

Functional Specification

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Member1: Andrew Hall

Member2: Christopher Miotto

Member3: Matthew Ghera

Member4: Braden Kirkendall

Team: 2

Project: MOUSE

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Email: hall657@purdue.edu

Email: cmiotto@purdue.edu

Email: mghera@purdue.edu

Email: bkirkend@purdue.edu

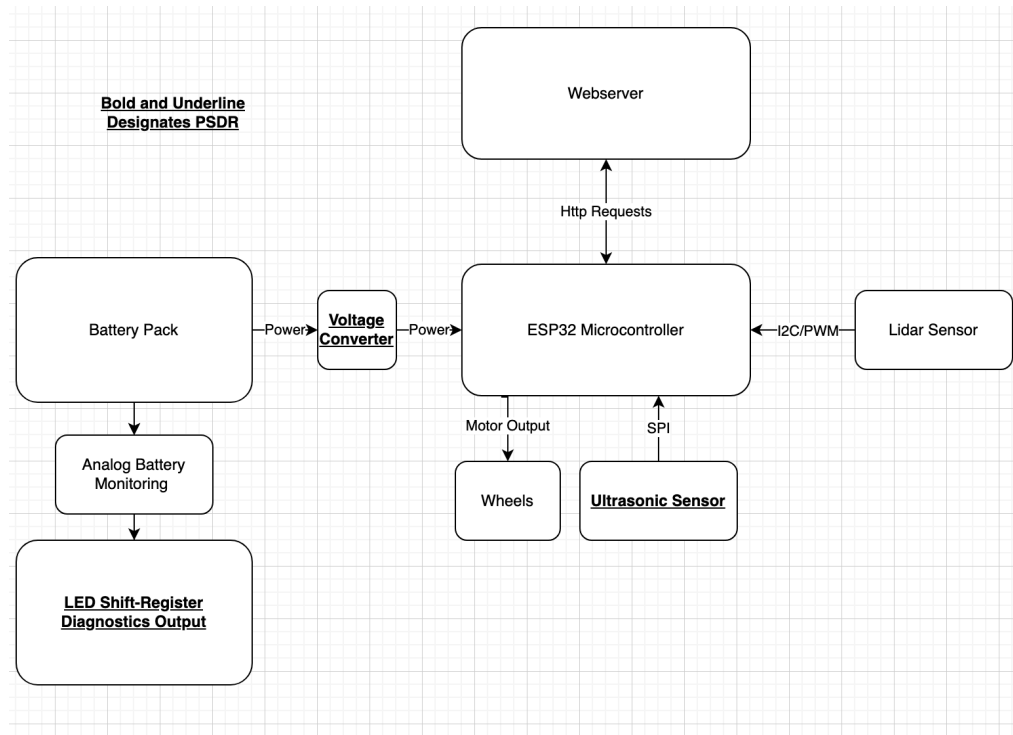
Assignment Evaluation: See Rubric on Brightspace Assignment

1.0 Functional Description

MOUSE is a mobile surveillance robot intended for indoor use, in corporate office or residential environments. MOUSE will be powered by four motors, each controlling its own wheel for mobility. There will be a large 12V battery allowing MOUSE to perform surveillance overnight without needing to have its battery replaced. When the battery does die, it will need to be recharged manually. There will be a series of LEDs on MOUSE which will be used to display diagnostics such as battery life. MOUSE will also have a custom circuit to step down the 12V from the battery to 5V for the microprocessor, motors and sensors.

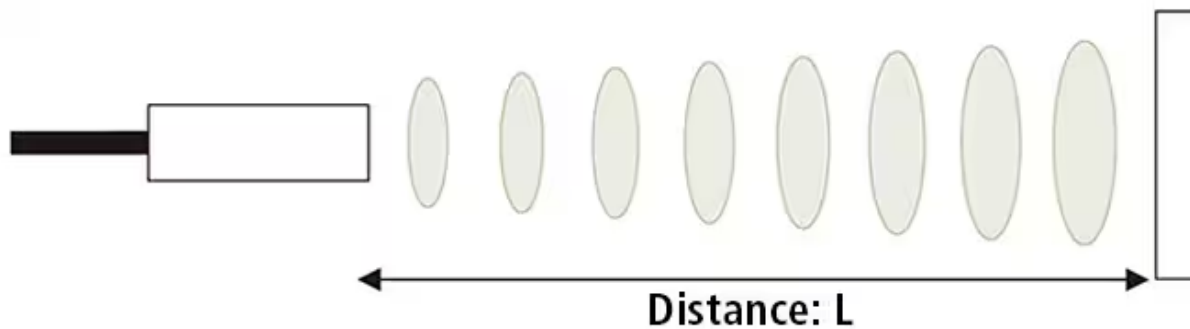
To complete its surveillance functionality, MOUSE will have ultrasonic sensors on all four sides, allowing for the detection of movement. While stationary, MOUSE will use these sensors to detect any movement in its vicinity. Finally, there will be a viewable UI on a webpage to use MOUSE's movement controls and display if any objects have been detected. MOUSE and the web interface will send data wirelessly through WiFi via a web server. The block diagram below represents the connections between the described functional components of MOUSE.

Additionally, we have the following stretch goals for the functionality of MOUSE. MOUSE may have the ability for the motors to have variable speed control through the use of PWM signals. There may be an ability to measure data from a lidar sensor to provide redundancy and confirm the readings from the ultrasonic sensors. Finally, MOUSE may be able to follow a predetermined path set by the user.



2.0 Theory of Operation

We will be using ultrasonic sensors to detect movement around the MOUSE. To use ultrasonic appropriately we must understand the relevant theory behind the operation of these devices. The main usage of these devices is to detect the distance away from objects by using the equation $L = 1/2 \times T \times C$, with L = length T = time and C = sonic speed [2]. This is multiplied by $1/2$ due to the fact that the time it takes is twice as far away the object is due to the bounce back of the sonic waves. This can be seen in the figure below.



3.0 Expected Usage Case

The expected use case of our project is primarily inside of residential buildings or commercial buildings. It will be used as a general indoors mobile security device, so families, landlords, and property owners are our expected target customers. This device will be able to be controlled via a web server, so it is portable in the sense that it is easy to get it from one place to the next; however, it will not be portable in the sense that it will be easy to pick up and manually move.

We do not expect more than a few users to control each individual robot; however, it will have the capability to be used by more than several people at a given time. Our users are expected to be adults, but are not expected to have any technical literacy other than understanding simple usage of a mobile device.

4.0 Design Constraints

4.1 Computational Constraints

The software will be relying on making quick http requests to our hosted web server, receiving the sensor data, and sending signals to the shift registers. Because of this, it needs to be fast enough to be able to make at least one request every second while also handling the processing for receiving and sending data with the external peripherals. There are not any strict memory constraints as no data will be stored directly on our microcontroller and instead will be stored on our web server.

4.2 Electronics Constraints

The microcontroller will need several types of GPIO pins as follows: 2+ clock pins for controlling shift registers and SPI devices (ultrasonic sensors), MISO pin for SPI devices, voltage-in pin to be powered by external battery, 2+ data PWM out pins for the motors, and 4+ data digital out pins the motors and shift registers. The microcontroller also needs WiFi capabilities as WiFi is how we will be communicating to the web server.

4.3 Thermal/Power Constraints

The maximum operating temperature for our robot is 65 degrees celsius because this will ensure any 3D printed components on our robot do not warp. As our robot is meant to patrol through buildings, our target battery life is approximately 12 hours. This will allow the robot to patrol and operate throughout the night while no employees are at work, and the people living in a residence would be asleep. The target charge time for our robot is 12 hours because the robot can be fully charged while home residents are awake or employees are at work; during this time, there would be limited need for the robot to operate.

4.4 Mechanical Constraints

Due to the long-lasting nature of a surveillance robot, the design must be high-durability and should be able to withstand exposure to dirt, grime, liquid, or other messes on the floor that could be contained in work spaces. It does not need to be particularly easy to transport, but should be light enough to be picked up and moved to an area of interest by the average person. Because the primary use case of the design is a place of work, exposure to environmental hazards and rough terrain is expected to be minimal.

4.5 Economic Constraints

The hard maximum for our project is the \$425 limit. This current product does not have a large amount of competition that is at an affordable price. With this in mind we would still like to allow our product to be in a reasonable price range. The total cost of the product if they were mass manufactured would be approximately \$500. We expect the only operational costs to be the cost of recharging the battery and replacing the battery every 3-5 years (\$40). Additionally, if this was a large-scale product, there would be an additional monthly server cost depending on how many futures users there would be.

4.6 Other Constraints

One use case that could merit a constraint is placing the robot in a location that contains confidential information. Our design is able to provide an alert without using a media recording mechanism that could compromise such information. Thus, the robot is constrained to not use devices like a camera in this instance. Other important constraints could be related to safety as the design must be constrained to a reasonable speed and be able to be activated/deactivated readily by authorized personnel.

5.0 Sources Cited:

[1] "How to succeed when printing in PLA: Imagine-that-3d," imagine,
<https://www.imaginethat-3d.com/how-to-succeed-when-printing-in-pla> (accessed Jan. 17, 2024).

[2] "Detection based on 'ultrasonic waves' what is an ultrasonic sensor?," KEYENCE,
<https://www.keyence.com/ss/products/sensor/sensorbasics/ultrasonic/info/#:~:text=As%20the%20name%20indicates%2C%20ultrasonic,between%20the%20emission%20and%20reception.>
(accessed Jan. 17, 2024).

[3] "WEIZE 12V 20AH Lead Acid Battery Replace UB12200 FM12200 6fm20 EXP12200 12V 20AH 22AH Batteries," Amazon,
<https://www.amazon.com/Battery-Replace-UB12200-EXP12200-Batteries/dp/B07TG7PJ41>
(accessed Jan. 11, 2024).