ICON Journal of Engineering Applications of Artificial Intelligence
Volume 02 | Issue 01 | 2026
e-ISSN: 3051-3820
p-ISSN: 3051-3812
Journal homepage: https://iconpublishers.com/icon-j-eng-app-ai/

Research Article

DOI: 10.5281/zenodo.18390265

Design and Development of a Motion Sensor-Based Security Alarm System using Artificial Intelligence, Arduino, and GSM Module: Potential Improvements

[1]Abdurrahman Yusuf Abdullahi*, [2]Ibrahim Usman Aikawa, [3]Musa Dan-azumi Mohammed, [4]Ahmad Muhammad Ahmad, [5]Munirah Abdullahi Said, [6]Umar Farouk Musa, [7]Abdulhamid Shariff Mahmoud, [8]Suleiman Rabiu Dansharif, [9]Muhammad Ahmad Baballe.

[1] Department of Electrical Engineering, Kano University of Science and Technology Wudil, Kano State, Nigeria.
[2] Department of Mechanical Engineering, Kano State Polytechnic, Nigeria.
[3,4,5] Kano State Institute for Information Technology, Kano State, Nigeria.
[6] Kano State Polytechnic, Department of Architectural Technology, School of Environmental Studies Gwarzo, Nigeria.
[7,8] Department of computing science, Kano state Polytechnic, Nigeria.
[9] Department of Mechatronics Engineering, Nigerian Defence Academy Kaduna (NDA), Nigeria.

Corresponding author: Abdurrahman Yusuf Abdullahi
Department of Electrical Engineering, Kano University of Science and Technology Wudil, Kano State, Nigeria.

Received Date: 11 Dec. 2025

Published Date: 27 Jan. 2026

Abstract

This study presents the design and development of a motion sensor-based security alarm system using artificial intelligence (AI), Arduino, and a GSM module. The system detects intruders and alerts homeowners or security personnel through SMS notifications. When an intruder is detected, the Arduino Uno microcontroller triggers the buzzer and alarm, displaying a warning message on the liquid crystal display (LCD). The GSM module sends a short message service (SMS) to a pre-registered mobile number, utilizing AT commands for communication. The system's performance is evaluated based on its accuracy, response time, and reliability, showing effectiveness in detecting motion and sending alerts with minimal false alarms. Potential improvements include integrating additional sensor types, leveraging machine learning to reduce false alarms, incorporating IoT capabilities for remote control and monitoring, and upgrading hardware components for enhanced functionality and speed.

Keywords: Artificial Intelligence (AI), Motion Sensor, Detection System, Arduino Uno, Burglary, GSM Module.

I. INTRODUCTION

The development of the security detection system begins with the creation of man. To alert frightening information, man implements a form of a signal through shouting and sound. He then later replaced it with the help of the clapping of hands and with the introduction of signals to inform society or to blow out a certain message if there is any kind of abduction or burglary, during the early periods of some African societies, especially in my country, Nigeria [1, 10]. All such methods of notifications or warnings are unnecessary, undependable, and unmethodical. The earliest electronic fire security detection system was established by a man named William F. Channing. Later on, an electrical electronics engineer called Mr. Moses G. Farmer invented the construction of the system. The alarm detector uses an automatic indicator box to label the position of the fire outbreak and was first launched in Boston, United States of America. The advancement of the alarm detector by Dr. William was then followed by the advancement of distinctly beautiful and arduous intruder and fire security alarm system technology that has so much to measure. The most noteworthy among this security detection system technology is the use of a remote signaling thief security alarm. This kind of security alarm system was the first design in the early 1970s. This administers a fast inventive reaction to alarm calls. Nonetheless, industries and organizations are

based on the supply of security service apparatus that usually come in dissimilar designs to keep burglars and thugs away from the environment that is not built for them. Straightaway, we have an innovative group of electronic security alarm systems with complexity at various levels. With the latest flow in crime rates in the world, it has become very essential to safeguard our buildings and our property with the aid of sophisticated stages of various advanced security alarm devices [2]. The prices of such kinds of security alarm devices depend on their apparatus technology and solicitation desires. The alarm security gadget is characterized by present electronic security detection systems. Some of today's modern security detection systems are threat alarms, housebreaker alarms, industrial alarms, anti-theft vehicle alarms, and speed limit alarms. This intruder security alarm is initiated by a cycle from a comprehensive automated circuit loop that is closed with an alarm at its output or an indication to inform the owner of danger. They are a central control box that normally observes different gesture indicators and the perimeter protections that give an alarm or notify the owner when any of these sensors is triggered. Some of the intruder's security detection system normally functions delicately on the conception of magnetic contact. For those types of security systems operating with the sensor, these devices are usually positioned at any entrance to the industries, organizations, and buildings. In this case, the sensor will activate an alarm if the device gets a signal above its set inception. In the case of motion detection, the ultrasonic sensor is normally used; the point indicator can be used in the concession of a criminal alarm, theft, or illegal individuals at certain points such as doors or windows [3]. For instance, when a precise environment needs to be looked over, the awareness of the burglar in the protected environment is used, which is executed with the help of ultrasonic sensors and is normally fixed at an appropriate location. A security detection system can be used to identify trespassers, illegal entry, or break-ins into a secure zone or building. These days Security detection alarms are usually used in hospitals, commercial and residential buildings, industrial buildings, schools, and universities. This security detection system can also be used in prisons to monitor the prisoners and their movements. Today, the security detection system and closed-circuit television (CCTV) are an important part of any modern programmed security detection system. The design of any security detection starts with considering the needs of the residents, measuring existing hardware and technology, reviewing the costs of the system, taking into account the watching choices, and lastly scheduling the installation. Now if we are going to look at one of the world's richest countries, which is the United States of America, we can see that they are placed 6th in auto theft and 9th in break-ins. Their investigation also indicates that most of the break-ins happened in banks and residential areas, as well as offices. Non-automated security detection systems were found to be unreliable. Doors were fitted with a lock and key system, which can be opened easily. Even with the help of human presence as a security guard, it may not be reliable. Every system from the past is very much vulnerable. Our home is a place where security is a must-have to keep all the appliances and vulnerable people safe. You as the homeowner should have the full assurance to step out from your house with the feeling that nothing is going to happen to your home or organization. This feeling will only arise when the house or organization that needs to be secure is fully equipped with a reliable security detection system [4].

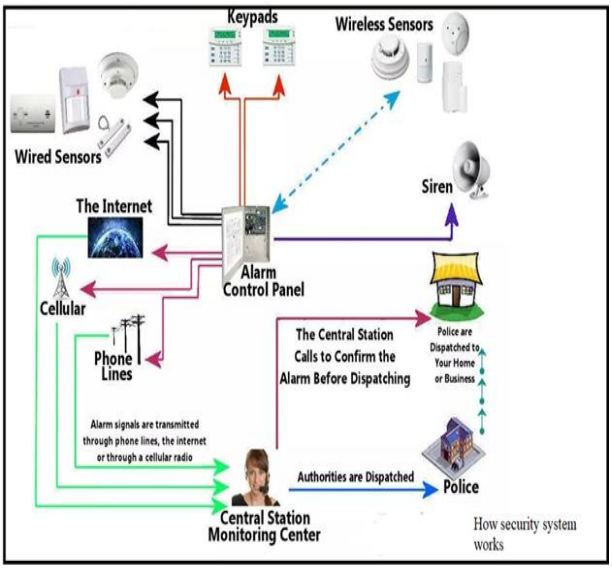

Fig. 1: How the professional security system works

II. RELATED WORKS

In 2013, a security detection system was designed using a fingertip- or fingerprint-based verification system to unlock a door or curtain in a closed place. This type of security system aids users to unlock a certain place because they are the ones whose fingerprint is registered to the system, so if you put the unregistered fingertip, it will not unlock the place or anything the finger is registered to [5, 6]. This type of security detection system is connected with some more alarm security protection features; this includes fire accident and gas leakage sensors or detection devices. However, a great system,

fingertip devices are complex and expensive, as they want amplified sensor resolution to join into the internet of things system [7]. Some professionals likewise argue that merely depending on a fingertip sensor is not wise because it is quite simple to put someone's fingertip on something and reproduce it, that is, to duplicate the fingertip. That is why it is consistently considered to make use of fingertip scanners in two-way authentication systems whereby an added layer of security is made in the form of a passcode, PIN, or voice recognition. Some researchers suggested an idea of a powerful Internet of Things security system whenever a defect in one of the components used in the security system would not fail the whole security system. The knowledge of making use of numerous gadgets, which may not be directly or may not be suitable with one another; however, it can be made to work in such a way that they can interchange a present item of the security detection system in case they are a failure. In line with this, the prototype can use connections among several appliances, which may result in conserving energy, therefore making the prototype more effective. The design of this said model will use a Wi-Fi component, a temperature sensor, and an entrance sensor to change an unreliable system [8]. LDR and laser ray sensors are also used to identify an invasion using the intruder's movement. The method the system will work is that a light ray is faced towards the LDR sensor, and if there is an interruption between the light ray and the LDR, the alarm linked to the sensor starts alarming and sends an SMS to the house owner or place where the intrusion takes place. This type of system will assist in solving the problems of securing the spaces, which may be out of range from your immovable cameras but may face the same problems, which are faced by systems involving GSM components to send a short message service, which is that the transmission of the message is dependent on network coverage. Likewise, due to the condition of the light rays, which is a straight light beam, the intruders who know about the security detection system will be capable of dodging the light beams since it is only made up of one light-emitting diode and one light-dependent resistor facing each other, rendering the whole security system useless since an intruder can avoid it. An innovative method of implementing and designing an electronic lock security system using the internet of things technology and Morse code. The authors said that this is a unique awareness, which has never been done previously and is going to be the first of its kind, an “optical Morse code-based electronic locking system.” This type of system makes use of LED as an encipher intermediate to send signals. To make it more available to the overall community, the LED in our mobile phones has been made use of. On the side of the receiver is a photosensitive resistor as well as a microcontroller, such as an Arduino processor, which normally can crack the photosensitive signal after collecting it from the LED. Upon untangling this signal, it can then transfer the present situation of this lock to a cloud system. This will be where the owners of the house, organizations, or industries can monitor the whole security system. This author has made an experiment on the system in real-life time, and it has shown to perform underneath various brightness surroundings with all the features functioning as they are designed to operate. For this purpose, this research has focused on the upkeep of home security. A security alarm system evolved to protect any of the walls that are interrupted. The walls are the east, north, west, and south walls. The walls are designed to be in the form of a square environment; each of the walls has an LED that functions as a transmitter and an LDR that functions as a receiver. A CCTV was used to capture the real-time video of any of the crossed walls. An LCD was used to display the status of these walls and display the name of the crossed walls. A magnetic buzzer is also used to alert the security personnel after a system has displayed the name of the crossed wall on the LCD. A microcontroller (PIC16F877A) is used as the brain of the developed security system. A computer system is used to display the system status through the computer parallel port, to display the real-time video captured by the CCTV camera, to save the video on the computer hard drive, and to control the developed system from the computer, such as activating, deactivating, and resetting the developed system [9]. In this research, if the user activated the system, the microcontroller will read the information when the PIR sensor detects an unknown person or motion. The Arduino microcontroller activates the buzzer and then sends a signal to the LCD displaying "Intruding," and then the GSM modem gets a signal from the Arduino and sends an SMS to the designated mobile phone number registered in the system. To communicate between the GSM modem and mobile phone, the AT command is applied to this research. This is because the GSM modem can merely comprehend AT command statements. From this, it can communicate with mobile phones, computers, and Arduino. To complete this research, the whole module must work successfully. The GSM modem used acts as a medium to receive the instructions from the Arduino and sends a message to the designated mobile number. C programming is used for Arduino applications to develop a program.

III. MATERIALS AND METHOD

3.1. The materials used in this research are shown in Table I below.

Table I: materials used in this research

S/N	Name of components	Number used
1	Arduino Uno Board	1
2	Passive infrared rays sensor	1
3	Liquid crystal display	1
4	SIM900	1
5	GSM module	1
6	Buzzer	1
7	Jumper wires	20
8	Resistor	2
9	Number of connections	10

3.2. Method

This section of research handles the operation of the whole system. When the user activates the system, the Arduino microcontroller will read the data when the PIR sensor detects an intruder. The Arduino activates the buzzer and also sends a signal to the LCD displaying the intruder. The GSM modem gets information from the Arduino and sends SMS to the designated mobile number registered in the system. For communication between the GSM modem and phone, the AT command is applied to this research. This is because the GSM modem can merely comprehend AT command statements. From this, it can communicate with phones, computers, and Arduino. To complete this research, the whole component must work efficiently. The GSM modem acts as a medium to receive the instructions from the Arduino and sends a message to the designated mobile number. C programming is used for the Arduino application to develop the program.

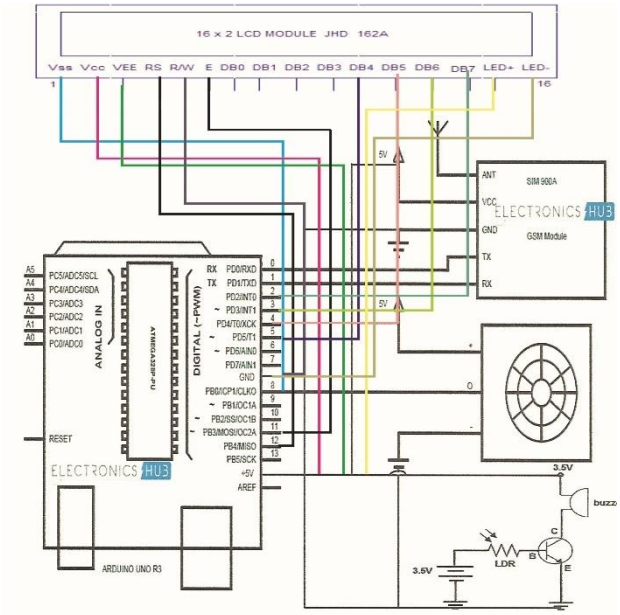

Fig. 2(a): Circuit Diagram Showing all the Connections between the Components

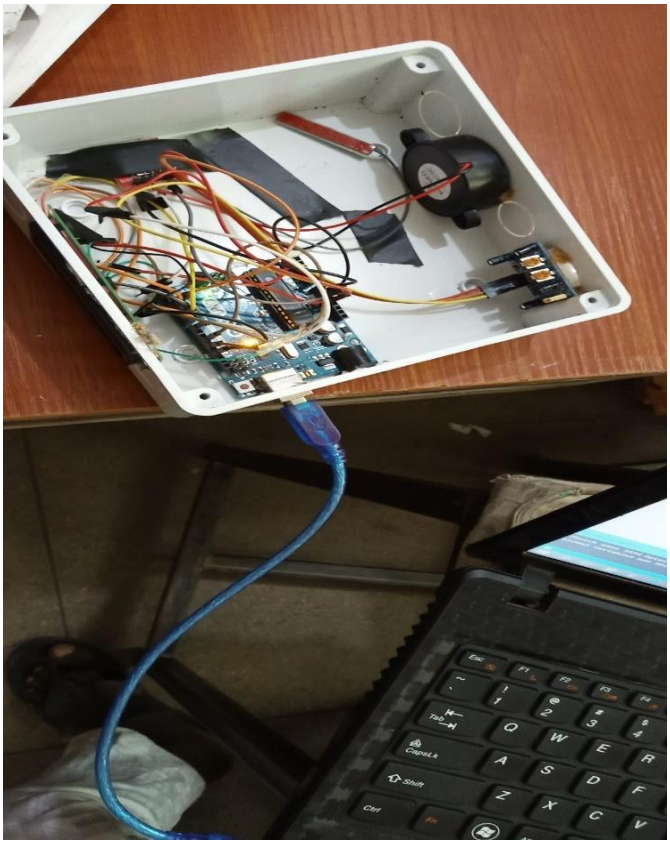

Fig. 2(b): Implementation of the whole circuit showing all the connections between the Components

3.2.1. The pin assignment of the whole system connection is as follows below.

GSM MODULE

1. The V_{CC} pin of the GSM module is connected to 5 volts of the Arduino.
2. The ground pin of the GSM module is connected to the ground of the Arduino Uno.
3. The T_X pin of the GSM module is connected to R_X Arduino Uno that is Pin zero.
4. The R_X pin of the GSM module that is connected to T_X Arduino Uno is Pin (1).

PIR MOTION SENSOR

1. The V_{CC} pin of the PIR sensor is connected to 5 volts of Arduino Uno.
2. Ground pin of the PIR sensor is connected to the ground of Arduino Uno.
3. V_{out} of the PIR sensor is connected to digital pin 3 of Arduino Uno.

BUZZER

1. The ground of the buzzer is connected to the ground of Arduino Uno.
2. The V_{CC} of the Buzzer is connected to digital pin 8 of Arduino Uno.

LIQUID CRYSTAL DISPLAY

1. The LCD RS pin to digital pin 12 of Arduino.
2. The LCD enables pin to digital pin 11 of Arduino.
3. The LCD D4 pin to digital pin 7 of the Arduino Uno.
4. The LCD D5 pin to digital pin 6 of Arduino Uno.
5. The LCD D6 pin to digital pin 5 of Arduino Uno.
6. The LCD D7 pin to digital pin 4 of Arduino Uno.
7. The LCD R/W pin to the ground of Arduino Uno.
8. The LCD V_{ss} pin to the ground of Arduino Uno.
9. The LCD V_{cc} pin to 5 volts of Arduino Uno.
10. The LCD V_O to 10K resistor ends to +5 volts and ground Arduino Uno.

3.2.2. Interfacing Arduino to the buzzer

The ground of the buzzer is connected to the ground pin of the Arduino and the Positive terminal of the buzzer is connected to Arduino Digital Pin 8.

3.2.3. Sending a message in text mode

To send an SMS message in text mode using the AT+CMGS command.
The format of this command is as follows:-
AT+CMGS="<destination number>" [, <type of destination] <CR>
The GSM machine will then respond with a > prompt, next enter the message to send followed by Control-Z. The Appliance will then retort with a reference number or an error.
Example:
At+CMGS="+2347036982781"

>test'\Z

+CMGS: 1880K Note:
The Conexant device does not correctly support the <type of destination> Held, the <destination number> field must be an international ISDN number as in the example above and the <type of destination> file must be left outright.

3.2.4. Interfacing of Arduino to GSM module

To join the GSM module to the Arduino Uno microcontroller we have to connect the Tx pin of the GSM module to the Rx pin of Arduino and the Rx pin of the GSM module to the Tx pin of Arduino. The ground pin of Arduino is then connected to the ground pin of the GSM module.

3.2.5. PIR motion sensor for sensing an intruder

The PIR motion sensor serves as the medium for detection of motion or movement. The Vcc pin of the PIR motion sensor is connected to the 5-volt pin of the Arduino, while the ground of the PIR sensor is connected to the ground of the Arduino as well as the output of the PIR connected to the pin 7 of the Arduino. After establishing these connections, the system will work. Below is the circuit diagram showing the connection of PIR motion to Arduino.

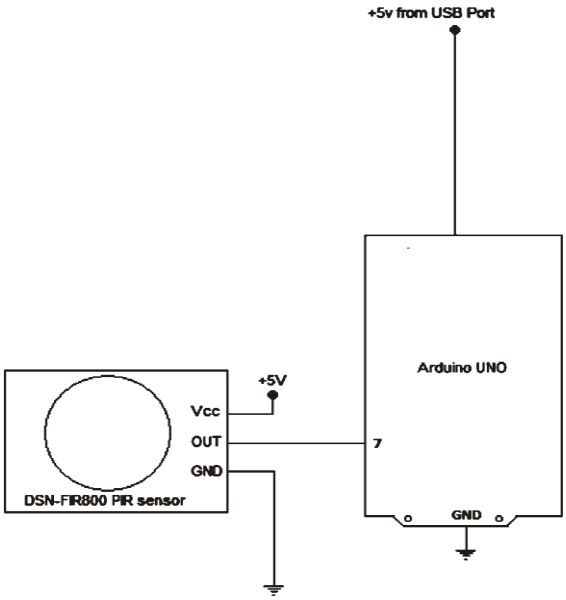

Fig. 3: Circuit Diagram of Interfacing PIR Motion Sensor to Arduino

IV. RESULT

The PIR sensor was tested by connecting the output pin to the digital pin port of the Arduino. The motion was used to test the performance of the PIR sensor. The SIM900 GSM module was connected properly, and AT command codes that communicate with the controller were written and uploaded in the Arduino Uno through the Arduino Integrated Development Environment (IDE). The designed PIR sensor, which is meant to detect motion and alert users through alarm action using a buzzer and send SMS through a GSM modem, was tested. Physical testing was done to ensure that the system is working properly.

The procedures used in the testing of PIR motion sensors are as follows:

1. Plug the Arduino UNO and GSM module into the power supply
2. Plug the power supply into the mains
3. Switched ON the Arduino UNO to On.
4. Make a move towards the PIR sensor.

The PIR sensor senses a change in the motion caused by a body and passes the signal to the Microcontroller with triggers the buzzer and sends SMS to the designated phone number (The Number is Incorporated in the Arduino Microcontroller through program code). The user reads the message “Hello Boss! Check your door” and take proactive actions.

Table II: Shows the simulation testing and results obtained

S/N	Test conducted	Result obtained
1	System Activated	Initializing, please wait for one minute's figure 4 (a and b)
2	After one minute	No motion was detected in figure 5 (a and b)
3	If they are an intrusion	Motion detected in figure 6 (a and b)
4	Message sent to the registered phone number	Hello boss, motion detected, please check your door! (figure 7)

Fig. 4 (a): Showing the result from the implementation of the circuit, wait for one minute.

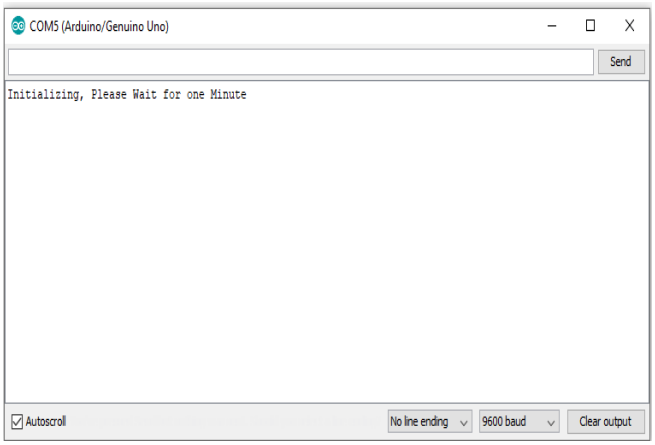

Figure 4 (b): Showing the simulation result displaying, please wait for one minute

Fig. 5(a) Showing the result from the implementation of the circuit, Relax no motion

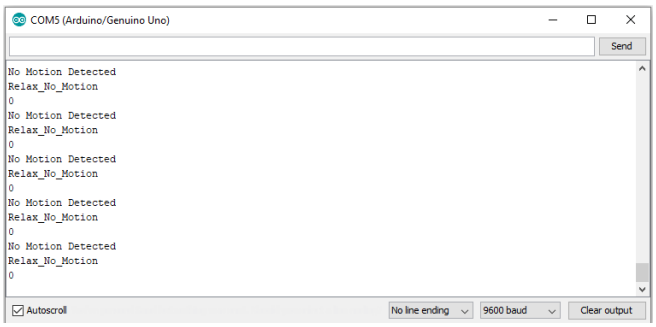

Fig. 5(b): Simulation result showing, no motion detected

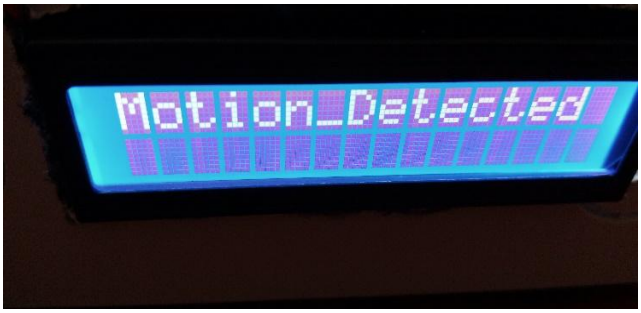

Fig. 6 (a): Showing the result from the implementation of the circuit, motion detected

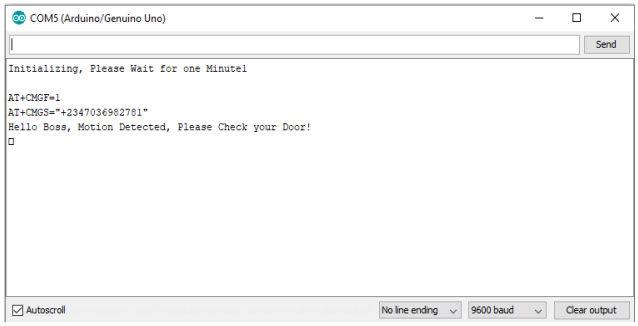

Fig. 6(b): Simulation result showing motion detected

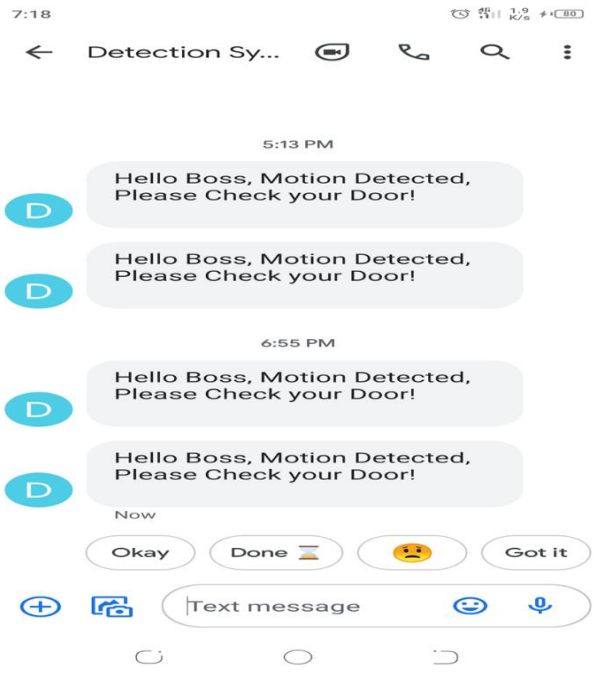

Figure 7: Message sent to registered phone number from the security

V. CONCLUSION

Design and installation of a portable, reasonably priced, and incredibly effective security alarm system utilizing an Arduino board, motion sensor, and GSM module. Since these alarm systems are highly sought after for security reasons, the aforementioned characteristics can demonstrate the system's usefulness and efficacy [13-30].

Future enhancements

i. **Add an LCD Display:** Include an LCD screen to display the system's current status, such as "ARMED," "DISARMED," or "MOTION DETECTED".
ii. **Integrate Multiple Sensors:** Expand the system by incorporating additional sensors, such as ultrasonic sensors or gas sensors, for more comprehensive security.
iii. **Two-Way Communication:** Implement a feature that allows the user to send a command via SMS to the Arduino to perform an action, such as disarming the alarm remotely.
iv. **Logging Capabilities:** Add an SD card module to log events (e.g., time of motion detection) for later review

References

1. Baballe, M. A., & Cavas, M. (2018). Design and simulation of four walls crossed security system against intrusion using PIC microcontroller. *American Journal of Engineering Research, 7*(12), 233–244.
2. Baballe, M. A., & Cavas, M. (2019). Design and simulation of personal computer base walls crossed security system against intrusion using PIC microcontroller. *International Journal of Engineering Science Invention, 8*(3), 59–74.
3. Baballe, M. A., Abdullahi, A. B., Muhammad, A. S., Saleh, Y. B., & Usman, U. B. (2019). The various types of sensors used in the security alarm system. *International Journal of New Computer Architectures and Their Applications, 9*(2), 50–59.
4. Baballe, M. A., & Cavas, M. (2019). A review advancement of security alarm system using Internet of Things (IoT). *International Journal of New Computer Architectures and Their Applications, 9*(2), 38–49.
5. Baballe, M. A., Muhammad, A. S., Abdullahi, A. A., Tijjani, A., Iliyasu, A. S., Muhammad, I. M., Ibrahim, I., Tijjani, S., Idris, Y., Dahiru, I. K., Umar, A. A., Sulaiman, J., Musa, A. L., Mohammed, S. A., Abdullahi, S. I., Naisa, A. H. K., Surajo, M., Muhammad, S. A., Imam, B. A., Ayagi, S. H., & Sani, K. M. (2019). Need for security alarm system installation and their challenges faced. *International Journal of New Computer Architectures and Their Applications, 9*(3), 68–76.
6. Baballe, M. A., Muhammad, A. S., Iliyasu, A. S., Umar, A. A., Imam, B. A., Ayagi, S. H., & Ahmad, M. B. (2019). Gabor-based band selection for multispectral palmprint recognition system using feature fusion. *i-manager's Journal on Image Processing, 6*(2), 14–19.
7. Baballe, M. A., Mukhtar, I. B., Abubakar, S. M., & Bello, A. I. (2021). Design and simulation of crossed walls security detection system. *International Journal of New Computer Architectures and Their Applications, 11*(1), 10–21.
8. Baballe, M. A., & Fatima, A. N. (2021). The need of using a radio frequency identification (RFID) system. *International Journal of New Computer Architectures and Their Applications, 11*(2), 22–29.
9. Baballe, M. A. (2021). Detection of crossed walls security alarm system against invasion. *Review of Computer Engineering Research, 8*(1), 14–26.
10. Baballe, M. A. N., Varol, S., & Azeez, —. (2018). A review of home alarm systems against intrusion. In *Proceedings of the 35th National Informatics Congress* (pp. 193–196). Ankara, Turkey.
11. Muhammad, A. B., et al. (2021). Implementation of security alarm using Arduino with P.I.R motion sensor and GSM module. *ResearchGate.* https://www.researchgate.net/publication/354696205_Implementation_of_Security_Alarm_using_Arduino_with_PIR_Motion_Sensor_and_GSM_Module
12. Ibrahim, I. A., Abdurrahman, I. A., & Muhammad, A. B. (2025). Artificial intelligence enhanced wireless medical alert systems: Overcoming challenges, mitigating effects, and addressing limitations. *Global Journal of Research in Engineering & Computer Sciences, 5*(3), 53–58. https://doi.org/10.5281/zenodo.15521486
13. Ibrahim, I. A., & Baballe, M. A. (2024). Essential elements required for a successful AI application in the healthcare industry. *Global Journal of Research in Engineering & Computer Sciences, 4*(5), 46–51. https://doi.org/10.5281/zenodo.13755067
14. Ibrahim, I. A., & Baballe, M. A. (2024). Bidirectional people counters as a catalyst for smart cities in the technological singularity era. *Journal of Emerging Technologies and Innovative Research (JETIR), 11*(10).
15. Ibrahim, I. A., & Baballe, M. A. (2024). Developing a user-friendly smart blind stick for visually impaired individuals in the digital era. *JETIR, 11*(9).
16. Isa, A. I., & Muhammad, A. B. (2024). Overcoming facility management challenges using IoT-based smart energy management systems. *Global Journal of Research in Engineering & Computer Sciences, 4*(5), 95–99. https://doi.org/10.5281/zenodo.13823585
17. Ibrahim, I. A., & Abubakar, Y. (2016). The importance of identity management systems in developing countries. *International Journal of Innovative Research in Engineering & Management, 3*(1).
18. Ibrahim, I. A., Mohammed, I. B., & Saidu, B. (2015). Fraud management system in detecting fraud in cellular

telephone networks. *International Journal of Innovative Research in Computer Science & Technology, 3*(3).
19. Ibrahim, I. A. (2018). Nigeria's ethical issues in the use of ICT. *ITNOW, 60*(2), 12–13. https://doi.org/10.1093/itnow/bwy035
20. Lawal, L. S., et al. (2022). Digital health inclusion: A pilot study of health services deployment using communications satellite for the underserved in Nigeria. *SSRN.* https://doi.org/10.2139/ssrn.4141456
21. Ibrahim, I. A., et al. (2025). Bluetooth smart attendance system design and simulation with SMS alert: Considerations and limitations. *JETIR, 12*(10), 404–412.
22. Lawal, L. S., et al. (2022). Overview of satellite communications and its applications in telemedicine for the underserved in Nigeria: A case study. In *Proceedings of the International Conference on Electrical, Computer, Communications and Mechatronics Engineering (ICECCME)* (pp. —). Maldives.
23. Ibrahim, I. A., & Abubakar, M. (2015). Technological adoption of e-commerce in Nigeria. *International Journal of Innovative Research in Engineering & Management, 2*(6).
24. Ibrahim, I. A., et al. (2025). Recommendations and future directions: A bidirectional visitor counter and gate control. *JETIR, 12*(10), 257–263.
25. Ibrahim, I. A., et al. (2025). Future directions and suggestions for the management information system's design and implementation. *JETIR, 12*(10), 404–412.
26. Ibrahim, I. A., et al. (2025). Smart home control and management system design and development: Future directions. *JETIR, 12*(10), 404–412.
27. Ibrahim, I. A., et al. (2025). Harnessing the power of RFID tags technology with artificial intelligence: Enhancing efficiency and innovation. *JETIR, 12*(6), 648–653.
28. Ibrahim, I. A., et al. (2025). Sustainable power planning in the Kano zone through accurate long-term demand forecasting using machine learning. *JETIR, 12*(6), 107–110.
29. Ibrahim, I. A., Abdurrahman, I. A., & Muhammad, A. B. (2025). Navigating the challenges of artificial intelligence in healthcare: Overcoming barriers in the 4th industrial revolution and beyond. *Global Journal of Research in Engineering & Computer Sciences, 5*(3), 81–87. https://doi.org/10.5281/zenodo.15538505