Intruder Detection System

ECE 445 Project Proposal - Fall 2018

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1 Introduction

1.1 Objective

Our objective is to create the standalone intruder detecting device. Its goal is to detect if any unwanted strangers are following the authorized personnel hence effectively blocking out the intruders from attempting to bypass the entrance security system that we see on campus. The team seeks to solve the issue in the lack of campus security by providing a direct method of enhancing it.

1.2 Background

The first measure of campus security within its buildings is the entrance, where the students are required to swipe their i-card before entering the building. This system, however, has proven to be faulty because strangers could bypass the security system by following the student without their consent. The rule of not allowing strangers in without confirming their identity or their respective access key has been loosely enforced and has failed to prevent crimes that happened on campus. Numerous theft incident that has and is occurring within the campus buildings[1] and even some of the more tragic incidents[2] that have occurred in the past stands as evidence for faults within the security system.

This device will activate once the input on the keypad is given from the authorized personnel on how many people are to go through the entrance. When input of number of people authorized to pass through is given this device will then detect the number people passing through the entrance and make sure that the count is respected. When the count is not respected it will raise alarm to the respective authorities notify them of any possible dangers within their building. This device is designed to minimize the authorized user's interaction with strangers and enforce the rule mentioned above by adding it as a layer of required input before unlocking the entrance.

1.3 High-Level Requirements

1. Device must be able to detect people.
    a. People moving through specified region and their directions
    b. People moving in a cluster and be able to distinguish them individually.
2. Device must be able to raise alarm
    a. Notify the respective authorities by updating them with number of people entered and the number given in the input
    b. Notify the respective authorities by lighting the LED with specific colors signifying whether the count is respected or not.

2 Design

2.1 Block Diagram

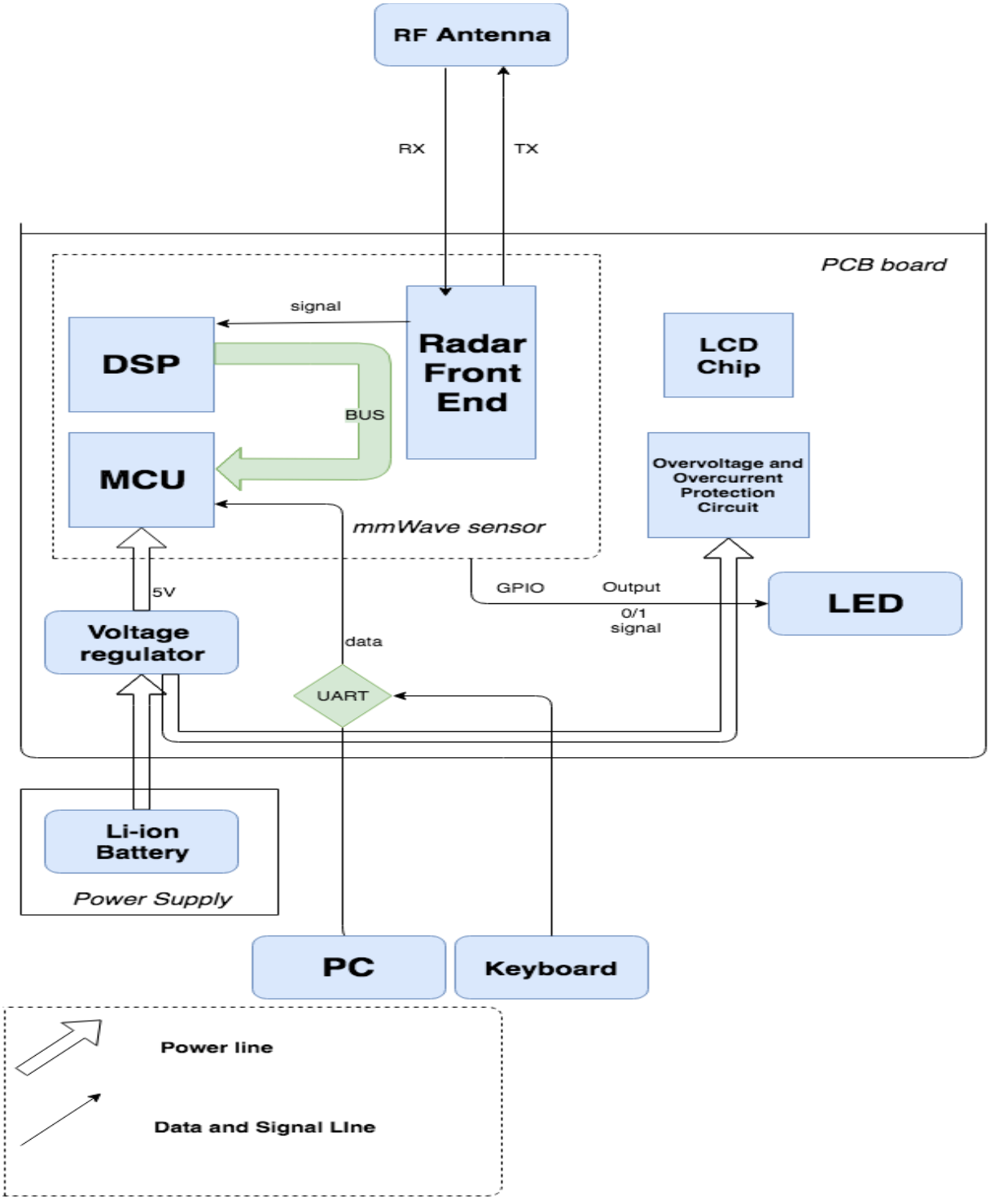

Figure 1: *Block Diagram For The Intruder Detecting Device*

The block diagram(Figure 1) shows the main components and how they link to each-other for our device. We use the Li-ion battery to power our PCB board, once our device is activated, the system will turn on, the mmWave sensor will send continuous frequency signal and will enable our software components to do signal processing coding to parse the data. Once the authorized personnel enters the number of people they want to bring in with them via keypad, it will send the generated data to the NAND gate to decide whether the number of people detected by the sensor matches the number they entered. If the number does not match it will light up the LED light accordingly to alert the respective personnel. The LCD chip will be used to tell how many people have been detected by the sensor. Lastly, we utilize the overvoltage and overcurrent protection circuit to protect our system.

2.2 Functional Overview

2.2.1 Power Module

Requirement(s):

- Supply enough voltage (5V) to power the PCB board.
- Input voltage should be controlled.
- Power consumption should be around ~4W

Li-on Battery:

We use two 3.6V Li-on Battery to power our PCB board. We want the input voltage to be 5V, therefore we use voltage regulator to adjust the voltage.

Voltage regulator:

The voltage regulator will provide a 5V input voltage to the components, protecting components and providing the smooth voltage the PCB system.

2.2.2 mmWave Sensor[3]

Requirement(s):

- Radar detection, field of view range of 120° horizontal 30° vertical
- Different RF range configuration, Short <= 6m, Long <= 14m
    - Radar range resolution
        - Short: 4.9cm
        - Long: 12cm
- Maximum number of object that can be detected is 20

The sensor chip which will be triggered by 5V voltage. Three main components are the following: MCU, DSP and radar front end. The radar front end will send continuous frequency wave to the objects(people we want to count) through Tx antenna. Rx antenna will receive the reflected wave from the object to the chip. After using ADC converter inside the chip, radar front end will then transmit the digital signal to DSP core. DSP is where we put the signal processing code of the input signal, So we need MCU to connect the sensor with PC through UART port. MCU and DPS are connected on the bus. Thus, we can transmit data between PC and sensor to complete the coding process.

2.2.3 LCD

Requirement(s):

- LCD chip needs to show at least 2 digits.
- Cheap and easy to buy
- Small enough to put on the PCB

LCD is used to show the number of people the sensor detected and the number of people that were inputted by the authorized personnel. Not only that it helps to detect the errors and provides safeguard against false positives it provides the respective authorities with the quality of life improvement to know exactly what is going on in their building.

2.2.4 Overvoltage and Overcurrent protection circuit

Requirement(s):

- Circuit needs to be able to protect the following
    - Input overvoltage
    - Overcurrent
    - Overvoltage
- Maximum input voltage is 30V

The bq24311[4] chip will be used for our device, this is a highly integrated circuit used to protect Li-ion batteries. It is programmable, allowing us to limit the amount of current applied to the board. An internal switch inside the system can be turned off to remove overvoltage power. Moreover, it can monitor its own temperature, hence preventing itself from overheating problems.

2.2.5 Control Unit

Requirement(s):

- MCU(Microcontroller unit) should work when input power is around 3.4w
- The input power will be supplied by the battery.
- LED should turn on when the input is 1

MCU:
MCU gets its input from the PC and then give the output to the tasks, LED can connect to MCU through the GPIO, and it also control the notification LED via IO, if IO is high, LED will not be red, if the IO is low, LED will be red. We also put the NAND Gate block into MCU, and use PC to compile the hex binary and save it to the MCU flash.
LED:
LED will be red if the number of people the sensor detect is not equal to the input entered using the keyboard. LED is designed on the PCB board, and LED gets its power from the battery.

2.2.6 RF Antenna

Requirement(s):

- Operating Temperature Range :-40°C to + 85°C
- Power Capability 3W max

RF Antenna chip contains transmitter and receiver antenna. Tx will receive the radar signal and transmit to a continuous frequency wave to detect people. Rx will receive the reflected wave, this analog signal will then pass through the AD converter for further coding.

2.2.7 PC and Keyboard

The keyboard will be used to take in the inputs that will be used in the detection algorithm for number of people that are allowed to enter. PC will be used to program the software and communicate with MCU.

2.3 Risk Analysis

The major components which possess the greatest threat to the success of our project is the sealing of the components of the PCB board as the pins are all very thin. The difficulty of soldering the chips and being able to parse the data (detected by mmWave via DSP chip) is our major concern, especially in a different

environmental settings where it may be raining or lightning won't be as ideal. We stress the importance of parsing the data consumed, because our project deals heavily with security and relies on its ability to detect multitude of objects in an assumed clustered environment; the accuracy of the data is crucial to project's success.

Additional noticeable challenges that exist outside of the above mentioned major concerns are power efficiency and software false positives. In regards to power, since we will be running the entire system on Li-ion battery we want to make sure that the system runs as long as possible. Software aspects of the project involve around a lot of data handling and making sure that no false positives or loopholes exist within the system. We already noted how the accuracy is crucial to the success of this project and just from the feedback received regarding vibrating object we will have to be able to tell accurately if the object detected is a human, door, or none of the above.

3 Ethics and Safety

The most important ethics relative to our project is making sure that the our users feel secure and is able to trust our project. Our enhancement of security seeks to achieve one thing "To keep good people good" intrusion via following authorized personnel has proven to cause crimes that started from harmful intentions or from sudden impulse. We want to make sure that when making the security system better within the campus we want to have the design that works accurately to earn trust and does a simple job of keeping the door closed and locked for unauthorized personnel.

There are no ethical problems when it comes to detecting human beings as we are only checking the vibration that comes from any objects within a specified region. Meaning that we have no way to identify a person with our sensors nor does it store data. The potential ethical problem may arise when this standalone project and its data can be misused by attached functionals, for example, campus could store the student i-card and number of people they have allowed into the campus dorm which could be a violation of privacy if it was to be stored and if the data was to be used against them.

The safety of our physical design itself is high as the sensors nor the possible overheating components do not directly interact with the users themselves. However, this does not mean that we will be lacking in trying to hold the highest standard when it comes to designing and implementing the hardware to prevent any possible accidents.

References

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[4]"Overvoltage and Overcurrent Protection IC Li+ ... - Texas Instruments." 8 Jul. 2014, http://www.ti.com/lit/ds/symlink/bq24311.pdf. Accessed 19 Sep. 2018.