Journal of Mechatronics and Robotics

Original Research Paper

Access Control, Fire Prevention and Surveillance Security System

Akande Saheed, Adeoye Adeyinka O.M. and Adeola-Bello Zulikha

Mechatronics Engineering, Afe Babalola University, Ado-ekiti, Ekiti State, Nigeria

Article history
Received: 03-09-2019
Revised: 11-09-2019
Accepted: 30-09-2019

Corresponding Author:
Akande Saheed
Mechatronics Engineering, Afe Babalola University,
Ado-ekiti, Ekiti state, Nigeria
Email: sakande1@abuad.edu.ng

Abstract: This system is designed to detect intruders, gas leakages as well as to serve as a surveillance system. This work focuses on the development of a reliable access control and fire prevention system synergized with surveillance system. In developing the system, Passive Infrared (PIR) sensors, gas sensor, buzzer, Global System Mobile (GSM) module, Liquid Crystal Display (LCD) and RGB Light Emitting Diode (LED) were connected to an Arduino Mega microcontroller. Fingerprint module and keypad were connected to Arduino Nano for access control. For the surveillance system, a 3D camera was connected to the PC to view the screen of the LCD and surroundings of a building with the aid of a Yaw am, Many Cam, Mirror OP and Google Remote Desktop (RDP). In addition, the system also contains Light Dependent Resistor (LDR) which turns ON in the dark and OFF when there is light. The performance evaluation of the system was carried out through the rate of access allowed correctly and access denied incorrectly, accuracy as well as the precision. The result showed 71.8% efficiency for positive access allowed rate and 28.2% false access denied rate. The practical application of this system is that it can be adopted at home and industrial environment as an efficient means of controlling intruders, fire-outbreak as well as serving as a surveillance system.

Keywords: Access Control, Fingerprint Module, Arduino Mega Microcontroller, Surveillance System, Access Allowed Correctly, Access Denied Incorrectly

Introduction

Security is one of the main concerns of the present day. Chaudhuri (2015) stated that proper measure should be taken to ensure the security of life and properties by exploring technological advancement systems. The phase of detection needs a highly efficient management system, which can predict, prevent and trigger immediate response. Agarwal (2013) defined Security system as literally a means by which something is secured through a system of interworking components and devices. Security challenges arise not only from increasing crime rate but also from the day to day accidents. In this regard, this work intends to develop a system that can detect the occurrence of both challenges. Therefore, the aim of this work is to develop an access control and fire prevention security system with a surveillance system. A wide array of research has been carried out on security systems. Security system has steadily progressed in the last three decades due to advancement in science and technology. However, there is much room for innovation and creative thinking with regards to automating the security system. Kumari *et al*. (2016) designed an automatic smart home security system using the GSM module for sending Short Message service (SMS) incorporated with PIR sensor. Though, the work includes buzzer for alarm in case of intruder, it is mainly limited to security against burglar with no consideration on hazard due to fire and other environmental challenges. Khurana, (2017) proposed a multi-function security system which involves controlling and checking the status of devices connected in the banks like fire alarm, Burglar Alarm etc by remote control using Arduino Uno. The proposed system connects these systems through wireless-Finder (Wi-Fi) module to alert the owner online for necessary actions. Also, the manual operation of the system is also eliminated to maintain the integrity of the specifications. This work is of limited use in developing country due to its application only in Wi- Fi environment. Furthermore, Rada, (2017) proposed a mechanism to resolve the object detection tracking problem on the video security

surveillance system. He suggested a new mechanism using Raspberry pi, PIR Sensor, to make intelligent detection tracking and recording as well as produce valid high and improve video's quality. This work is a tracking system and thus, send no information at the point of action but rather record the action for tracking purposes.s

Saifuzzaman *et al*. (2017) also proposed a design that consists of motion sensor, gas module, reed sensor, laser sensor, and LCD Display. The sensors are used to detect theft and unwanted occurrences. This work is very good for detection of theft but the cost of reed sensor and laser sensor makes the system a very expensive one.

Sharma *et al*. (2018) explored a mobile robot like system that was able to alert and react to an emergency situation using various sensors to detect the environment variables. This system can be easily deactivated by the burglars being a visible mobile robot.

Advancement in technology has reveals that a system may consists of several securities based module performing different functions. For an instance, a production firm workshop may have fire alarm systems, intruder system, gun or metal detectors among others. However, integration of these sub components requires a new design. The developed system in this work considered all the existing system and synergized them together to create a system which did not only provide automation to the building but also explore the additive properties of the sub-system.

Materials and Methodology

The methodology employed in the design and construction of the smart security system will be elucidated subsequently.

Materials

The materials used for the design and construction of smart security system includes: Arduino microcontroller, PIR sensor, Flame and LPG gas sensor, Liquid Crystal Display (LCD), Finger print module, Keypad, GSM module, among others.

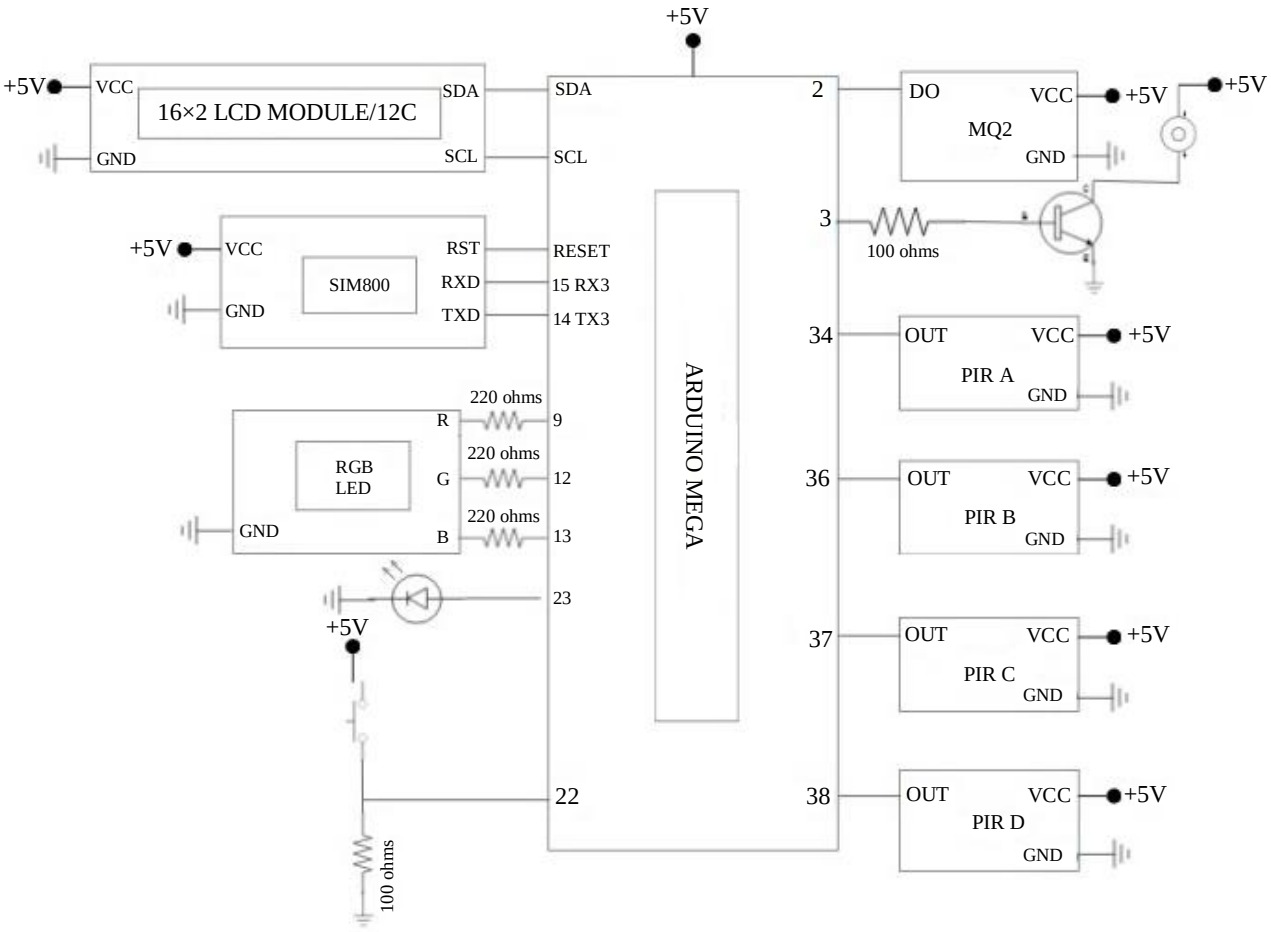

Fig. 1: Circuit diagram for LCD, GSM module, RGB LED, PIR and gas sensors connected to Arduino Mega Microcontroller

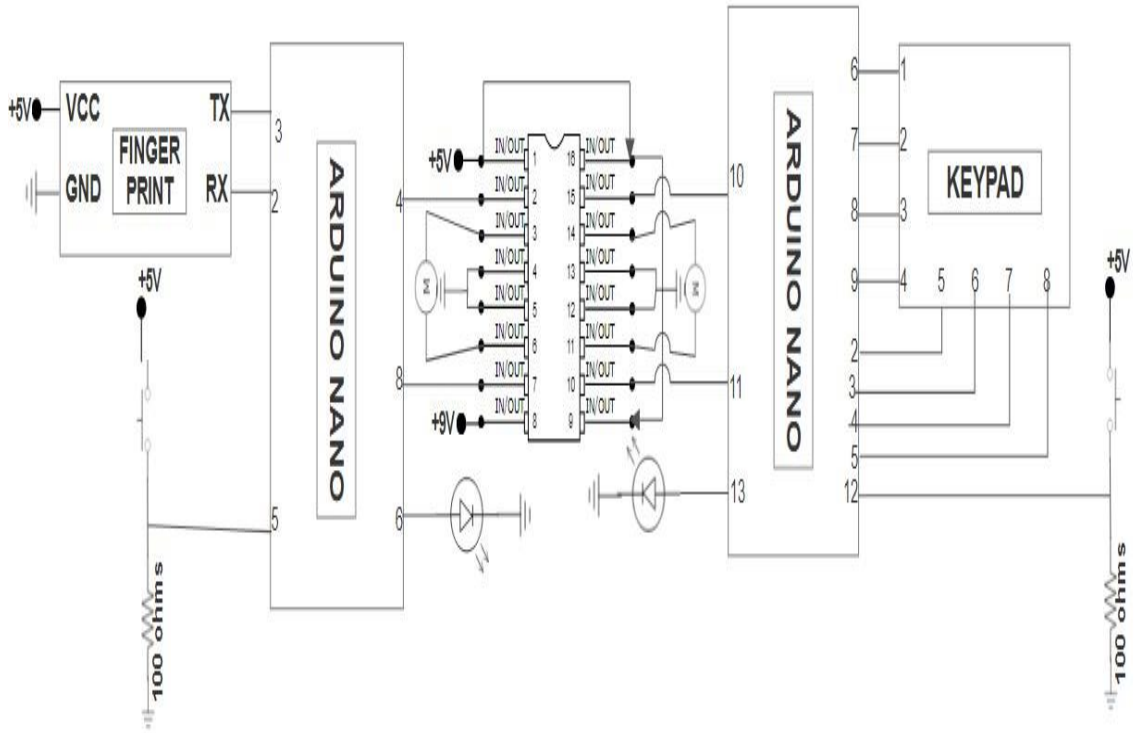

Fig. 2: Circuit diagram for Finger print module, Keypad, LD293 IC and dual DC motor connected to two Arduino Nano Microcontroller

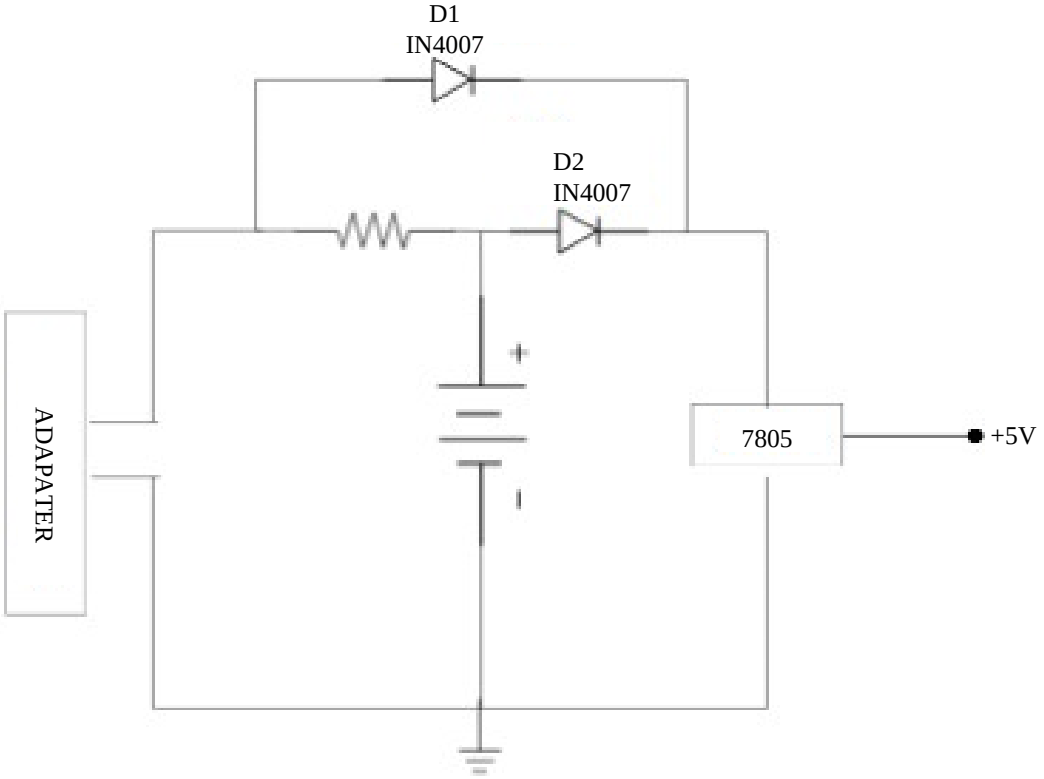

Fig. 3: 5V Power supply circuit diagram

Methodology

The stepwise procedure explore in this work are now discussed;

Passive Infrared (PIR) sensors, gas sensor, buzzer, Global System Mobile (GSM) module, Liquid Crystal Display (LCD) and RGB Light Emitting Diode (LED) were connected to an Arduino Mega microcontroller to detect intruder, gas/smoke as well as alert occupants and required authorities. Also fingerprint module and keypad were connected to Arduino Nano respectively in order to control access in the building. For the surveillance system, a 3D camera was connected to the pc to view the screen of the LCD and surroundings of the building with the aid of Yaw cam, ManyCam, MirrorOP and Google Remote Desktop (RDP). In addition, the system also contains a lightening regulator with the aid of Light Dependent Resistor (LDR) in which when it is dark the light turns ON and when it is in the day the light turns OFF. The system circuits were designed with the aid of smart work and the various components of the circuit was built on the breadboard.The circuits were sketched on Printed Circuit Board (PCB) and was printed out. Figure 1 shows the circuit diagram of for LCD, GSM module, RGB LED, PIR and gas sensors connected to Arduino Mega Microcontroller. Figure 2 illustrates circuit diagram for fingerprint module, LD293 IC and dual DC motor connected to two Arduino Nano Microcontroller. Figure 3 illustrates the power supply circuit diagram for the system. The components were soldered to meet the desired workability of the project. The software code for the microcontroller was developed using the Arduino IDE.

The developed circuit was implemented and simulated with the code using circuito.io and proteus.

Implementation and installation of camera with the aid of Yaw cam and many cam CCTV view display on PC and phone with the aid of chrome RDP and MirrorOP. The final stage was the casing and well-arranged structure of the system. The stepwise analysis of the procedure is illustrated by flowchart in Fig. 4.

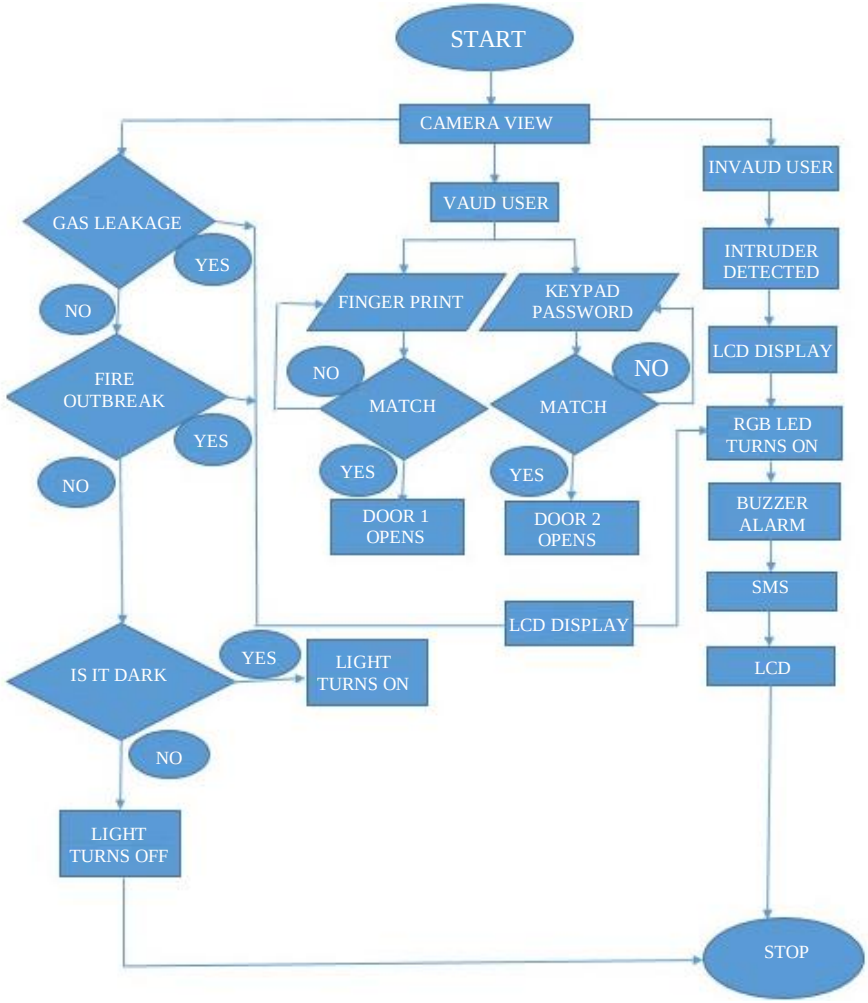

Fig. 4: System flowchart

Performance Evaluation

The access control and fire prevention security system developed was tested and simulated with the aid of proteus as shown in Fig. 5. The camera was installed and viewed with the aid of Yaw cam and many cam. The camera records were viewed in form of Closed CircuitTeleVision (CCTV) on the laptop and mobile phone with the aid of Mirror OP and Google Remote Desktop (RDP).

Performance testing was carried out to ensure proper execution and effectiveness. Figure 6 shows results obtained from the fingerprint module under testing.

Table 1 shows the result of attempted access in the system using enrolled fingerprint of different persons to measure the effectiveness and accuracy of the fingerprint module.

Table 1: Test and results of fingerprint module

S/N	Name	ID	Trial 1	Trial 2	Trial 3
1	Kel	#12	0	1	1
2	Toyo	#9	1	1	1
3	Ade	#1	1	1	1
4	Ayo	#4	0	1	1
5	Ake	#2	1	1	1
6	Dol	#11	1	1	1
7	Ike	#7	0	0	0
8	Ab	#13	1	1	1
9	Gord	#15	0	1	0
10	Sah	#6	0	0	0

Key: Fingerprint not detected therefore no access
Fingerprint detected therefore the person is granted access

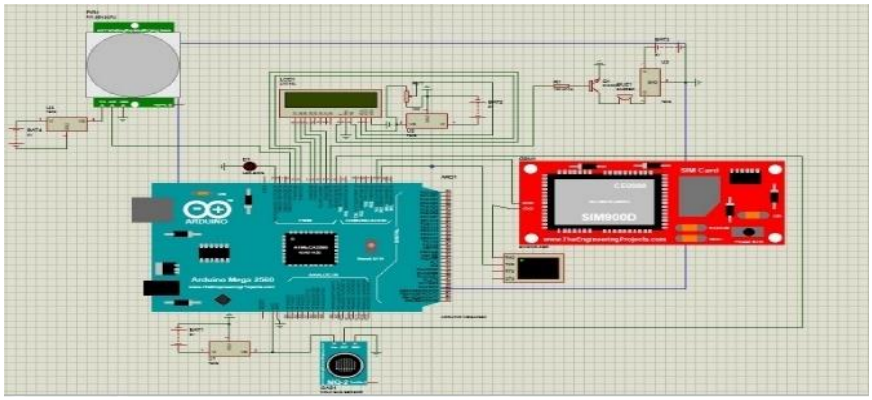

Fig. 5: Simulation of the developed system using Proteus

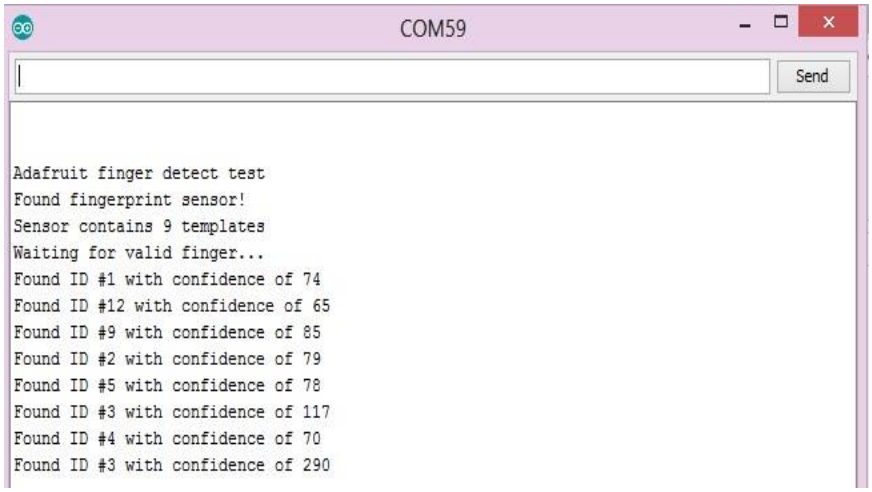

Fig. 6: Fingerprint module under testing

Confusion Matrix

Confusion matrix is a table layout used to visualize the performance of a system (Ting, 2011). It is a table used to describe the performance of a classification model (or "classifier") on a set of test data for which the true values are known. The matrix has two rows and two columns, with elements True Positive (TP), True Negative (TN), False Positive (FP) and False Negative (FN). In this project the classifier is the fingerprint module.

From the Table 1, the result from each trial can be converted to confusion matrix as follows;
For trial 1:

TP = 7 (attempted access correctly allowed)
FP = 6 (attempted access incorrectly denied)
TN = 0 (no other attempts included in trial 1)
FN= 0 (no other attempts included in trial 1)

$$\begin{matrix} TP & TP \\ FP & FP \end{matrix} = \begin{pmatrix} 7 & 0 \\ 6 & 0 \end{pmatrix}$$

For trial 2:

TP = 10 (attempted intrusion correctly allowed)
FP = 3 (attempted intrusion incorrectly denied)
TN = 0 (no other attempts included in trial 2)
FN = 0 (no other attempts included in trial 2)

$$\begin{matrix} TP & TP \\ FP & FP \end{matrix} = \begin{pmatrix} 10 & 0 \\ 3 & 0 \end{pmatrix}$$

For trial 3:

TP = 11 (attempted intrusion correctly allowed)
FP = 2 (attempted intrusion incorrectly denied)
TN = 0 (no other attempts included in trial 3)
FN = 0 (no other attempts included in trial 3)

$$\begin{matrix} TP & TP \\ FP & FP \end{matrix} = \begin{pmatrix} 11 & 0 \\ 2 & 0 \end{pmatrix}$$

$$\sum TP = TP1 + TP2 + TP3$$
$$\sum TP = 7 + 10 + 11 = 28 \quad (1)$$

$$\sum FP = FP1 + FP2 + FP3$$
$$\sum FP = 6 + 3 + 2 = 11 \quad (2)$$

There are rates that are often computed from a confusion matrix for a binary classifier they include:

Accuracy: It is overall, how often is the classifier correct.

$$\frac{\sum \text{TP} + \sum \text{TN}}{\sum \text{Trial}}$$
$$^{(28+0)}/_{39} \quad (3)$$
$$= 0.7179 = 71.79\%$$

Misclassification Rate: This involves how often it is wrong, it is equivalent to 1 minus Accuracy` and also known as "Error Rate".

$$\frac{\sum \text{TP} + \sum \text{TN}}{\sum \text{Trial}} \quad (4)$$
$$^{(11+0)}/_{39} = 0.2821 = 28.21\%$$

Precision: This is how often the classifier is correct.

$$\frac{\sum^{\text{TP}}}{\sum^{\text{TP}} + \sum^{FP}} \quad (5)$$
$$^{(28)}/_{28+11} = 0.7179 = 71.79\%$$

False - Positive Rate

$$\frac{\sum^{\text{FP}}}{\sum^{\text{TP}} + \sum^{FP}} \quad (6)$$
$$= {}^{(11}/_{28+11} = 0.2821 = 28.21\%$$

Results and Discussion

The false positive rate is 28.21%. This is the rate of access deny of registered fingerprint, The closer the false positive rate to zero, the better the system performance.

From the confusion matrix test carried out on the fingerprint, it was shown that fingerprint module efficient has an accuracy of 71.79%. The gas/smoke sensor sensitivity is averagely efficient as it responds within a period of about 50 sec and varies. The PIR sensor sensitivity is also averagely efficient as it responds within a period of about 1mins 10 sec and varies.

For the surveillance system, the camera was installed and viewed with the aid of Yaw cam and many cam. The camera records were viewed in form of Closed CircuitTeleVision (CCTV) on the laptop and mobile phone with the aid of Mirror OP and Google Remote Desktop (RDP) as shown in Fig. 7 and 8 respectively.

Figure 9 shows the developed access control and fire prevention security system.

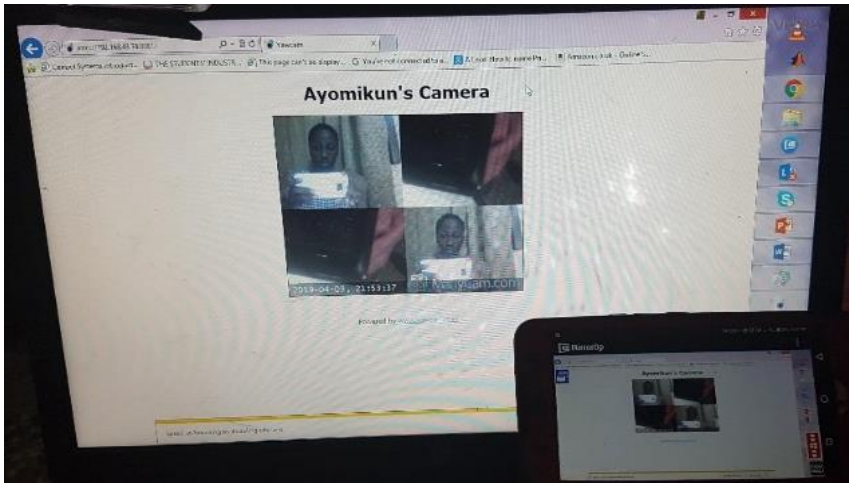

Fig. 7: Camera view on android phone and pc using MirrorOP

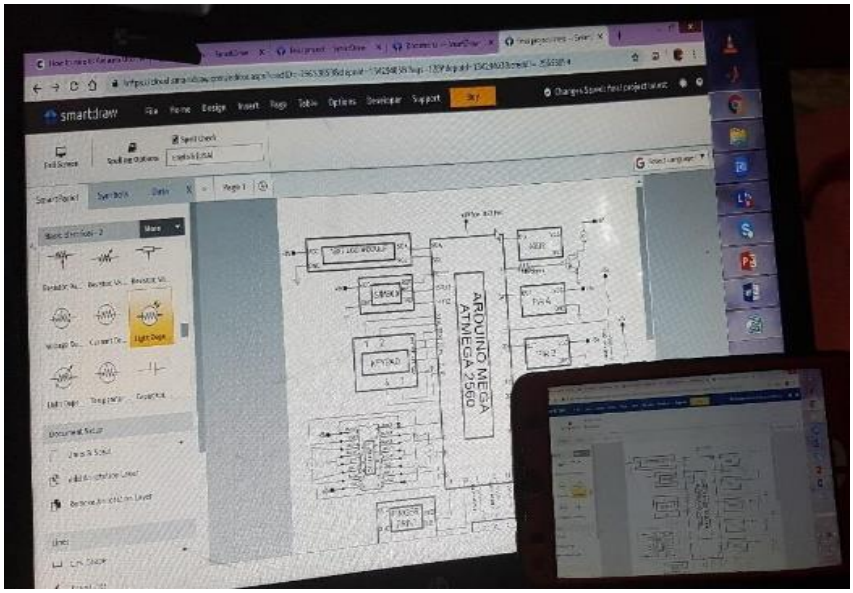

Fig. 8: Camera view on android phone and pc using Chrome Remote Desktop

Fig. 9: The Developed security system

Conclusion

The first stage of engineering design is the identification of needs. Having identified the need for a security system that can be incorporated with more devices for better performance, then the conception and development of this system was pursued. The system contains complete security program which includes; deterrence (fingerprint, keypad), detection (PIR sensor, gas sensor), assessment (Video surveillance system), response (alarm, SMS) and evidence collection (camera).

In this regard, this work has achieved a cost effective and efficient means of checking the activities of burglars/intruders, fire outbreak, gas leakage, lightening control and surveillance system.

References

Agarwal, T., 2013. Importance and classification of electronic security system.

Chaudhuri, D., 2015. GSM based home security system. Int. J. Eng. Technical Res., 32: 2321-0869.

Khurana, S., 2017. IOT based safety and security system. Int. J. Adv. Res. Ideas Innovations Technol., 33: 2454-132X.

Kumari, P., K. Pawar, P. Dhonde, R. Deshmukh and T.C Engg, 2016. Automatic smart home security system assistance. Int. Res. J. Eng. Technol., 34: 2178-2180.

Rada, Z., 2017. Smart motion detection: Security system using raspberry Pi. J. Eng. Res. Institute,

Saifuzzaman, M., A. Hossain, N. Fernaz and N. Nur, 2017. Smart security for an organization based on IoT. Int. J. Comp., 165: 33-38. DOI: 10.5120/ijca2017913982

Sharma, A., S. Pal and V. Jain, 2018. IoT based smart security system for prevention of industrial hazards. Int. J. Eng. Technical Res., 53: 886-891.

Ting, K.M., 2011. Confusion Matrix. In: Encyclopedia of Machine Learning. Springer, Sammut, C. and G.I. Webb, (Eds.). Boston, MA. DOI: 10.1007/978-0-387-30164-8