THEFT PREVENTION STAND

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Abstract

This project aims to solve the problem of the lack of security in leaving your belongings unattended in a public space. The original solution to this problem was a blanket with sensors on it to monitor your belongings and disturbances to its surface. Our solution is a water bottle shaped stand that will detect approaching people and emits a warning sound and light upon detection. The key difference in our design from the original design is its range of detection allows for better protection.

Contents

1. Second Project Motivation

This first section details the problem of theft in a public area and our updated solution on how to combat this issue. We have revised parts of this section in accordance with the feedback we were given from our design reviews.

1.1 Updated Problem Statement

Cafes and Libraries are two common areas that students and workers use for working outside of their own houses or apartments. Since they work in these areas for up to hours at a time, they usually have to take a break for various reasons such as using the restroom, getting food, or just taking a break to get up and stretch. The issue with taking a break from the public workspace is that it is out in the open, and anyone could come and steal your belongings that are laid out. The problem that we are looking to prevent is the theft of one's personal belongings in a public workspace.

Theft of belongings in a public space is a well known issue. People do not feel safe leaving their belongings alone even for a short trip to the bathroom without someone there to keep watch. The FBI reported that in 2018 only an average of 28.4% of lost belongings were ever recovered, 5.2% being office equipment and 11.4% miscellaneous, categories applicable to belongings one would leave alone in a public space [1]. The Grainger Engineering Library is well known for having a high theft rate and patrons are constantly warned to keep their belongings attended at all times. Our project aims to provide users with the confidence that they will be able to leave their belongings alone for short periods of time without fear of being stolen from. We do not need to worry about the low recovery rate of belongings if we prevent them from being stolen in the first place.

1.2 Updated Solution

Rewrite your solution given feedback from design review. Write this so it is clear to someone who is just reading about your project for the first time. Explain exactly why this solution addresses the problem in section 1. What are the main differences between your solution and the original solution? Why would the person having this problem be interested in this solution? Are there any competing solutions such as the original solution or something already on the market? What advantages does your solution bring to the tables?

Our solution to this problem would be a portable, battery charged security device that can stand on the table or workspace area that monitors the movement of people nearby. Attached to the top of this device are 12 HC-SR04 ultrasonic distance sensors that will measure both the movement and distance of surrounding objects. If movement is detected within a certain range then the device will emit a corresponding warning sound and flashing light. This is to account for general movement that may be detected from people walking near the workspace, but not getting within arms reach of the workspace to steal items. If movement is detected within a tighter range, the device will emit a louder and higher pitched sound and a red light will flash at a higher frequency. This security device would also be connected to an app that allows the user to arm and disarm the security measures and will notify the user when the device detects potential thieves.

This device addresses the main problem described earlier, which is the lack of security at a public workspace when you must leave your desk unattended for periods of time. When you need to leave for any reason, you can turn on the device, which would be connected to your phone with a simple app. This app would help you monitor your workspace area and will alert you to any suspicious activity that is occurring near your belongings.

The original project which we based this project on is called Warning Coverage. It is a blanket that is used to cover one's belongings. When suspicious activity is detected, it loudly buzzes, then an internal twine will cinch the blanket shut, tightly protecting the contents inside. The main difference between our project and the Warning Coverage project is the range of detection and security. Warning coverage uses a physical blanket which only has as much range of area as the blanket can cover. There is no advance warning that something is being stolen, other than when the blanket is physically disturbed. Our device provides a range of detection due to the range of the ultrasonic sensors reaching up to 2 meters. This range is 360 degrees and we included various warning levels for different ranges. We have also taken into account the size of the device in order for it to be easily carried. Instead of having to bring a blanket around in your bag or backpack, you can easily slip our device into your bag or backpack's bottle pockets.

1.3 Updated High-Level Requirements

- The device must be portable and must be able to be powered for at least 4 hours.
- The system can detect approaching objects within a range of 0-2 meters and activate the buzzer and LEDs based on the output from the sensors.
- The app will allow a user to arm or disarm the device at will as well as send a notification to the user whenever an approaching object is detected within either the warning or alarm range.

1.4 Updated Visual Aid

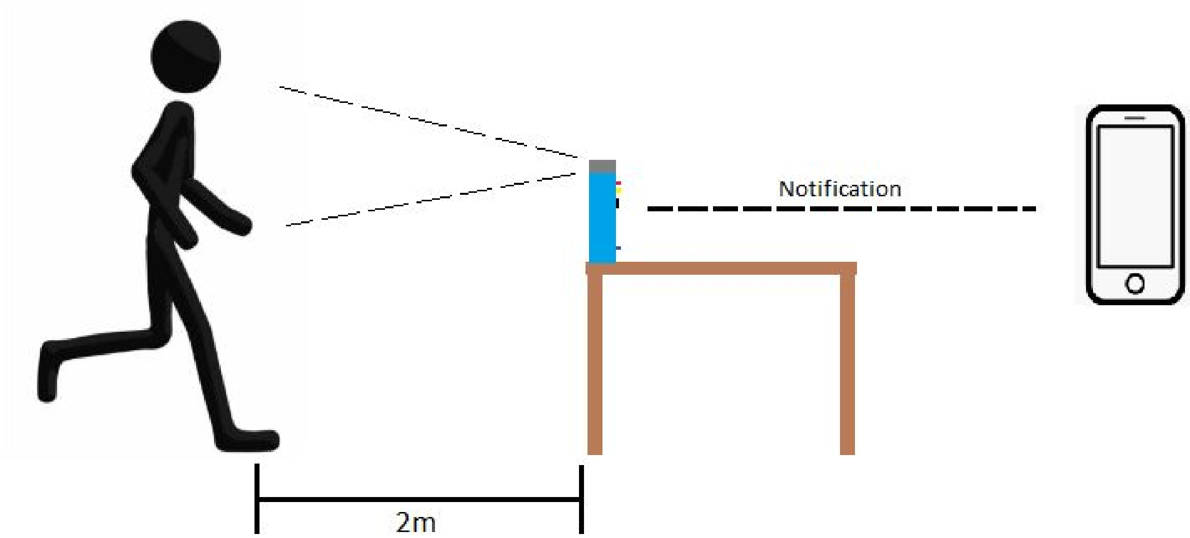

Figure 1: Visual Aid

This is a representation of our project in action. When a person walks into its range it will activate, turning on the buzzer and LED depending on how close the person is. It will also send an alert to the user's phone to let them know that a potential thief has entered the stand's range.

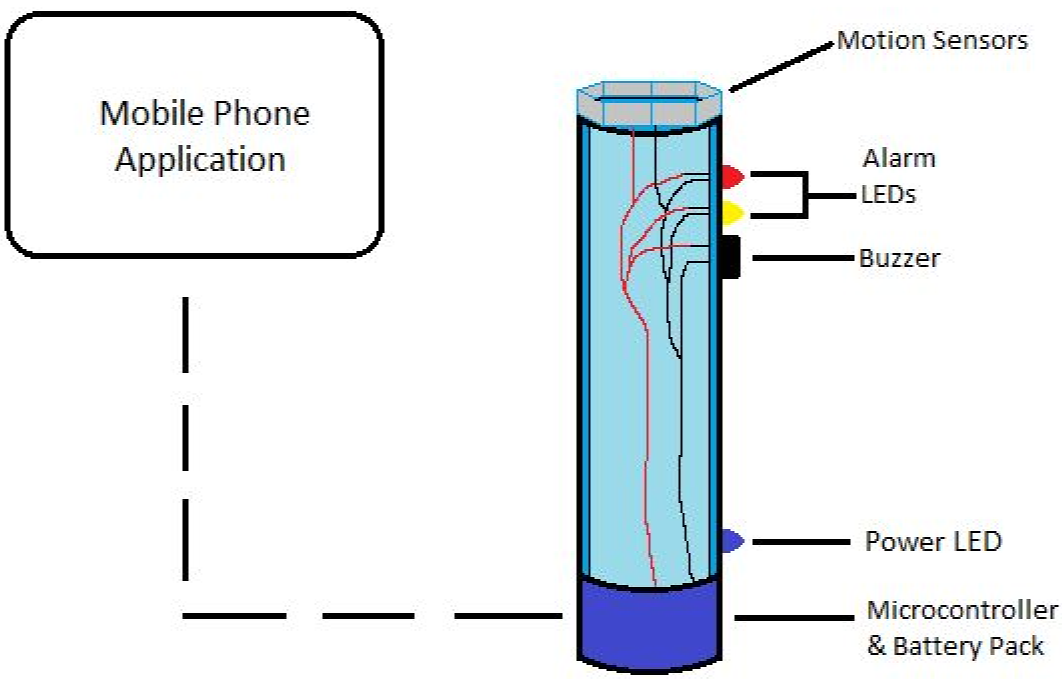

Figure 2: Physical Design

1.5 Updated Block Diagram

Our project requires four different subsystems for proper functionality: the power source subsystem, the sensor subsystem, the microcontroller subsystem, and the alarm subsystem. The power source ensures that every component receives the required amount of power necessary to run by drawing power from a battery pack. The sensor subsystem will provide the functionality for scanning for people approaching the stand and the belongings it is guarding. The alarm subsystem is used as a deterrent for thieves by scaring them and alerting any other people in the vicinity that a crime may be taking place. Lastly, the microcontroller system is in charge of taking the information given by the motion sensors and deciding whether to trigger the buzzers and LEDs on the stand. The Wi-Fi module in the microcontroller system is also responsible for alerting the associated phone app so that the user can be alerted as soon as a thief is detected.

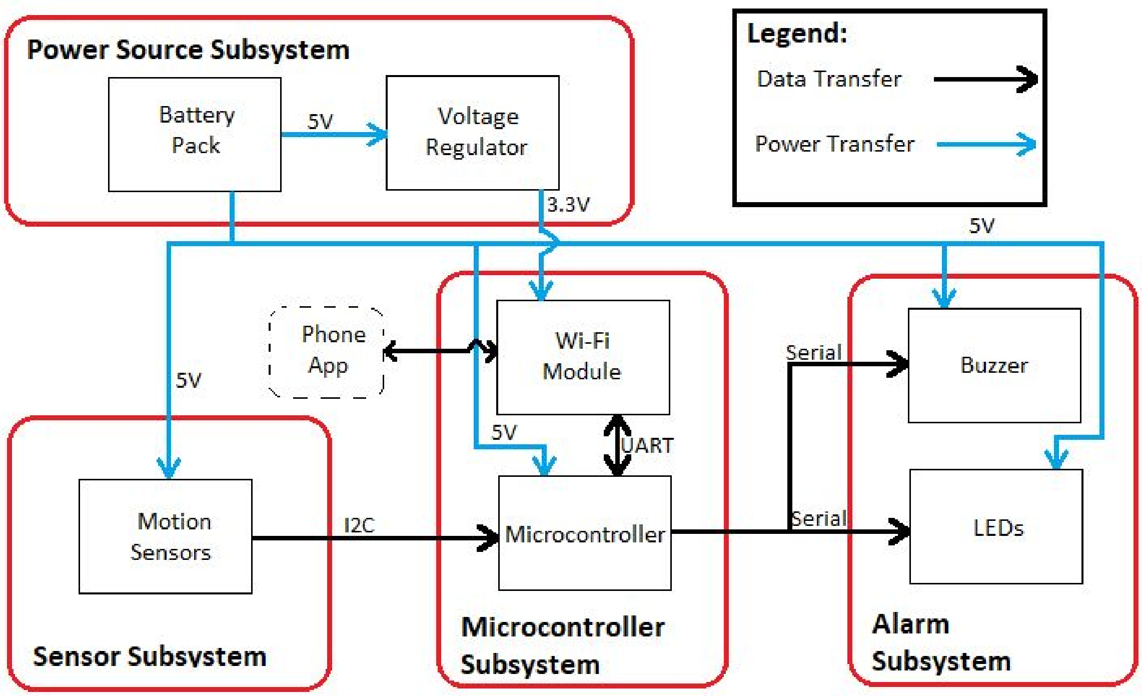

Figure 3: Block Diagram

2. Second Project Implementation

Although we are limited in how much of the project we can physically build due to circumstances outside of our control, there are still certain aspects of the project we can design and implement. We have chosen to design the PCB of the device. We have also written pseudocode for the critical software components of our project.

2.1 Pseudocode Implementation Details and Analysis

The pseudocode for the two microcontrollers needed for each group of 6 ultrasonic sensors goes over the general steps for setting up the ultrasonic sensors on a microcontroller. Both microcontrollers will be connected to the I2C bus of a master microcontroller as slaves. We will use a total of 12 digital pins from each of the microcontrollers, two for each ultrasonic sensor. When using the trigger pin on an ultrasonic sensor, we first set the pin to low to ensure a clean signal, minimizing the risk of possible signal noise. When we set the pin to high, the ultrasonic sensor will send out a ping and we will set the trigger pin back to low. The echo pin will receive the ping once it returns from bouncing off an object and calculate the time in microseconds it took for the ping to return. We will use this to calculate the distance between the object and the ultrasonic sensor by dividing the time by two and then further dividing it by 29.1 to convert the distance into centimeters. We will repeat this process for all 6 ultrasonic sensors and store the calculated distances into an array. The contents of this array will be sent across the I2C bus to the master microcontroller when a request is received. This code helps us fulfill our second high-level requirement of detecting intruders within our 2 meter range.

```
assign trigger and echo pins for 6 ultrasonic sensors
set up array of size 7

setup ultrasonic sensors
      set trigger pin modes to output
      set echo pin modes to input
end setup

for all ultrasonic sensors
      send ping with trigger pin
      duration = reading from echo pin
      calculate distance based off of duration
      store distance into array, leaving first entry in array clear
end loop

setup I2C communication
      set up I2C bus and join as slave
      fill first entry in array with relevant error code
      send information through I2C bus
end setup
```

Figure 4: Pseudocode for Slave Microcontrollers

The next chunk of pseudocode is for the master microcontroller. This microcontroller will be responsible for the main functionality of our stand: the ability to react to approaching people by emitting sound from a buzzer and light from LEDs as detailed in our second high level requirement. This microcontroller takes the distance information sent to it by the two slave microcontrollers, receiving new readings every second. The first time we receive distances we will save those into an array as our base distances. This set of distances will be used to compare to any new distances to see if there has been a change, allowing us to check for people approaching the stand and any new intruders leaving the stand's vicinity. We check for a distance change of at least 1cm in order to account for any small fluctuations in readings due to sensor noise. The alarm will only be triggered if the change in distance is detected while the new distance is within the 2m range. The alarm will stop when the distances are measured to have returned to original distances within a +/- 1cm range.

```
assign pins for buzzer and leds
set up I2C bus as master
make two arrays of size 12
analyze distances taken from ultrasonic sensors
      retrieve info from both slave microcontrollers
      if this is the first set of distances taken:
            store distances into both premade arrays
      else:
            compare distances retrieved to distances in array
            if a distance is within 2m and differs by at least 1cm:
                  trigger buzzer and LED based on distance from stand
                  alert user through mobile phone app
                  replace distances in array one with new distances
            else:
                  replace distances in array one with new distances
                  standby for next distance reading
            if alarm was triggered, turn off when distances are normal as
            dictated by array two
end analysis
```

Figure 5: Pseudocode for Master Microcontroller

2.2 PCB Implementation Details and Analysis

We chose to design and implement the PCB circuit which includes the microcontrollers and the ultrasonic sensors. This circuit is important because this is how we are able to physically accomplish the second high level requirement of detecting approaching objects and outputting a response accordingly through the LEDs and the buzzer.

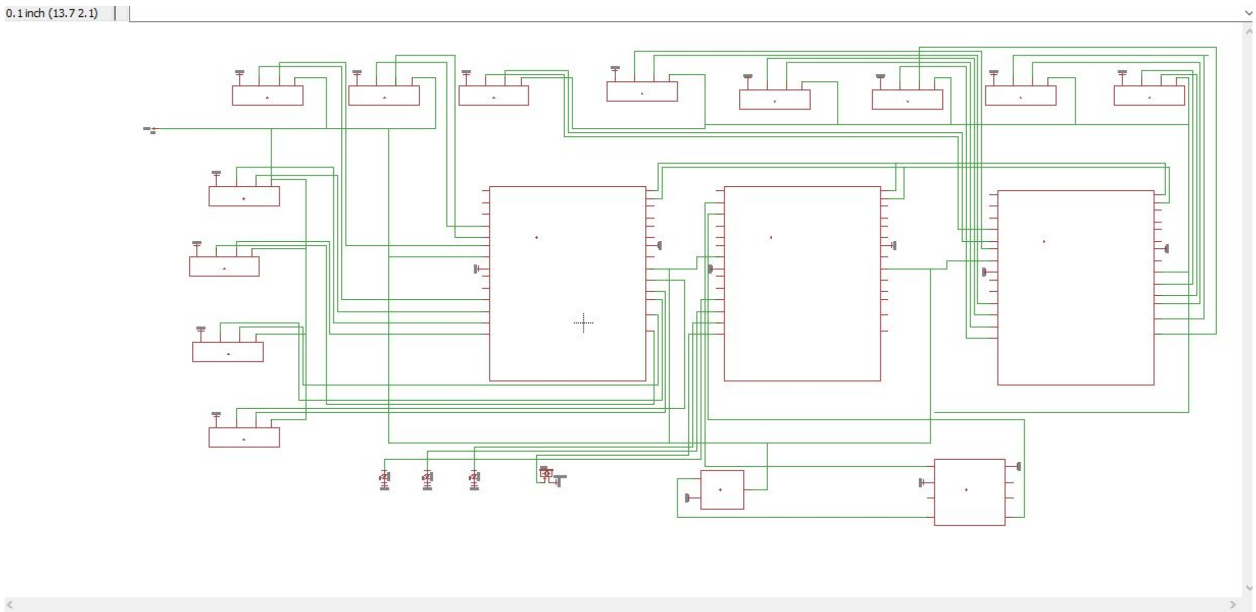

Figure 6: Circuit schematic for Microcontrollers and Ultrasonic Sensors

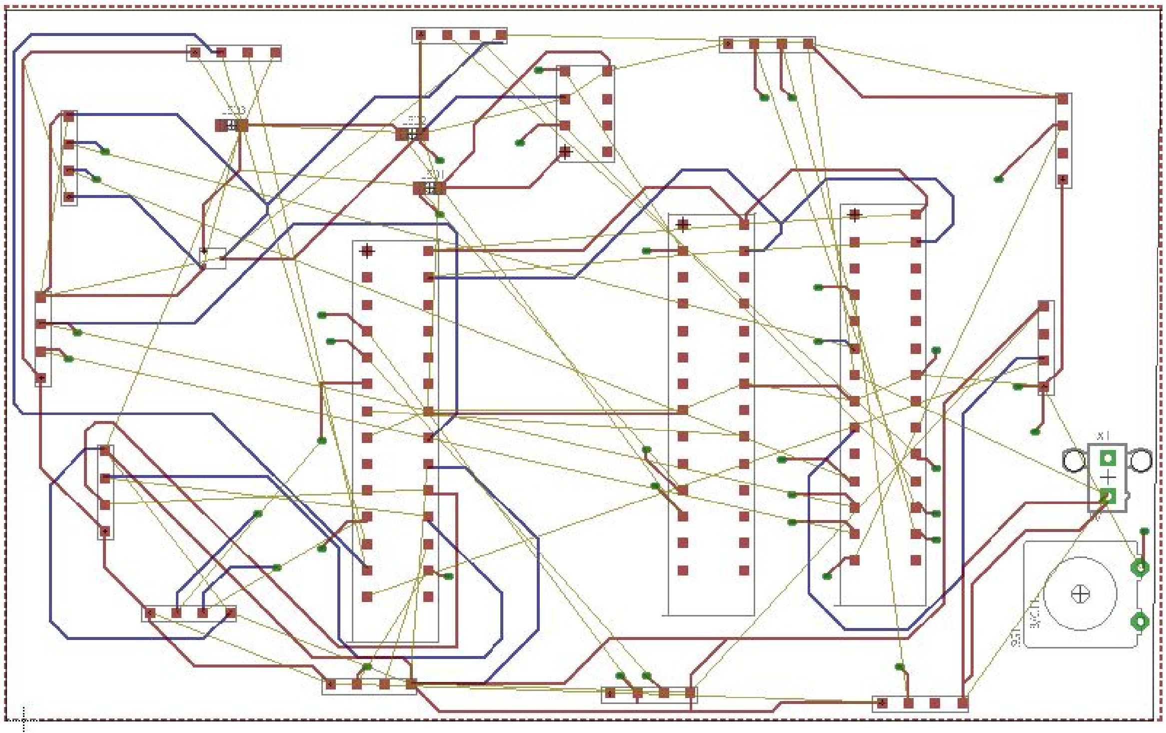

Figure 7: PCB Design

In order to implement our PCB, we actually had to utilize three microcontrollers, since we needed to use more digital inputs to handle the 4 additional sensors not used in our example SonicDisc project, as well as the buzzers and LEDs needed for our alarm system. In order to connect the wifi module, we connected the TXD output of the module to the PD0 input on the microcontroller, and the RXD output of the module to the PD1 input on the microcontroller, in addition to powering it with 3.3V source from our voltage regulator. The rest of our circuit, including the regulator, was powered by a 5v source from the battery pack.

3. Second Project conclusions

The events that led to the new structure of the second half of this class have left us with little in the way of being able to implement our hardware and test our design. We did the best we could to consider what could go wrong if we were able to test our project and work around that. There are some changes we consider to be possible improvements to our project, but we did not have the time or resources to act upon these.

3.1. Implementation Summary

In chapter 2 we were able to implement certain parts of the device such as the circuit schematic and PCB layout for the sensors and the microcontrollers. Robert worked on the PCB and the circuit. This circuit is the most important part of our device because it is the central hub from which the external devices will connect to such as the buzzers and LEDs as well as the power supply unit feeding into the microcontroller subsystem. We also included pseudocode and explanation of the code which details how the sensors will relay the information to the microcontrollers. Michael designed and implemented the pseudocode. One discovery we made that we would not have found out if we hadn't begun the implementation phase was the need for 2 extra microcontrollers in addition to the main microcontroller. The ATmega328p microcontroller we chose to use does not have enough I/O pins for the 12 sensors that we need to mount, so we chose to have 2 extra microcontrollers, each holding 6 sensors. These two microcontrollers would relay information to the third main microcontroller.

3.2. Unknowns, uncertainties, testing needed.

Due to the global pandemic and the subsequent shelter in place order that has occurred, we have lost access to the ECEB lab room and the machine shop. The biggest detriment to not being able to use the Senior Design lab equipment is testing and verifying our devices which require certain voltage and/or current inputs. With our device, there are 2 main parts that we would not be able to test which are the alarm buzzer and our power subsystem. We need to test the alarm buzzer because it is a variable alarm buzzer but since we were not provided a datasheet, we need to test the output decibel range with respect to the input voltage. Without having access to a waveform generator we would not be able to test varying input DC voltage ranges. We also need access to the lab in order to test our power supply module in order to make sure it outputs the correct current and voltage. Because our device draws a specific amount of current (~460mA) we need to make sure that our power supply module can provide that. Similarly, our wifi module operates at a specific voltage range of 3.3V so we need to make sure that our voltage regulator properly steps down the input voltage to match the requirement of our WiFi device. In order to measure the current and voltage, we need to make a simple circuit with a load across the outputs and connect the circuit to the multimeter in order to verify that the parts work correctly. Without access to the ECE lab we are not able to do this properly.

Finally, another resource that we lose out on that isn't necessary but definitely helps a lot with the building process is the ECE Machine Shop. The ECE machine shop was introduced to us as a tool to help us build the main device frame onto which we would place all of our circuits and parts. With this new project, we would have given them the dimensions and the specifications of the main water bottle shaped container for them to build, which would not cost us anything and help ease the burden of making. Although we theoretically would be able to make our own prototype model for our device, having a professional team help out for no cost helps a lot during the implementation and building phases.

3.3. Ethics and Safety

With any product relating to safety and security, there is some degree of danger or abuse that is present. Our product is designed to protect the users belongings from theft or harm, but it can also be abused to irritate others or to prevent them from using their belongings. Since the stand can be armed and disarmed remotely at any time, it is completely at the user's discretion where and when the stand may be used. For example, the user could place the stand near someone else's belongings, and then arm the system remotely. In doing this, the user could either scare the other person, or deter/prevent them from reaching their own belongings. This would also make it seem like the owner of these belongings is actually a thief trying to steal them, an action directly in violation of item 9 on the IEEE code of ethics [2]; to avoid injuring others, their property, reputation, or employment by false or malicious action. Also, people moving nearby the item could be misinterpreted as having malicious intent, and the alarm will go off regardless, which is not the intention of the stand. One helpful bit of feedback we have received from the design review helps address this issue. We could add some code to our program which would make it so that the movement detected within the range would need to be detected for a certain amount of time before the lights or alarms are triggered. This would help to mitigate the chance that a passerby could trip the alarm system.

In general, the stand's alarms and flashing could prove to be annoying to others nearby. If the lights flash fast enough, it could also endanger those with epilepsy, causing them to go into a seizure and require hospitalization. In addition, if the buzzer is too loud, then it could possibly cause hearing damage for those nearby. Depicted below are some common symptoms of epilepsy [4] as well as the dangers of exposure to loud noise [3]. Thankfully, our buzzer only goes up to 85 dB at the max, which is below the maximum safe exposure limit. Above 90 dB, one is susceptible to nausea, headaches, and hearing damage [5].

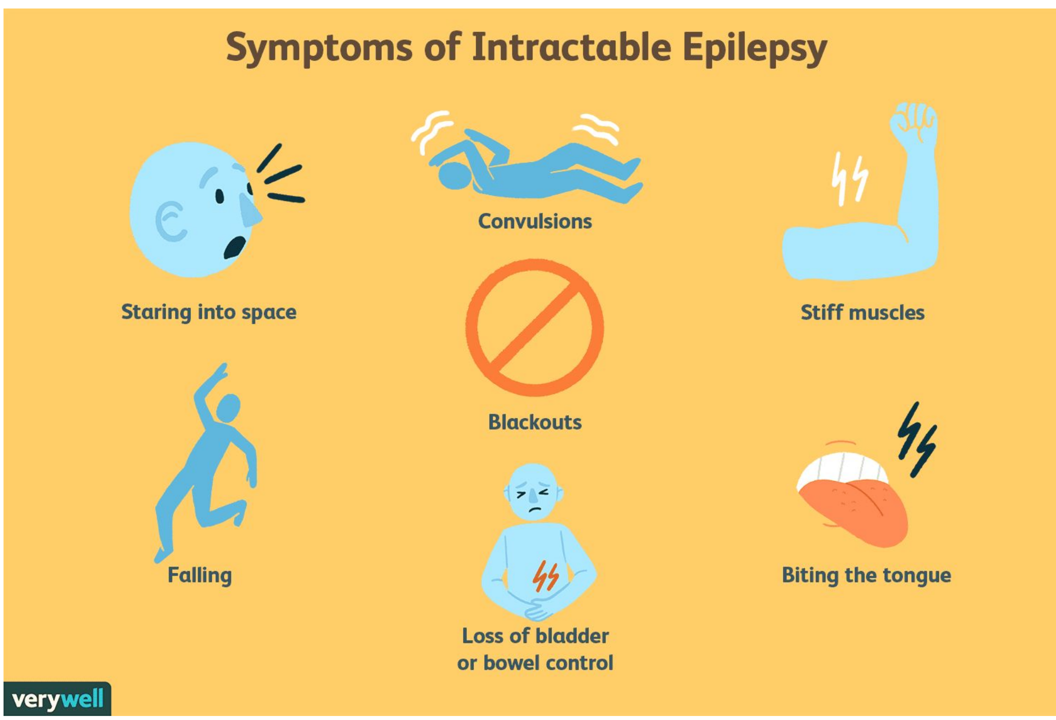

Figure 8: Symptoms of Epilepsy [6]

Figure 9: Noise Stress [5]

3.4. Project Improvements

One design improvement that was given to us as feedback from our design review was an extra security measure in the case that your belongings do get stolen. As our device works currently, the user is notified when suspicious activity has been detected, and the alarms and LEDs will go off in order to draw attention to the area to deter the potential thief. However, nothing is stopping the potential thief from still grabbing the belongings and running away with it before the user is able to come back in time. In order to increase security measures, we could add a camera to the device which would take photos if movement is detected within the red region of 0.5 meters. This would help identify the potential thief if any of the user's belongings were stolen.

A second improvement that we could focus on given more time to work on the project would be the reliability of the sensors. While choosing a sensor that would fit our needs for our project, we looked into both PIR sensors and Ultrasonic distance sensors. After researching we determined that Ultrasonic distance sensors were better suited for what we wanted to accomplish since it was a distance sensor but could also be programmed to detect movement. The PIR sensor detects movement only and outputs a logic high value when movement is detected within the range. Given more time to figure out the code and circuitry, we believe that using both the PIR sensor solely for motion detection and the HC-SR04 ultrasonic distance sensor purely for distance measurement in our device would make the device more reliable. As a pure motion detector the PIR sensor has advantage over the ultrasonic distance sensor since the PIR sensor is a passive device whereas the distance sensor sends out pings of sound waves every 10 ms. This gives some latency between the signal being sent out and coming back. As a distance sensor only the ultrasonic distance sensor is viable, so using the PIR sensor in conjunction with the distance sensor would give a more accurate and reliable sensing device overall.

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