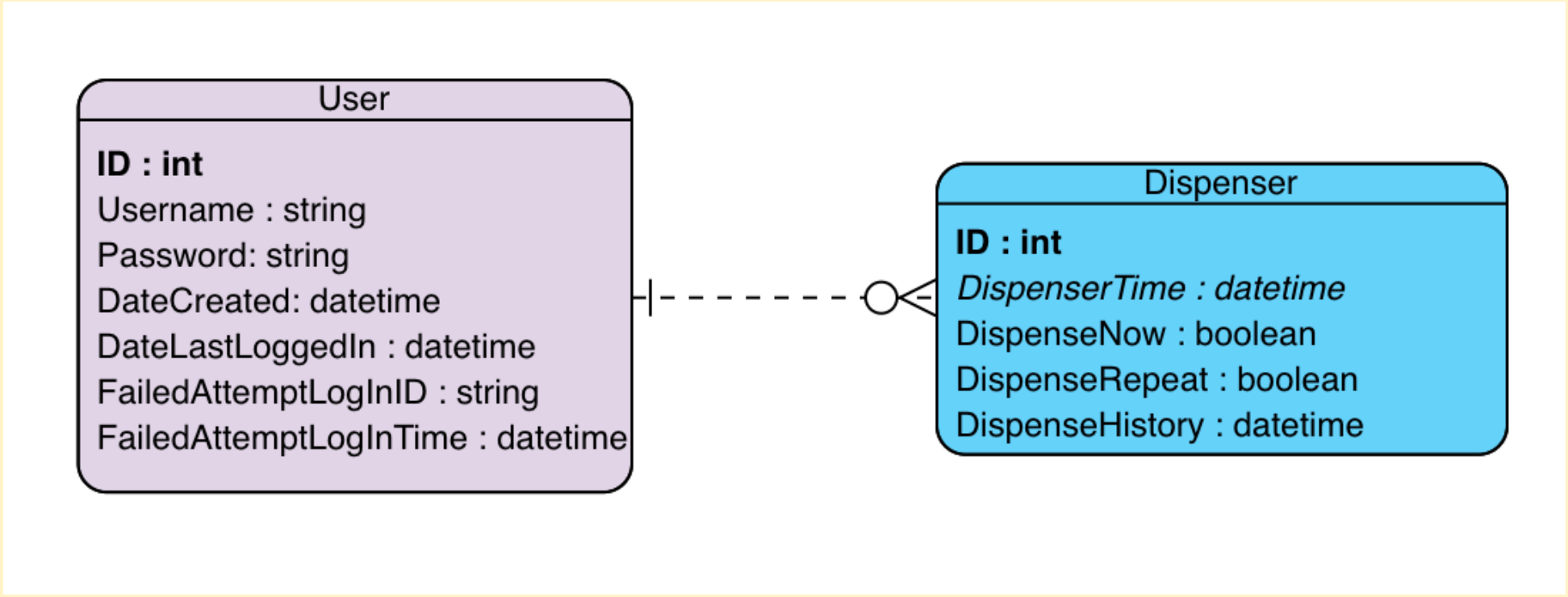
Description

- Users will be able to create a secure profile and login remotely via Wi-Fi into our web application
- Once signed in, users will be able to remotely view, add, edit, and remove food dispensing actions and times done by the system on our webpage
- Once the user is done using the website, they can logout using the log out button to safely exit out of the program.

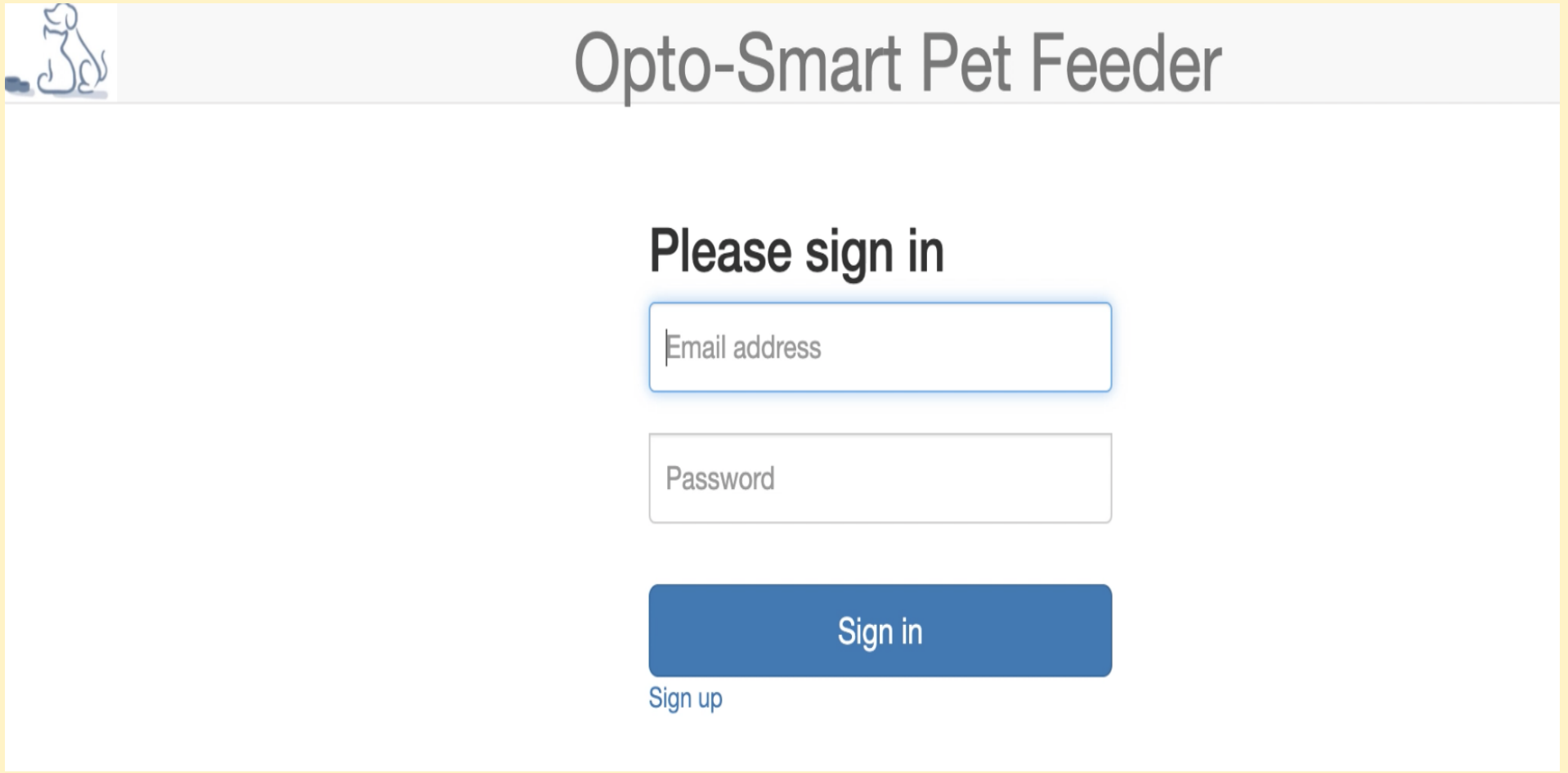
Use Case Diagram

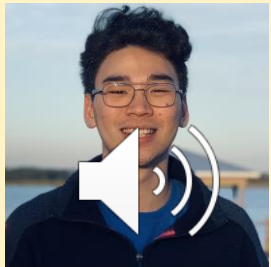


Entity Relationship Diagram (ERD)

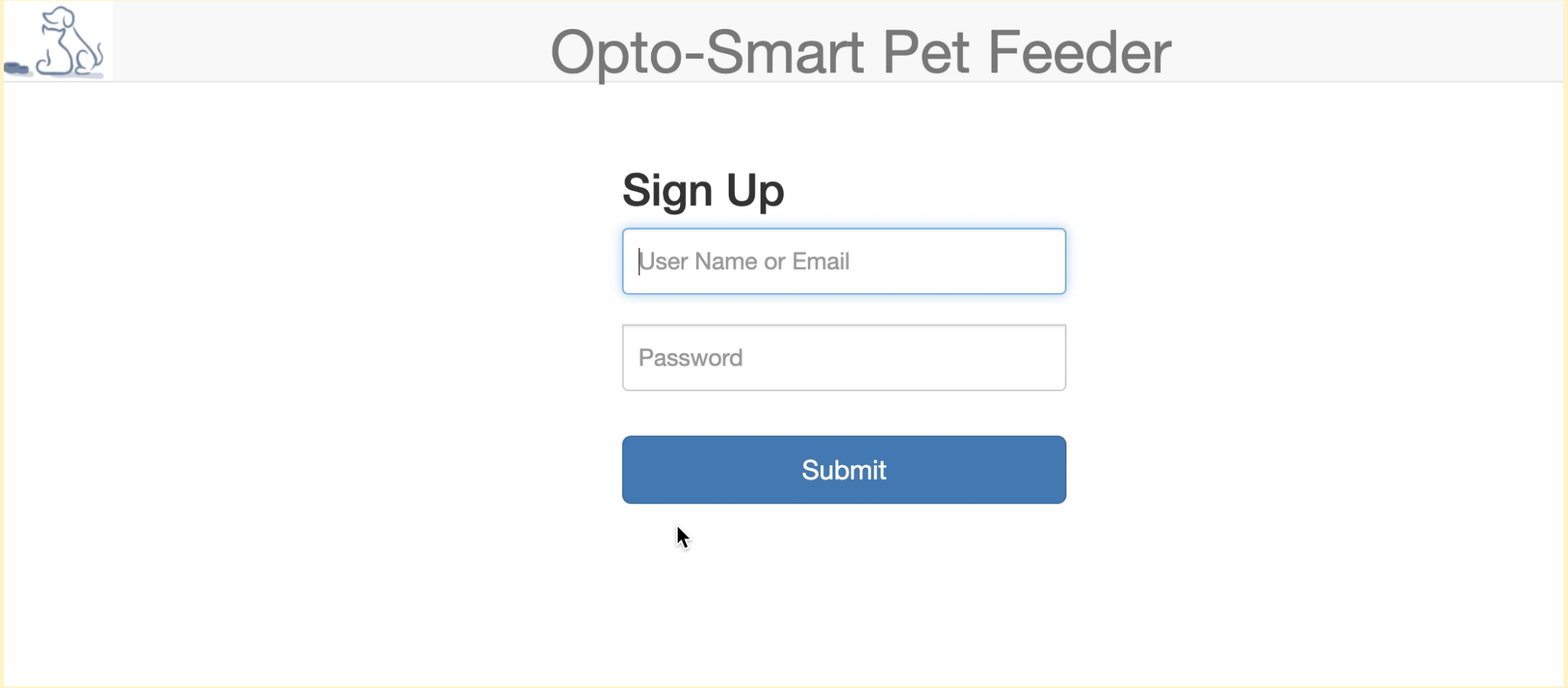


Web Application Sign in Page

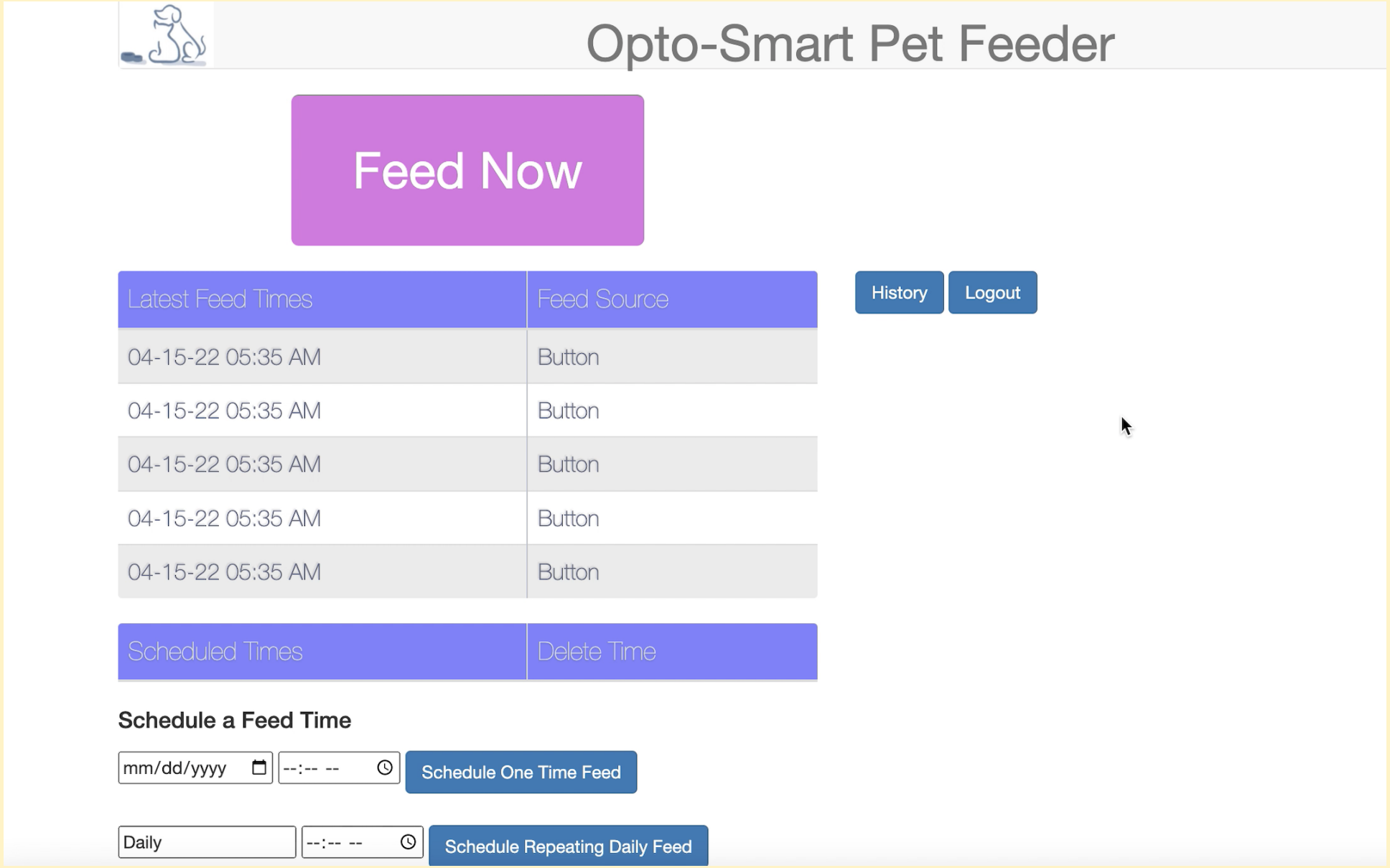




Web Application Sign up Page



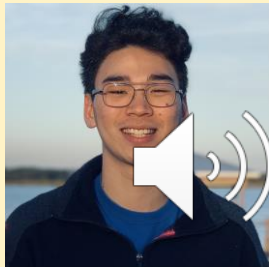
Web Application Homepage

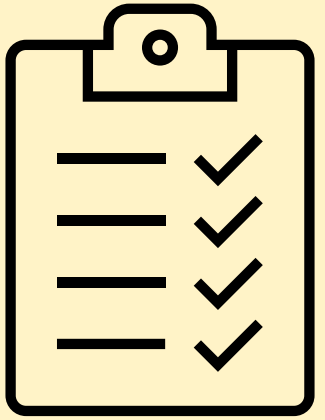


Web Application History page

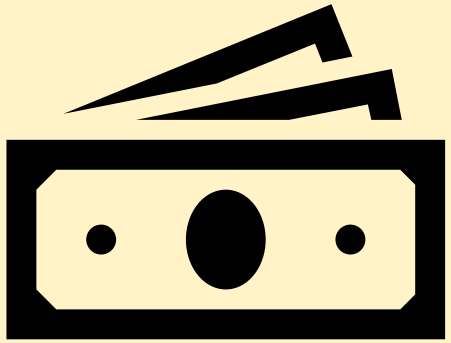
Opto-Smart Pet Feeder

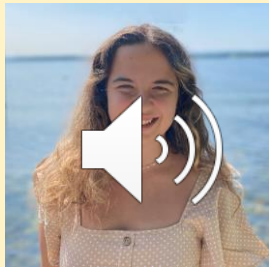
Latest Feed Times	Feed Source
04-15-22 05:39:57 AM	Web Feed
04-15-22 05:35:27 AM	Button
04-15-22 05:35:24 AM	Button
04-15-22 05:35:21 AM	Button
04-15-22 05:35:18 AM	Button
04-15-22 05:35:15 AM	Button
04-15-22 05:35:12 AM	Button
04-15-22 05:35:09 AM	Button
04-15-22 05:35:06 AM	Button
04-15-22 05:35:03 AM	Button
04-15-22 05:35:00 AM	Button
04-15-22 05:34:57 AM	Button
04-15-22 05:34:54 AM	Button
04-15-22 05:34:51 AM	Button





Opto-Smart Pet Feeder Planning





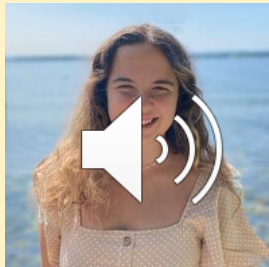
Work Distribution

Project Characteristic	Tyler	Cassidy	Ricky	Jacob
Collar Tag	Secondary	Primary	-	-
IR LED Detection	Primary	-	-	Secondary
Camera System	-	Primary	Secondary	
PCB Design	Secondary	-	-	Primary
Web Application	-	Secondary	Primary	-
Software Design	-	-	Primary	Secondary
Enclosure Design	Primary	Secondary	-	-
Electrical System Testing/Design	-	-	Secondary	Primary

Finance and Budget

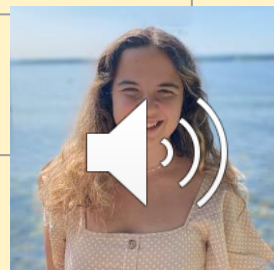
Item	Cost	Quantity	Purchased?	Total
Camera	$11.07	1	☑	$11.07
FRP125 Lens	$38.11	3	☑	$114.33
RL5-R8030 (Red LED)	$0.28	25	☑	$7.00
Green LED (25 pk)	$8.00	1	☑	$8.00
Blue LED	$8.00	1	☑	$8.00
Photodiode	$1.03	25	☑	$25.75
IR LED	$0.87	25	☑	$21.75
Optical Component Cost			☑	**$195.90**
Raspberry Pi Kit	127.79	1	☑	$127.79
Soldering station	41.59	1	☑	$41.59
Pet collar battery- 10 Pack (CR1632)	6.38	1	☑	$6.38
ProtoBoards	12.77	1	☑	$12.77
Satin Polyurithane (Wood stain)	11.97	1	☑	$11.97
Tung Oil (Wood Stain)	22.98	1	☑	$22.98
Sandpaper 100 grit	5.98	1	☑	$5.98
Sandpaper 220 grit	5.98	1	☑	$5.98
Propane cylinder	15.29	1	☑	$15.29
Plywood	12.06	1	☑	$12.06
PCB Board (Set 5)	123.24	1	☑	$123.24
12V 40 RPM Motor	29.99	2	☑	$59.98
Arduino	19.95	1	☑	$27.05
12V 5A Power Supply	10.99	1	☑	$10.99
Lead Free Solder	12.99	1	☑	$12.99
Dog food holder	13.29	1	☑	$13.29
Lid motor high torque	9.99	1	☑	$9.99
Non-Optical Cost				**$520.32**
Total				**$716.22**

- $500 supplied from CREOL fund
- Remaining cost will be split evenly among group members



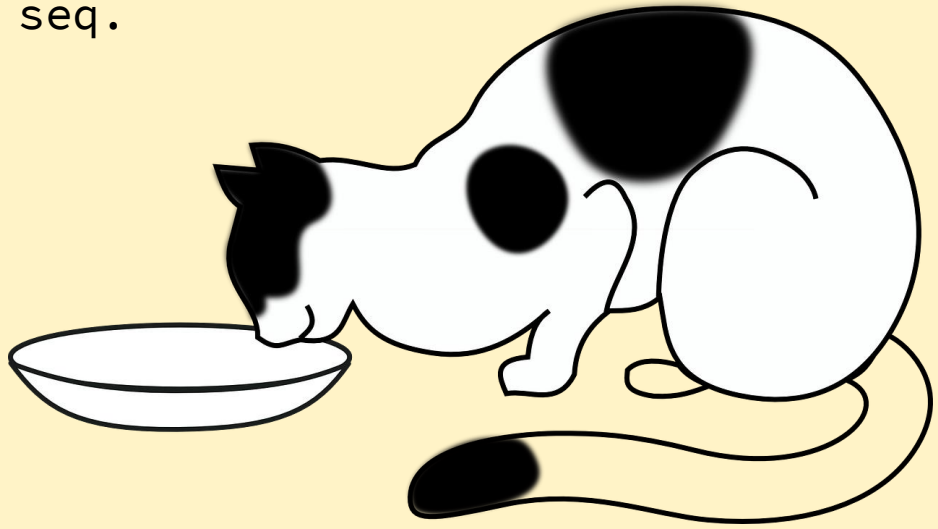
Design Constraints

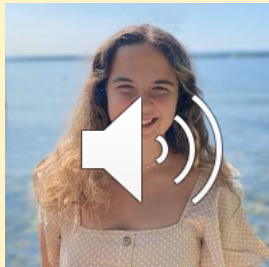
Economics and Time	• Our pet bowl will be more expensive than others on the market due to high-tech features • Limited two semester time limit for research and development of product
Environmental	• Design sourced from off the shelf components • Product must last lifetime of pet
Social	• Ongoing pandemic may push potential sales down due to many people working from home and not needing an automated pet feeder
Political	• Not relevant towards project
Ethical	• Care must be taken when working with animals • Product must be 100% safe and tested (no exposed motors, gears, electronics must be shielded, etc.)
Health and Safety	• Materials must be safe for food contact.
Manufacturability	• Ongoing pandemic may cause material shortages, must plan ahead.
Sustainability	• Product must last years before material degradation.



Related Standards

- Animal Health and Safety Requirements
  - The Animal Welfare Act, 7 U.S.C. § 2131 et seq.
- Soldering Standards
  - Lead soldering safety
  - Guidelines for soldering
- C Language Programming Standards
  - ISO/IEC 9899:2011
- PCB Standards
  - IPC-221A





Demonstrated Design Requirement

Component	Parameter	Design Specification	Demo Results Mean	Demo Results Variance
Camera	Detection range	> 5 Feet	12 Feet (Approx.)	N/A
Photodiodes	Response time	< 10 seconds	1.588 seconds	0.0658 seconds
Lid Motor	Activation Time	30 seconds ± 10 seconds	30.714 seconds	0.0563 seconds