Development of building security integration system using sensors, microcontroller and GPS (Global Positioning System) based android smartphone

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Abstract. Security system is one of the common problems to protect an environment such as personal house or a warehouse. There are numerous methods and technologies that can be used as part of a security system. In this paper, we present a security system that offers a better efficiency. The purpose of this study is to build a system that can monitor home security at any time in particular fire and theft. Through sensors, the system will be able to provide warning information of hazard conditions via LCD monitor, sound, and alarm. This information will be sent automatically to the home owner's smartphone as well as to the corresponding to the security agency. Thus the prevention of theft and fire hazards can be immediately anticipated by the police and firefighters. The system will also notify the position of the coordinates of the location of the building (the house) by a link to the Google map in order to make it easier to get the location quickly.

1. Introduction
The security system is one of the most important things right now. The availability of integrated security systems with multiple agencies has become a necessity nowadays. Using only labor for security is no longer considered an effective method. Therefore, the role of technology needs to be involved to support the security system.

The cost to hire adequate person to cover a certain area and the inability to guarantee an effective 24-hour security are two of the biggest problem in security system. Hence, the role of technology has replaced man based security as the vital part of the security. There are many methods and technology available to develop a solid security system. However, the use these technologies to achieve a better security should be in line with efficiency. For example, while recording a 24-hour event is considered as the most effective system, it is still considered inefficient due to redundant amount of recording that contains no crucial information. Moreover, the cost of maintaining the system to work in 24-hour can be extremely expensive.

The objective of this work is to introduce a method that solves the efficiency problem without jeopardizing the effectiveness of the security system. This proposed system uses the sensors, such as gas sensor, infrared and vibration sensor. The sensors will detect if any occurring intrusion event or
fire accident. In addition, the system also able to perform a one-way communication to registered user in order to notify the user should any event is occurred. We build this system using Raspberry Pi as its main board. Moreover, the system will be connected to a PC that will operate as an SMS gateway.

2. Related Work

Due to increasing crime, the current security system is also a lot of modifications by using sensors that are connected directly to the microcontroller and Raspberry Pi. Raspberry Pi [1] is basically a single board computer mini hardware that can be used as a computer server. This minicomputer was developed and introduced first by the Raspberry Pi Foundation in 2012, with the aim of this device is to simplify computer hardware while reducing costs. Raspberry Pi is made simpler but its ability to work as computer hardware is the same as any other computer. In addition, with Raspberry Pi also provides an opportunity for students and researchers to create specific computers for specific tasks such as for building security systems in this study. Raspberry size is made relatively small compared to ordinary computers, but Raspberry Pi functions like a common computer hardware that uses processor, memory, storage, it also has the ability to run basic operating systems like Linux and Windows. There are many research-based uses Raspberry Pi as its platform. Russell Barnes wrote several projects using raspberry pi [2]. Shaijupaul, et al wrote Home Based Android Automation Using Raspberry Pi [3]. Pawan Singh, et al has conducted a review paper on GSM Smart Home Automation System. [4].

Basicly, the sensor can detect an event in a building that can be connected directly to the microcontroller and Raspberry Pi. For example, a PIR (Passive Infra-Red) sensor is an electronic sensor that detects events based on the infrared light changes emitted from the object in view. The principle of the infrared sensor operation is that all of the objects radiate heat energy in the form of radiation. This radiation is largely invisible because it emits infrared wavelengths. Infrared sensors are able to detect the radiation emitted by objects. Normally, the sensor does not need to expend any energy to perform the detection, then the term passively pinned to the sensor. Infrared vision is widely used to detect objects in dark environments. In the case of security, where disturbances mostly occur at night to avoid crowds, the use of infrared vision may be very important for recording objects [5]. One of the PIR sensor models can be seen in Figure 1.

![Passive infrared-motion sensor block diagram](image)

**Figure 1.** The main part of the PIR sensor

The PIR sensor used in this project only detects infrared transmitters with wavelengths of 8-14 micrometers. Beyond that wavelength, the sensor will not detect it. Generally, humans have a body temperature that can produce infrared emissions with a wavelength of about 9-10 micrometers (standard value 9.4 micrometers), the wavelength can be detected by the PIR sensor. (Generally, PIR sensors are designed to detect humans).

3. System description

3.1. The Block Diagram

In the Block Diagram described a system configuration used. The system uses electricity from PLN 220 Volt AC 50/60 Hz, then transmitted to 2 output DC voltage (Direct Current) which is 12 Volt DC is used to supply Arduino ATMEGA 2560 and 5 Volt DC power microcontroller for Active Power
Speaker. All sensors and modules use power from a microcontroller that is converted by a microcontroller from 12 Volts to 5 Volts DC. All gas, smoke and PIR sensors will report their respective output values each time to the microcontroller. The microcontroller will identify the detection value of the sensor. If the microcontroller gets the sensor value at a predetermined threshold, then the microcontroller will perform the reporting function and the neutralizing function.

The detection resulted will send to the smartphone in the form of SMS via phone to a specified number (e.g. to the building owner, security, and police) by utilizing SIM900 Module. May also report in the form of sounds using VS1053 MP3 Module and forward it to the active speaker. Then use the 16X2 LCD monitor as a writing indicator, light alarm as alarm warning alarm. Then there is this Neutralization function like fan blower (Exhaust Fan) by using the Opto-Triac driver. Control on/off channel 1-5. This alarm light uses direct power from PLN 220 Volt AC with SMS command received by SIM900 module then executed according to SMS command by the microcontroller to enable Opto-Triac as a driver from channel 1-5 and Light Alarm. The PIR sensor will report if there is theft at some point that has been installed sensors on the doors (windows) building. We can see the Block diagram in Figure 2.

4. The experimental set up and testing result
The first part of the implementation process is to connect all of the devices described above. In this section, we will go through the process of connecting the devices based on the architecture.

4.1. The Experimental Set Up
After compiling all the wiring neatly and sequentially, then re-check the wiring that has been installed to ensure that the wiring matches the schematic. All modules and sensors are installed in miniature of the house as shown in Figure 3.
4.2. Testing system sensors
In a testing of the performance of the sensor functions on the system carried out aims to test the sensors used by the system.
The test consists of 7 sensor testing i.e. PIR sensor, MQ-2 gas, MQ-2 smoke, DHT-22 temperature sensor and 2 magnetic switch sensor:

4.2.1. PIR sensor testing. PIR sensor testing aims to determine the ability of the sensor in detecting human presence at a distance of 500 Cm from the sensor. This test by simulating the existence of human and microcontroller will send data to SIM900 Shield which will send SMS message "There is People In Front of House!!". This experiment was conducted as much as 9 times and resulted in the test seen in Table 1

| No. | Distance (Cm) | SMS status | System Performance Status |
|-----|---------------|------------|---------------------------|
| 1.  | 50            | Sent       | Works                     |
| 2.  | 100           | Sent       | Works                     |
| 3.  | 150           | Sent       | Works                     |
| 4.  | 200           | Sent       | Works                     |
| 5.  | 250           | Sent       | Works                     |
| 6.  | 350           | Sent       | Works                     |
| 7.  | 400           | Sent       | Works                     |
| 8.  | 450           | Sent       | Works                     |
| 9.  | 500           | Sent       | Works                     |

By the table 1 it can be concluded that the PIR sensor used to detect a distance of 50 to 500 Cm and work well as expected. Long delivery of SMS depending on operators Provider used. In this test the old SMS sending is 4-8 seconds.

4.2.2. The MQ-2 gas and MQ-2 smoke sensors testing. The MQ-2 gas and MQ-2 smoke sensor test aims to find out whether the sensor can detect the presence of gas and smoke and send a report of threshold conditions via SMS. The MQ-2 gas test will be tested using a gas lighter and the smoke MQ-
2 is tested using cigarette smoke. Lighters and cigarette smoke near the sensor for fast detection. This experiment was conducted 7 times and produced test data which can be seen in the Table 2.

Table 2. Sensor Test Results of MQ-2 Gas and MQ-2 Smoke

| No. | Range MQ-2 Gas (%) | MQ-2 Gas Detected (%) | Range MQ-2 Smoke (%) | MQ-2 Smoke Detected (%) | SMS Status | System Performance Status |
|-----|--------------------|-----------------------|----------------------|-------------------------|------------|---------------------------|
| 1.  | 30-100             | 32                    | 10-100               | 13                      | Sent       | Works                     |
| 2.  | 30-100             | 42                    | 10-100               | 16                      | Sent       | Works                     |
| 3.  | 30-100             | 34                    | 10-100               | 18                      | Sent       | Works                     |
| 4.  | 30-100             | 45                    | 10-100               | 15                      | Sent       | Works                     |
| 5.  | 30-100             | 37                    | 10-100               | 17                      | Sent       | Works                     |
| 6.  | 30-100             | 33                    | 10-100               | 12                      | Sent       | Works                     |
| 7.  | 30-100             | 46                    | 10-100               | 15                      | Sent       | Works                     |

If there is a gas leak detected by the MQ-2 gas sensor in the house above of the threshold value of 10%, then the system will report the condition in the form of LCD with the text format as follows: "Ada Gas bocor!! Kadar (detected)%". The gas leak monitor is shown in Figure 4.

Figure 4. The Text LCD Indicator Gas Leak

When the leaking gas is detected by the sensor above 40% then the system will report the condition via a short phone and SMS to the homeowner, firefighters, and Police or another number that has been set. The text format "FIREFIGHT: There's Gas Leaking, Triggering Fire, Google Map Locations: https://www.google.com/maps/place/3.55468,98.63993".

4.2.3. The DHT-22 temperature sensor testing. The DHT-22 temperature sensor used to detect the ability of the sensor in detecting heat of temperature. This test simulates will show the presence of hot temperatures by using matches as a trigger of hot temperatures. The microcontroller will send the data to SIM900 Shield which will send SMS message "Detected heat with Temperature: (temperature detected), Humidity (moisture detected)". This experiment was conducted 7 times and resulted in Table 3.

Table 3. Temperature Sensor DHT-22 Test Result

| No. | Range DHT-22 °C | Gas Detected °C | System Performance Status | System Performance Status | SMS Status | Status |
|-----|-----------------|-----------------|---------------------------|---------------------------|------------|--------|
| 1.  | 35-100          | 40              | Works                     | Works                     | Sent       |        |
| 2.  | 35-100          | 37              | Works                     | Works                     | Sent       |        |
| 3.  | 35-100          | 48              | Works                     | Works                     | Sent       |        |
| 4.  | 35-100          | 43              | Works                     | Works                     | Sent       |        |
| 5.  | 35-100          | 36              | Works                     | Works                     | Sent       |        |
| 6.  | 35-100          | 44              | Works                     | Works                     | Sent       |        |
| 7.  | 35-100          | 47              | Works                     | Works                     | Sent       |        |
The DHT-22 sensor testing and SMS Status Condition of DHT-22 as shown in Figure 5 (a) and (b).

Figure 5. (a) DHT-22 Sensor Testing, (b) SMS Status Condition of DHT-22

4.2.4. Testing the magnetic switch sensor. Sensor magnetic sensor testing aims to determine the ability of sensors in this system to detect whether the door/window is open or closed. This magnetic switch sensor has the same conditions as the PIR sensor that provides input to the microcontroller in the form of 2 conditions i.e. open or closed conditions (logic 1 or 0). This test is done by simulating a miniature door/window that opened and/or closed intentionally. Then Microcontroller will send data to SIM900 Shield which will send SMS message "Door / Open window!!". This test is done 7 times and the result is shown in Table 4.

Table 4. The Magnetic Sensor Switch Test Results

| No. | Magnetic Switch Status | SMS Status | System Performance Status |
|-----|------------------------|------------|--------------------------|
| 1.  | Open                   | Sent       | Works                    |
| 2.  | Open                   | Sent       | Works                    |
| 3.  | Open                   | Sent       | Works                    |
| 4.  | Open                   | Sent       | Works                    |
| 5.  | Open                   | Sent       | Works                    |
| 6.  | Open                   | Sent       | Works                    |
| 7.  | Open                   | Sent       | Works                    |

5. Conclusions
The design and development of integrated Home Security systems Using SMS Android-Based Microcontroller ATMEGA 2560 has been described in this paper, and all components work properly. In this Project, we can see that the sensors automatically detect the state of the building and send the detection resulted to the ATMEGA 2560 Arduino microcontroller and controlled by the smartphone. We have tested for any sensor, e.g. PIR sensor testing aims to determine the ability of the sensor in detecting human presence at a distance up to 500 Cm from the sensor. In the gas sensor, when the leaking gas is detected by the sensor above 40% then the system will report the condition via a short phone and SMS to the homeowner, firefighters, and Police or another number that has been set. The text format "FIREFIGHT: There's Gas Leaking, Triggering Fire, Google Map Locations: https://www.google.com/maps/place/3.55468,98.63993". In the gas sensor, we have tested that the DHT-22 temperature sensor testing aims to determine the ability of the sensor in detecting heat temperature. And the last testing is magnetic sensor testing aims to determine the ability of the sensors in this system to detect the door/window is open or closed. This magnetic switch sensor has the same conditions as the PIR sensor that provides input to the microcontroller in the form of 2 conditions i.e. open or closed conditions (logic 1 or 0). This test is done by simulating a miniature door/window that opened and/or closed intentionally. Then microcontroller will send the data to the SIM900 Shield which will send by SMS message.
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References
[1] Raspberry pi.[Online].Available:http://www.raspberrypi.org/
[2] Russel Barnes, The Official Raspberry Pi Project Book. Available: https://www.raspberrypi.org/magpi-issues/Projects_Book_v1.pdf
[3] Paul S, Antony A, Aswathy B 2014 Android Based Home Automation Using Raspberry Pi Int. J. Comput Technol 1(1) 143-147.
[4] Singh P, Chotalia K, Pingale S, Kadam S 2016 A Review Paper on Smart GSM Based Home Automation System. Int. Res. J. Eng. Technol. 3(4) 1838-1843.
[5] Gupta, A 2015 Intelligent Home security using GSM communication module.
[6] Asif O, Hossain MB, Hasan M, Rahman MT, Chowdhury ME 2014 Fire-Detectors Review and Design of an Automated, Quick Responsive Fire-Alarm System Based on SMS Int. J. Commun. Network Syst. Scie. vol. 7 386-395
[7] Gurav MR, Jagtap MR 2015 Wireless digital notice board using GSM technology Int. Res. J. Eng. Technol. vol. 2 1-3.
[8] Sadagopan VK, Rajendran U, Francis AJ 2011 Anti theft control system design using embedded system. Proc IEEE ICVES vol.85 239–242.
[9] Pany JK, Choudhury RD 2011 Embedded Automobile Engine Locking System, Using GSM Technology Int. J. Instrum. Control Automa. 1(2).
[10] Sebastian S 2013 Literature survey on automated person identification techniques Int. J. Comput. Sci. Mobile Comput. 2(5) 232-237.
[11] Sehgal VK, Singhal M, Mangla B, Singh S, Kulshrestha S 2012 An embedded interface for GSM based car security system Proc. 4th CICSyN
[12] Bajaj R, Ranaweera SL, Agrawal DP 2002 GPS: location-tracking technology Comput. Scie. Eng. 92-94.
[13] Kumar BP, Raj VD, Harika P, Mallikarjun P, Kumar DK 2013 Wireless Unmanned all-Terrain Vehicle With Gsm and Gps Proc. IJMCA 1(3)
[14] Mazidi MA, Mazidi JG, McKinlay RD 2006 the 8051 microcontroller and embedded systems Department of Computer Science and Information Engineering National Cheng Kung University of Taiwan