

Embedded Surveillance System using Multiple Ultrasonic Sensors

Harshad S. Patil¹ Dr. Mrs. S. S. Deshpande²

¹PG Student ²Associate Professor

^{1,2}Department of Electronics, Walchand College of Engineering
^{1,2}Sangli, India

Abstract— In this paper we give a brief review of traditional surveillance systems drawbacks and aims to design and develop an efficient surveillance system using multiple smart ultrasonic sensors to detect any kind of suspicious activity around a secured block like home, corporate offices, ATM and smart environments. The multiple ultrasonic sensor modules are used for intruder detection. The Majority Voting Mechanism (MVM) algorithm is used for multiple sensors which state that if more than half sensors in a sensors group show the detection, the MVM initializes the camera. The camera module is used to capture the images of intruder detected in surveillance area. The captured images are uploaded to internet using LAMP server, which user can easily observe it. The alert of detection is also provided to user through GSM.

Key words: Embedded Surveillance System; Raspberry Pi; Ultrasonic Sensors; LAMP Server

I. INTRODUCTION

In the recent days, security and safety comes out as an important aspect/concern for most of the fields (areas). Those fields can be categorized in detail such as surveillance, industrial application, corporate sectors and smart environments [2]-[3]. To provide security and safety to various fields, lots of research is going in the field of surveillance. The traditional surveillance systems for detecting images are replaced by improved one, with improved hardware and software modules, surveillance area, low cost and low power consumption. The improved surveillance system for detecting images must have high performance embedded core to achieve low power consumption and low cost [4]-[5].

The surveillance system involves the monitoring of particular area continuously, which leads to the more power consumption. This power consumption can be minimized, by monitoring the secured area only when any kind of suspicious activity is detected with the help of sensors, hardware and software.

The detection of any kind of suspicious activity is achieved by using ultrasonic sensors over PIR sensors due to its high miss rate for slow intruder action. The ultrasonic sensors now-a-days found in automatic cars and robots for distance measuring.

The refraction and reflection affects the single ultrasonic sensor; hence, to receive the ultrasonic transmission multiple sensors are used which improves the system reliability as well as the overall surveillance area. The Majority Voting Mechanism (MVM) algorithm is applied to multiple sensors, which determines the voting results of multiple sensors and accordingly the system initiates the web camera to capture the images [1]. These captured images are uploaded by web server and made available to user.

II. SYSTEM ARCHITECTURE

The overall system architecture is as shown in Fig.1 where embedded platform is system core. The ultrasonic transmitter and receiver are placed on same side; the receiver is receiving continuous ultrasonic transmissions from the transmitter which are reflected from stationary wall of secured block. The receiver will not receive any kind of reception when ultrasonic transmissions are blocked due to the presence of any intruder. The embedded surveillance system will monitor the state of each sensor and decides whether to initiate the web camera or not according to the MVM result. The web camera captures the images, which are uploaded to internet by embedded surveillance system. The alert is also provided to user through the GSM module simultaneously.

A. System Flow:

The flow chart of the system is as shown in Fig. 2 which shows various processing steps involved.

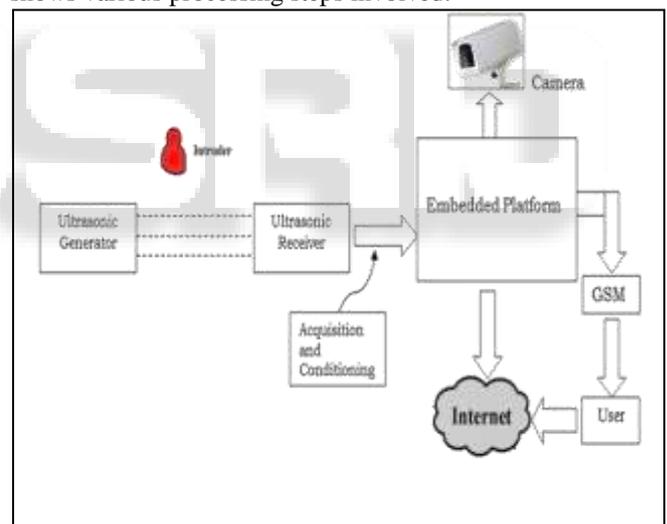


Fig. 1: Block Diagram of System Architecture

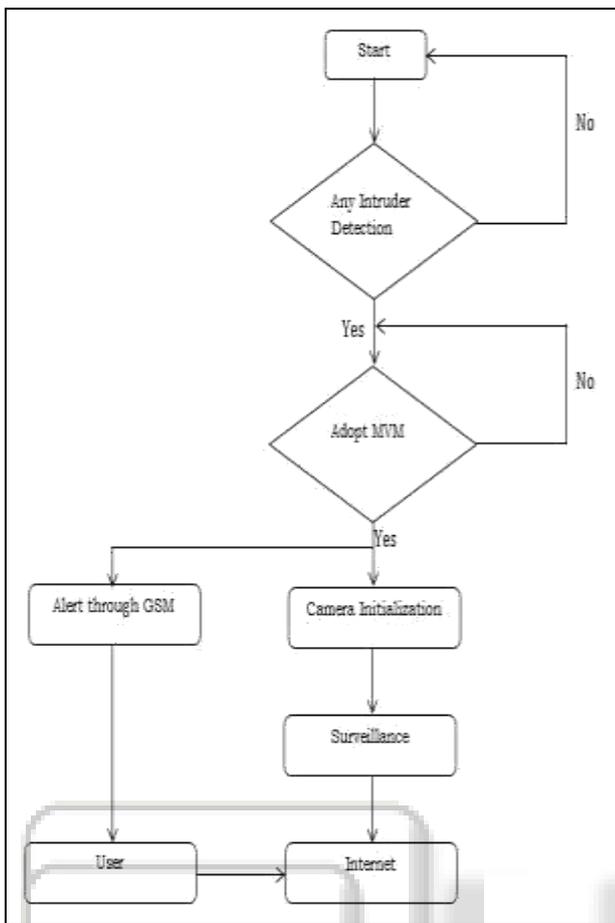


Fig. 2: Flow Chart of System Architecture

The ultrasonic sensor is continuously monitoring the surveillance area for any suspicious activity around secured area. If any intruder detection occurs, embedded core will initiate the web camera. Also, the alert to user is provided via GSM modem. The web camera will capture images, these images are uploaded to internet using web server.

B. Hardware Modules:

The system consists of different kinds of hardware modules each performing its specific task.

1) Ultrasonic Sensor Module:

The HC-SR04 ultrasonic sensor module is used in this system, this sensor module has built-in transmitter, receiver and control circuit on a single chip.

The ultrasonic transmissions from transmitter are received by receiver after reflected from stationary object or wall of a secured area. The ultrasonic transmitter module is configured in such way that it will provide distance travelled by ultrasonic transmission. If the distance travelled is less than the reference distance, then suspicious activity is detected and intruder is present in between sensor modules and stationary walls of secured area.

Using IO trigger for at least 10us high level signal, the module automatically sends eight 40 kHz and detect whether there is a pulse signal back. If the is signal back, through high level, time of high output IO duration is the time from sending ultrasonic to returning and the corresponding distance is calculated as

$$\text{Distance} = (\text{high level time} \times \text{velocity of sound}) / 2$$

2) Arduino UNO:

The Arduino Uno is a micro-controller board based on the ATmega328 as shown in Fig. 3. Arduino is a tool for making computers that can sense and control more of the physical world. It's an open source physical computing platform based on a simple micro-controller board, and a development environment for writing software for the board. Arduino can be used to develop interactive objects, taking inputs from a variety of switches or sensors, and controlling a variety of lights, motors, and other physical outputs. It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog input pins suitable for multiple sensor application.

The configuration of ultrasonic sensor module is achieved using an Arduino board. The Arduino is used to control all sensor activity as well as deciding presence of intruder based on measured distance by ultrasonic transmission. The ultrasonic sensor module with Arduino board will work as single sensor node. Similarly, more than single sensor node can be created. The sensor node will communicate with high performance embedded core using ZigBee communication protocol, providing the status of sensor modules.

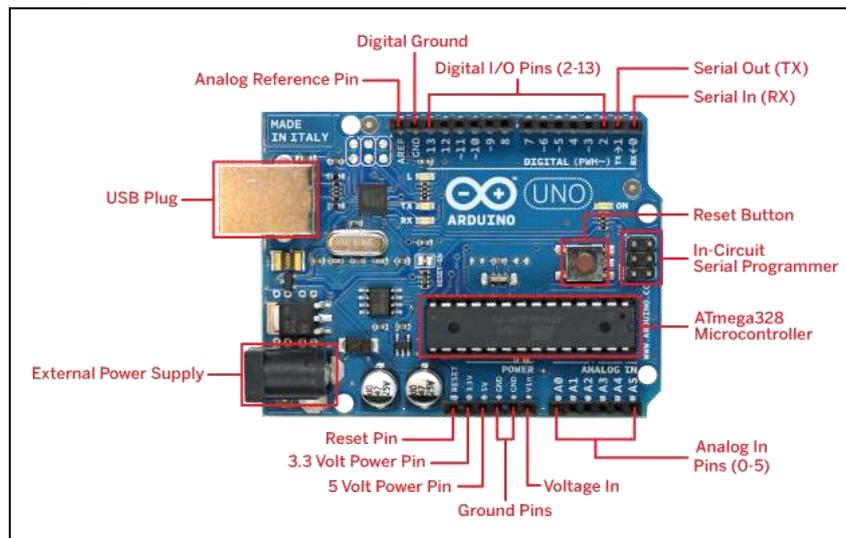


Fig. 3: Arduino Board

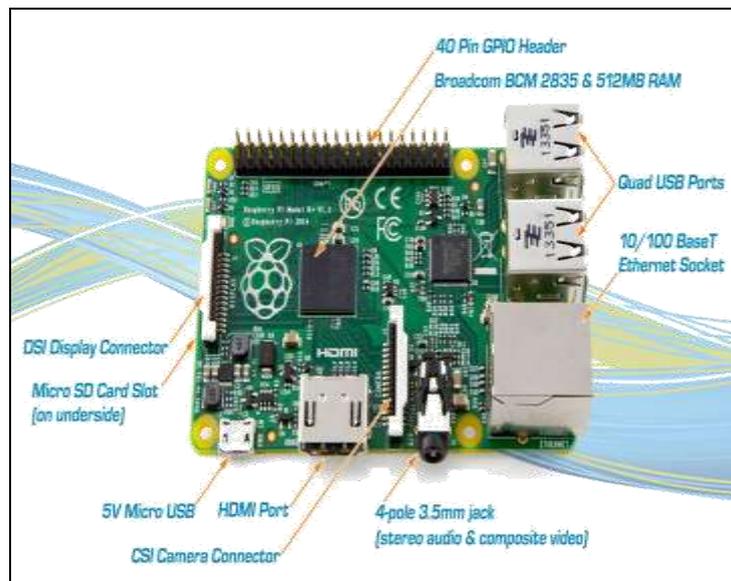


Fig. 4: Raspberry Pi

3) Raspberry Pi:

The high performance embedded core used in this system is Raspberry Pi as shown in Fig. 4; it is low cost, low power, credit size single board computer. The Raspberry Pi is ARM11 powered Linux operating system capable single board computer. The operating frequency of an ARM11 microcontroller is 700MHz and it has 512 Mega Bytes of RAM memory. The B+ version of Raspberry Pi is used in this system as shown in Fig. 4. There are variety of operating systems available for Raspberry Pi including PIDORA, debian based Linux distro, Raspbian which recommended by Raspberry Pi foundation. The Raspberry Pi can be accessed by more than one client from anywhere through SSH remote login or by putting Raspberry Pi ip address in putty software after connecting to Ethernet.

The important task of Raspberry Pi in this system is to initiate web camera based on results from the sensor node. The Raspberry Pi will also works as web server which will upload the images captured by camera to internet.

4) GSM Module:

In this system we used SIM 900 GSM/GPRS module which provides an alert to user via SMS. It is small in size and easy to use as GSM modem. The quad band GSM/GPRS TTL modem works on four different kinds of frequencies 850 MHz, 900 MHz, 1800 MHz and 1900 MHz. This modem can be operated at 3V3 and 5V DC supply. The major advantage of this modem is that it can be directly interfaced with microcontrollers (AVR, Arduino, 8051, PIC).

The GSM modem is interfaced with Raspberry Pi using USART (Universal Synchronous Asynchronous Receiver and Transmitter) serial communication. The AT commands are used for the operation of GSM modem.

C. Software Modules:

The system also uses various software modules to accomplish the task of intruder detection, image capture and its upload.

1) Arduino IDE

The Arduino IDE (Integrated Development Environment) is open source software for Arduino which makes it easy to write the code and upload it to the board. It is compatible for various operating systems including Windows, Mac OS X,

and Linux. The Arduino IDE allows user to write the program in C and embedded C. It interacts with the Arduino hardware to burn the programs and communicate with them. In this system ultrasonic sensor modules are configured with Arduino board. The program for detecting the travelled distance by ultrasonic transmissions is uploaded to Arduino board with the help of Arduino IDE software environment. The MVM is also implemented using Arduino board and Arduino IDE. In this system we are using three ultrasonic sensor modules which are connected to Arduino board. The Arduino board will monitor the status of each ultrasonic sensor module and decides whether to acquire MVM or not. Then according to the result of MVM the Arduino board will sent an interrupt to Raspberry Pi through ZigBee communication protocol.

2) Python:

The python language is recommended to interact with Raspberry Pi by Raspberry Pi foundation. Python is a powerful programming language that's easy to use and with Raspberry Pi it allows to get connected with the real world. Python is a widely used general-purpose, high-level programming language. The code readability is achieved because of python's design, and its syntax allows users to write a concept in minimum lines of code when compared to Java or C++.

The task perform by python script in this system is to initialize the hardware which is the Raspberry Pi camera module. The Raspberry Pi receives interrupt from ZigBee protocol as a result of MVM, after detecting the result the Raspberry Pi executes the python script to wake up the camera. The camera further captures the stream of images.

3) LAMP Server

LAMP stands for the four components which construct it as the Linux operating system, the Apache HTTP Server, the MySQL relational database management system and the PHP programming language. The important reason behind using a LAMP server is it's an open-source and totally freely available.

The images captured by Raspberry Pi camera after intruder detection is uploaded to internet by web server. In this system LAMP server will act as web server and it will upload the captured images to internet. The MySQL

component of the LAMP server is a relational database management system which holds the capability of storing large number data. The images are stored in MySQL database in the form of Binary Large Object (BLOB), such a large number of images can be stored in MySQL database. The stored images in MySQL database can be viewed on web page, the PHP programming language is used to access the dynamic web page. The images are accessed using PHP programming script. To access the MySQL database PHP is most widely used programming language, also PHP is easier than any other programming language to access the database. It has lots of other advantages such as auto refresh mechanism can also be provided to view the updated images on web page.

III. IMPLEMENTATION AND RESULTS

The system we implemented uses three ultrasonic sensor modules which are interfaced with single Arduino board at different locations and different directions. Fig. 5 shows the single ultrasonic sensor module to be interfaced with Arduino board. The experimental result shows that when any suspicious activity is detected along the transmission path of sensing area, the distance travelled by ultrasonic transmissions is less than the reference distance. The Arduino serial monitor shows the intruder detection in Fig. 6. It causes status of ultrasonic sensor module to be changed from OFF to ON. When the two or all three ultrasonic sensor modules have ON status due to intruder activity, Arduino board generates an interrupt signal. The interrupt signal is provided to Raspberry Pi through ZigBee communication protocol, which turns on the camera. The camera module interfaced is as shown in Fig. 7. The alert provided to user through SMS using GSM modem is as shown in Fig. 8

The observed detection can be viewed on Raspberry Pi's terminal shown in Fig. 9 and the corresponding image sequence captured is shown on web page in Fig. 10.

The experimental result also shows that as the number of ultrasonic sensor modules increased, the overall surveillance area covered by the sensors also increases. The power consumption is achieved by initializing the camera only when intruder is detected instead of continuously monitoring the secured block.

In this system we observe and measure the working of single and multiple sensor modules at various distances. Table I shows the result of our experiment.

Distance	Overall Probability of Sensing	
	Single Sensor	Three Sensors
1 m	100 %	100 %
2 m	98 %	100%
3 m	91%	97%
4 m	83%	91%

Table 1: Sensing Probability for Single and Three Ultrasonic Sensor Modules

From the Table I it is observe that as the numbers of sensors are increased the covered surveillance area by sensors increases and also the sensing efficiency of the system improves.

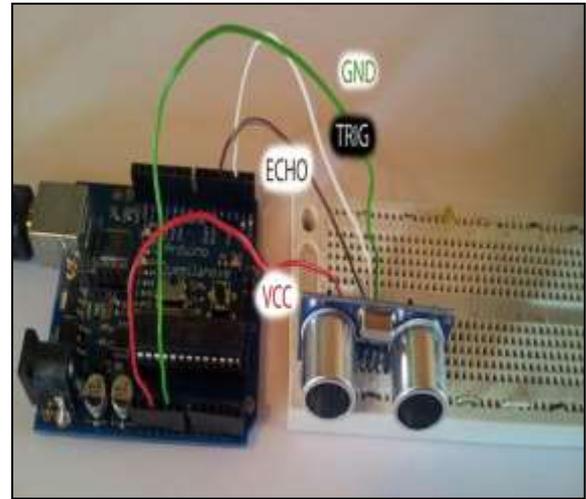


Fig. 5: Arduino Board Interfaced with Ultrasonic Sensor Module

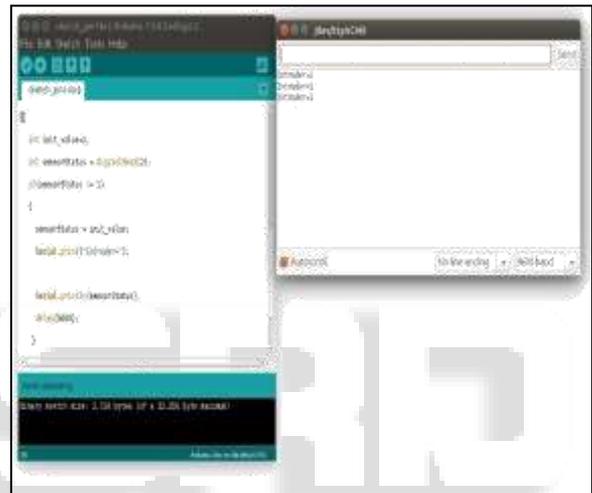


Fig. 6: Arduino Serial Monitor Showing Detection



Fig. 7: Raspberry Pi Interfaced With Camera Module

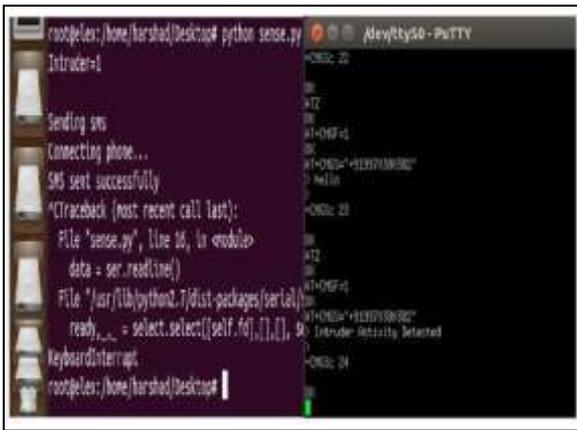


Fig. 8: Alert to User Through GSM

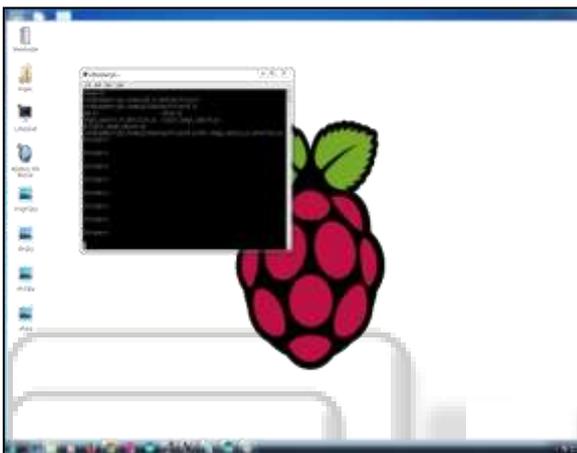


Fig. 9: Detection on Raspberry Pi's Terminal



Fig. 10: Web Page Showing Captured Images

IV. CONCLUSION

The system we implemented shows that the overall probability of sensing improves for multiple sensor modules according to MVM. The overall surveillance area covered by the sensor modules also increases for multiple sensors as compared to single sensor. The effective cost of the system increases due to inclusion of multiple ultrasonic sensor modules, Arduino board and Raspberry Pi camera module, but the efficiency and reliability of the overall system is improved. The probability of false detection is less as compared to the previous systems. The camera module is initiated only when detection observed instead of continuous

monitoring, which results in less power consumption compared to previous systems.

REFERENCES

- [1] Ying-Wen Bai; Li-Sih Shen; Zong-Han Li, "Design and implementation of an embedded home surveillance system by use of multiple ultrasonic sensors," Consumer Electronics, IEEE Transactions on , vol.56, no.1, pp.119,124, February 2010
- [2] Liang Hsu, Sheng-Yuan Yang, Wei-Bin Wu, "Constructing intelligent home-security system design with combining phone-net and Bluetooth mechanism,"
- [3] I. A. Zualkernan, A. R. Al-Ali, M. A. Jabbar, I. Zabalawi, A.Wasfy, "InfoPods: Zigbee-based remote information monitoring devices for smart-homes," IEEE Transactions on Consumer Electronics, vol. 55, no. 3, pp. 122 1226, Aug. 2009.
- [4] Hui-Huang Hsu, Po-Kai Chen, Chi-Yi Lin, RFID-based danger prevention for home safety,, in Proc. ISAC10, pp. 5660, Nov. 2010.
- [5] Chun-Liang Hsu, Sheng-Yuan Yang, Wei-bin Wu, 3C intelligent home appliance control system Example with refrigerator, Expert Systems with Applications, vol. 37, no. 6, pp. 4337-4349, June 2010.
- [6] Qinjun Du and Xueyi Zhang, "Ultrasonic Image Analysis and 3-D Reconstruction for Minimally Invasive Surgery," 3rd International Bioinformatics and Biomedical Engineering , 2009. ICBBE 2009, pp.1-4, 11-13 June 2009.
- [7] Powers, Shawn. "The open-source classroom: your first bite of raspberry pi." Linux Journal 2012.224 (2012):7 [http:// www.raspberrypi.org/](http://www.raspberrypi.org/)
- [8] <http://www.arduino.cc/en/Guide/Introduction>
- [9] <http://www.raspberrypi.org/products/camera-module/>