Rodent Deterrent and Classification System

Design Document

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Team 55

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1. Introduction

1.1: Problem

Every summer and fall, thousands of backyards, lawns, golf courses and open grass fields suffer from rodents and birds digging the ground searching for earthworms, soil-dwelling insects, and insect larvae. This leaves behind large patches of loose turf and ruins the grass. Not only is this a huge problem for the grass farming industry but is also a nuisance for every backyard owner, ruining the aesthetics and plants grown on the lawn. The current deterrent methods are technologically naive including just a motion sensor, lights and loud sounds which cause loud noises at night, fail to prevent lawn digging, and leave the user unaware of the type of rodent affecting their lawn.

1.2: Solution

We propose a rodent detection and deterrent system which comprises many parts. Using infrared and ultrasonic sensors on a rotating servo, we would detect any rodent outside of the usual landscape of the lawn the device is placed in. The PI camera system would simultaneously work to take a clean shot of the rodent/bird and store it in the file system. If recognized to be a ground digging rodent, for the actual deterrent, our colored lights and localized speaker beeps go in the direction of the rodent rather than in a single direction like previously commercialized methods. This ensures rodent deterrence and also informs the user the type of animals responsible for digging their lawn.

1.3: High Level Requirements

1. The system must be able to successfully and accurately detect rodents with > 90% success rate and also avoid false detections based on other movements in the environment (eg. person walking, dog running).
2. Components should have high durability and battery capacity to ensure a long lasting solution (battery life of up to a month).
3. Sensors should be capable of detecting at a relatively long range while also being able to scan a large field of view (360° field of view and 10m radius).

1.4: Visual Aid

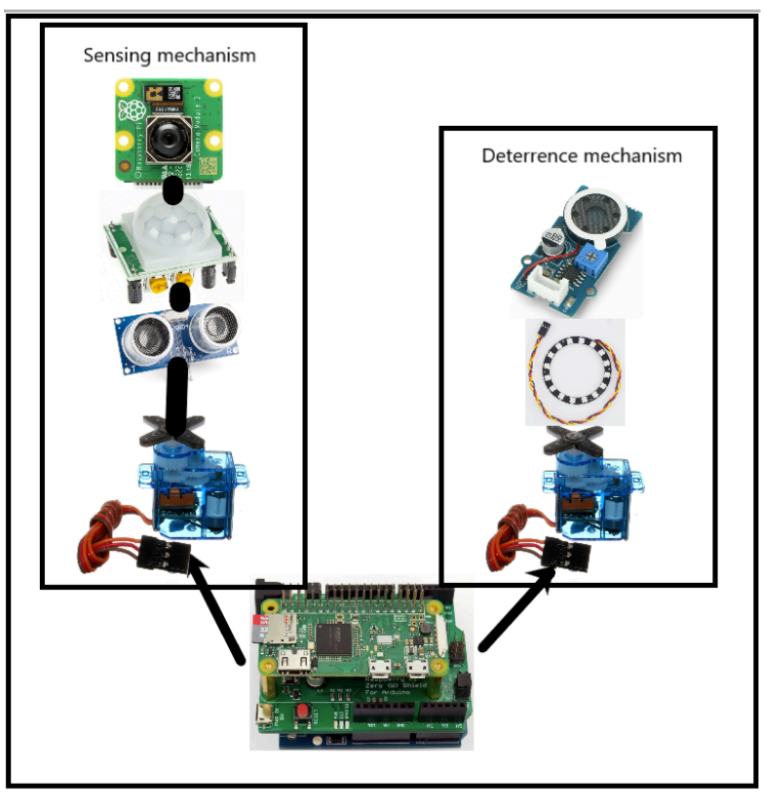


Figure 1: Visual Aid

2. Design

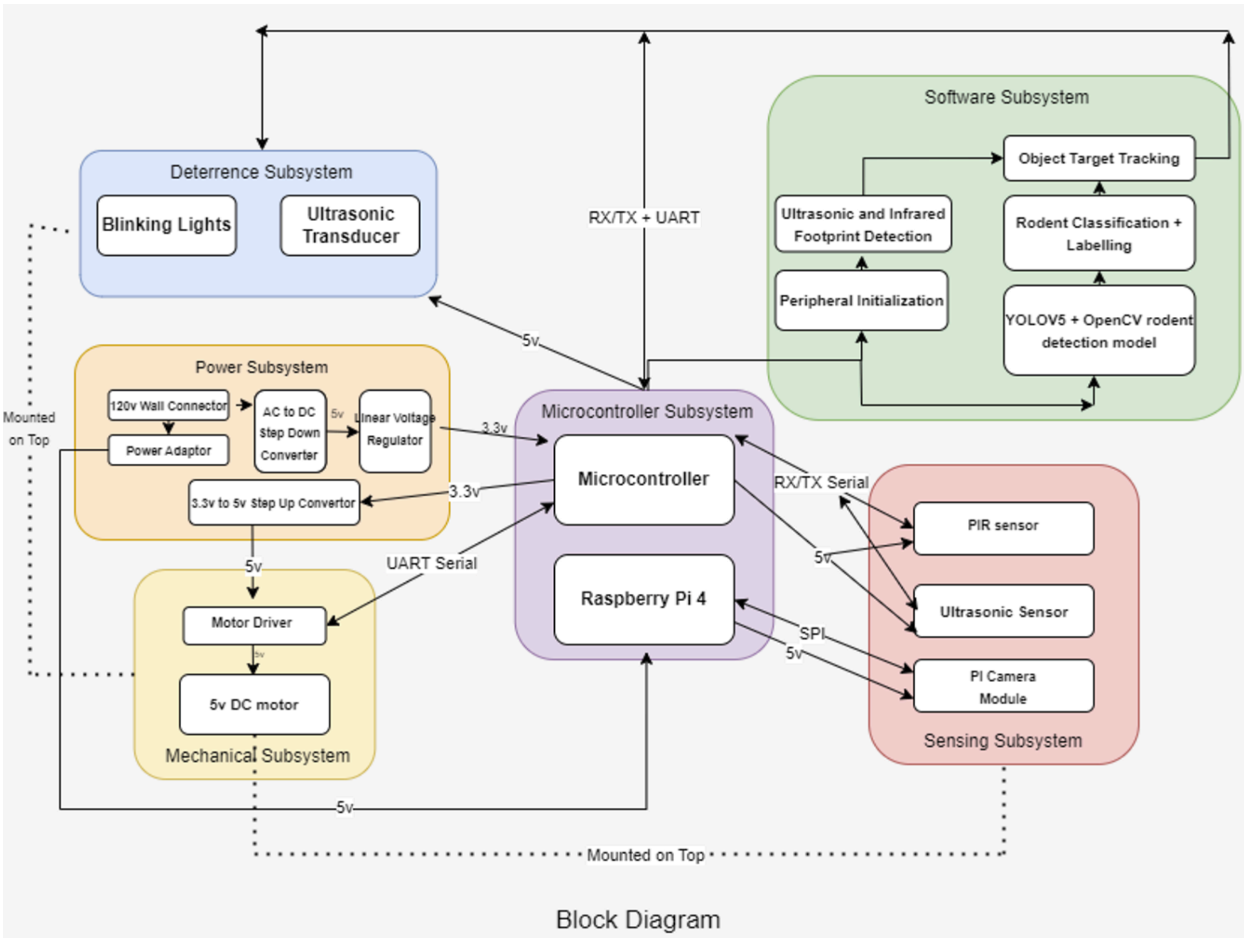


Figure 2: Block Diagram of Deterrent System

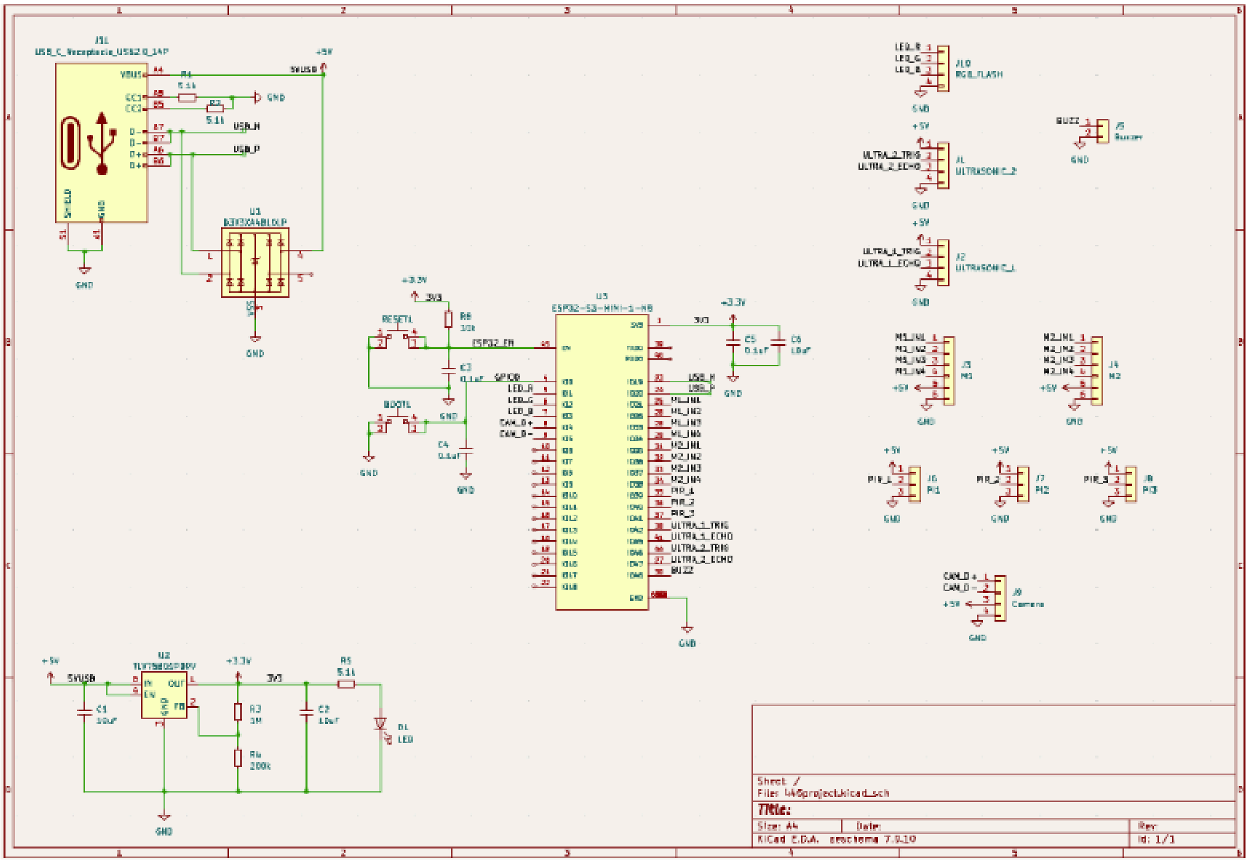


Figure 3: Final PCB Design

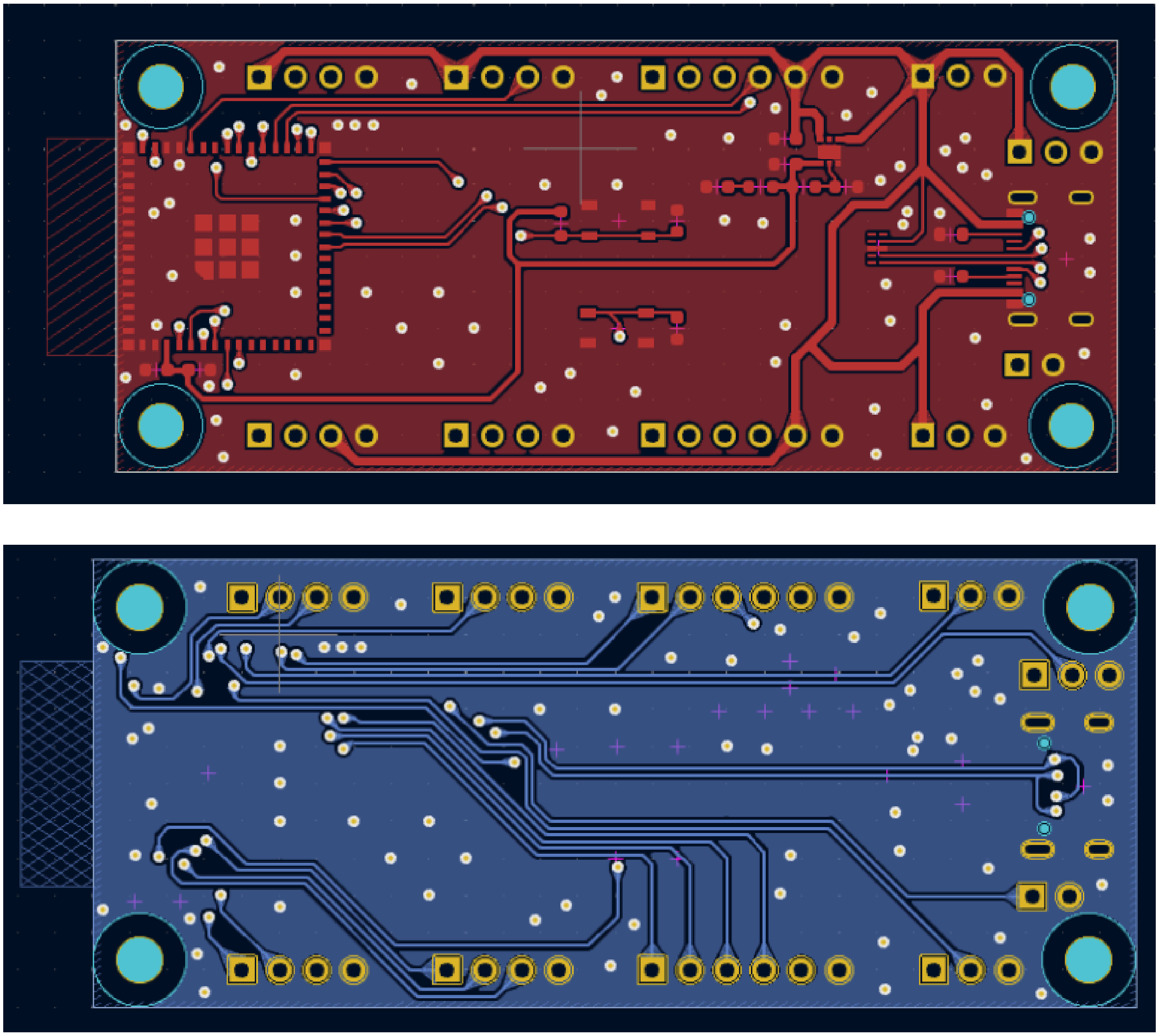


Figure 4: PCB Wirings

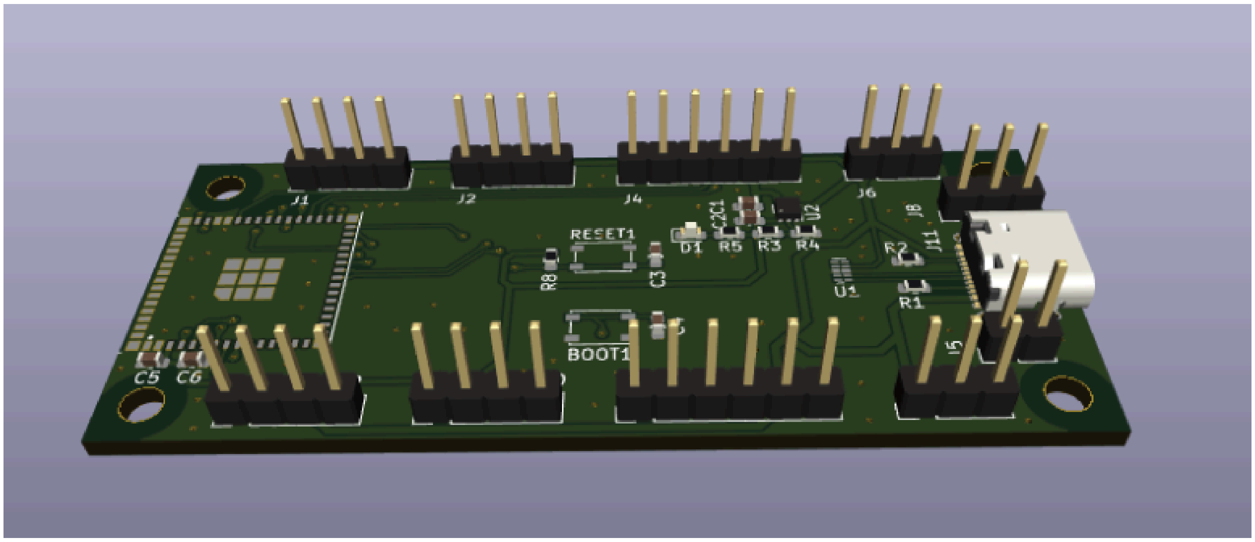


Figure 4: PCB Model

3. Subsystems

3.1: Subsystem Overview

This project consists of several integral subsystems that our team needs to build to ensure the success of this project (See Figure 2 for visual diagram of our system). These subsystems will need to work together to reach our goal of deterring rodents. Our system is comprised of 6 core subsystems:

1. **Deterrent Subsystem**
2. **Microcontroller Subsystem**
3. **Software Subsystem**

4. **Power Subsystem**
5. **Mechanical Subsystem**
6. **Sensor Subsystem**

For each of the subsystems, we will briefly discuss their importance within the whole scope of the project, while also discussing essential requirements we need from components that are core to the subsystems. Lastly, we discuss how the team will verify each of the subsystem requirements in a procedural manner.

3.1.1: Deterrent Subsystem

The deterrent subsystem receives signals from the sensory and microcontroller subsystem. When the sensory subsystem detects a rodent, the sensory subsystem and the microcontroller subsystem sends appropriate signals, activating the deterrent system. The deterrent subsystem is core to our entire system, and the success of this subsystem relies heavily on the success and reliability of the devices we are using. Therefore, this subsystem requires heavy attention and thoughtfulness in its design.

a. **Lights**
    i. When the deterrent system detects a rodent, the system should produce a lighting mechanism to startle the rodent.

#	Requirements	Verification
1	The lights should be red and flashing in 0.2s intervals	● Set up the lights according to the specified configuration (red color, flashing at 0.2s intervals). ● Use a stopwatch or timing device to measure the duration of each flash. ● Confirm that the lights flash at intervals of 0.2 seconds consistently by observing multiple cycles of flashing. ● Record the timing of each flash and calculate the average interval to ensure compliance with the requirement. ● Repeat the verification process multiple times to ensure consistency and reliability of the flashing pattern.
2	The lights should have a capacity to reach 500 nits	● Use a photometer or light meter capable of measuring luminance ● Initially position the sensor of the light meter within the industry standard of 10-50 cm from the lights. ● Activate the lights and measure the luminance emitted by the lights. ● Record the luminance value and compare ● Repeat the measurement process from steps 3 at varied distances to account for variations in light intensity.
3	The lights require 20mA current and should be gated to create flashing	● Measure the current flowing through the lights using a multimeter or current probe. ● Connect the lights to a power source capable of supplying the required current. ● Verify that the current drawn by the lights does not exceed 20mA

		during operation. ● Use an oscilloscope or logic analyzer to observe the gating signal applied to the lights for flashing. ● Confirm that the gating signal effectively controls the on-off cycling of the lights to create the flashing effect. ● Ensure that the gating signal maintains the specified flashing pattern (0.2s intervals) consistently. ● Validate the performance of the gating mechanism under different operating conditions and loads.

b. **Speaker**

i. When the deterrent system detects a rodent, the speaker should produce sounds that repels the rodent. The sounds should be outside the human hearing scale such that the deterrent system won't be an annoyance to the users. Furthermore, the speakers should vary their frequency range such that the rodents don't become used to the sounds.

#	Requirements	Verification
1	The frequency at which the speaker sound should be at should above between 20kHz and 60kHz	● Use a frequency analyzer or spectrum analyzer capable of measuring ultrasonic frequencies. ● Power the speaker and play the sound ● Use the frequency analyzer to measure the output frequency of

		the speaker ● Verify that the measured frequencies fall within the specified range (20kHz to 60kHz). ● Repeat the frequency measurement to ensure consistency.
2	The speaker should be able to reach ranges up to 5m	● Set up the speaker and a sound level meter at a known distance (e.g., 5 meters) apart in an open space. ● Generate a sound signal with a constant intensity level through the speaker. ● Measure the sound pressure level (SPL) at the specified distance using the sound level meter. ● Verify that the measured SPL meets the specified threshold for audibility at the given distance. ● Repeat the measurement at different distances to confirm the range capability of the speaker
3	The speaker should have a minimum strength of 60 dB	● Use a sound level meter to measure the output strength (sound pressure level) of the speaker. ● Generate a sound signal with a constant intensity level through the speaker. ● Measure the SPL at a specified distance from the speaker. ● Verify that the measured SPL exceeds the specified minimum threshold of 60 dB. ● Repeat the measurement at different distances to record strength fall off

4	The speaker should have a current source that doesn't exceed 50 mA given a 5V power source	- Connect the speaker to a 5V power source. - Measure the current passing through the speaker using a multimeter. - Ensure that the measured current does not exceed 50 mA. - Repeat the measurement multiple times to confirm consistency. - Document the results and compare them against the specified requirement.
5	The speaker should be randomly vary the timing of the bursts of ultrasonic sound waves	- Use an oscilloscope or logic analyzer to monitor the timing of the bursts of ultrasonic sound waves generated by the speaker. - Play a series of sound signals through the speaker and observe the timing of the bursts. - Verify that the timing of the bursts exhibits random variation, with no discernible pattern or repetition. - Analyze the waveform to confirm that the bursts occur at irregular intervals, as required by the specification. - Repeat the verification process multiple times to ensure consistent random variation in timing

ADD SPEAKER (SONIC)

ADD SCHEMATIC

3.1.2: Microcontroller + Communication Subsystem

The microcontroller will process all the information with lowest possible latency and integrate the sensors with the deterrence system. The success of the microcontroller is integral, as it will serve as the middle-man for passing critical information from the software subsystem, to the deterrence and power subsystems. Furthermore, the microcontroller is also essential for translating the data from our sensor subsystem, to the software subsystem, such that the software subsystem can perform at the highest level. Although the microcontrollers themselves that we are using for our design is off-the-shelves, we do include requirements that we need from our microcontrollers for this subsystem to successfully work

#	Requirements	Verification
1	Microcontroller should have communication interfaces capable of at least 1 Mb`ps for UART, 10 Mbps for SPI, and 400kHz for I2C	• Connect the microcontroller to a compatible device for UART, SPI, and I2C communication. • Transmit and receive data through each communication interface while measuring the transfer speed. • Use a suitable measuring device or protocol analyzer to monitor the data transfer rate. • Verify that the UART communication achieves a minimum speed of 1 Mbps, SPI achieves 10 Mbps, and I2C achieves 400 kHz.

2	Microcontroller should support USB 3.0 for high communication protocols for data transfers of at least 100 Mbps	● Connect the microcontroller to a USB 3.0 compatible device or host. ● Transfer data between the microcontroller and the USB host while measuring the data transfer rate. ● Use appropriate tools or software to monitor the USB data transfer speed. ● Verify that the microcontroller supports USB 3.0 and achieves a minimum data transfer rate of 100 Mbps. ● Ensure that the USB communication remains stable and reliable during the verification process.
3	Microcontroller should have processing speed of at least 100 MHz to handle real-time data processing and communication efficiency	● Execute real-time data processing tasks and communication protocols on the microcontroller. ● Measure the execution time of critical operations or algorithms using a stopwatch or timing device. ● Verify that the microcontroller can complete essential tasks within the specified time constraints. ● Monitor the microcontroller's clock frequency during operation to ensure it operates at or above 100 MHz.
4	Microcontroller should have minimum RAM of 32 KB and minimum flash memory capacity of 256 KB to store program and code data	● Access the microcontroller's datasheet or specifications to confirm the RAM and flash memory capacity. ● Utilize debugging tools or software to retrieve information about the microcontroller's memory resources. ● Verify that the microcontroller's RAM capacity is at least 32 KB

		and flash memory capacity is at least 256 KB. ● Allocate and store program code and data on the microcontroller to ensure it fits within the available memory

ADD SCHEMATIC

3.1.3: Software Subsystem

The software subsystem's success is essential to our whole project succeeding. The software subsystem will work side by side with data provided from any sensors module (which is given by our microcontroller subsystem) to ensure that the tracking of the rodents is accurate and effective. The software will perform analysis on the live feed of the camera sensors as a means of detecting and tracking the rodent. The vision detection should occur with low latency, such that the analysis can essentially be done in real time. The goal in the end of this subsystem is to identify the rodent within the view accurately. Figure 3 shows a high level flow diagram of how the software subsystem will work. The model we will create will be trained on a robust dataset and be processed using open source databases and libraries like OpenCV and PyTorch. The model will be extensively tested using the dataset to tune and analyze its performance. In the end, the results of the software subsystem will provide signals to the other modules.

#	Requirements	Verification
1	Software should detect rodent with +95% accuracy	● Set up a testing environment with representative input data for rodent detection ● Pass in random images from the rodent image dataset to the model ● Measure the accuracy and F1

		score for the run ● Repeat the testing with different input images to ensure robustness and reliability ● Collect data and see if the accuracy exceeds the specified amount
2	The detection time should be done in real time and should have latencies lower than 0.1s	● Set up a testing environment with representative input data for rodent detection. ● Implement the rodent detection algorithm or model on the software subsystem. ● Simulate the detection process with various inputs representing different scenarios and conditions. ● Measure the time taken for the software to process each input and detect the presence of a rodent. ● Verify that the detection latency is consistently lower than 0.1s for all test cases. ● Repeat the testing with different input configurations to ensure robustness and reliability of real-time detection.
3	Require a database of at least 1000 images of rodent to train vision model on	● Collect or curate a dataset comprising at least 1000 images of rodents for training the vision model. ● Ensure that the dataset includes diverse images representing various rodent species, poses, environments, and lighting conditions. ● Verify the integrity and quality of the images in the dataset to ensure suitability for training. ● Use data validation techniques to confirm that the dataset meets the specified quantity requirement. ● Perform statistical analysis to ensure the dataset's diversity and

		representativeness for effective model training. ● Document the sources of the images and any preprocessing steps applied to the dataset for transparency and reproducibility.
4	Data should be constantly publishing information for other subsystems to use	● Implement data publishing functionality within the software subsystem to continuously transmit relevant information. ● Set up a data monitoring system to track the publication of information in real-time. ● Subscribe other subsystems or modules to receive the published data streams. ● Monitor the data flow between subsystems and verify that information is consistently published at regular intervals. ● Perform stress testing to evaluate the software's ability to maintain continuous data publishing under varying loads and conditions. ● Ensure that the published data is accurate, relevant, and up-to-date for consumption by other subsystems. ● Validate the interoperability of the software subsystem with other components by confirming successful data reception and utilization by downstream systems

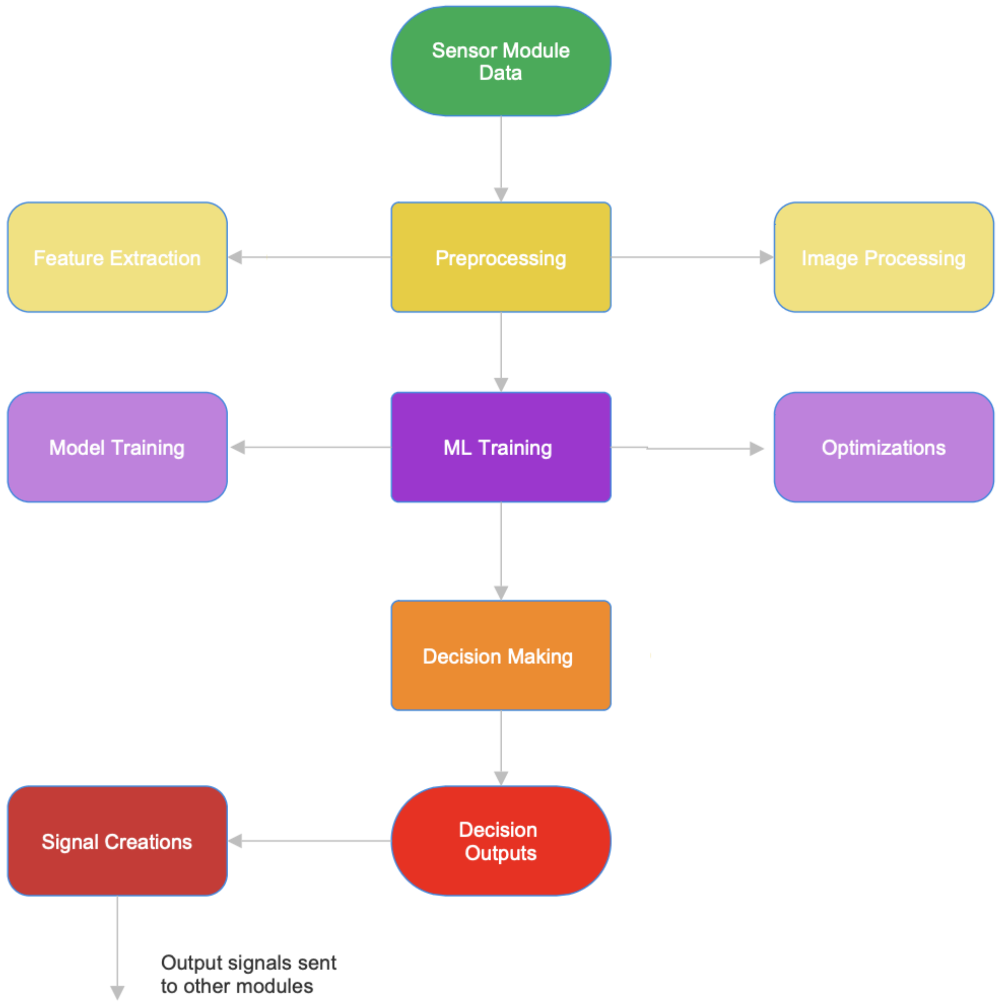


Figure 6: Software Detection High Level Overview

ADD DRAWING

3.1.4: Power Subsystem

The power subsystem is responsible for generating, storing, regulating, distributing, and managing electrical power to ensure the proper functioning of onboard systems and instruments. This system includes using a 120v wall connector and then using multiple power adaptors, voltage regulators, 5v to 3.3 step up and step down converters.

#	Requirements	Verification
1	The power is set to ensure overcurrent protection, overvoltage protection, and thermal management to prevent damage to electrical components and ensure safe operation.	● Review the design and specifications of the power subsystem to ensure it includes overcurrent protection mechanisms such as fuses or circuit breakers. ● Verify the presence of overvoltage protection components such as voltage regulators or surge protectors in the power supply circuitry. ● Test the thermal management system under various operating conditions to ensure it effectively dissipates heat and prevents components from overheating. ● Conduct stress tests and fault simulations to confirm that the protection mechanisms trigger appropriately in case of overcurrent, overvoltage, or thermal issues. ● Measure the temperature, voltage, and current levels at critical points in the power subsystem during operation to validate compliance with safety standards and specifications
2	Using power from a wall connector ensures continuous power to all the subsystems and rotation of the sensors mounted on top of servos.	● Test the protection circuits for handling overcurrent and overvoltage conditions. ● Monitor the temperature of the regulators during operation to ensure they do not exceed thermal limits. ● Perform tests to confirm that the step-up and step-down regulators maintain a stable output voltage under varying load conditions. ● See if a system performs well with power surges and outages in

		the wall connection and does now damage other subsystems.

ADD SCHEMATIC

3.1.5: Mechanical Subsystem

The mechanical subsystem involves any of our parts that requires any movement. In the scope of this project, this includes all the rotors and servos that will move our device so that it is able to scan the entire area. Ensuring these mechanical components work are important, as we want to ensure we can scan the entire field of view.

#	Requirements	Verification
1	The rotor should have a minimal RPM of 10 RPM to allow for continual monitoring of the environment	● Install the rotor in the intended environment and measure its rotational speed using appropriate sensors or instrumentation. ● Validate that the rotor consistently maintains a minimum RPM of 10 RPM under various operating conditions. ● Monitor the rotor speed continuously over an extended period to confirm its suitability for continual monitoring. ● Conduct performance tests to ensure that the rotor speed remains stable and within the specified range during operation

2	Servos should have a MTBF (mean time between failures) of 10,000 hours to ensure the servos are capable of constant activation and maintaining performance	• Gather reliability data for the servos or reference similar models with known MTBF values. • Conduct accelerated life tests on a sample of servos to estimate their failure rate over time. • Analyze the test results to calculate the MTBF and compare it against the specified requirement of 10,000 hours. • Verify that the servos demonstrate reliability and durability through extended operation without significant degradation or failures. • Implement monitoring and maintenance procedures to track servo performance and address any issues that may arise during operation
3	The platform, which consists of the necessary systems (sensors, camera etc.), should be able to withstand at least 10 N of force such as to prevent dislodgement.	• Apply a controlled force of at least 10 N to the platform in different directions to simulate potential dislodgement scenarios. • Inspect the platform and its mounting mechanisms for any signs of damage or deformation after applying the force. • Repeat the force tests multiple times to ensure repeatability and consistency of results. • Verify that the platform remains securely attached and functional after exposure to the specified force levels. • Consider environmental factors such as vibration, shock, and temperature variations during the verification process. • Make any necessary design adjustments or reinforcements based on the test results to enhance the platform's stability and durability.

3.1.6: Sensor Subsystem

The sensor subsystem is essential to our project. It will feature an array of sensors that we will congregate to ensure that we can accurately track the rodent. Furthermore, the need for multiple sensors acts as a failsafe, to ensure that we can still perform the task should any of the other sensors be inhibited in doing their job. The data from these sensors will interact directly with the microcontrollers of our system, which will pass the data onto our software subsystem. The parts within the sensor subsystem feature off-the-shelf items, so we won't mention any requirements and verifications.

4. Tolerance Analysis

We need to make sure that we have constant power for the spinning DC motors and the sensing systems. Thus we decided to go with a constant wall power supply instead of a battery for the longevity and smooth operation of the subsystems. However, this means that we need to carefully measure the voltage going into the subsystems to not damage any components.

We plan on using a 120v input, which supplies power from an ac to dc converter and reduces the voltage to a stable 5v output. We then feed this output to a linear voltage regulator stepping it further down to 3.3 volts, suitable for an arduino. The regulator has a tolerance of ±2%, giving is a range between 3.24 to 3.36 volts. The regulator also ensures that systems are not damaged due to power surges or outages. The Arduino and Raspberry Pi get power form this regulated voltage, ensuring that sensors and motors receive consistent power. The Arduino operates within a range of 2.7V to 5.5V, 3.3v for input, whereas the Raspberry Pi needs a strict 5V ±5% tolerance, thus needing an input of 4.75 to 5.25 volts. The power subsystem has 3.3V to 5V step-up and step down converter for components that require a higher/lower voltage with a tolerance of ±5%, resulting in an output voltage of 4.75V to 5.25V. This voltage output is then also compatible with L298 IC with similar tolerance levels.

Aside from this we also wanted to analyze the speaker system, which is crucial to our deterrent system. The speaker system is essential because sound is a proven deterrent mechanism. Irregular sounds can startle rodents, especially when the sound is not common to its environment. However, there is proven research that few species of rodents adapt to these noises, especially if they are played statically, so our team believes that our implementation of the sound system is essential to the effectiveness of our deterrent innovation. Our team has analyzed five core requirements for the speaker subsystem:

1) The frequency range of the speaker should be between 20kHz and 60kHz
2) The speaker should be able to reach ranges of at least 5m
3) The speaker should have an intensity of 60dB at 5m distance
4) The speaker should have a current source that doesn't exceed 50 mA given a 5V power source
5) The speaker should be randomly vary the timing of the bursts of ultrasonic sound waves

Many of the requirements listed are tied to one another. Specifically, depending on the frequency of the speaker we work with, it will affect the breadth of its range, while also affecting its intensity over those distances. The last requirement of these 5 are within our control and can be done systematically, so we will focus on the others first.

Air resistance causes sound waves to lose energy due to air resistance. The loss of energy is quantified by an attenuation coefficient which describes how much the intensity of the sound wave decreases per unit distance traveled. Furthermore, the attenuation of higher frequencies attenuates stronger compared to lower frequencies. This concept is important because we want to make sure that, even at the lowest frequencies that we have in the range, the deterrent system is still effective for the range we listed within the requirements. Furthermore, it is hard to find strong speakers that can be powered by relatively low voltage power sources, so we want to ensure that we can find if lower frequencies satisfy the distances listed in our requirements, since we are more likely to find speakers with lower frequencies.

$$A(f, d) = \alpha(f) \times d$$

Equation 1: Simplified Model of Attenuation of Frequencies in Air

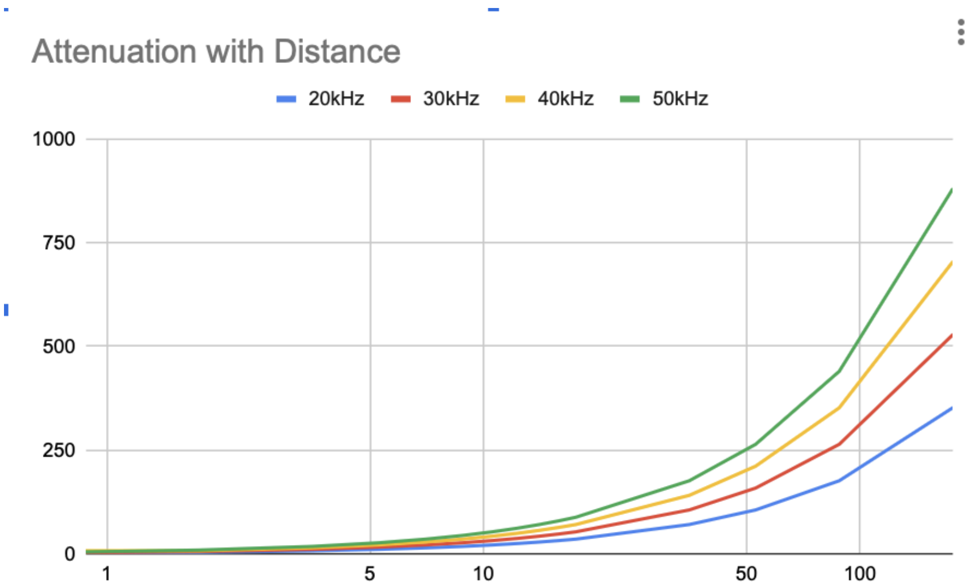
$$\alpha(f) = 2\pi f \left(\frac{2\eta}{\rho}\right) \left[1 + \left(\frac{f}{f_c}\right)^2\right]^{1/2}$$

Equation 2: Equation for the attenuation coefficient

$$A(f, d) = \left(2\pi f \times \frac{2\eta}{\rho} \times \frac{1}{1+\left(\frac{f}{f_c}\right)^2}\right) \times d$$

Equation 3: Combined Equation of Equation 1 and Equation 2

The attenuation of a frequency can be modeled by the equation listed in Equation 1. The equation calculates how much attenuation of the wave has occurred ($A(f,d)$) given the absorption coefficient ($\alpha(f)$) and the distance travelled (d). The absorption coefficient is another function (Equation 2) that measures how much a medium absorbs sound energy per unit distance traveled by the wave. It is dependent on the frequency of the wave (f) , the density of the medium (ρ), the dynamic viscosity of the medium (η) and the relaxation frequency of the medium (f_c). For the sake of the example, we can assume a relaxation frequency of the air to be around 10^9 Hz, a known density of 1.293 kg/m^3 and a dynamic viscosity of 1.81 × 10-5 kg/(m·s).



Graph 1: Attenuation with Distance (X-axis = Distance (m), Y-axis = Decibels/m (db/m))

Graph 1, displays how different frequencies attenuate over time.The graph shows how, at higher frequencies, we see increasingly higher attenuation of our system. However, we see at lower distances (which we will be working with), the attenuation value means significantly less since we are working with values within the range of 1-10m. Table 1 tabulates all the numbers that created Graph 1.

	Distances	0.5	1	2	3	4	5	6	7	8	9	10	20	30	50	100
Frequencies (Hz)																

20000		1.75909751	3.51819502	7.03639004	10.55458506	14.07278008	17.5909751	21.10917012	24.62736514	28.14556016	31.66375518	35.1819502	70.3639004	105.5458506	175.909751	351.819502
30000		2.638646264	5.277292527	10.55458505	15.83187758	21.10917011	26.38646264	31.66375516	36.94104769	42.21834022	47.49563274	52.77292527	105.5458505	158.3187758	263.8646264	527.7292527
40000		7.036390031	7.036390031	14.07278006	21.10917009	28.14556012	35.18195016	42.21834019	49.25473022	56.29112025	63.32751028	70.36390031	140.7278006	211.0917009	351.8195016	703.6390031
50000		4.397743765	8.795487531	17.59097506	26.38646259	35.18195012	43.97743765	52.77292519	61.56841272	70.36390025	79.15938778	87.95487531	175.9097506	263.8646259	439.7743765	879.5487531

Table 1: Tabulated Data for Attenuated Distance

5. Cost Analysis

5.1: Labor Costs

The average ECE graduate student earns around $45-$50 an hour. Our team is committed to working a **minimum** of 10 hours a week henceforth. Committing this time will be necessary to complete the several requirements along the way. Given the calendar, we will have around 8 weeks to complete this project. With these numbers, we are approximating the lower bound of the labor costs to be around $4,000 USD per member. Considering our group has 3 members, we are looking at labor costs of around $12,000 USD for the entire team.

5.2: Parts Cost

Description	Quantity	Cost
Raspberry Pi 4	1	$100
ESP-32E Microcontroller	1	ECE store
PI Camera Module	1	$25
PIR sensor	1	$8
Ultrasonic Sensor/transducer	2	ECE store

LED rgb lights	1	ECE store
DC motors	2	$20
3.3 to 5v Step Up convertor	2	$2
5v to 3.3 Step down convertor	2	$2
Linear Voltage Regulator	1	ECE store
5V Power Adaptor	1	Home

5.3: Grand Total Cost

The total labor cost for this project was approximated to be $12,000 USD and the cost of parts that are essential to our project is $157. Therefore, the grand total cost of this project is **$12,157** USD.

6. Schedule

Week of	Task	Person(s)
2/26	Design Review	All
	Order parts for prototyping	All
	Develop program for detection	Rishab

	Visit machine shop if needed	All
	Begin designing PCB	Jung Ki / Mankeerat
3/4	Complete and test software subsystem	Rishab
	Finish initial design of PCB, review it and order if possible	Jung Ki / Mankeerat
3/11	Spring Break	All
3/18	Soldering of PCB parts	All
	Ordered parts come in, test software subsystem on Arduino/Rpi	Mankeerat, Rishab
3/25	Integrate the sensors onto the PCB and test	Rishab
	Finish building mechanical subsystem	Mankeerat, Jung ki
4/1	Combine all subsystems	All
	Test for minor bugs	
4/8	Run tests for deterrence	All
4/15	Mock Demo	All
4/22	Final Demo	All
	Mock Presentation	All

7. Ethics and Safety

Ethics:

It's crucial that we adhere to ethical guidelines throughout the duration of this project. One particularly prominent ethical consideration is the potential for causing harm (Code 1.2 in the ACM Code of Ethics and Professional Conduct). Within the scope of our project, a primary concern is the welfare of the animals we're trying to prevent entering areas where our system is placed. Our group is committed to upholding this code by prioritizing the well-being of these animals above all else.

As a team, we've recognized that our approach involves influencing the behavior of these species to help them recognize restricted areas (where our system will be deployed). For this reason, to prevent any ethical breaches, we are using indirect methods, such as audio and visual cues, as a means of solving the core problem. We believe this strategy not only safeguards the animals but also mitigates the necessity for harsher measures like pest control, particularly in situations where it is unwarranted.

Safety:

Safety is of the utmost concern to our group. We want to ensure that the application of our device will be safe for both the users and the animals we are targeting with our device. Our first safety concern is the user. With the use of ultrasonic sound, we want to ensure that its being utilized at a low intensity, since ultrasonic sounds can be damaging to humans even if they are not within the human hearing frequency range. Our second safety concern is with regards to the animals and is related to the use of lights and sounds within our system. We want to ensure that this deterrent system is effective, but also not harmful to them. Therefore, our light system will be implemented such that the intensity will not be damaging to the animal, and the sound system will be run at high frequencies, but not high enough that it will cause damage to the ears of the animals.

Our second safety concern will be the moving parts of our invention. The device will be moving in a 360° fashion, and this will require several moving parts. Therefore, we want to ensure that our design is safe and make sure nothing can get clamped and affect these moving parts. Lastly, is the safety regarding lithium batteries the project will require. Lithium batteries are notorious for igniting, especially in heated settings. Given that our device will be placed outside, we want to make sure that our batteries are sealed in a safe encasing, such that it does not have direct exposure to sunlight.

8. References

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