IJCRT.ORG ISSN : 2320-2882

INTERNATIONAL JOURNAL OF CREATIVE RESEARCH THOUGHTS (IJCRT)

An International Open Access, Peer-reviewed, Refereed Journal

Low Cost Security System With Feedback Control Loop

Hardik Gossain[1], Sumnit Singh Gulshan[2], Avneet Kaur Batra[3], Atul Kumar Mishra[4]
Department of Electronics and Communication Engineering[1, 3, 4]
Dr Akhilesh Das Gupta Institute of Technology and Management
New Delhi

Abstract: Security is one of the grossing topics in today's market. There are various techniques used and being made to make the system more secure and easy for a person to use. Surveillance along with security systems are really costly in today's time. We have designed a reasonable system with few sensors and prediction algorithms to get information about any intruder or security break down. It is an IOT based system and uses a server-based on Django. The system also has two-factor authentication and uses the user's GPS location to disable the system's outer most security layer for further authentication and correct identification. This system is designed to work in a closed-loop and even gets feedback whenever unlocked. The system is practically implemented and is being further improved for production purposes. It can be used in multiple places like home, offices, banks, schools, etc.

Index Terms - IOT, Security, Prediction, STM32

I. INTRODUCTION

Nowadays, most people across the world are dependent on the traditional lock and key locks to secure their precious belongings and other kinds of stuff. These security locks are very vulnerable to intruders. Many users try putting multiple locks and layers that have to be used manually to lock and unlock which is not only a tiring task but even doesn't guarantee the security of their belongings. This is not true that people today don't know about the IoT based security systems, but the main problem lies that not everyone can afford to buy it dues to their high prices and further higher maintenance cost. The main reason for these systems having higher cost is so because these systems include the cameras for motion detection and costly SoC power computers to process them. The majority of the population do not prefer to buy such expensive products and relies on traditional manual locks with no alert systems. There are many home automation systems which consist of a security system within the system but have many disadvantages like the home automation systems are frequently used and if the system is not properly tried and tested, could lead to freezing of the main computer and the area would be vulnerable until checked or restarted the system.

Security systems are mainly responsible for opening and closing door locks without any physical key using a local or remote server. Apart from these functions, it is also responsible for surveillance of the environment around the secured area and report whenever an intruder is detected. After detection, it is responsible either to inform the user or the concerned authority about the issue. Depending on the confidentiality of the secured area, the system could work manually or automatically. Even its manual operation is useful, like where 10-20 people are needed to survey a particular area, using this system only a single or two persons would be required to secure the whole area that too by just sitting in one office. These system's automatic operations are independent and don't require any human intervention.

Thus, the objective of this paper is to explain a security system we have developed with simple and cost-effective sensors. This system is supposed to be cheap because we have used the most basic sensors available and we completely rely on our prediction algorithms that take input from multiple sensors and then according to their efficiency generates a final output and then take the required action.

II. PROPOSED MODEL

The security system's main function is to secure an area and unlock it whenever required by the user or the administration. We have used motion sensors like PIR, Infrared, Ultrasonic sensors for the movement detection in place of a camera which reduces the cost of the whole system drastically. The brain of our system is a 32-bit microcontroller that is an STM32F103C8T6 [1] [2]. Despite using an 8-bit microcontroller like ATmega328p or ATmega2560 which are easier to use and program, due to their available resources we instead used STM32. The peripheral of the control unit consists of two esp8266 for both remote server connectivity and local server creation. STM32 has three usable UART pins so it was a simple task. All the sensors are connected to the control unit for either giving the input or feedback to the processor. The area is covered with PIR sensors and ultrasonic sensors which detect the movement within the area when the system is set active. Each door consists of electronic solenoid locks that could be unlocked by the controller whenever required by the user. Each door is fitted with magnets and Hall Effect sensors along with a push sensor inside the solenoid lock to check whether the door ko physically locked or unlocked. IR sensors along with infrared lights are to be installed on each possible entrance like windows, doors, ceiling entrances (if any), etc. [7] the main component of this system will be the app that we have developed. This app is responsible to disable the first layer of security and also give the command to unlock the door. The app tracks user's GPS location and when the mobile enters the virtual boundaries around the secured area, the first layer of security consisting of all the motion sensors gets off automatically giving a notification that the “outermost security layer is turned off”. As the GPS is inaccurate to 15-20 meters that’s why we have set a radius of 30 meters around the area (Figure 1). Now the doors can be unlocked by just pressing a single touch of a button. The app sends two requests to the main control unit: one via the internet and the second one using local server connectivity hosted on one of the esp8266 [3]. Apart from this, there is always a notification sent when any moment is detected around the area and in case the door is opened manually or by breaking through the locks, it generates an emergency alert and sends the information to the concerned authority.

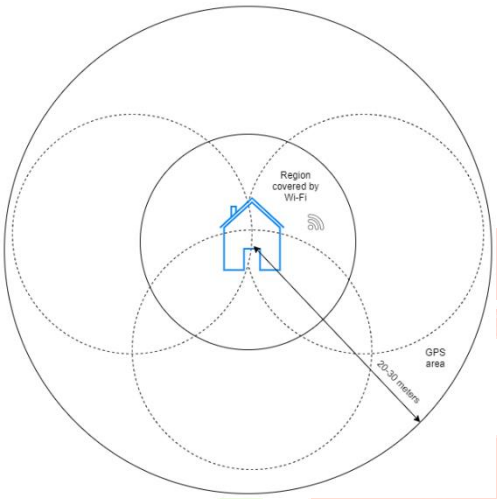

Figure 1 Area Covered by Wi-Fi and GPS

III. ARCHITECTURE

The system’s hardware consists of STM32F103C8T6, IR sensor, IR LED, Hall effect sensor, PIR sensor, Ultrasonic Sensors, ESP8266 while its software comprises Cube IDE, Arduino IDE, and Django Framework.

A. Hardware Components

STM32F103C8T6:

The STM32F103C8T6 is an ARM Cortex-M3 32bit microcontroller in a 48 pin LQFP package. It incorporates a high-performance RISC core with a 72MHz operating frequency. The STM32F103C8T6 features 12bit ADC, timers, PWM timer, standard, and advanced communication interfaces. It is preferred over microcontrollers like ATmega328p because a 32-bit microcontroller gives a higher resolution, speed, and more interrupt pins than an 8-bit microcontroller (figure 2).

Figure 2 Blue pill (based on STM32F1032C8T6)

ESP8266:

The ESP8266 (Figure 3) is a low-cost Wi-Fi microchip, with a full TCP/IP stack and microcontroller capability. The ESP8266 with 1 MiB of built-in flash, allowing the building of single-chip devices capable of connecting to Wi-Fi. In our system, we have used two of them. One responsible for connecting to the firebase while the other one is responsible for making a local server for connecting to the APP locally

Figure 3 ESP8266 Wi-Fi module

IR Sensor

IR sensor also is known as an infrared sensor is used for detecting infrared light that a human cannot see from naked eyes. It consists of an OP-AMP along with an IR receiver LED.

IR LED

This LED emits infrared light that is supposed to directly fall on the IR sensor. When the security system is active, it will constantly emit light on the receiver and whenever any discontinuity is detected, the controller would detect it.

Hall Effect Sensor

This sensor is used for magnetic field detection. It will be mainly used on objects that could be opened like doors and windows. It is used as feedback that will inform the controller whether that door/window is open or close using the magnets attached to them.

PIR Sensor

A passive infrared sensor (PIR sensor) is an electronic sensor that measures infrared light radiating from objects in its field of view. They are mainly used as PIR-based motion detectors. It has a detecting angle of around 120°. It is a self-sufficient sensor that can produce digital output to the controller whenever any motion is detected.

Ultrasonic Sensor

An ultrasonic sensor is an electronic device that measures the distance of a target object by emitting ultrasonic sound waves and converts the reflected sound into an electrical signal. It along with the PIR sensor will detect movement in and around the secured area.

Push Sensor

It is a simple switch that will close when the door is locked and open when the door is unlocked. It is fixed inside the solenoid lock so that whenever someone tries to break in the door, this will be used to know whether the door was unlocked before opening or not.

B. Software Stack

ST Cube IDE

STM32CubeIDE is an advanced C/C++ development platform with peripheral configuration, code generation, code compilation, and debug features for STM32 microcontrollers and microprocessors. It is based on the Eclipse/CDT framework and GCC toolchain for the development, and GDB for the debugging. It allows the integration of the hundreds of existing plugins that complete the features of the Eclipse IDE. It is a great tool to program STM32F103C8T6. By just selecting the modes and pins to be used as an output or an input, it generates a basic code structure for setting the internal registers of the microcontroller as it is very complicated to set registers of a 32-bit microcontroller.

Arduino IDE

The open-source Arduino Software (IDE) makes it easy to write code and upload it to the board. This software can be used to program most of the boards available. It is basically used for programming ESP8266.

Django based server

We have made our own server for making this project work. The server is programmed using python on the Django framework. As the system involves IoT for verification, sending the command to disable the outermost security layer, and sending notifications of any intruders, we preferred making our own server.

IV. MOTION PREDICTION

Alone a PIR sensor is self-sufficient for motion detection but in many cases like in a house or places where there are domestic animals or any other moving object, there could be a false detection. In our system, we are using multiple sensors for motion detection. Mainly a PIR and Ultrasonic sensor is used for this purpose.

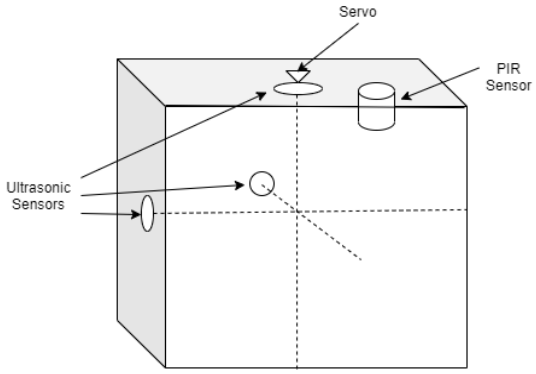

Figure 4 orientation of sensor inside room

Figure 4 shows the orientation of sensors in a single room. After setting up the sensors, in the first run, the ultrasonic sensors will calibrate and store the recorded distances of all the stationary objects. This is notes that for proper accuracy, one would need to calibrate them whenever there is any change in the environment. The Ultrasonic sensor on the rooftop will be couple with a 180-degree servo. It will all the distance in a form of an array. The other two sensors will be kept stationary.

Whenever the PIR sensor gets triggered, the ultrasonic sensors check the distances and compare them to the stored distances. As there is some inefficiency in these sensors, a neglection of ± 25 cm. Running at 10hz, if any deviation in the data is detected in the rooftop and either of the two ultrasonic sensors, an intruder is detected.

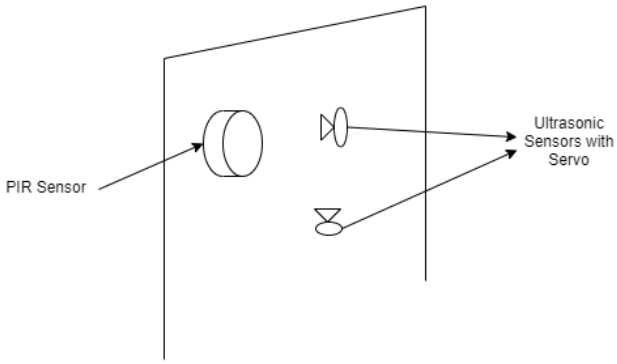

Figure 5 orientation of sensor on an outside wall

.

Figure 5 works similarly but it is the case outside a room. It contains two ultrasonic sensors in-place of three but both of the sensors are coupled with servo one in the x-direction and the other in the y-direction.

V. IMPLEMENTATION

The mobile app is mainly responsible for locking, unlocking, enabling, and disabling the security system. As the user's location enters a predefined radius around the secured area, the outmost layer automatically disables. The outermost layer of security mainly comprises of all the motion detection sensors and the IR sensors. The user after reaching the secured area can give the command to unlock the doors. He is simply supposed to touch a button on his app but the internal functioning of the app is the main part. [4] [5] it uses two-factor authentications before unlocking the door. As the button is clicked, the app sends a hashed code to the remote server and the local server built on ESP8266. The code is decoded in Esp8266 and by the controller that was received by the remote server. After decoding both are matched and then the door will get unlocked. The Wi-Fi hotspot made by the ESP8266 to connect the app locally is also hidden and remains active whenever it receives the code on the remote server. This is the overall system responsible for unlocking the doors.

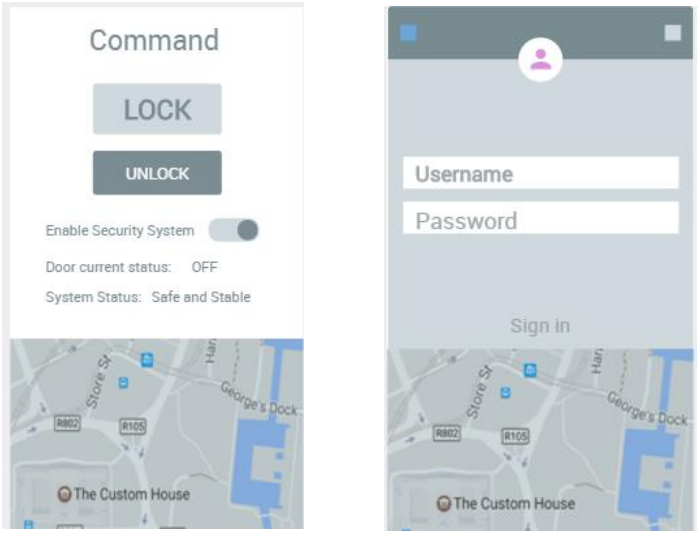

Figure 6 mobile App interface

The second part of this system consists of surveillance. The motion prediction algorithm is explained in the last section. As the motion is detected, a notification is sent to the mobile app. There are very rare chances of fall detection still the main problem will be when the IR sensors at the entrances detect discontinuity. Now comes the feedback system of this system. [6] The door will not get locked until the door is properly closed. The Hall Effect sensors help in this part. Until the magnets on the door are not detected by the Hall Effect sensors, the door will not get locked and the security system will not get active. The app will too help in informing that which door is not properly closed and one should close it before activating the system. In the rarest case when someone tries to break through the door, the switch inside the lock will inform that the lock is active and still the door got opened. In such an emergency, the system will send an emergency notification to the app and also to allotted emergency contacts like the police, etc.

VI. CONCLUSION

Through this paper, we were able to explain the security system we have developed. We have tried our best to minimize the overall cost of the system so that maximum people could afford to buy it if ever it is produced in the market as a product. We have used simple sensors and applied the best possible algorithm to get the best results from these sensors. Using a 32-bit microcontroller was a good idea as it has many benefits over any other 8-bit microcontroller. To make the system safer we used two-factor authentications along with hashing. The system is a closed-loop system which gives feedback that enhances security even more.

References

[1] A. Iqbal and T. Iqbal, "Low-cost and Secure Communication System for Remote Micro-grids using AES Cryptography on ESP32 with LoRa Module," 2018 IEEE Electrical Power and Energy Conference (EPEC), Toronto, ON, 2018, pp. 1-5, doi: 10.1109/EPEC.2018.8598380.

[2] M. A. Raja, G. R. Reddy and Ajitha, "Design and implementation of security system for smart home," 2017 International Conference on Algorithms, Methodology, Models and Applications in Emerging Technologies (ICAMMAET), Chennai, 2017, pp. 1-4, doi: 10.1109/ICAMMAET.2017.8186705.

[3] X. He, M. Papa and R. Gamble, "Extending Over-the-Air Libraries to Secure ESP8266 Updates," 2019 IEEE International Symposium on Technologies for Homeland Security (HST), Woburn, MA, USA, 2019, pp. 1-6, doi: 10.1109/HST47167.2019.9032969.

[4] R. K. Kodali and S. Soratkal, "MQTT based home automation system using ESP8266," 2016 IEEE Region 10 Humanitarian Technology Conference (R10-HTC), Agra, 2016, pp. 1-5, doi: 10.1109/R10-HTC.2016.7906845.

[5] R O. Barybin, E. Zaitseva and V. Brazhnyi, "Testing the Security ESP32 Internet of Things Devices," 2019 IEEE International Scientific-Practical Conference Problems of Infocommunications, Science and Technology (PIC S&T), Kyiv, Ukraine, 2019, pp. 143-146, doi: 10.1109/PICST47496.2019.9061269.

[6] R. K. Kodali, S. C. Rajanarayanan, A. Koganti and L. Boppana, "IoT based security system," TENCON 2019 - 2019 IEEE Region 10 Conference (TENCON), Kochi, India, 2019, pp. 1253-1257, doi: 10.1109/TENCON.2019.8929420.

[7] T. Yang, C. Yang and T. Sung, "A Dynamic Distributed Energy Management Algorithm of Home Sensor Network for Home Automation System," 2016 Third International Conference on Computing Measurement Control and Sensor Network (CMCSN), Matsue, 2016, pp. 174-177, doi: 10.1109/CMCSN.2016.46.