Theft Prevention Stand

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1. Introduction

1.1 Objective:
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.

Our solution to this problem would be a portable, battery rechargeable security device that can stand on the table or workspace area that monitors the movement of people nearby. 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.

1.2 Background:
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. 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.

Differences from previous project:
The previous project was a blanket that was placed over the user's valuables in order to protect them. The blanket was connected to a control board and would report changes in proximity detection or shape in order to alert the user of any malicious intent towards the valuables underneath. In addition, the blanket was connected through bluetooth to a mobile app, allowing the user to view the status of the blanket on their phone, and thereby see the security of their belongings.

Our project has several distinct differences. Firstly, we are using a physical stand that the user will place among their belongings. It will look similar to a water bottle, and will have 360 degree sensors in order to detect movement. The water bottle shape provides a small but stable footprint, as well as giving the detector height and a range of visibility from which to sense things. In addition, it will have alarms, flashing lights, and vibrating capability to indicate how much danger the items are in. We will have a range of colors as well as light flashing and vibrating intensity to indicate various levels of danger.

Our project will also have an app for the user to arm and disarm the stand so that they can ensure that the theft deterrent systems are only online as long as the user wants them to be: typically, just the length of time that the user is away from their belongings. In addition, this app will notify the user any time the alarm reaches a high threshold of danger, meaning that their items have likely been or will imminently be tampered with.

1.3 High Level Requirements List:

- The device must be portable and must be able to be powered for at least 5 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.

2. Design:

Physical Design

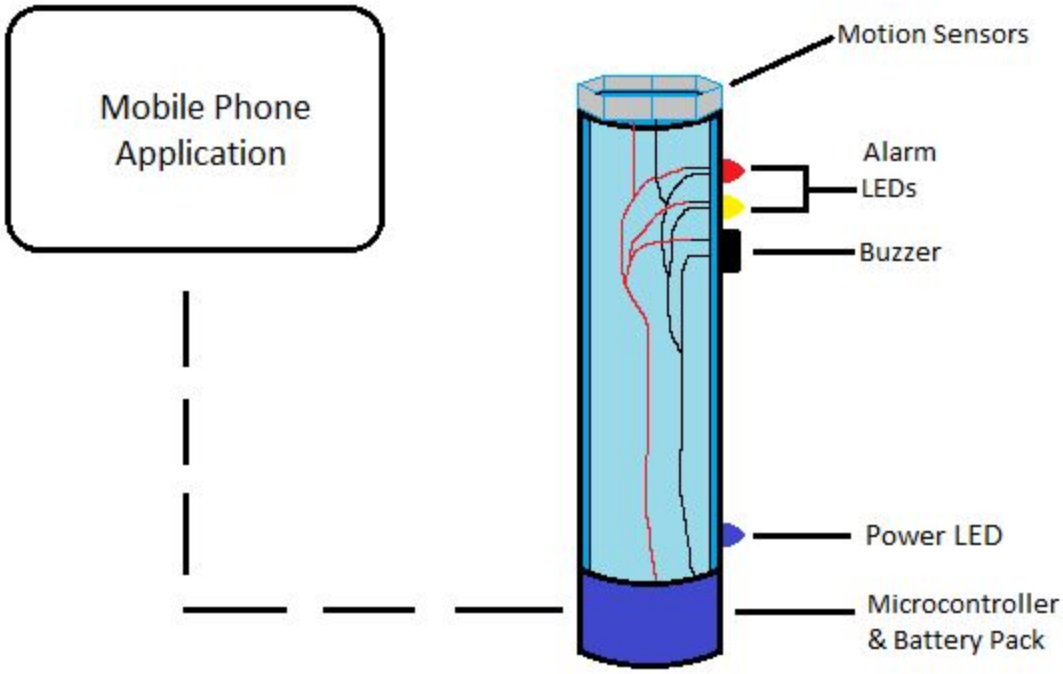

Figure 1: Physical Design

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.

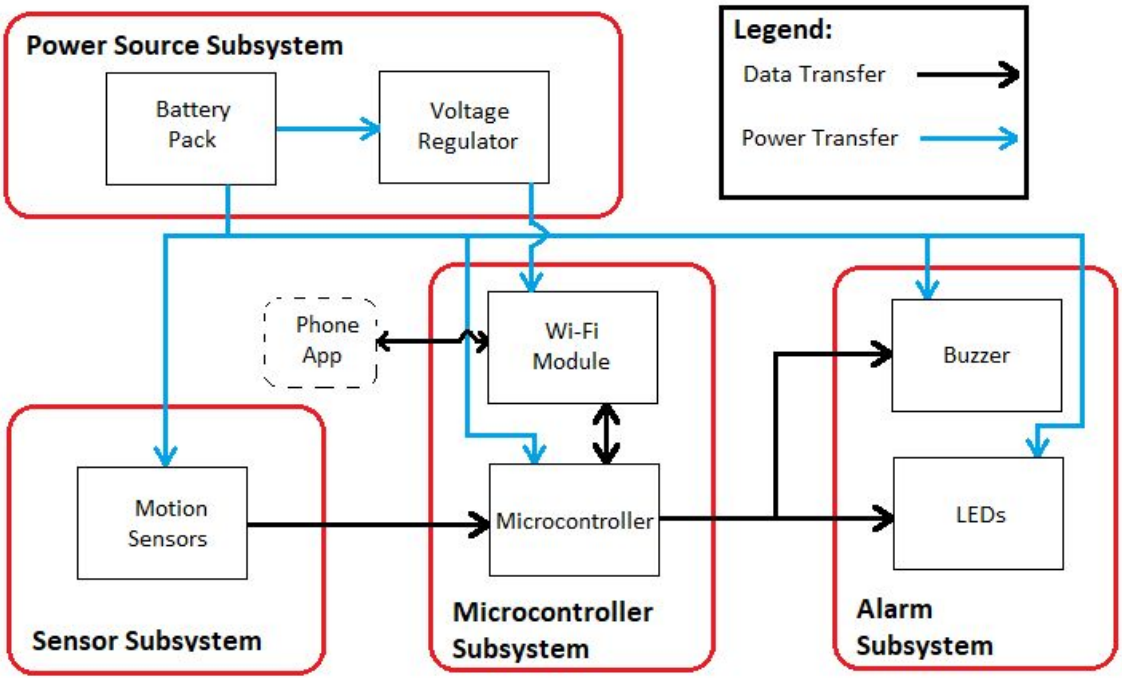

Figure 2: Block Diagram

2.1 Power Subsystem

A power supply is required in order to power up our device. Because our device is meant to be portable, we will use a simple battery pack that holds 4 AA batteries to supply our device with power.

2.1.1 Battery Pack

Our device will be powered by a battery pack which holds 4 AA batteries. This battery pack must supply enough power to allow our device to be on for at least 5 hours. A connected blue LED will alert the user when the batteries are starting to run low.

Requirement: Must store enough charge to provide at least 400mA current at 5V (+/-5%) for at least 5 hours when turned on.

2.1.2 Voltage Regulator

This circuit will step down the 5V output of our battery to the required 3.3V input to power our Wifi Module.

Requirement: The voltage regulator must provide 3.3V +/- 5% from a 5V (+/-5%) input.

2.2 Sensor Subsystem

In order to detect movement, we chose to use ultrasonic sensors, which detect movement by sending out a pulse and measuring the time it takes for the pulse to reflect back. We will use enough ultrasonic sensors to cover a 360° field of view.

2.2.1 Ultrasonic sensor

The ultrasonic sensors will check for approaching people, providing the information the microcontroller needs to decide whether to trigger the buzzer and LEDs or not. Releases a pulse by request and sends a signal to the microcontroller when the pulse returns.

Requirement 1: Detects people approaching within a 5 feet radius.
Requirement 2: Does not trigger false positives from belongings located in the vicinity.

2.3 Control Subsystem

In order to control when the alarm portion of the project is activated, the microcontroller is necessary to process the data provided by the ultrasonic sensors and signal the LEDs and buzzer to turn on. If a person is judged as having entered the warning range based on the sensor output, the microcontroller will trigger the warning pitch for the buzzer and the yellow LED while entering the alert range will trigger a higher pitch and the red LED. When triggered, an alert will be sent to the phone app associated with the project as well.

2.3.1 Microcontroller

Our microcontroller for this project will be the ATmega328p. It will communicate with the ultrasonic sensors using I2C protocol with the sensor as a slave. It will communicate with the Wi-Fi module through UART.

Requirement: Must be able to read an output from each ultrasonic sensor and calculate the distance given by each sensor based on timing of each return pulse.
Requirement: Able to communicate over UARt and I2C.

2.3.2 Wi-Fi Module

Our Wi-Fi module will be the ESP8266 chip. This chip will allow us to use Wi-Fi to communicate to the phone app associated with our project. It will communicate with the ATmega328p through UART.

Requirement 1: Able to communicate over IEEE 802.11 b/g/n at a rate of more than 100kbps.
Requirement 2: Able to communicate over UART.

2.4 Alarm Subsystem

This alarm system is used to deter the possible thief and also alert others in the vicinity to the potential of a theft occurring. The buzzer will start emitting a sound when a person is detected within the warning zone while the yellow LED will light up. In the alarm phase the buzzer will emit a higher pitched sound and the red LED will start blinking rapidly.

2.4.1 Buzzer

A simple piezo buzzer with adjustable pitch will be used as a warning to approaching thieves.

Requirement: Pitch emitted by buzzer increases inversely proportional to distance from stand.

2.4.2 LEDs

One yellow and one red LED will be used as part of the warning to potential thieves.

Requirement: LED must be visible from a distance of at least 3 meters.

2.5 Risk Analysis:

A significant risk to our project's success is the ultrasonic sensor detection range. For our project to successfully notify the user when movement is detected, it must cover a 360 degree field of view. If there are any gaps in the sensing range then this means that someone could move within that gap of sensing range and there would be no movement detected. This is particularly challenging because in the case of ultrasonic sensors as a motion detector, the angle of detection is only 15 degrees.

Another issue with the sensor's detection range is the vertical range of detection. The ultrasonic sensor works by emitting a pulse which would then bounce off an object and return to the receiver. The sensor is only a 2D sensor, so it can only see horizontally. This creates issues with holes in detection, such as if an intruder came in below or above the sensor's horizontal plane of detection.

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. 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.

References:

[1]“Table 24 Property Stolen and Recovered.” *FBI*, [Online] https://ucr.fbi.gov/crime-in-the-u.s/2018/crime-in-the-u.s.-2018/tables/table-24/table-24.xls. Accessed 3 Apr. 2020.

[2]"IEEE Code Of Ethics". Ieee.Org, 2020, https://www.ieee.org/about/corporate/governance/p7-8.html. Accessed 13 Feb 2020.

[3] *DigiKey Electronics - Electronic Components Distributor*. [Online]. Available: https://www.digikey.com/products/en?mpart=3942&v=1528. [Accessed: 04-Apr-2020].

[4] *DigiKey Electronics - Electronic Components Distributor*. [Online]. Available: https://www.digikey.com/products/en?mpart=3859&v=1528. [Accessed: 04-Apr-2020].