EQUIPMENT, SECURITY PERSONNEL TRACKING AND LOCALISATION USING GEO-LOCATION TECHNIQUE

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ABSTRACT

Insecurity has been a challenge faced by developed and developing countries with Nigeria being a typical example. This work intends to adddress these problems using remote monitoring technique with geo-location facilities for real-time monitoring and tracking of security personnels and equipments. This paper presents a system that comprised of both hardware and software resources. The hardware resourses is based on a controller, a sensing block, a communication unit and power supply. The sensing unit whose major component is the Ublox Neo 6 Global Positioning System (GPS) module, captures the location after locking a minimum of four satellites, it then passes the location data to the controller (Arduino Uno Mini Pro). The controller interprets the data captured and send it as Short Message Service (SMS) through the communication unit (Sim 800L GSM module) to the administrator. A Graphic User Interface was developed to help the administrator interpret the location data received via SMS to a visible map. Tracking details saved into the database system. The result obtained from testing of the device through different location at the Testbed in Federal University of Technology Minna, Nigeria showed that the system achieved an average accuracy of 70 % in identifying the location and the sensitivity of the device in areas where satellite cannot be detected was recorded to be 90 %. The accuracy level depend on to the number of satellites captured in areas under consideration. This numerical value shows that the system is reliable and can be used in tracking.

KEYWORDS: *Global Positioning System (GPS); Global System for Mobile communication (GSM); Short Message Service (SMS); security*

1.0 INTRODUCTION

Nigeria is a country in West Africa and has enjoyed several awards for its outstanding performance whenever her security agents are on foreign peace mission to maintain peace like the United Nations, The Economic Community of West African States Monitoring Group (ECOMOG) was a West African multilateral armed force established by the Economic Community of West African States (ECOWAS). ECOMOG African Union (AU) just to mention a few. However, several security agents amongst them tend to undermine this good record.

Today, Nigeria is facing security challenges as life and property are threatened by the activities of armed bandits and criminals. In some cases, security agents saddled with the

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responsibility of protecting lives and properties are sometimes found to be biased in their activities such disgruntle security agents compromise their oath of office and allegiance to the state by given out their security gadgets like guns, walkie-talkie and vehicles to criminals under their cover. In some cases, security agent abandons their respective duty post to enable criminals carry out their dirty and sinister missions. Nigeria security personnel are not only saddled with the duty of monitoring criminals alone, but also dirty security agent in their midst. In light of all these issue, it is unambiguous that the present security apparatus seems overstretched. Therefore, there is a need for geo-location system for monitoring security personnel and equipment using GPS/GSM sensing module (Abid & Ravi, 2012).

Furthermore, the security of life and property is a dire need of any thriving country. Without security, a country remains exposed to threat and vulnerabilities. In such a state, the attainment of such a country's objective and projects becomes an extraordinary task. The reason being that it disturbed production process and prevent investors from coming to invest in such a country (Uzonuwanne, 2015). There are a lot of other activities that lead to insecurity, some of which are kidnapping, armed robbery, hired assassin, religion crises and so on. As a result of this level of insecurity, the need for security personnel is required, and the security personnels cannot do without their defensive equipment (such as cars for mobility,cellular phones for communication and guns).

Tracking is a process of monitoring or observing a person or objects on the move, and supplying a real-time data of the location. Insecurity has been an obstacle that stands as a barrier to economic development. It poses a threat to investors and hinders business activities. In order to tackle this, several measures have been put in place to see an end to this. One of the measure is to have both public and private security personnel equipped with tools that will enhance their work. Figure 1 is an illustration of the proposed system, where the security personnel and the gadget are all being tracked and monitored (Kartik, 2013).

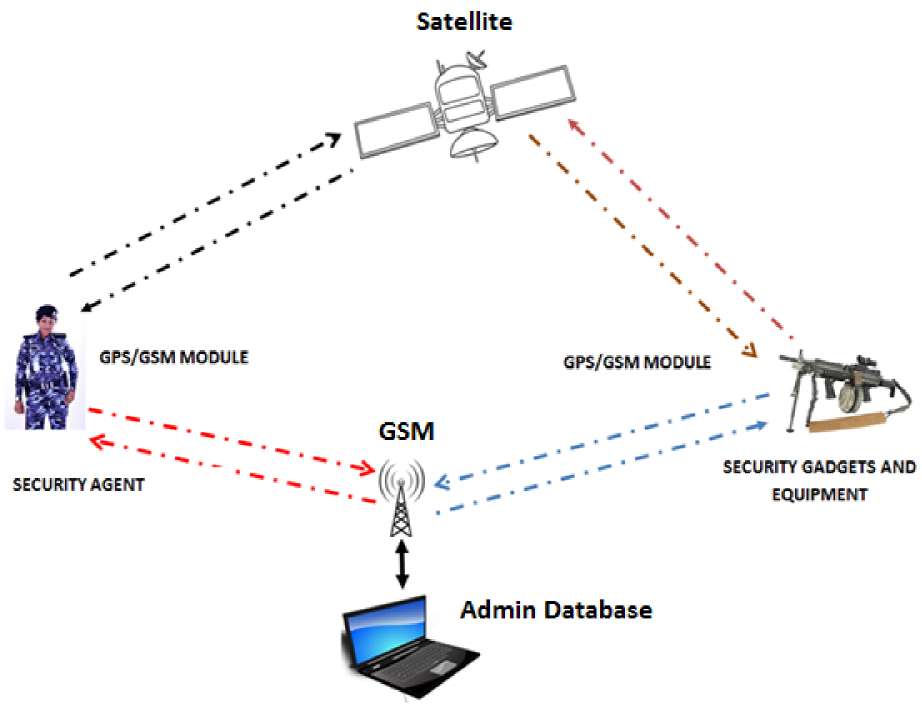

Figure 1. Layout of monitoring and tracking structure (Kartik, 2013)

2.0 RELATED LITERATURE

The relevant literature in this research is further discussed in this section.

2.1 Satellite Orbit

There are four satellites in each of six orbital planes. Each plane is inclined 55° relative to the equator, which means that satellites cross the equator tilted at a 55° slant. The scheme is planned to maintain full operational capability even if two of the 24 satellites fail. Figure 2 shows a GPS setup with a constellation of satellites.

Figure 2. The satellite orbit (Agajo, 2015)

GPS satellites complete a revolution in approximately 12 hours, which implies that they pass over any point on the earth about two times a day. The satellites rise (and set) about four minutes earlier each day (Cooksey, 2016).

2.2 Equations

The four satellites are the minimum number of satellites required to capture the location of a receiver. The satellite captures the longitude, latitude, altitude and the fourth satellites captures the time it takes the GPS signal to reach the receiver from the satellite. The distance can be calculated using pythagoras formula as shown in Equations (1) to (4).

$$Pu_1 = \sqrt{(X_1 - Ux)^2 + (Y_1 - Uy)^2 + (Z_1 - Uz)^2} + cd(T_n) \qquad (1)$$

$$Pu_2 = \sqrt{(X_2 - Ux)^2 + (Y_2 - Uy)^2 + (Z_2 - Uz)^2} + cd(T_n) \qquad (2)$$

$$Pu_3 \;=\; \sqrt{(X_3 - Ux)^2 + (Y_3 - Uy)^2 + (Z_3 - Uz)^2}\; + cd(T_n) \qquad (3)$$

$$Pu_4 \;= \sqrt{(X_4 - Ux)^2 + (Y_4 - Uy)^2 + (Z_4 - Uz)^2}\; + cd(T_n) \qquad (4)$$

A mathematical representation for the scenario, the device monitors both security personnel and equipment are proposed. It should be mentioned that the device is installed to monitor positioning and this has wireless nodes that incoporates GPS/GSM Module put together. Let the D_E is device monitoring equipment and D_P is device monitoring security personnel. Therefore, it can be found that

$$\text{Total device on equipment} = \sum_{i=1}^{n} D_{E(i)} \qquad (5)$$

$$\text{Total number of device security personel} = \sum_{j=1}^{m} D_{P(j)} \qquad (6)$$

$$\text{Total number of device security equipment} = \sum_{\substack{i-1 \\ j=1}}^{nm} D_{E(i)} D_{P(j)} \qquad (7)$$

Since four GPS have the task of locating a security personnel at a time, a localisation technique given by the characteristic equation are given, as expressed in Equations (8) to (15) as follows:

From

[**P**] [**G**]=[**L**] and

[**E**] [**G**]=[**L**]

where P represents security personnel while E represent security personnel equipment, this gives

$$\begin{bmatrix} P_{11} & P_{12} & P_{13} & P_{14} \\ P_{21} & P_{22} & P_{23} & P_{24} \\ P_{31} & P_{32} & P_{33} & P_{34} \\ P_{41} & P_{42} & P_{43} & P_{44} \end{bmatrix} \begin{bmatrix} G_1 \\ G_2 \\ G_3 \\ G_4 \end{bmatrix} = \begin{bmatrix} L_1 \\ L_2 \\ L_3 \\ L_4 \end{bmatrix} \qquad (8)$$

$$\begin{bmatrix} E_{11} & E_{12} & E_{13} & E_{14} \\ E_{21} & E_{22} & E_{23} & E_{24} \\ E_{31} & E_{32} & E_{33} & E_{34} \\ E_{41} & E_{42} & E_{43} & E_{44} \end{bmatrix} \begin{bmatrix} G_A \\ G_B \\ G_C \\ G_D \end{bmatrix} = \begin{bmatrix} L_A \\ L_B \\ L_C \\ L_D \end{bmatrix} \qquad (9)$$

The eventual function becomes

$$F(P,G,L) = P_{11} G_1 + P_{12} G_1 + \dots\dots\dots + P_{1(n+1)} G_n \qquad (10)$$

and

$$F(E,G,L) = E_{11} G_1 + E_{12} G_1 + \dots\dots\dots + E_{1(n+1)} G_n \qquad (11)$$

Position is taken as location in Equations (12) to (15)

$$P_{11}G_{1}+P_{12}G_{2}+P_{13}G_{3}+P_{14}G_{4}=L_{A} \quad (12)$$

$$P_{21}G_{1}+P_{22}G_{2}+P_{23}G_{3}+P_{24}G_{4}=L_{B} \quad (13)$$

$$P_{31}G_{1}+P_{32}G_{2}+P_{33}G_{3}+P_{34}G_{4}=L_{C} \quad (14)$$

$$P_{41}G_{1}+P_{42}G_{2}+P_{43}G_{3}+P_{44}G_{4}=L_{D} \quad (15)$$

The + sign in the equation represents the adding up of all data that are collected from the satellites. All the four satellites are responsible for localising the positions for security personnel and equipment. The sum of signals from the satellites are intercepted to locate the positions of the equipment and device. The GPS/GSM module fits into the security personnel service phones.

2.3 Satellite Signal

GPS satellites uninterruptedly communicate satellite position and timing information through radio signals on two frequencies (L_1 and L_2). The radio signals travel at the speed of light (186,000 miles per second) and take roughly 6/100 ths of a second to reach the earth.

Figure 3 is a typical architecture of the system which shows a setup where nodes are attached to security agents these are classified as must use device like phones and other security equipment utilities like guns , armoured vehicles and so on. The constellation of satellites capture the GPS module installed on the device meant to be compulsorily carried by the security agent and equipment.

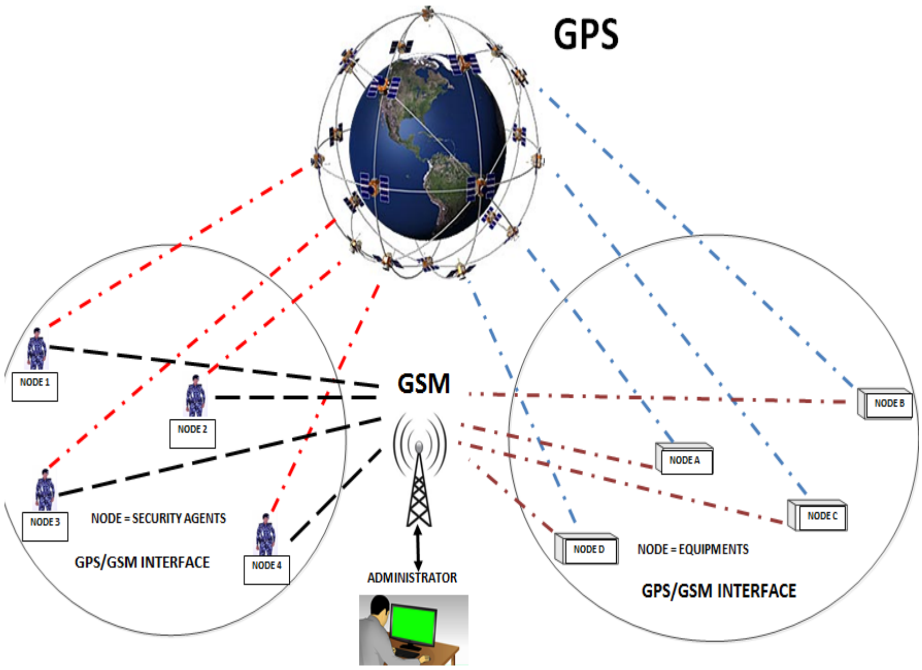

Figure 3. Architecture of the geolocation systems for remote monitoring

2.4 GSM Module

The satellite signals require a direct line of sight on the GPS receivers and cannot penetrate water, soil, walls or other obstacles. For example, heavy forest canopy causes interference, making it difficult, if not impossible, to compute positions. In canyons (and "urban canyons" in cities) GPS signals are blocked by mountain ranges or buildings. If GPS receiver antenna is blocked, it will stop computing positions (Cooksey, 2016). Global System for Mobile communication (GSM) is a second generation cellular standard developed to provide for voice services and data delivery using digital modulation. The aim of GSM technology is to make mobile communication digital and to compress streams of data. In Europe, GSM is the essential wireless telephone service and GSM boasts one billion users on a global scale. In addition to Europe, GSM operates and is readily available as a digital network in over 190 countries . Initially GSM was set up to act as a common, more unified European Mobile Telephony System. After a few years, GSM as a technology trickled down to the cellphone and mobile technology arena. Basically, GSM allows all users of mobile phones and data devices to switch carriers and roam without having to go out and replace their cell phones. Among the task that GSM was able to perform successfully is SMS sending and receiving (Shijun, 2008).

3.0 METHODOLOGY

3.1 Hardware

Hardware comprises of four units, the location sensing unit, the communication unit, the control unit, and the power unit as shown in Figure 4 (Amin & Khan, 2014). The hardware are integrated with each other to achieve the development of the tracking device. The control unit is the Arduino Uno min pro; it is a microcontroller based on ATMEGA 328 board (Banzi & Shiloh, 2014). It helps in processing all the functionalities of the module integrated to it. There is a GPS module at the sensing unit. module. It captures the longitude and latitude of a place and transmit the data using transistor to transistors logic (TX, RX). The GSM module helps in communicating remotely the value captured data from the GPS Module through TX and RX. The system consumed a lot of power. In order to overcome this, buck converter is used alongside with the battery to reduce power consumption level.

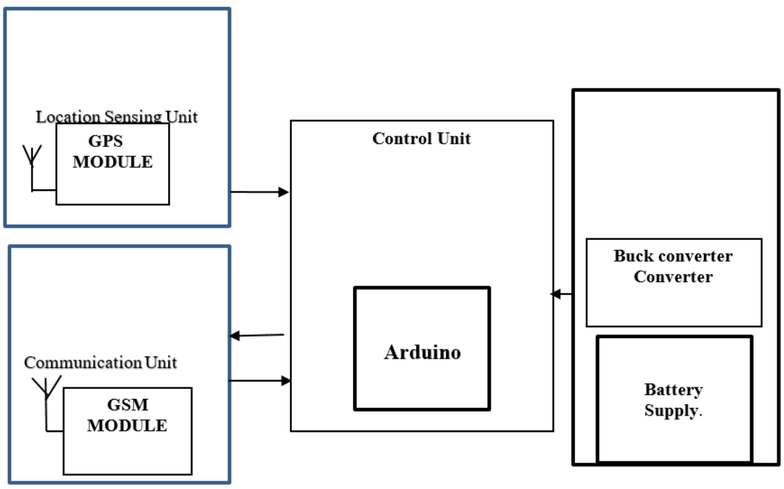

Figure 4. Block diagram

3.1.1 Buck Converter

A bulk converter is DC to DC electronic converter in which the output voltage is transformed to less level than the input voltage.it can also be refer to as a step down converter. The efficient power conversion extends the battery live, reduces heat and allows for smaller gadget to be built. The buck converter comprises of a capacitor, a diode, an inductor, and a switch all connected with a wire as shown in Figure 5 (Coates, 2016).

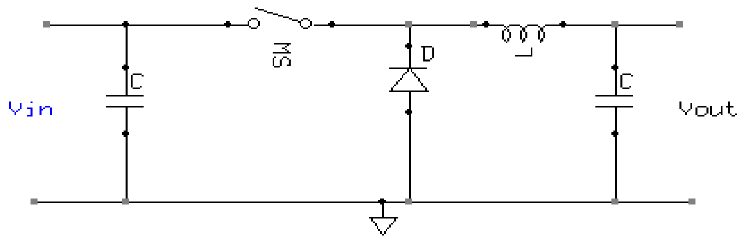

Figure 5. Circuit diagram of a buck converter (Coates, 2016).

The buck converter is used in switched-mode power supply (SMPS) circuits where the DC output voltage needs to be lower than the DC input voltage. The DC input can be sourced from a rectified AC or from any DC supply. It is useful where electrical isolation is not needed between the switching circuit and the output. However, where the input is from a rectified AC source, isolation between the AC source and the rectifier could be provided by a main isolating transformer.

The switching transistor between the input and output of the buck converter continually switches on and off at high frequency. In order to maintain a continuous output, the circuit uses the energy stored in the inductor (L) whenever the swtiching transistor is turned on. Therefore, even when the switching transistor is turned off, energy is supplied continuously. The circuit operation depends on what is sometimes also called a flywheel circuit. This is because the circuit acts rather like a mechanical flywheel that, given regularly spaced pulses of energy keeps spinning smoothly at a steady rate.

3.1.2 GPS Receiver

The GPS receiver helps to capture the location using satellite. There are several types of receiver, but due to availability, reduced cost and easy communication, Ublox Neo 6 GPS module was chosen for this project. Figures 6 and 7 show the GPS module and its block diagram, respectively.

GPS receivers require different signals in order to function. These variables are broadcast after position and time have been successfully calculated and determined. In order to ensure that the different types of appliances are portable, there are either international standards for data exchange (NMEA and RTCM), or the manufacturer provides defined (proprietary) formats and protocols.

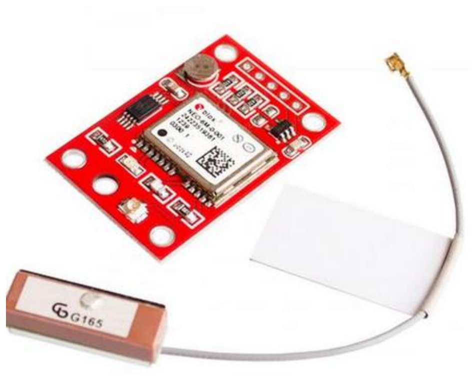

Figure 6. Diagram of a GPS module

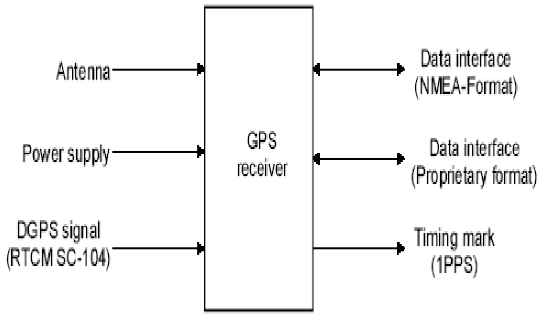

Figure 7. GPS Receiver Block Diagram (Cooksey,2016)

In order to relay computed GPS variables such as position, velocity and course to a peripheral, (e.g. computer, screen, transceiver), GPS modules have a serial interface (TTL or RS-232 level). The need to use a more friendly, easy to interact with, mini size and market availability brought about the use of Arduino Uno Mini Pro. It is similar to Arduino Uno in terms of function and working principle. The Arduino Uno Mini Pro is shown in Figure 8.

Figure 8. Arduino Uno Mini Pro

Figure 9. GSM Module

Arduino Uno is a microcontroller board based on the ATmega328P. It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz quartz crystal, a USB connection, a power jack, an ICSP header and a reset button. It contains everything needed to support the microcontroller. It is used to control all other module.

3.1.3 The GSM module

This caters for the communication between the device and the user. It achieves this communication through SMS. SIM900A was used in this project because of its flexibility, the range of network captured, the voltage level and easy interfaced with Arduino. Figure 9 shows the diagram of SIM900a (Banzi, 2014). Global System for Mobile (GSM) is a second generation cellular standard developed to cater for voice services and data delivery using digital modulation. The purpose of GSM technology is to make mobile communication digital and to compress streams of data.

3.2 Software Application

A graphical user interface GUI application was developed using C Sharp language and a SQL database system. The main aim of the application is to monitor or track each security personnel location and save the tracking detail in a database. The login page provides access to the application. It is designed so as to prevent unauthorized access to the information in the system. It can only be accessed by the administrator with username and password.

4.0 RESULTS AND DISCUSSION

Outcomes of this research are discussed in terms of hardware and software development outputs.

4.1 Hardware

The hardware part of the system was simulated using Proteus (8.3) version to see the behavior of the system. Figure 10 shows the screen capture of the simulation. After the simulation, thorough research and testing were done on each component, and component configurations are done when required. Figure 11 shows the screen captured of the GPS configuration and Figure 12 shows the interface for signal testing/configuration showing strength of various satellite within GPS.

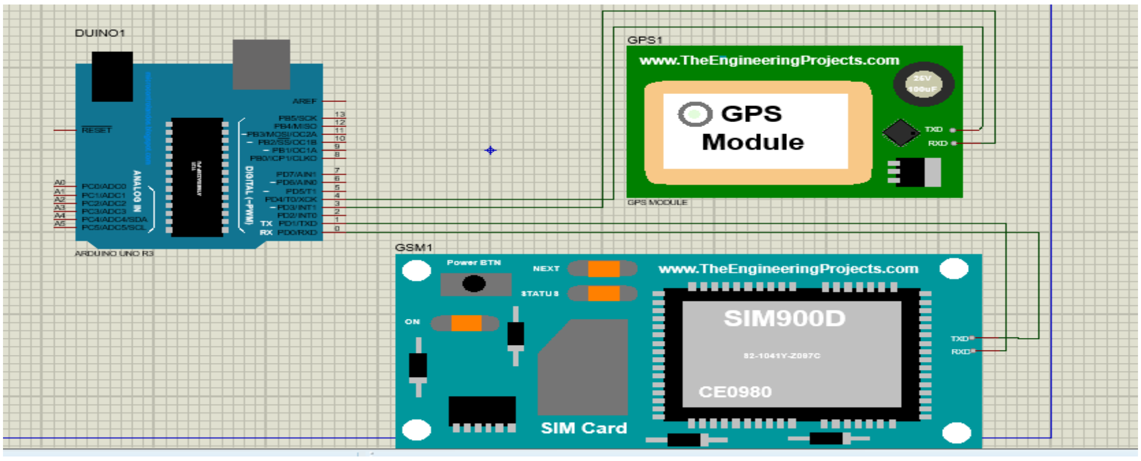

Figure 10. System Proteus simulation

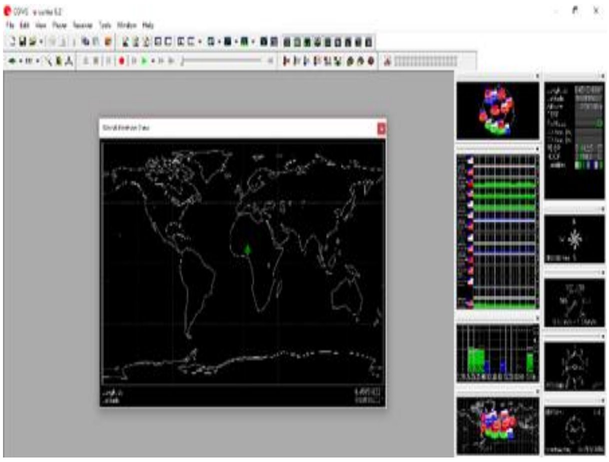

Figure 11. Screen captured of GPS

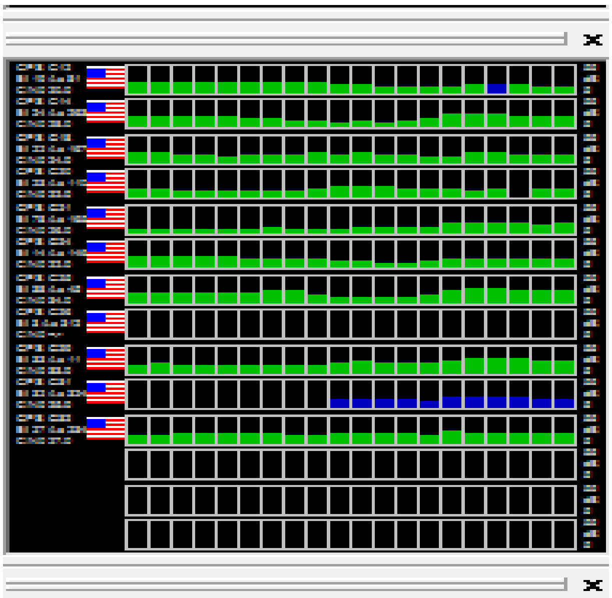

Figure 12. Interface for signal testing/configuration showing strength of various satellite within GPS

4.2 Software development

The software was developed to manage the security personnel tracking details as shown in Figures 13 to 18.

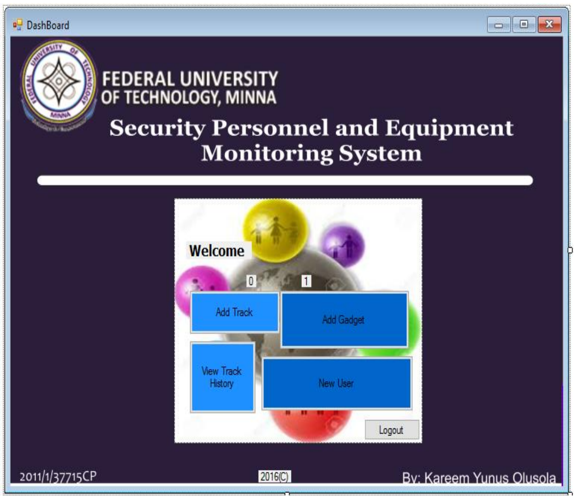

Figure 13. The login homepage

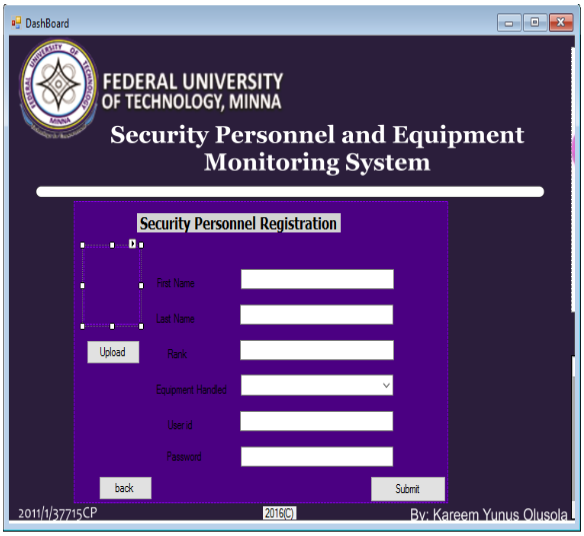

Figure 14. Registration page

Figure 15. History page

Figure 16. Equipment page

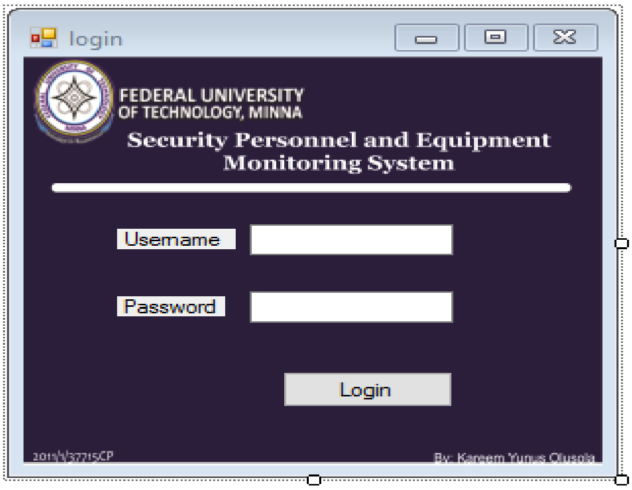

Figure 17. Login page

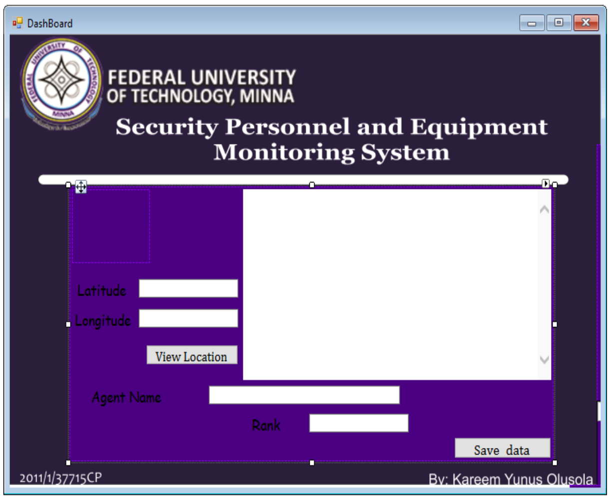

Figure 18. Tracking page

4.3 Implementation and system testing

The system is implemented following the Arduino code written for Arduino Nano (Mini) to control the remaining modules. The GUI application was written using C Sharp language on visual studio compiler. Figure 19 shows the Arduino serial monitor showing the value of location (the longitude, latitude, altitude, time and the number of the GPS satellite tracked). The development of the software was achieved and Figure 20 shows the development result.

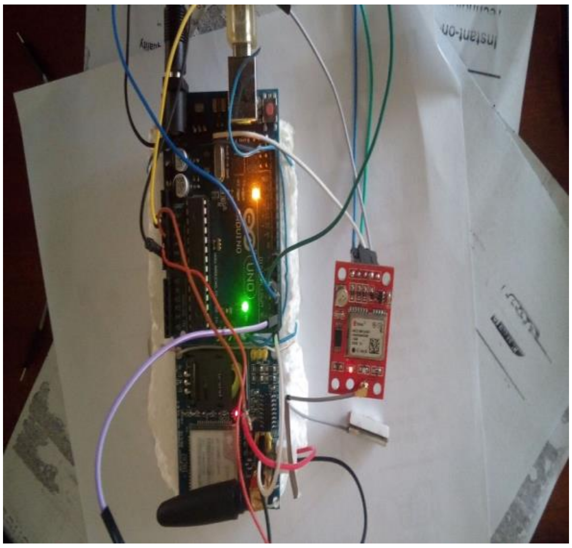

Figure 19. Hardware setup for testing

Figure 20. Interface showing security personnel and geographical location

Table 1. Location comparison between the Google Map value and device value

S/N	**Real**	**True Value**		**Trackers Value**		**No.of satellite**
0	Location (Address)	Longitude	Latitude	Longitude	Latitude	
1	School of Information and Communication Tech. FUT, Minna	6.451576	9.531347	6.451516	9.531150	4
2	Road to School of Engineering Tech. FUT, Minna	6.44974	9.533757	6.447071	9.533252	4
3	Electronic Test Center, FUT, Minna	6.449688	9.536088	6.450002	9.535971	5
4	Information Technology Service (ITS), FUT	6.526976	9.65382	6.452486	9.534047	3
5	School of Agriculture and Agricultural Engineering	6.527783	9.656447	6.452179	9.535871	3

The case study result was obtained from the system implementation and tested at Federal University of Technology Minna which related to the true value of the positioning and the level of precision is determined. The result obtained varies with the number of satellites captured. It was noted that as the number of satellite captured increases the longitude and latitude change respectively, thereby becomes more accurate comparing to the value on google map as shown in Table 1.

The system was evaluated based on sensitivity, accuracy and success level. The sensitivity of the device to areas under consideration is 95 % and the device was able to capture the location successfully. The Standard Positioning Service one can realize 15-meter horizontal accuracy 95 % of the fourth dimension. This means that 95 % of the fourth dimension, the coordinates from GPS receiver display will be within 15 beats of true location along the ground. P (Precise) matrix is broadcasted on both the *L1* and *L2* frequencies. Figure 19 shows the sensitivity, satellite and success level at different location.

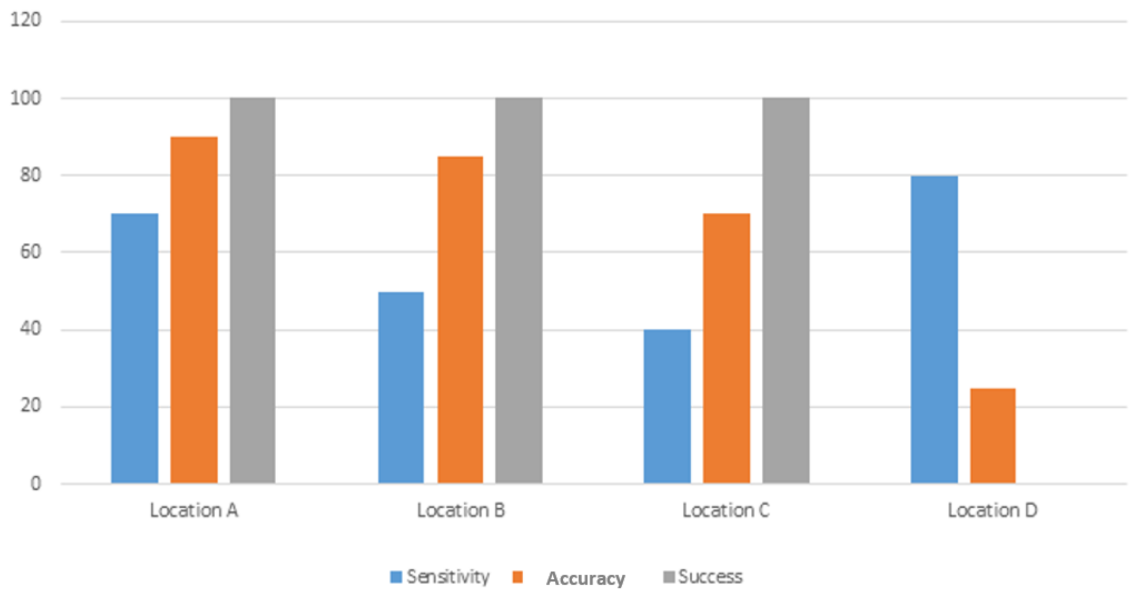

Figure 19. Sensitivity, accuracy and success level at different location

5.0 CONCLUSION

The paper was able to present a way out of effectively monitoring equipment and security personels using GPS/GSM module, which makes up a security enhanced system by ensuring effective performance of personnel and also tracking of equipment all in an attempt to prevent them from getting into wrong hands. The system optimises the use of the GPS system that is always monitored by four satellite in space at a time, real-time localisation was achieved since the location and status of the equipment is monitored in the Google Earth output.

ACKNOWLEDGEMENT

The authors are grateful to the authorities of the School of Engineering and Engineering Technology and Departments of Computer and Telecommunication Engineering, Federal University of Technology Minna Niger State Nigeria for their technical and financial support for this research project.

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