DESIGN AND CONSTRUCTION OF A COMMUNITY SECURITY BREACH DETECTION AND MITIGATION SYSTEM

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ABSTRACT

Security of an arena is crucial as it measures the situation awareness and safety. Security breaches often lead to chaos and attacks that must be managed. This project addressed the development of an air raid siren system that is capable of alerting the public of impending danger. The necessary theory for establishing the basis for the work and the parameters for constructing the security system were considered. The communication within the security system network is wireless, the various stations were determined to be capable of communicating within a 100m radius. These stations that communicate with each other are the breach detection, base station, Ground Control Unit (GCU), and also, air raid siren sections. The first set of sensors detects the intrusion signal and sends the notification to the GCU and then from the GCU to the air raid siren. In this study, the threat is detected when an intruder breaches the monitored environment, an arena of about 600m as captured by ultrasonic sensors which detect motion within the perimeter of intrusion. This signal is transmitted by the NRF24L01 transmitter to the GCU and finally to the air raid siren as a warning of a breach. The microcontrollers that run the wireless transceivers were programmed to carry out specific tasks. The detection unit uses an ultrasonic sensor which sends and receives sound pulses. The time it takes for this to happen is 294µs with a power consumption of 1.52729W. The GCU takes 0.22729W of power while the air raid siren section takes 8.1729W. The air raid siren was traveled up to a distance of 300m. The results show the system design and implementation are quite reliable and can be mass-produced for the community.

Keywords: *Intrusion detection, Security breach, Threat, Signals, Air raid siren*

1.0 INTRODUCTION

Security is crucial as it measures the situation awareness and safety of an arena. When security is breached, it leads to conflict, chaos war, and other havoc. To prevent mishaps or security threats, various technological systems were invented to alert against suspicious activities. security breaches are often a challenge to life and properties in Africa. Nigeria as a case study has witnessed incessant attacks on locals at odd hours without the knowledge of security personnel in the community. It is pertinent to create an awareness of breaches in a community to help alert people or security personnel to repel such attacks.

To mitigate these challenges and create an awareness of breaches, this study aims to develop a security breach system in a perimeter to call the attention of locals and personnel of breaches. The study proposed the design and construction of a model of such a system using low-cost available resources and testing to examine the reliability when deployed in a defined perimeter. One such system was the air raid security system which is a siren used to provide an emergency warning to the general population of impending danger. It is sometimes sounded again to indicate when the danger passed [1].

Sirens were developed as a general warning device, and one would expect their use to be limited to circumstances of community danger, such as an imminent flood or some type of hazard requiring collective response. These air raid sirens are only being used to summon a few part-time firefighters from their houses, causing the entire community to be shocked so that half a dozen or so personnel can be informed of a fire. During the war, the wailing and moaning of the air raid sirens were widely recognized as one of our most grievous inflictions. No single weapon of war caused more anguish to certain classes of people, and in the raided areas everybody found the noise extremely disturbing. Many people said they found even the noise of the bombs less disturbing than that of the preliminary warnings that were given by these sirens [2].

During emergencies such as security breaches, tornadoes, tsunamis, wildfires, or hazardous chemical spills, public alerts and warnings are broadcast to initiate precautionary measures. When such a siren sounds, two options for protecting oneself are to shelter in place or evacuate to safety. Alerts aim to attract the public's attention before a warning or instructive message. Warnings are used to offer information about emergencies, such as the sort of disaster when it will occur, and what preventative measures should be taken [3].

Attacks on residents have been a widespread concern in Nigeria. These can occur at unusual hours for extended periods, with even close neighbors unaware of what is happening. This has resulted in widespread panic and bewilderment among citizens. Having common awareness of what is going on somewhere inside a community regarding a separate location may help inform the individuals there to either seek cover or identify an evasive measure to repel such an attack [4]. An air raid siren, often called a civil defense siren, warning siren, or bomb siren, is a loud noise intended to alert people to danger. During WWII in the UK, air raid sirens were strategically placed atop tall buildings to increase their reach. They were used to warn of an impending air raid.

In cities, sirens were powered by electricity and sent out two signals: the first was a warning. The works of [5] affirm the most frequently recognized signal is a rising and falling signal, akin to a siren or alert. Security is a crucial aspect of every institution. Ultrasonic sensor technology detects intruders within its range (conic beam) in typical security systems that rely on door and window opening and closing. Microcontrollers are used to process sensor feedback. For the hardware required as auxiliary units to the sensor, associated timers are responsible for scheduling the execution of various tasks, generating an alarm tone, and generating a Pulse Width Modulation (PWM) signal with the appropriate duty cycle and frequency to control whatever needs to be driven, such as an electric motor. An ultrasonic sensor range is modified by modifying the programming put into the microcontroller board [6].

Rapid population growth leads to increased security risks. This is especially true at the grassroots and community levels. A cost-effective and efficient method of notifying a community of all security emergencies is offered. It includes the usage of a mobile application dubbed "CEMAS" (Community Emergency Alarm System). The mobile application has a "Panic button" that allows the community to activate two SMS-activated central alerts. The first alarm is positioned in the community center, while the second is at the community police station. When a security threat is detected, press the "Panic Button" to activate the central alarm system. [7] reported that the system they built and implemented performed effectively. We designed and installed an intruder identification

framework border using an IR sensor and IoT to detect infrared rays from human bodies. Multiple passive infrared sensors (PIR) are disguisedly put on the border fencing to watch for any infiltration. A few objects were placed in front of the ultrasonic sensor to test the system's functionality after it was designed, built, and programmed. As the motor began to revolve, the monitor revealed the output from the processing IDE. As a result, as the sensor crossed over the object, it displayed a red segment indicating the distance and angle at which the object was paced. The calculated efficiency came out to be 95%.

Perimeter intrusion detection systems are essential components of most physical security systems. Perimeter fencing is commonly used to segregate and defend public and private areas, including airports, military bases, and security applications. A heightened level of security is required to monitor and investigate actions on or near the campus. The Perimeter Intrusion Detection System (PID) focuses on fence incursions. Major components in the system included an Arduino board, an 8x8 LED, an ultrasonic sensor, a 16x2 LCD module, and a speaker. An unauthorized person attempting to enter the university would be detected, and an alarm would sound to alert authorities that an intruder was attempting to enter. The system was conceived and built using an Arduino microcontroller [8].

A cost-effective option for security systems is presented. It combines the Passive Infrared (PIR)--based security alarm system, which uses a PIR sensor instead of a transmitter or receiver. This sensor conserves energy while also being cost-effective to implement. The PIR sensor detects the infrared radiation generated by persons and produces a digital output. In turn, the Arduino Uno receives this digital output. After receiving a digital signal from the PIR sensor, the Arduino UNO activates the UM3561 siren. As a result, it produces the sound when only humans are detected. It generates various sounds, including ambulance sirens, machine gun sounds, fire engine sirens, and police sounds [9].

Nowadays, wireless technology is employed to control appliances rather than a wired topological connection. GSM (Global System for Mobile Communication) technology is utilized to transmit input signals from appliances and output messages to the device. This implies that when the GSM Modem detects an intruder, it transmits the relevant message to the security control system. A GSM module digitizes signals or data from sensors or other equipment before sending them to a receiver [10]. Remote control makes switching equipment or appliances easier for the elderly, physically handicapped, young people, and anybody else who requires comfort and security in any situation. Remote control makes use of multiplexers, demultiplexers, encoders, decoders, and Radio Frequency modules. [11] implemented a traffic breach awareness system with RFID and Arduino for motor raids for a police patrol to minimize human error in the manual system in traffic violations. A security system can be integrated into a remote control for secure usage and triggering from a distance of meters. [12] conducted work in this regard by creating a transmitter system that sends signals in a remote location when a button is pressed, and received by the receiver system

2.0 MATERIALS AND METHODS

In this section, the practical theories and methods for the system design and implementation processes are discussed. The block diagram in Figure 1 shows the communication flow of the design and implementation processes. The threat detection arena is the part that continuously scans for intrusion within the monitoring environment and transmits the signal received to the Ground Control Unit (GCU) should intrusion through the NRF2401 transmitter which afterward sends a signal to the Air raid siren to alert the community of security breach.

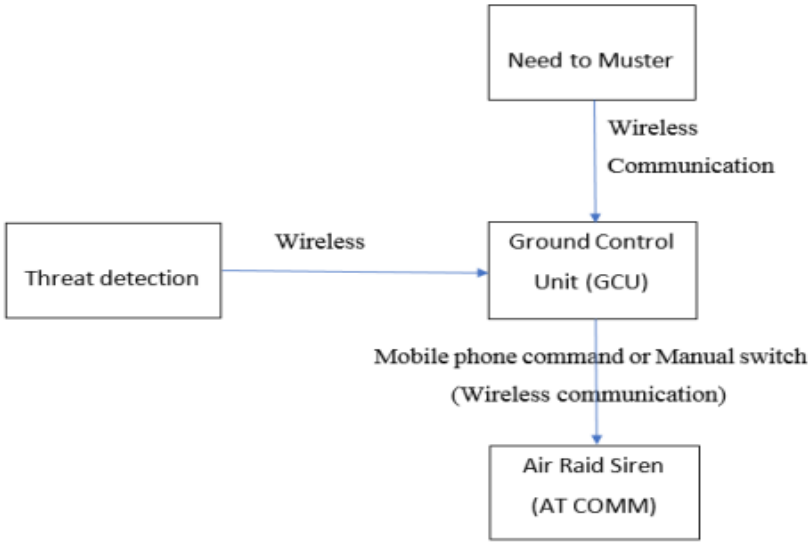

Figure 1: Block diagram of the system design

The development of the system takes into consideration these design units to achieve the stated objectives;

i. Design of Threat Detection Unit
ii. Design of Ground Control Unit (GCU)
iii. Design of Air Raid Siren Unit

2.1 Design of the Threat Detection Unit

The threat detection is carried out by ultrasonic sensors connected opposite each other and mounted on a servo motor that sweeps 170° in dual directions. One sensor covers the entire area for the first half of the swept angle while the second sensor covers the reverse side for monitoring possible restricted areas closely.

The threat detection box also holds the signal processing and transmission unit. This consists of Arduino Nano and also an NRF24L01 module. When an intrusion is detected by either or two of the sensors, they send the signal to the Arduino Nano which then processes it and transmits it to the GCU through the transceiver module. The circuit diagram of the threat detection and scanning unit is shown in Figure 2 while Figure 3 shows the threat detection assembly.

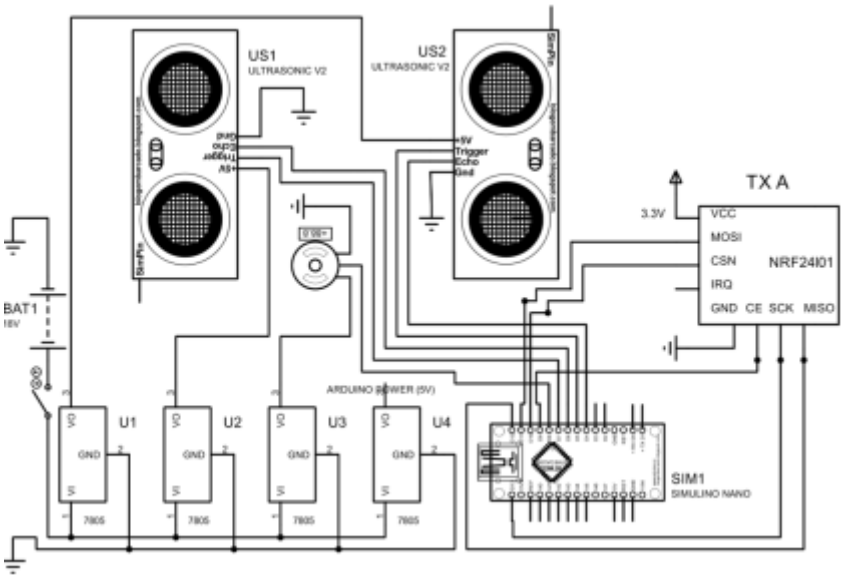

Figure 2: Circuit diagram of the threat detection unit

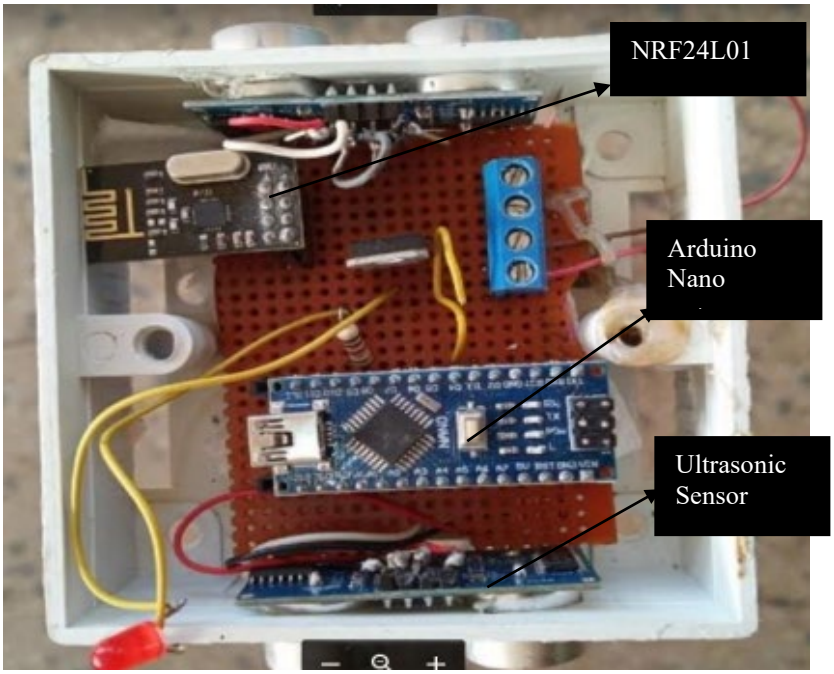

Figure 3: Threat detection circuit assembly

Table 1: Power requirement chart for the Threat Detection Unit

S/No	Name of component	Quantity	Rating	Power Requirement
1.	Arduino Nano	1	5V, 19mA	10V * 0.019A
2.	HC- SR04 Ultrasonic sensor	2	5V, 14uA	(5V*0.005A) *2
3.	NRF24L01 transceiver	1	3.3V, 26uA	3.3V * 0.0113A
4.	Arduino UNO	1	5V, 10mA	10V* 0.05A
5.	Servo motor	1	5V, 200mA	5V*0.2A

The total power (Load) requirement for this unit is:

$$L_T = 0.19VA + 0.05 + 0.0373VA + 0.5 + 1VA \quad (1)$$

$$L_T = 1.773W$$

Where,

L_T = Total load on unit

2.2 Design of the GCU

The Ground Control Unit is a two-way control station that receives distress signals from the monitoring sensors and sends alerts to community dwellers for them to take cover. The GCU has only one option of receiving a distress signal but then designed to have dual options for triggering the air raid siren. This unit is designed to have personnel stationed permanently, or personnel that work in shifts. Figures 4 and 5 respectively show the circuit diagram and the coupled circuit of the GCU. The power requirement of the GCU is shown in Table 2.

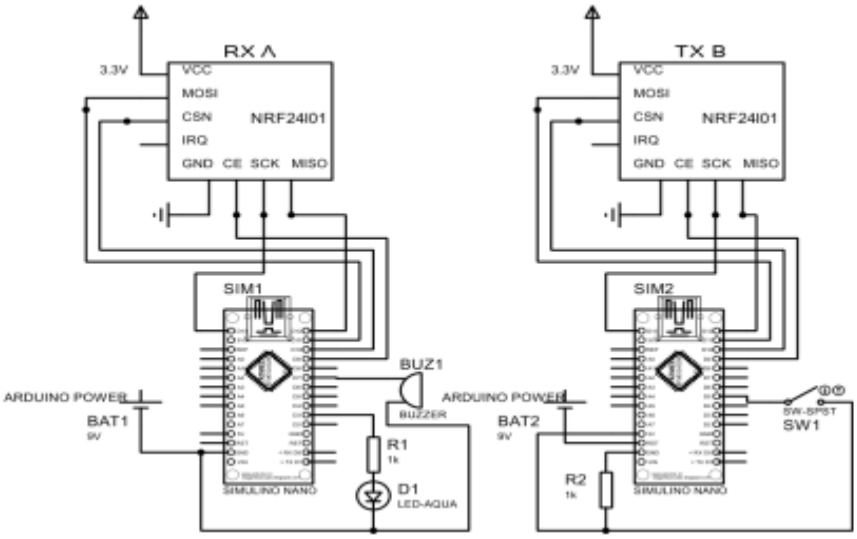

Figure 4: Circuit diagram for the GCU

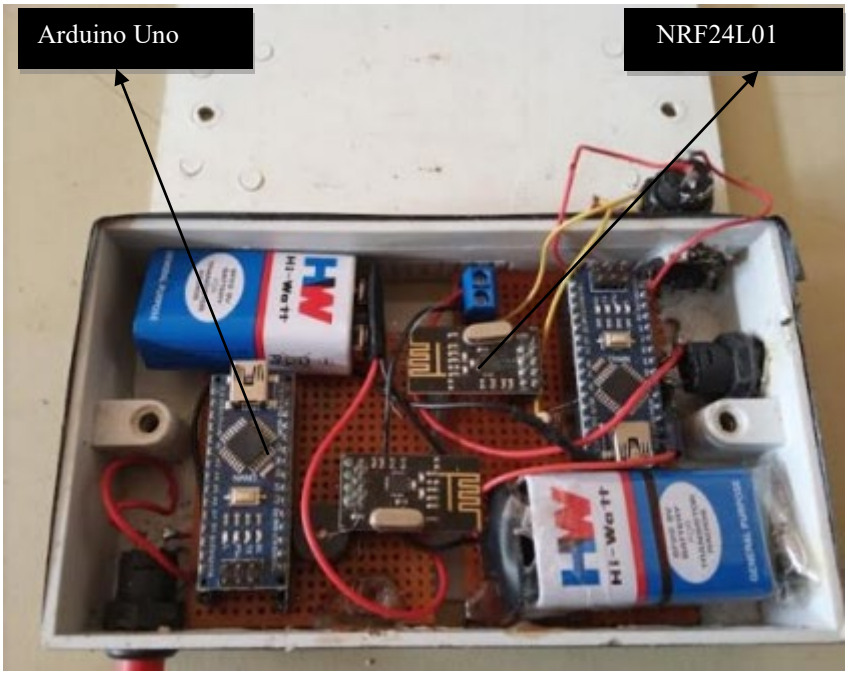

Figure 5: Coupled circuit of the GCU

Table 2: Power requirement for the GCU

S/No	Name of component	Quantity	Rating	Power Requirement
1.	Arduino Nano	2	5V, 19mA	10V * 0.019A
2.	NRF24L01 transceiver	2	3.3V, 26uA	3.3V * 0.0113A

The total power (Load) requirement for this unit is:

$$L_T = 0.19VA + 0.0373VA \quad (2)$$
$$L_T = 0.227W$$

2.3 Design of the Air Raid Siren

The air raid siren is connected to power through a receiver which is engaged by a signal that emanates from the GCU. When motion intrusion is detected as captured by the motion detector which is an ultrasonic sensor in the threat detection unit, the GCU receives the signal through the NRF24L01 and sends the signal to the air raid siren for an alarm to indicate a security breach detected by the sensors. Figure 6 shows the circuit diagram of the public alert section while figure 7 shows the circuit assembly. Figure 8 shows the image of the air raid siren in the public section. Table 3 shows the power requirements for the air raid siren unit.

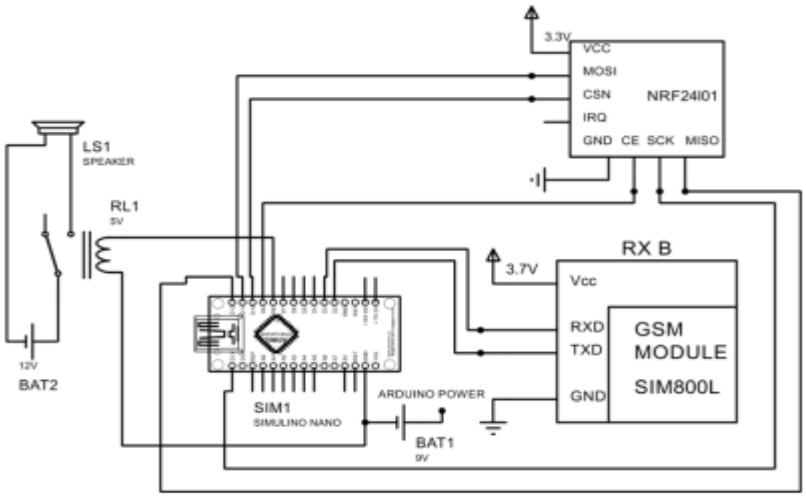

Figure 6: Circuit diagram of the public alert section

When the system is turned ON, a signal from a mobile phone or NRF24L01 module programmed on the same address as the transmitter is received. When the signal is intercepted, pin 8 of the Arduino goes HIGH, turning ON a $5V$ relay. As the relay comes up, $12V$ supply passes through it to turn on the air raid siren for public awareness.

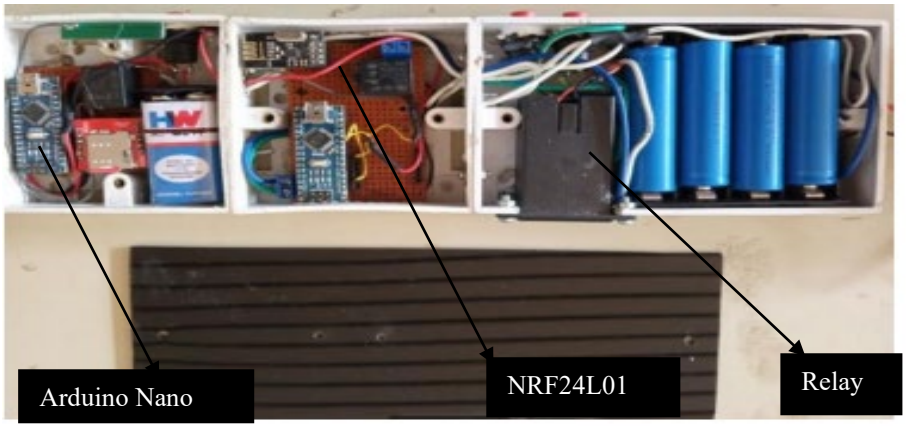

Figure 7: Public alert circuit assembly

Figure 8: Image of the Air Raid siren in the public alert section

Table 3: Power requirement for the Air raid siren Unit

S/No	Name of component	Quantity	Rating	Power Requirement
1.	Arduino Nano	2	5V, 19mA	10V * 0.019A*2
2.	GSM Module	2	5V, 14uA	(5V*0.005A) *2
3.	NRF24L01 transceiver	1	3.3V, 26uA	3.3V * 0.0113A
4.	Air raid Siren	1	12V, 6 tones	20W
5.	Relay	2	5V, 200mA	5V*0.2A

The total power (Load) requirement for this unit is:

$$L_T = 0.38VA + 7.4VA + 0.373 + 1VA \quad (3)$$

$$L_T = 8.173W$$

2.4 Working Principle of the System

Upon the construction and assembly of the system, the setup motion detector in the threat detection unit continuously scans for intrusion in the defined perimeter, in the advent of intrusion, a signal is received at the GCU which is further processed and transmitted to the Air raid siren. The air raid siren gives an alarm signal as an indication of a security breach in the arena due to the intruder in the perimeter. The working principle is shown in the flow chart diagram in Figure 9.

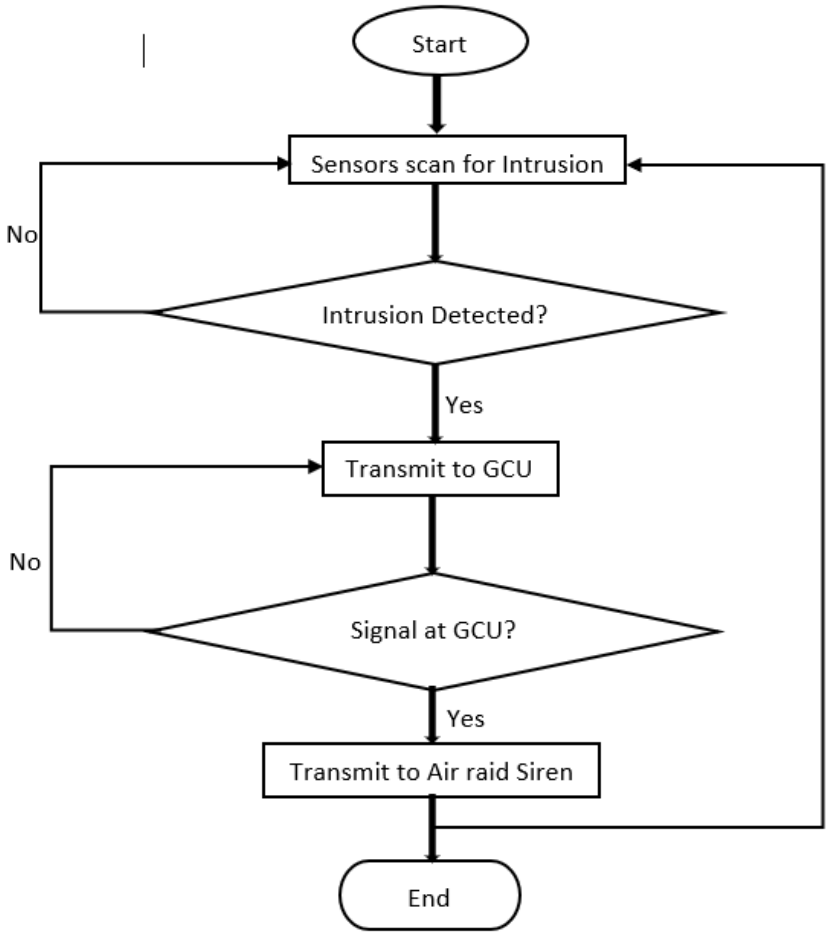

Figure 9: Operational flow chart diagram of the system

Upon completing the assembly of the entire system, an experiment was carried out on a range test to determine the functionality of the threat detection system. A set of distances was programmed into the microcontroller to compare the results with the measured distance with the help of the ultrasonic sensor to detect threat distance. The microcontroller was programmed to detect the intruder's motion through the HCSR04 ultrasonic sensor at 50 cm distance intervals to 350 cm distance

3.0 RESULTS AND DISCUSSION

From the experiment, the actual measured distance at each interval was recorded and compared with the programmed distance for variation. When an intruder is introduced at a defined distance as programmed via the microcontroller. The recorded distance from the motion detector through the use HCSR04 Ultrasonic sensor was compared with the actual distance from the microcontroller to observe the proximity and reliability of the sensor. The variation observed is due to the errors in the ultrasonic sensor as a motion detector. This error increases with the intruder distance demonstrating great reliability at the proximity of intrusion.This data is presented in Table 4.

Table 4: Threat detection range test

S/No	Programmed Distance (cm)	Measured Distance I (cm)	Measured Distance II (cm)	Average Distance (cm)
1.	50	48.20	47.80	48.00
2.	100	97.50	98.10	97.30
3.	150	146.40	147.20	146.80
4.	200	195.10	194.80	194.95
5.	250	242.60	241.20	240.90
6.	300	289.40	288.20	288.80
7.	350	338.20	336.40	337.30

From the calculations, it was discovered that the time it takes for the detection unit to send and receive pulses is 294µs with a power consumption of 1.52729W. The GCU takes 0.22729W of power while the air raid siren section takes 8.1729W.

4.0 CONCLUSION

Security remains a crucial challenge that needs to be addressed in every society and organization. Security techniques or devices may not be entirely new but have gone through upgrades to suit the current and diverse attack methods. This study addresses the challenge by developing and testing a model security breach detection system in a predefined perimeter and reporting to a ground control unit to alert residents for further action. The prototype design was tested to ascertain its performance and possible adoption in society. It is recommended that a more sophisticated sensor with better accuracy could be used for threat detection.

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