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DESIGN AND PERFORMANCE EVALUATION OF GSM BASED HOME SECURITY USING HYBRID SENSOR ARRAY

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Abstract- *One of the most major concerns in the previous decades is the development of adaptive security system to prevent both the loss of asset and the life of human being. Though much research work is done for the security of industrial and commercial area, the residential security system development is ignored in the prospect of Bangladesh which makes our socio economic structure much vulnerable. Our work is to implement nodes of hybrid sensor array (HSA) and global system of mobile (GSM) to provide security of residential area at the time of absence of people from home. In this project the whole residence is divided into several zones and in every zone there exists an array of passive infrared ray (PIR) sensors and gas sensors. If any anomalous activity is detected by the system, it will send SMS to the house owner's cell phone and also inform in which zone intrusion is identified. At the entrance of the main door there is an array of force sensitive resistors (FSR) which detect the presence of person. Significant amount of response from this sensor array will also send a warning SMS to the owner of the house. The performance of the developed system is excellent.*

Keywords: HSA, PIR, Gas sensors, FSR and GSM.

1. INTRODUCTION

Bangladesh is a developing country and as like most of the developing countries many people in this country are poor and unemployed. Thus the crime incidents are increasing in our country rapidly. One of the major crimes in Bangladesh is house theft while the house resident are away from house. Preventing this type of crime would not be possible if effective measures are not taken to improve security system as well as to improve the life standard of general people. This project aims at developing a security system using a hybrid sensor array. The performance of this system is also evaluated at the latter section of this paper.

2. LITERATURE REVIEW

Security system concept is not new actually but any system before development must be analyzed so that it can fit in a specific environment. In [1] zigbee based sensor is used to accumulate the data and then pass through the GSM which is done using pervasive computing. Implementation of sensors with both zigbee and GSM together make the system costly and reliability of this system is questioned when any of the sub system is failed. Similar type of system is proposed in [2]. Zigbee and GSM based monitoring is done in [3]. But for long range and cost effectiveness consideration, this system will not be able to meet the demand. Literature [4] offers home security and appliance control by GSM network but when the android application password is broken by social engineering the system will be vulnerable. Almost identical type of system is introduced in [5] using an android application. Both the system are based on android application. Users may find it uncomfortable if he/she is not an android user. In literature [6], photosensitive security system is developed which might be cost efficient but the reliability of this system will not be enough if the crime scene is well organized.

Since our system implements the hybrid sensor array, it is efficient against organized intrusion and theft.

3. SYSTEM CHARACTERISTICS

The characteristics of the developed system can be described as follows:

i. Hybrid sensor array in which PIR sensor, FSR and gas sensor MQ135 are integrated.
ii. Design concentrates on development of different module i.e. modular design.
iii. Improved algorithm for detection of abnormal activity.
iv. Wider communication range as GSM is used.
v. User friendly and reliable system.

These characteristics make our system better than other systems.

4. METHODOLOGY

The methodology can be expressed by the following block diagram:

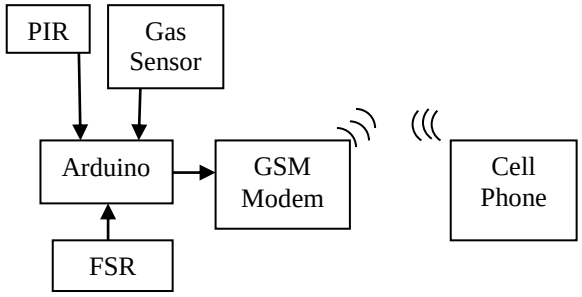

Fig.1: Block diagram of the implemented system

5. SYSTEM DESCRIPTION

The system will be divided into two parts−

(A) Home unit

(B) User unit

Only home unit development is described in this paper.

Home unit: This unit consists of two main parts which is controlled by a processing system. Arduino mega 2560 is used for processing purpose. The two parts are−

(i) Hybrid sensor array and

(ii) GSM module.

The description is given below−

i. *Hybrid sensor array:* The sensor module is called hybrid sensor array because it is not made with one sensor. It is made with multiple sensors. The sensors used in HSA are PIR, FSR, MQ135 for perfect authentication of crime scene. The description of the individual sensor is given below−

A. PIR sensor: The sensor that measures the level of infrared (IR) radiation in its field of view is called passive infrared sensor (PIR) or Pyro electric sensor or IR motion sensor. Most of the time they are used to detect motion. Infrared radiations are invisible to the most of the living being including humans. Every object (may be living or without life) radiates heat energy if its temperature is above absolute temperature (>-273K). PIR sensors are designed to detect this particular radiation i.e. it can detect motion. Fresnel Lens is used to focus the infrared radiation to the sensor. But if only one Fresnel Lens is used then motion from only one direction can be detected. To overcome this inconvenience a group of Fresnel Lenses are accommodated in a half sphere shaped white window. White window is used so that radiation of all frequencies can be absorbed.

When motion is detected it will give a positive pulse. This pulse is fed to one of the analog pins of Arduino mega 2560.

Though there is a possibility that non-human movement may be detected and false alarm may cause inconvenience, the PIR sensor output was analyzed for reducing the possibility of error. The calibrated value is inserted after thirty test trials. The calibrated value has improved the capability of the hybrid sensor to detect motion more efficiently.

Fig.2: Passive Infrared Sensor

B. Force Sensitive Resistor: The resistor that changes its resistance when physical pressure or weight is applied is called Force Sensitive Resistor (FSR). If the sensor is squeezed then also resistance is changed.

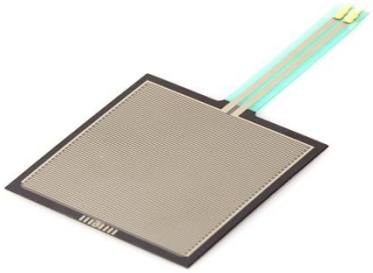

Fig.3: Force Sensitive Resistor (FSR)

Force Sensitive Resistor has mainly three parts−

- Printed semiconductor with flexible substrate
- Adhesive Spacer
- Printed integrated electrodes with flexible substrate.

The output values from sensor to sensor may vary at 10%. The sensor has nonlinear output resistance with respect to the force applied. It will be clear from log - log graph of input - output characteristics.

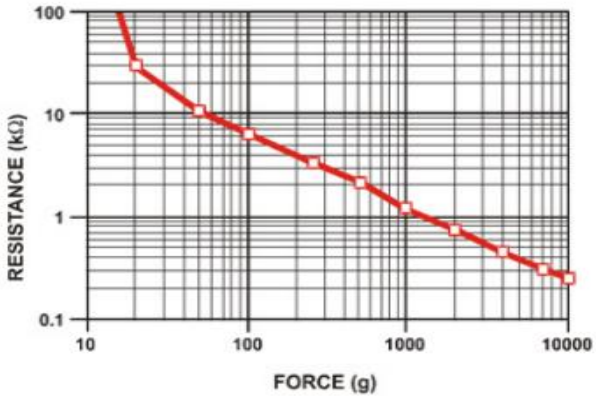

Fig.4: FSR characteristics curve [9]

C. CO_2 sensor (MQ 135): Equipment's those are environment sensitive or to detect any gaseous change in a specific environment, gas sensor is used. For our system we choose MQ 135 which can detect ammonia

(NH_3), oxides of nitrogen (NO_x), alcohol, benzene (C_6H_6), smoke, CO_2 etc. But in this particular case we will use CO_2 and derive its equation. From the datasheet we get the following set of curves of sensitivity characteristics for different gases.

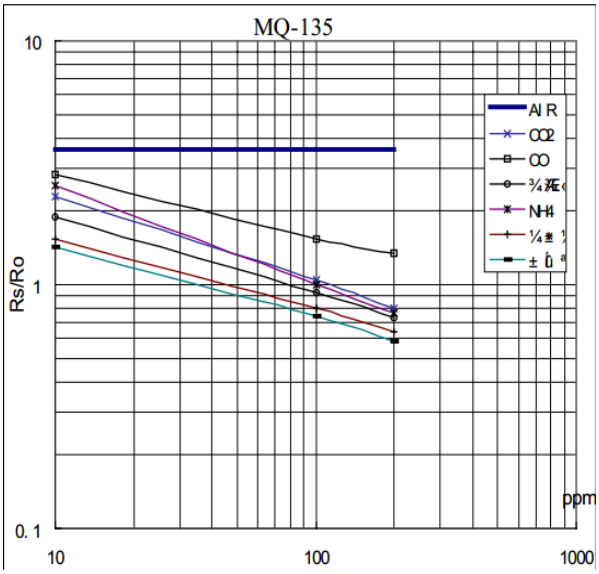

Fig.5: MQ135 characteristics curve [10]

This curves are plotted in log-log scale .So the R_s / R_o vs. p.p.m relation is nonlinear. The original equation will be in the form−

$$y = bx^m \quad (1)$$

Now taking logarithm on both side we get−

$$\log_{10} y = m \log_{10} x + b \quad (2)$$

where y refers to R_s / R_o and x refers to ppm (parts per million)
Now taking two points of the curve we get our required equation−

$$ppm = 106.1996 \times \left(\frac{Rs}{Ro}\right)^{-2.8367} \quad (3)$$

Which can be reduced to−

$$Ro = Rs \times \sqrt[2.8367]{\frac{106.1996}{ppm}} \quad (4)$$

Now from [7] we get the amount of CO_2 and find the value of Ro.

Now the sensor need to be calibrated and for this reason the sensor is powered for 24 hours and then next 24 hours it is left on the environment. When the sensor is calibrated, the analog output from it is used to measure the output resistance Rs. Then the concentration of CO_2 is found exactly.

ii. *GSM Modem:* There are different models of GSM modem available. For this experiment the most popular GSM modem model SIM900 is chosen. The Tx pin of the Arduino goes to the Rx pin of the modem whereas Rx pin of the Arduino goes to the Tx pin of the GSM modem. One important thing is that the power supply of the GSM modem must be capable of giving at least 2A current otherwise the modem will never work perfectly. The ground of the Arduino and the ground of the power source of the GSM modem must be connected as both of them have been working at the same reference.

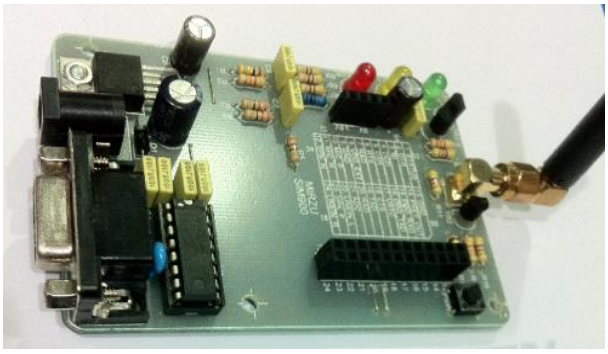

Fig.6: GSM modem

When only Force Sensitive Resistor (FSR) is sensing at the door side, the GSM module sends a message to the owner. For this we have to select the text messaging mode. So the command is "AT+CMGF=1". This command is sent to modem via software serial. After that the message is sent via the command "AT+CMGS "\owner's number\"". One thing we need to follow that the owner number must be given in international format i.e. the number must first contain the country code. When the gas sensor (MQ135) and PIR sensor sense the unwanted human presence in the room then the GSM modem will send a voice call to the owner of the house. In order to send the voice call we must use the command "ATD+ + owner's number". Then after certain period (in our case 10 seconds) the call is ended by using the command "ATH". All of the commands have been sent by using software serial function of Arduino IDE.

6. DEVELOPED PROTOTYPE

The developed prototype system is shown in the following figure:

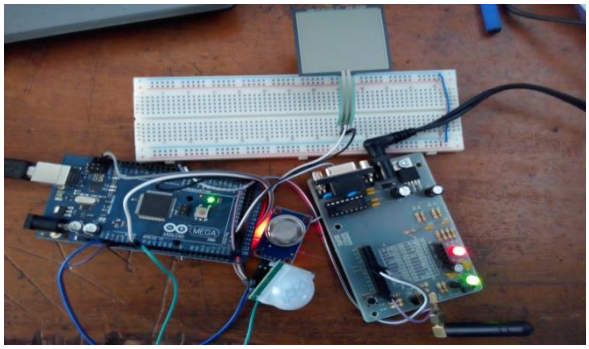

Fig.7: Developed system

The test message is shown in the following figure:

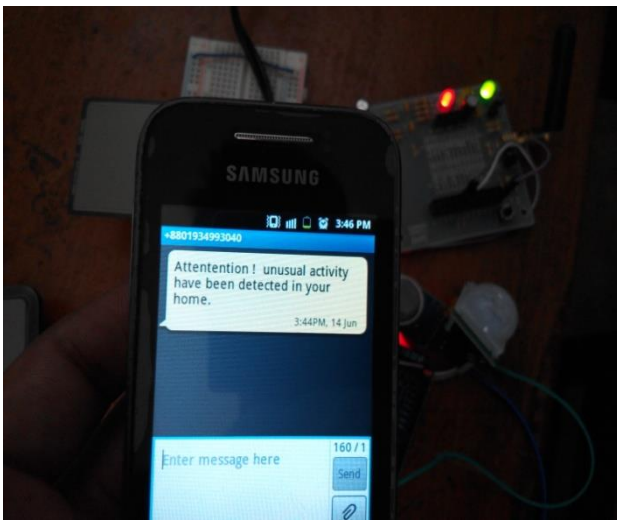

Fig.8: Test message

7. PERFORMANCE EVALUATION

The performance of the developed system is evaluated by trial and error basis. The summary of the performance evaluation is given in the following table.

Table 1: Performance analysis of developed system

System security	System Error (in 20 trials)	% of Error
moderate	1	5%

The empirical probability density function (PDF) of response time can be found from the histogram. The empirical probability density function of response time is derived from 20 trials. The probability density function of response time is shown below−

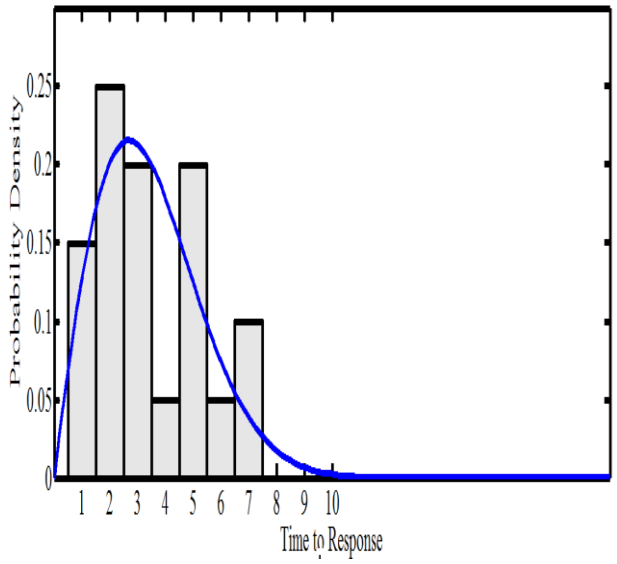

Fig.9: The empirical probability density function of response time

The distribution is positively skewed which means that the mean is greater than the median. If the system is operated then most of the time the response of the system will be within 2 to 3 seconds according to this empirical probability density function.

8. ACKNOWLEDGEMENT

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