ECE 445

SENIOR DESIGN LABORATORY

Design Document

Schedulable Automatic Fish Feeder

TEAM #18

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1. Introduction

Problem

Fish feeders currently on the market are limited on how much convenience they give fish owners when they are away from their tank. If you want to feed your fish at a certain time, you usually have to set a timer for 12 or 24 hours in advance to feed them. There is also no reassurance that your fish is actually being fed and eating. Owners just have to assume that the machine is working as intended. This poses a major problem when gone for extended periods of time, such as winter break.

Solution

With our fish feeder, the user will not only be able to feed their fish from any location by using a mobile app, but they will also be able to schedule the exact times they want the feeder to dispense food, allowing them to customize their feeding times. In addition, the feeder will have a sensor that will detect when the food container rotates and send a notification to the user so they can ensure that their fish was fed. The feeder will be plugged into the wall to make certain that the feeder will work for extended periods of time. If the power goes out or if the feeder is not being supplied with AC power from the wall, it would switch to battery power. This solution would require a PCB, microcontroller with wireless transmitter, rotating motor, sensors, mobile app, and a power system. Other components could be added, such as a camera, water quality sensor, and indicator LEDs.

Visual Aid

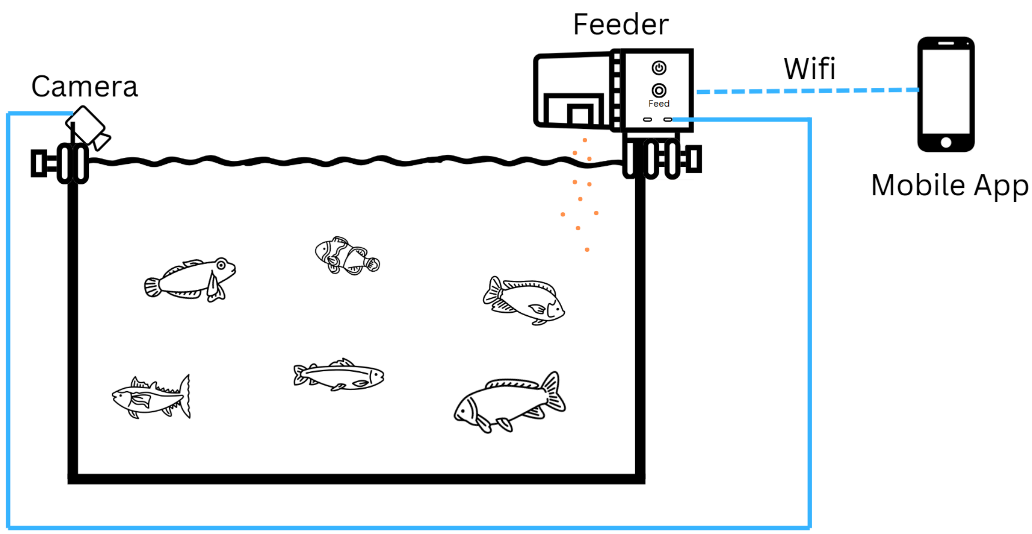

Figure 1: Visual Aid

High-Level Requirements

- Feeding via the button on the feeder and in the app works within 3 seconds of being selected or scheduled.
- The magnetic sensor detects that the food is actually dispensed into the tank and sends a notification to the app within 3 seconds of being triggered.
- When the camera icon is selected on the app, 3.3 V +/- 0.1 V is delivered to the camera and the feed is displayed in the app.

2. Design

Physical Design

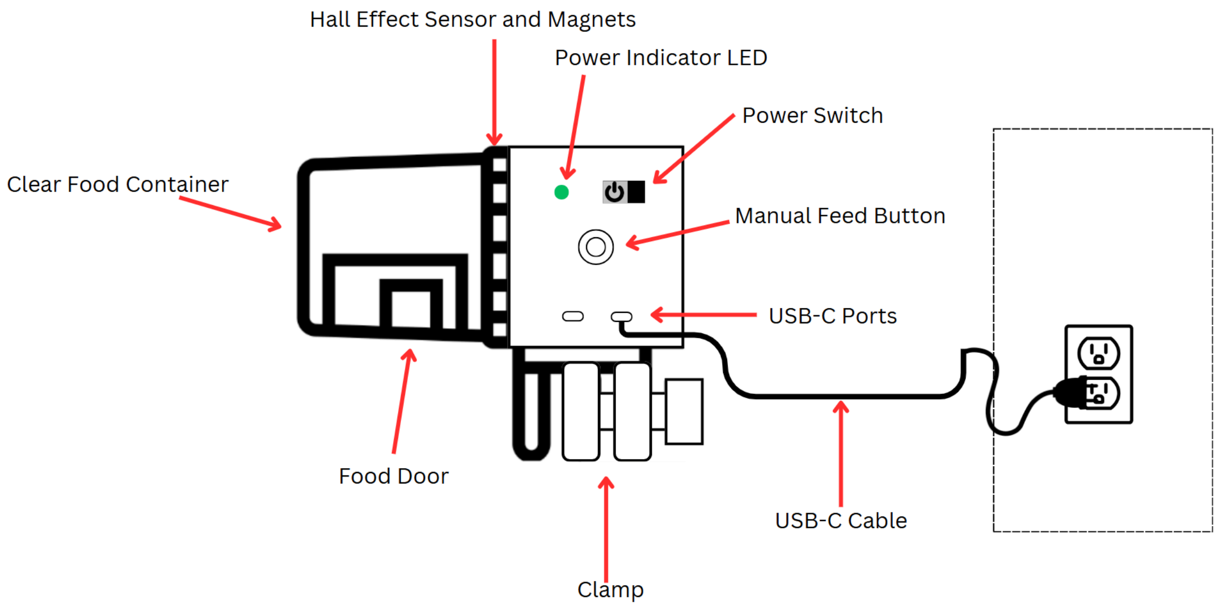

Figure 2: Physical Design of Feeder

The physical design will consist of a clear cylindrical-shaped container that will act as the storage for fish food. Connected at the end will be a box that will house the PCB and motor. When the feeder is instructed to feed, the motor will rotate the cylindrical part of the feeder. As it rotates, the swinging door of the container will open due to gravity allowing for food to drop into the tank as it rotates. Once the door is no longer over the fish tank, it will swing back closed. The hall effect sensor will be in between the food container and PCB housing, where there will also be magnets attached to the food container. Therefore, when the food container fully rotates, the hall effect sensor will detect the magnetic field, deliver a signal to the ESP32, and send a notification to the app, letting the user know that the fish were successfully fed. Also, there will be a power switch so the owner can manually turn off the feeder, a power indicator LED to show that the feeder is actually receiving power, and a manual feed button allowing the owner to feed their fish when they want. The feeder will be powered through a USB-C cable plugged into an outlet. The other USB-C port can be used for the camera or other add-ons such as a water quality sensor.

Block Diagram

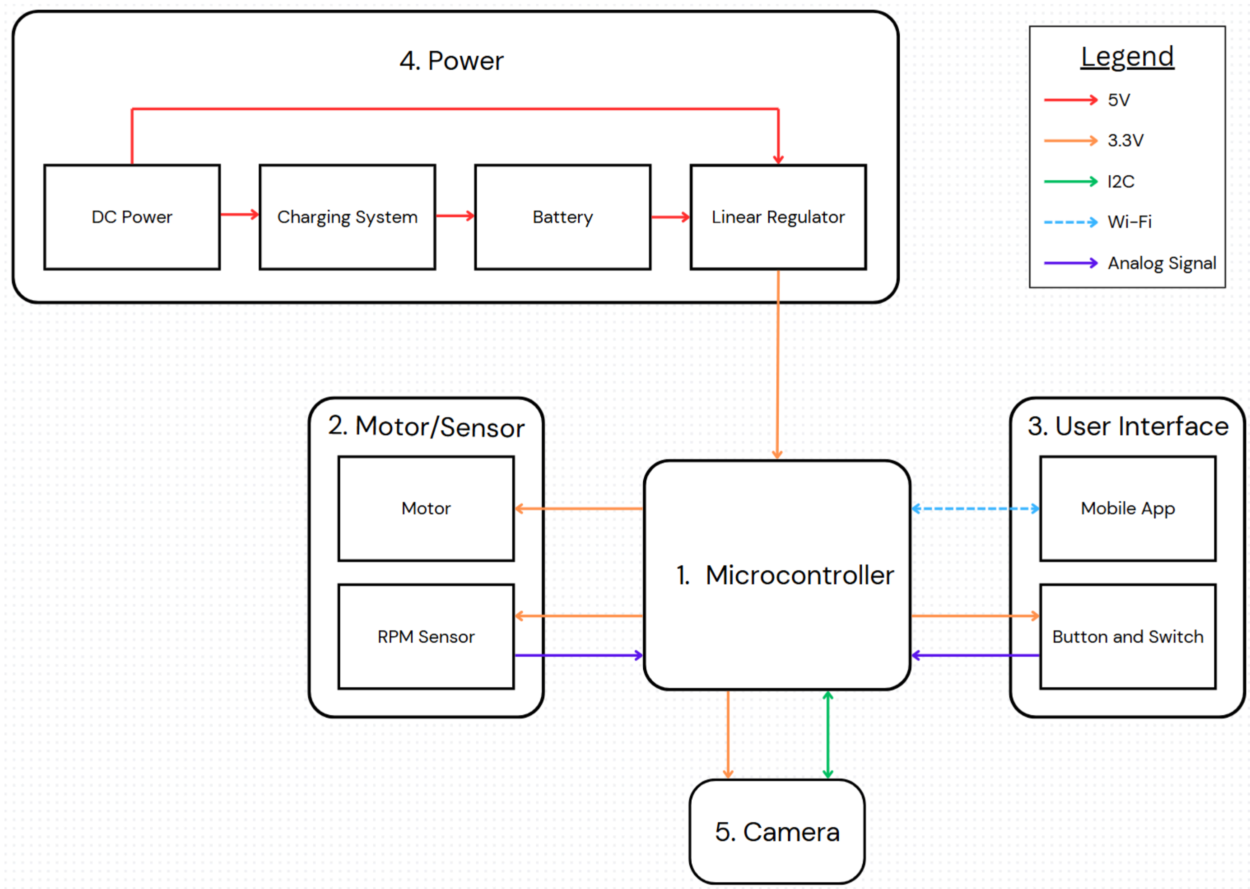

Figure 3: Block Diagram

Functional Overview & Block Diagram Requirements

Microcontroller Subsystem

The microcontroller subsystem manages voltage control for the motor, camera, and hall effect sensor while also handling data communication with the app and camera. The microcontroller subsystem uses an ESP32 microcontroller with wifi capabilities to communicate with the User Interface system. It sends 3.3V to the sources of two 2SJ652 transistors. The drains of the transistors are connected to the motor and camera. When the camera button is selected on the app a signal is sent from the ESP32 to the gate of the transistor, allowing for voltage to be delivered to the camera subsystem. Similarly, if the manual feed button is pressed, the feed button on the app is pressed, or scheduled feed time is reached, a signal is sent to the gate of the other transistor and 3.3V is sent to the motor. When the camera is powered, it will send data to the ESP32 through I2C. The hall effect sensor will always be powered and read by the ESP32.

Requirements	**Verification**
The ESP32 microcontroller must be able to communicate over I^2C serial protocols with the camera.	● Connect an oscilloscope that reads I2C signals in between one of the data pins connecting the OV7670 and ESP32. ● Ensure that the oscilloscope reading confirms I2C communication. ● Repeat for each data pins on the OV7670.
The ESP32 microcontroller must be able to communicate over Wi-Fi to the app.	● Turn the feeder on by flipping the power switch. ● Open the app. ● Verify the “Wifi Connected” symbol is visible on the app.
The ESP32 microcontroller must be able to communicate through analog signals from the manual feed button and hall effect sensor.	● Connect a voltmeter on the output pin of hall effect sensor ● Ensure that the voltage changes when a magnetic field is present ● Connect a voltmeter on the output pin of the manual feed button ● Ensure that the voltage is 3.3V once the manual feed button is pressed
The ESP32 microcontroller must only send 3.3V +/- 0.1V to the camera when the option is selected on the app.	● Connect a voltmeter to the drain of the transistor connected to the camera. ● Ensure that 0V +/- 0.2V is being read on the voltmeter. ● Select the camera icon on the app. ● Ensure that 3.3V +/- 0.2V is being read on the voltmeter.

The ESP32 microcontroller must only send 3.3V +/- 0.1V to the motor when the manual feed button is selected or when the scheduled time is reached.	- Connect a voltmeter to the drain of the transistor connected to the camera. - Ensure that 0V +/- 0.2V is being read on the voltmeter. - Select the camera option on the app. - Ensure that 3.3V +/- 0.2V is being read on the voltmeter.

Motor and Sensor Subsystem

This subsystem will consist of a 6V micro metal gearmotor that will be connected to the main PCB via a relay [1]. The relay will take input power from the linear regulator and a signal to switch on from the ESP32. The output shaft will hold the container of food. This container will have a magnet on the rotating section so that a Hall effect sensor can detect when it rotates to ensure that the food actually dispensed.

Requirements	**Verification**
3.3 V +/- 0.1 V is successfully supplied to the motor from the ESP32 when the feed button is pressed.	- Connect a multimeter on the gate of the transistor. - Press the feed button. - Ensure that 3.3V +/- 0.1V is being read on the voltmeter.
3.3 V +/- 0.1 V is successfully supplied to the motor from the ESP32 when the scheduled feed times are reached.	- Connect a multimeter on the gate of the transistor. - Set a scheduled feed time in the app. - Ensure that 3.3V +/- 0.1V is being read on the voltmeter.
The motor successfully completes a minimum rotation of 360-degrees once triggered from the ESP32.	- Mark starting position of container with a piece of tape. - Select the manual feed button and allow to complete the feed cycle. - Measure end point. End point should be the same as the start point.

The motor successfully stops within 2 seconds once the Hall effect sensor is triggered via the magnet inside the rotating cylinder.	● Connect multimeter to Hall effect sensor output. ● Press the manual feed button. ● Once Hall effect value raises or lowers from the value at any degree other than 0 degrees, start stopwatch.

User Interface Subsystem

The user interface subsystem is responsible for performing different actions based on user inputs. The two main parts of this subsystem are the app and the physical button and switch on the feeder. The feeder has a manual feed button on it that if pressed will give the motor power and food will be dispensed. The feeder has a power switch that turns the feeder on and off. The app has the ability to manually feed as well, trigger the camera feed, and set the feeding schedule. When the manual feed button is pressed on the app, a signal is sent from the app to the ESP32 which triggers the motor signal which initiates the feeding procedure. When the camera icon is selected on the app, a signal is sent from the app to the ESP32 which triggers the camera signal and delivers the camera power. The camera will send pixel data back to the ESP32 and the ESP32 will send that data to the app continuously until the camera feed is closed. When a new feeding schedule is set, that data is sent to the ESP32 and the feeding time is updated on the chip's memory. The app also displays information about the feeder such as the remaining power of the backup battery and the estimated amount of food left in the canister.

Requirements	**Verification**
Feeder successfully activates within 3 seconds of the manual feed button press on the app via Wi-Fi.	● Open the app. ● Press the manual feed button on the app. ● Ensure that the feeder dispenses the food within 3 seconds.

The ESP32 microcontroller must only send 3.3V +/- 0.1V to the camera when the option is selected on the app.	● Connect a voltmeter to the drain of the transistor connected to the camera. ● Ensure that 0V +/- 0.2V is being read on the voltmeter. ● Select the camera icon on the app. ● Ensure that 3.3V +/- 0.2V is being read on the voltmeter.
Feeder successfully activates within 3 seconds of the scheduled time set using the app.	● Open the app. ● Choose the Schedule Feeding Time icon. ● Schedule a new feeding time. ● Ensure that the feeder dispenses within 3 seconds of the new feeding time.
Feeder successfully activates within 3 seconds of the manual feed button being pressed on the feeder.	● Press the manual feed button on the feeder. ● Ensure that the feeder dispenses food within 3 seconds.

Power Subsystem

This subsystem will consist of an IC that will be used to switch between AC power and battery power and another IC to control the charging of the battery. The battery would be a LiPo battery that is used as a backup to AC wall power. When AC power is restored, the charge controller will calculate how much charge is needed to put 100% charge in the battery. When AC power is available, the unit will use AC power. The battery will solely be for a backup.

Requirements	**Verification**
5V drawn from the wall is converted to 3.3V +/- 0.1V after going through the linear regulator	● Connect a multimeter to the output of the linear regulator. ● Unplug the battery and plug in wall adapter. ● Ensure that 3.3V +/- 0.1V is being read on the voltmeter.

When wall power is unavailable, the feeder successfully switches to battery power.	● Connect a multimeter to the output of the linear regulator. ● Unplug the wall adapter and plug in a fully charged battery. ● Ensure that 3.3V +/- 0.1V is being read on the voltmeter.
The power subsystem supplies a stable voltage of 3.3 V +/- 0.1 V and 400 mA to the system, even with the temporary loss of AC power.	● Connect a multimeter to the output of the linear regulator. ● Have both the wall adapter and battery sockets plugged in. ● Simultaneously unplug and plug in wall adapter. ● Ensure that 3.3V +/- 0.1V is being read on the voltmeter and all the motor is still functioning properly.

Camera Subsystem

The camera subsystem supplies the camera feed that is viewed in the app. The camera module being used is the OV7670. The OV7670 will receive 3.3V from the 2SJ652 transistor drain when the ESP32 sends a signal. When the OV7670 receives power, it sends data back to the ESP32 through the I2C Bus.

Requirements	**Verification**
3.3 V +/- 0.1 V is successfully supplied to the camera module from the ESP32 when the camera icon is selected on the mobile app.	● Connect a voltmeter to the drain of the transistor connected to the camera. ● Ensure that 0V +/- 0.2V is being read on the voltmeter. ● Select the camera option on the app. ● Ensure that 3.3V +/- 0.2V is being read on the voltmeter.
The camera feed is displayed through the mobile app.	● Open the app. ● Choose the Camera Icon. ● Ensure that the camera feed is properly displayed.

Tolerance Analysis

One major area for concern that would be detrimental to the operation of the feeder would be heat. One major contributor to heat would be the linear regulator, which steps the voltage down to 3.3 V. If the heat dissipating off of the linear regulator is too high, this can cause the PCB to heat up other components, including the microcontroller. We will take this into consideration and find the maximum wattage that the linear regulator can handle and find the heat created from it at that state. The linear regulator we will be using is a Texas Instruments TLV75533PDBVR. This chip will provide 3.3 V up to half of an amp, which will be a good level for what we need [3]. We know that we will not be reaching this amperage, as the ESP32 will pull a max of 250 mA [4].

First, we will find the maximum power out with the equation below:

$$P = i_{out} * (V_{in} - V_{out})$$

We also know that via the datasheet, the max current is 0.5A and the max input voltage we will be using is 5V, so let us leave some error in the wall DC adapter and use 5.1V. The output voltage will be a fixed 3.3V.

$$P = 0.5\,A * (5.1V - 3.3V)$$

$$P = 0.5\,A * (5.1V - 3.3V)$$

$$P = 0.9\,W$$

Therefore our max power produced will be 0.9W. We can now use this number to calculate the junction temperature of this voltage via the following equation:

$$T_j = P(\Theta_{jc} + \Theta_{ca}) + T_a$$

Where

$T_j(max) = 150\,°C$ via datasheet [3]

$P = 0.9W$

$T_a = 35\,°C$ ambient temperature max

$\Theta_{jc} = 34.3\,°C$ via datasheet [3]

$\Theta_{ca} = 92.5\,°C$ via datasheet [3]

Therefore,

$$T_j = 0.9W * (34.3\,°C + 92.5\,°C) + 48\,°C$$

$$T_j = 0.9W * (34.3\,°C + 92.5\,°C) + 35\,°C$$

$$T_j = 149.12\,°C$$

This indicates that we will meet the maximum thermal requirements for the chip itself, thus there should be no thermal issues with the design due to the linear regulator.

3. Cost and Schedule

Cost Analysis

Description	Manufacturer	Part Number	Quantity	Extended Price
USB-C Port	CUI Devices	UJC-HP-3-SMT-TR	1	$0.75
LiPo Charger	Texas Instruments	BQ21040DBVR	1	$0.52
LiPo Battery	Jauch Quartz	LP503562JU+PCM+2 WIRES 50MM	1	$11.40
PMOS Transistor	Onsemi	2SJ652-1E	2	$4.25
Camera	OmniVision	OV7670	1	$4.50
Linear Regulator	Diodes Incorporated	AP2112K-3.3TRG1	1	$0.56
BJT	Comchip	SS8050-G	2	$0.48
ESP-32	Espressif Systems	ESP32-S3-WROOM-1	1	$5.06
Hall Effect Sensor	SING F LTD	49E	1	$0.59
1kohm Resistor	Stackpole Electronics Inc	RMCF0805JT1K00	5	$0.50
10kohm Resistor	Stackpole Electronics Inc	RMCF0805JG10K0	8	$0.80
100kohm Resistor	Stackpole Electronics Inc	RMCF0805JT100K	2	$0.20
1uF Capacitor	Samsung Electro-Mechanics	CL21B105KBFNNNG	6	$0.60
10uF Capacitor	Murata Electronics	GRM21BR61H106ME43L	1	$0.26
0.1uF Capacitor	Samsung Electro-Mechanics	CL21F104ZAANNNC	1	$0.10
Rare Earth Magnet	TRYMAG	X003716VW9	1	$0.05
Micro Metal Gear Motor	Fielect	GA12-N20	1	$10.35

Push Button	C&K	PTS645SL43-2 LFS	3	$0.66
PCB Bare Connector	Wurth Elektronik	61300811121	2	$0.72
4-pin Connector Female	Molex	0039299043	1	$0.54
4-pin Connector Male	Molex	0039012040	1	$0.27
10 Pin Connector	Amphernol	10056845-110LF	2	$2.62
Misc Wire	N/A	N/A	1	$5
Printer Filament	OVERTURE	850006233403	1	$15.99

Table : Cost of Parts

Total Cost of Parts: $66.70
Quoted Machine Shop Labor Hours and Cost: 7.5hrs per day 3 days - $1262.70
Estimated Engineering Man Hours: 220 hours @ $100/hour: $2200

Grand Total: $3529.40

Schedule

Week	Task	Person
2/2/25 - 2/8/25	Start initial PCB design	Colby
	Research app control of ESP32	Brandon
	Talk to Machine Shop about motor and container	Colby
2/9/25 - 2/15/25	Project Proposal (2/13 11:59 PM)	Everyone
	Team Contract (2/14 11:59 PM)	Everyone
2/16/25 - 2/22/25	Proposal Review (2/17 10:00 AM)	Everyone
	Work on camera communication with ESP32	Jeremy/Brandon
2/23/25 - 3/1/25	Order parts	Colby
	Obtain parts from self-service	Everyone
3/2/25 - 3/8/25	Finalize initial PCB design	Colby

	First Round PCBway Orders (3/3 4:45 PM)	Colby
	Design Document (3/6 11:59 PM)	Everyone
	Get design working on breadboard	Everyone
3/9/25 - 3/15/25	Finish camera communication with ESP32	Jeremy
	Start developing the app	Brandon
	Make revisions to PCB design	Colby
	Second Round PCBway Orders (3/13 4:45 PM)	Colby
3/16/25 - 3/22/25	Spring Break	Everyone
3/23/25 - 3/29/25	Continue work on the app	Brandon
	Make revisions to PCB design	Colby
3/30/25 - 4/5/25	Third Round PCBway Orders (3/31 4:45 PM)	Colby
	Individual progress reports (4/2 11:59 PM)	Everyone
	Get camera feed to display on app	Jeremy
	Finish app	Brandon
4/6/25 - 4/12/25	Finalize and test design	Everyone
	Fourth Round PCBway Orders (4/7 4:45 PM)	Colby
4/13/25 - 4/19/25	Fix existing bugs	Everyone
	Team Contract Assessment (4/18 11:59 PM)	Everyone
4/20/25 - 4/26/25	Mock Demo (4/21 1:00 PM)	Everyone
4/27/25 - 5/3/25	Final Demo	Everyone
	Work on final paper	Everyone
	Mock Presentation	Everyone
5/4/25 - 5/10/25	Final Presentation	Everyone
	Final Papers (5/7 11:59 PM)	Everyone

Table : Schedule for Project

4. Ethics and Safety

Ethical Concerns

One ethical concern with our fish feeder is that it takes away the hands-on interaction between the owner and their fish. When people feed their fish manually, they are not just giving them food. They are also checking in on their health, noticing any changes in behavior, and building a sense of responsibility. This fish feeder removes that connection, allowing oversight when it comes to issues like illness or poor water conditions. Also, feeding fish can be a calming, enjoyable routine for the owner that alleviates feelings like anxiety or stress [5]. However, the implementation of the camera in our design will hopefully mitigate some aspects of this concern as the owner will be able to check in on the fish when they are away.

Safety Concerns

One safety concern is overfeeding, which can harm the fish's health and disrupt the balance of their environment. Overfeeding can lead to excess waste and water contamination which would lead to ammonia and nitride buildup that would contaminate the ecosystem of the fish tank [6]. However, if the owner properly schedules the feeding times via the app, they should not have to worry about this concern since our design will ensure that the fish is fed on time. Another safety concern is that electronics will be near the water of the fish tank, but the feeder will be fully enclosed to ensure that no water comes into contact with the inner circuits. Also, we will make sure that the clamps that we use are strong enough for the weight of the feeder and camera so that there is no concern of them falling in the water.

References

[1] “Pololu - Micro Metal Gearmotors,” *www.pololu.com*.

https://www.pololu.com/category/60/micro-metal-gearmotors

[2] “Advanced Information Preliminary Datasheet OV7670/OV7171 CMOS VGA (640x480) CAMERACHIP TM with OmniPixel ® Technology,” 2005. Accessed: Feb. 13, 2025. [Online]. Available:

https://www.olimex.com/Products/Components/Camera/CAMERA-OV7670/resources/OV7670.pdf

[3] “LM3940 1-A Low-Dropout Regulator for 5-V to 3.3-V Conversion Input Voltage Range: 4.5 V to 5.5 V • Output Voltage Specified over Temperature • Excellent Load Regulation • Specified 1-A Output Current • Requires only One External Component • Built-in Protection against Excess Temperature • Short-Circuit Protected 2 Applications • Laptop and Desktop Computers • Logic Systems 3 Description.” Accessed: Feb. 13, 2025. [Online]. Available:

https://www.ti.com/lit/ds/symlink/lm3940.pdf?ts=1739371712085&ref_url=https%253A%252F%252Fwww.mouser.es%252F

[4] “ESP32C3MINI1 ESP32C3MINI1U Datasheet Smallsized 2.4 GHz WiFi (802.11 b/g/n) and Bluetooth ® 5 module Built around ESP32C3 series of SoCs, RISCV singlecore microprocessor 4 MB flash in chip package 15 GPIOs Onboard PCB antenna or external antenna connector ESP32C3MINI1 ESP32C3MINI1U.” Available:

https://www.espressif.com/sites/default/files/documentation/esp32-c3-mini-1_datasheet_en.pdf

[5] H. Clements *et al.*, “The effects of interacting with fish in aquariums on human health and well-being: A systematic review,” *PLOS ONE*, vol. 14, no. 7, p. e0220524, Jul. 2019, doi: https://doi.org/10.1371/journal.pone.0220524.

[6] “PetCoach - Ask a Vet Online for Free, 24/7,” *Petcoach.co*, 2019. https://www.petcoach.co/article/why-overfeeding-fish-is-a-problem-and-how-to-avoid-it/