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IOT Based Smart Security System with Metallic Weapon Detection for Community Vigilante

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ABSTRACT
Local crime has increase overtime due to improper securing of public places like the stadium, hospitals, viewing centers. Kidnapping and cattle rustling has become endemic in our communities and villages today.
The level of insecurity in most state is becoming unbearable. Lives and valuable properties are destroyed on daily basis by bandits who use deadly weapons to access even highly secured places.
Financial institutions are heavily under attacks nowadays and hence rendering most rich folks poor and frustrated. These robbers attack prisons, courthouses, airports and even psychiatric hospitals with dangerous weapons and hijack, kidnap and even kill their targets. Most times, even the gatemen are the first to be attacked. Due to high level of insecurity in the country, some researchers had come up with the idea of designing metallic weapon detecting systems to reduce the rate of robbery attacks. Most of the existing metal detectors especially in financial institutions like banks are able to detect individuals with metallic materials and deny them entrance or transaction. However, some of them did not integrate timely internet of things notification capability at the detection of a metallic weapon to the security department. This research work designed an Internet of Things (IoT) based smart security system with metallic weapon detection, IoT notification and remote cloud monitoring. The studied system used esp8266 Nodemcu which is programmed in c++ for all control operations, Ultrasonic sensor for detecting human presence, Inductive Metal Detector for metal detection, and Blynk cloud platform for remote monitoring and IoT notification. The system is mounted at the designated entrances and if any metallic weapon or material is detected by the Metal detector, timely information about the incident would be sent to the local vigilante in Ebonyi state for proper actions. This system will help to reduce the rate of robbery attacks in our offices, homes and locals etc. the system was tested in the department of computer science Ebonyi State University Abakaliki and was confirmed to be working perfectly.
Key words: *Internet of Things; Metallic dictator; Nodemcu; Ultrasonic Sensor; Blynk cloud.*

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I. INTRODUCTION

The idea of security systems came up many years ago as people began to use some deadly metallic materials to wreck havocs and attack homes, offices and financial institutions.

Several financial institutions have been attacked heavily and huge amount of money looted and their depositors rendered helpless. Also, several homes and offices have been broken into and their occupants robbed of valuable property and murdered. These attackers usually invade their target places with very complex metallic weapons and most times go uncaught.

According to Arab news, the brazen assault happened in part of Nigeria's volatile central region, where criminal gangs and cattle rustlers regularly attack security forces.

"They attacked the police station and at the same time attacked two banks," according to Kwara state police spokesman Ajayi Okasanmi, adding that nine police and six civilians died in the violence. The gang invaded a busy commercial area where several banks and the police station are located in broad daylight around 4:50 p.m. (1550 GMT), [1].

Security metal detectors are used to ensure the safety & security in the airport, the college, the office building or any other areas. There are different types and models of digital walk-through metal detectors, but the most commonly used detectors are the hand held models and walk through models.[2].

The metal detector uses the principles of the electromagnetic induction. The detection of the possible dangerous metallic object is notified with the alarm. It is more convenient and efficient in terms of functionality and application, so, the walk through and the handheld metal detector will give you the best security.

The hand-held detector is primarily used by security personnel to physically examine if the person is concealing a metallic object, The walk-through detector alerts the security personnel when the person passing through the arch is carrying metallic objects.The hand held metal detectors are more affordable & they are still

able to identify metallic objects that are considered to be dangerous, while walk though models are more convenient and more efficient.

With the help of the hand held detector , the security personnel can physically detect if the person is carrying the metallic object , while walk through metal detectors are much quicker and they alert the security personnel of dangerous objects such as the knives or the weapons .We can feel safety in the airport, the college, the office building or any other area where these detectors are being used. The people that are using them can control who enters a specific area and what he brings inside it.

Metal detectors can deter potential criminals because the criminal will think twice before walking through a security check point. They offer alarm indication. The signal warns of the detection metal object. The indication can be visual and/or auditory and the alarm indication is off until a metal object is detected.

The alarm indication is proportional to the size, proximity, orientation and material of an object. The device used to generate the alarm indication can be a light bulb, lamp, light emitting diode, etc. Generating device can be a horn, siren, buzzer or similar item for the auditory indication.

A metal detector is an instrument that detects the nearby presence of metal [2,3]. Metal detectors are useful for finding metal objects on the surface, underground, and under water. The unit itself, consist of a control box, and an adjustable shaft, which holds a pickup coil, which can vary in shape and size. If the pickup coil comes near a piece of metal, the control box will register its presence by a changing tone, a flashing light, and or by a needle moving on an indicator. Usually, the device gives some indication of distance; the closer the metal is, the higher the tone in the earphone or the higher the needle goes. Another common type are stationary "walk through" metal detectors used at access points in prisons, courthouses, airports and psychiatric hospitals to detect concealed metal weapons on a person's body

In 1926, two Leipzig, Germany scientists installed a walk-though enclosure at a factory, to ensure that employees were not exiting with prohibited metallic items.

A series of aircraft hijackings led the United States in 1972 to adopt metal detector technology to screen airline passengers. In 1995 systems such as the Metor 200 appeared with the ability to indicate the approximate height of the metal object above the ground, enabling security personnel to more rapidly locate the source of the signal. Smaller hand-held metal detectors are also used to locate a metal object on a person more precisely.

One of the early common uses of the first metal detectors, for example, was the detection of landmines and unexploded bombs in a number of European countries following the First and Second World Wars.

Metal detectors can be used if for several military uses, which can be summarized as follows:

i. Exposing the mines planted in the fields during the war or after the end of the war
ii. Detect dangerous explosives and cluster bombs dangerous to people's lives
iii. Hand-held metal detectors can be used to search people for weapons and explosives

II. RELATED WORKS

Since the discovery of metals, metallic objects and weapons have rather been abused by people living in different geographical zones. Metals were meant for construction of valuable structures like gates, tanks, pillars, guns etc.

According to Apoorva and Bali, (2022) defined metal as any substance that has a high electrical and thermal conductivity, malleability and lustre. It is an element which has metallic bonds and forms positive ions. The element metal forms the largest group in the periodic table, the group is defined according to its position in the periodic table.

James (2020) a man hit a 77-year-old woman on the head with a metal pipe, before stealing one of her pizzas. In a video released by the Tucson police Department, a woman carrying two pizzas attempted to leave Peter Piper Pizza, in Arizona, a man who was waiting outside and holding a metal pipe attacked her and made away with her items.

Over and over, violence has threatened Nigeria's peace, stability and unity. Even as the current administration is winning the war against terror in North East Nigeria, militants in Niger-Delta (South-South) have announced their resumption to violent attacks on crude oil facilities[4]. Since February 2016, militants have continued to issue threats, vowing to blow up more pipelines and damage more crude oil facilities in the region. On 16th of February 2016, The Guardian Newspaper published that Niger Delta militants held five foreigners ransom after hijacking a chemical tanker off the coast of Nigeria.

Most embedded systems like the system use microcontrollers as their control unit. This unit can be programmed with a programming language in other to perform specific tasks either in the home, offices, industries, etc. They work with sensors which are responsible for reading changes in the environment. A microcontroller (MCU or Microcontroller Unit) is an integrated circuit (IC) which is small, low cost and self-contained computer designed to handle a specific task in embedded systems [6].

Internet of Things (I.O.T) is a dynamic global network infrastructure with self-configuring capabilities based on standard and interoperable communication protocol where physical and virtual "things" have identities, physical attributes and virtual personalities and use intelligent interfaces and are seamlessly integrated into the information network [7]. The I.O.T concept was coined by a member of the Radio Frequency Identification (RFID) development community in 1999, and it has recently become more relevant to the practical world largely because of the growth of mobile devices, embedded and ubiquitous communication, cloud computing and data analytics. Gusmerolli *et al* (2011) imagine a world where billions of objects can sense, communicate and share information, all interconnected objects have data regularly connected, analyzed and used to initiate action providing a wealth of intelligence for planning, management and decision making, this is the world of internet of things. Jian (2011).

III. METHODOLOGY

Object-Oriented Analysis and Design Methodology (OOADM) has been used in this research work. Its development activity consists of objects, classes, frameworks and interactions. The use of this methodology helps to produce a better-quality software product for embedded systems and Internet of Things (I.O.T) in terms of documentation standards, acceptability to the user, maintainability and consistency of software. Some basic advantages of using the Object-Oriented Analysis and Design Methodology include:

i. OOADM eradicates the inherent risk of carrying forward incorrect or incomplete analysis into design and construction.

IV. SYSTEM SPECIFICATION

Table 1: Features and Specifications of Nodemcu

Specification	Values
Microcontroller:	Tensilica 32-bit RISC CPU Xtensa LX106
Operating Voltage:	3.3V
Input Voltage:	7-12V
Digital I/O Pins (DIO):	16
Analog Input Pins (ADC):	1
UARTs:	1
SPIs:	1
I2Cs:	1
Flash Memory:	4 MB
SRAM:	64 KB
Clock Speed:	80 MHz

Metal Sensor Module

This NPN inductive proximity sensor can detect the presence of metals objects in front of it. The detection distance may vary slightly depending on the shape, size, and type of metal the object is made of. It can detect through thin, non-metallic materials and has an LED indicator that turns on when the device is powered, and increases in brightness when an object is detected. This inductive sensor can detect metallic objects within 5mm and behaves like a switch that connects to a digital input.

This sensor consists an induction loop, electric current generates a magnetic field, which collapses generating a current that falls toward zero from its initial trans when the input electricity stops.

The inductance of the loop changes according to the material inside it and since metals are much more effective conductors that other materials the presence of metal increases the current flowing through the loop. This change can be detected by sensing circuitry which signal pass true to some other device whenever metal is detected.

This device is commonly used in automatons and is mostly used because it can adapt in a rugged and dirty environment.

Figure 11: Metal Sensor (https://hub360.com.ng/product/inductive-metal-sensor-sno4/)

Table 2: Specifications of Metal sensor

Specification			Values
Detecting		Distance:	4mm
Supply		Voltage:	DC6-36V
Current		Output:	300 mA
Response	Frequency: Detect	Object:	100Hz

Column Sensor Dia	Metal 12mm

V. HOW THE SYSTEM WORK

The case study in this research work is the Local Vigilantee Security Network which was set up by the government to help reduce the rate of criminal activities in the state. This special security group has used manual approach to detect criminals with weapons and hence disciplined them. However, this approach is not very effective as the group members can get tired and or sleep off in some cases.

The Local Vigilantee team obviously cannot be everywhere at all times. Some hardened criminals might follow uncommon routes to gain entry and carry out their attacks unnoticed. Some of the recent attacks by these criminals in Ebonyi State had led to the loss of lives of some individuals. The criminals came in unnoticed and lunched their attacks and the security agents were informed during the process. However, before their arrival, the criminals had run away. Even though they are later on apprehended, the lives lost cannot be restored. This approach is not completely effective as it is not proactive but passive. So, there is a need for system that will automatically detect the intruders with weapons and create awareness before they start their operations.

The detection unit is made up of ultrasonic and metal sensors which are used for ensuring human presence and metal detection respectively. The sensor readings are sent to the microcontroller for processing.

The processing unit is made up of the ESP8266 Nodemcu which is the microcontroller board programmed to do all logic work. It also integrated a wifi technology to enable the system to send I.O.T notification to the security agents remotely through the Blynk cloud platform. After processing sensor data, the processing unit triggers the feedback unit.

Control Unit (ESP8266 Nodemcu)

Esp8266 NodeMCU has been used as the main control and sequencing unit. It is an open-source Lua based firmware and development board specially targeted for I.O.T based Applications. It includes firmware that runs on the ESP8266 Wi-Fi SoC from Espressif Systems, and hardware which is based on the ESP-12 module.

Detection unit

This unit is responsible for detecting an intruder with a metallic weapon and sends corresponding signal to the control unit for further analysis and computing. Two sensors make up this unit: Metal and Ultrasonic sensors.

This is the block Diagram of the System

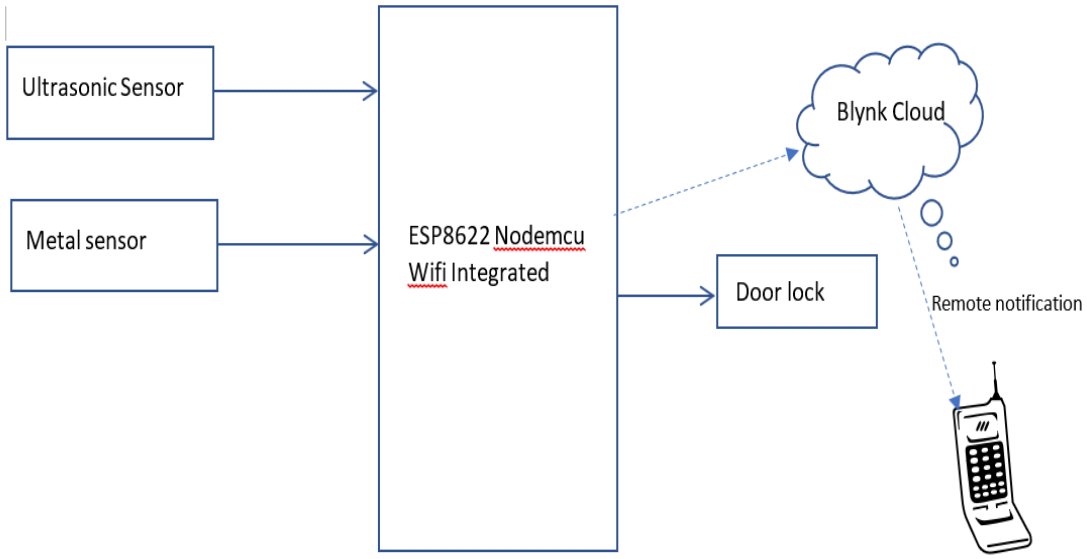


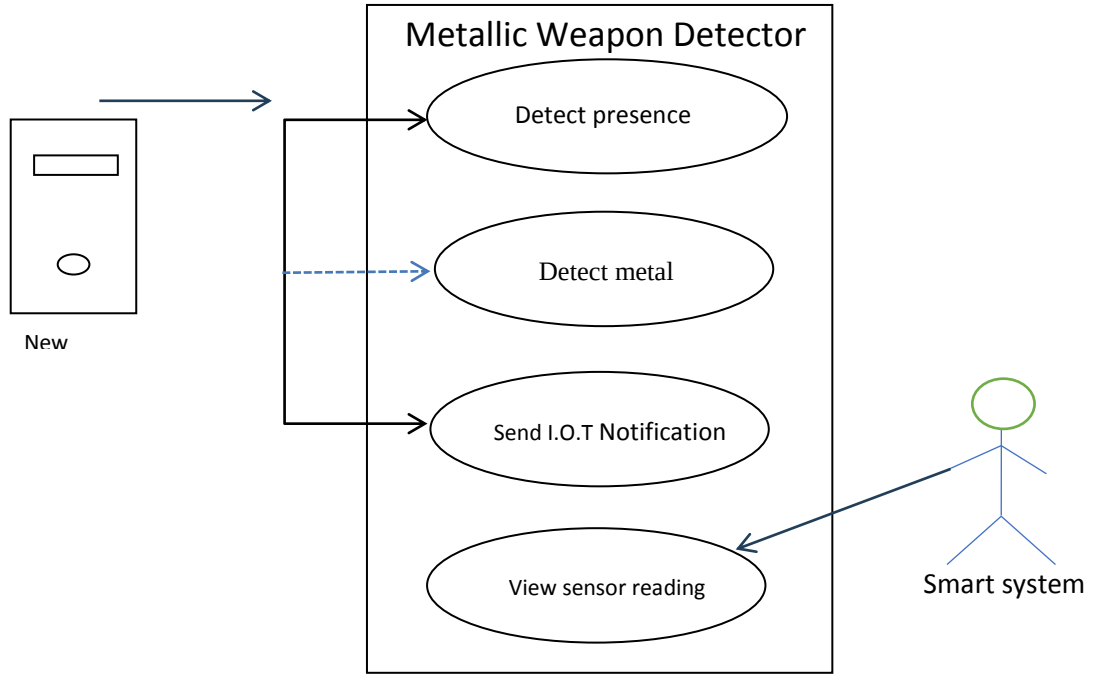
Figure 5: Block Diagram of The System

Use cases have been used to specify the functional requirements of the system. The use case of the entire system comes first, and then the various instances of the use cases followed.

This diagram shows the interaction between the Smart System and the outside world. Here, the smart system and the user are actors. The project title is housed in the outermost compartment while the individual use cases are housed in the inner rectangular boxes. The system is required to detect the presence and the weapons

of criminals at strategic locations in the city and create awareness. The system then uses its integrated WiFi technology to send sensor real time readings to the security agents' android phone through the blynk cloud.

The Use Case Diagram of The System



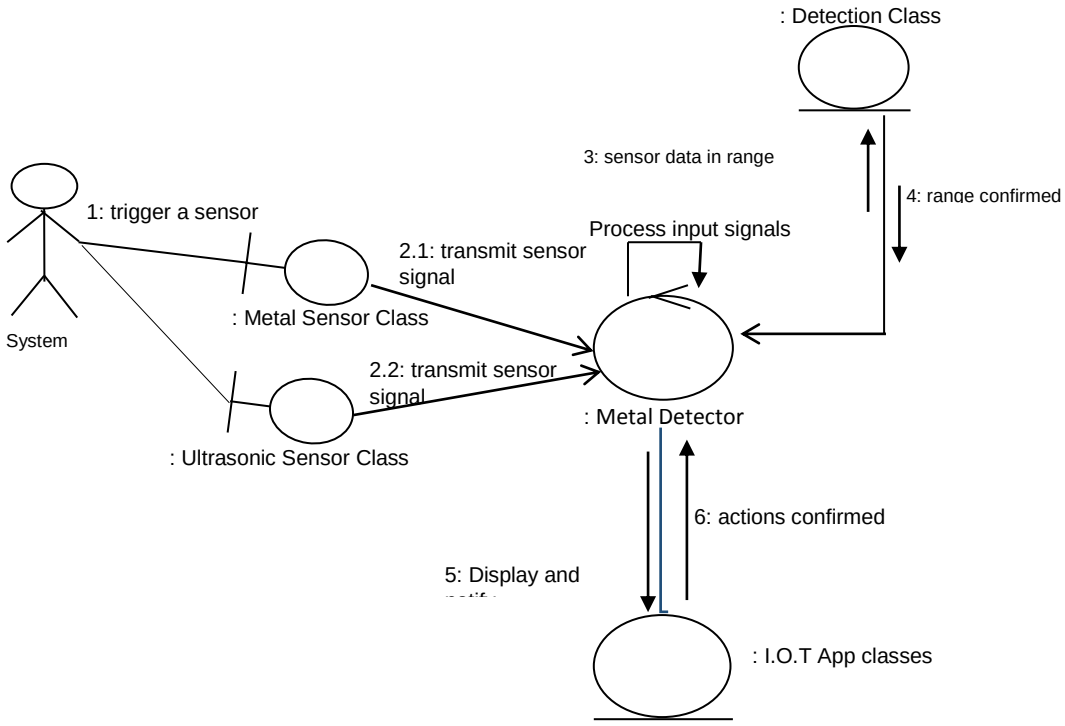


Figure 2: Communication Diagram of The System

The communication diagram above shows what objects are present and interact with other objects in the whole system. The Metal and Ultrasonic sensors are triggered by the system. They transmit their sensor output signals to the processing unit. The processing unit confirms that the signals value meet set condition and triggers the feedback units to takes actions. The arrows show the flow of control from one object to another. Each process is numbered from 1 to 6. The name of the classes is preceded by a colon (:).

VI. SYSTEM DESIGN AND IMPLEMENTATION

System module design

The system module design shows how the various sub parts of the system are interfaced. The entire system interfacing has been shown and the individual modules are shown subsequently.

Hardware Requirement

The system requires the following hardware components:

i. ESP8266 Nodemcu (x1)
ii. Metal Sensor (x1)
iii. Ultrasonic sensor (x1)
iv. Android Phone & Blynk I.O.T App
v. Breadboard (x1)
vi. Light Emitting diodes (x1)
vii. 9v battery and connector (x1)
viii. 100ohm resistor (x1)
ix. Misc

System components interfacing

The TRIG and ECHO terminals of the Ultrasonic sensor are connected to the PIN D2 and PIN D3 of the nodemcu respectively. The VCC and the GND pins of the sensor are connected to the power and ground rails on the breadboard. The signal pin of the Metal sensor is connected to the PIN D4 of Nodemcu. All the positive and negative terminals of all the parts are connected to the positive and negative rails of the breadboard. The system is powered by 9v battery. The LM2596 DC-DC Buck converter has been used to step down the external power source from 9v to 5v which is usable by the Nodemcu. This is because the Nodemcu can only source +3.3v and this is not enough to power sensors like soil moisture sensor, etc. The positive and negative terminals of the battery (external power source) are connected to the +IN and –IN of the converter. Then the +OUT and –OUT of the converter are connected to the VIN and GND pins of the Nodemcu and the bread board rails.

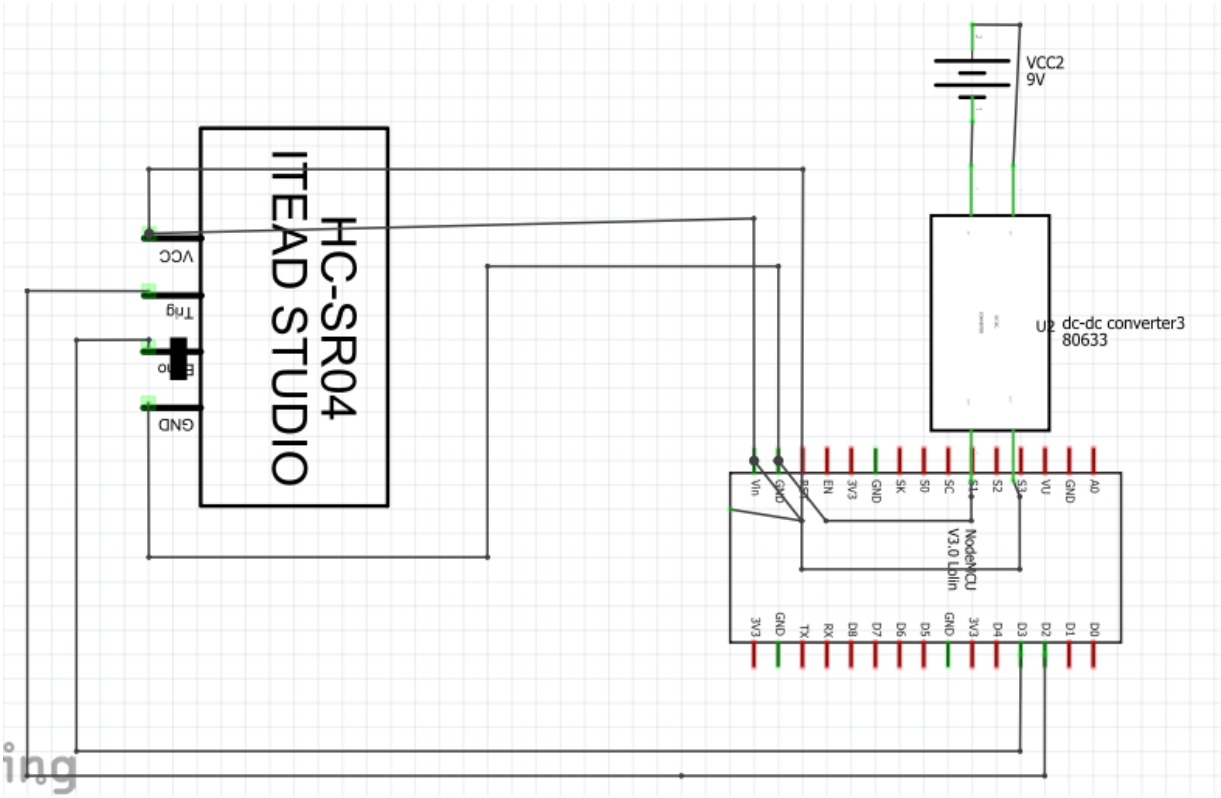


Figure 3: System Schematic View

Metal sensor interfacing

The metal sensor is responsible for detecting metallic objects supposedly held by the intruder. It has three connection pins: VCC, GND and Signal. The VCC pin is connected to the +5v rail while the GND pin is connected to the 0v rail. Then the Signal pin has been connected to the pin D4 of the Nodemcu

Powering Nodemcu with 9v battery through lm2596 converter

The system is powered by 9v battery. The LM2596 DC-DC Buck converter has been used to step down the external power source from 9v to 5v which is usable by the Nodemcu. This is because the Nodemcu can only source +3.3v and this is not enough to power sensors like soil moisture sensor, etc. The positive and negative terminals of the battery (external power source) are connected to the +IN and –IN of the converter. Then the +OUT and –OUT of the converter are connected to the VIN and GND pins of the Nodemcu and the bread board rails

The Procedure is listed below:

- Load the Fritzen Application.
- You can choose Breadboard, Schematic, PCB, or Code tab depending on what you want to do. Breadboard has been selected as we need to interface components only.
- Search for and pick any component models you want from the Part panel by the right of the window. This is done by dragging it out to the workspace. You can position it anywhere on the workspace by dragging method.

Configuring Blynk App for ESP8266

To set up a Blynk I.O.T App for the smart system, the app is first downloaded from the Play Store for Android users and the App Store for iOS users. Once the installation is complete, open the app and **sign-up** using your email address and password.

- **Click on create a new project**
- **Provide the Name of your project** *as* ***"Metal Detector"***
- **Choose NodeMCU Dev Board**
- **Select connection type as Wi-Fi, and then click on Create Button.**
- **The Blynk authentication token is sent to your email address. (it is needed later on programming)**

- Now, click on the (+) icon at the top right corner of the screen.
- Search for "Gauges" and add 2 of them to your main screen.
- Click on the First Gauge.
- Name it as "Metal"
- Set the Input Pin to Virtual Pin V1, Enter input Range & Choose the refresh rate as 1sec.

Figure 4: Configuring Blynk App Continued

Similarly, do the same for *Distance***.**
Finally, the Blynk App setup for project using NodeMCU ESP8266 is completed.
When the code is uploaded, ESP8266 will connect to the Blynk server. Now you can check the Blynk app on your mobile phone. The mobile phone receives smart system data.

Software requirement
The smart system was implemented using some software tools which are listed below:

i. Arduino IDE: making a sketch and programming the microcontroller
ii. Micro C++: used as the main programming language.
iii. Fritzing software: used for component interfacing

Program Development
The system program was developed using Arduino IDE. This IDE enabled us to design a sketch (Write code) for the system. It also provides facilities for verifying (compiling) and uploading the code to the microcontroller for all control and sequencing functions.
The procedure is as follows:

1. Load Arduino IDE.
2. Create a new sketch and save it with a file name.
3. Design the sketch (write your control code).
4. Click on the verify button to compile the code. If errors were found, debug them and verify again.
5. Click on the upload button to upload (send) the sketch to the microcontroller. If there is port connection problem, debug it and try again.
6. Observe the system work according to your sketch.

Choice of Programming Language
The implementation of this Smart system was done in Embedded C/C++ Programming language. This language was chosen as it had been optimized for talking to machines. It is easier to access the pins on microcontrollers or other programmable chips and program them using c++ compared to other high level programming languages like java, c# etc. The main component of the proposed system that is programmed is the ATMEGA328P Microcontroller. The code (sketch) is written in C/C++, verified (Compiled) and finally uploaded to the chip for all control

Language justification
Embedded c++ is relatively easier compared to other high level programming languages. For instance, to indicate that pin 4 on the microcontroller should be used to control a LED (Light Emitting Diode) the statement is as below:

```
Int ledPin = 4;
PinMode(ledPin, OUTPUT);
```

Writing the code above in java for instance would take a longer line of code.
Microcontroller Programming
The microcontroller is connected to the computer for programming through a 5V USB cable. Once the connection is made, the Microcontroller circuit will be detected by the computer and the actual port is selected by the programmer for programming operations.

VII. Results and discussion

The results have been shown in table 4.

Table 4: Summary of the Test Carried out on the Smart System

Operations	Expected result	Actual result	Remark
The system was powered on	All components should receive specified input voltage to power on	All components were powered by 9v battery used.	Good
The Ultrasonic sensor monitors the given space for any distance below the threshold (45cm). The current reading is displayed on the user's android phone.	The Ultrasonic sensor should monitor the given space for any distance below the threshold (45cm). The current reading should be displayed on the user's android phone in real time.	The Ultrasonic sensor monitored the given space for any distance below the threshold (45cm). The current reading was displayed on the user's android phone in real time.	Good
The metal sensor monitors the intruder for the presence of metallic weapon. The current reading is displayed on the user's android	The metal sensor should monitor the intruder for the presence of metallic weapon.	The metal sensor monitored the intruder for the presence of metallic weapon. The current	Good

phone. If metal is detected, the system sends notification to security agents.	The current reading should be displayed on the user's android phone. If metal is detected, the system should send notification to security agents.	reading was displayed on the user's android phone. When metal was detected, the system sent I.O.T notification to security agents.

The system was tested and all the expected results were equal to the actual results as seen in the table 1 above.

System usage

The system shall be used as stated below:

1. The user presses the ON switch on the system to power it.
2. The system boots for few seconds and the sensors get activated.
3. The system monitors the attack-prone points for armed intruders.
4. The user turns on his WiFi hotspot and the smart system automatically connects to the internet through the network.
5. Once connection is enabled, the sensor data will be sent to the user's mobile app interface in real time. The information will be displayed using gauge gadgets. In case, a metallic weapon is confirmed, the user receives notification remotely.
6. The system only displays the most recent value of the sensors on the mobile interface.

VIII. CONCLUSION AND RECOMMENDATION

The aim of this project was to Design and Construct IoI Based Smart Security System with Metalic Weapon Detection and Remote Notification. This system was designed to enhance the operation of the Ebube Agu security in Ebonyi State. The traditional method to security used by this group is not completely favourable.

The security agents have to stand at some entry points to check intrusion and attacks from criminals. They do not have automated I.O.T device that enables them to monitor those strategic locations remotely. Also, they are not able to get notification in case there is an attempt to intrude and invade a place.

This research work has contributed to the enhancement of their operation as they can now monitor all entry points were the I.O.T devices are mounted remotely. Also, they can now receive notification in case intruders with metallic weapons are detected from a distance. This will enhance their operation and reduce stress and cost of patrolling.

The chances of the security agents been attacked by the terrorists suddenly will also be minimized as they do not need to be at those unsecure places at all times. The system creates awareness and notifies them some minutes before they start lunching attacks. This also helps them to get prepared based on the nature of weapons the enemies come with.

Conclusion

This research work has been finally completed, tested and confirmed to be working in line with aim and objectives stated earlier. With this system now, the Local Vigilantee Security will be able to monitor the locations with high security concerns from afar. They are also notified when illegal armed men are detected. This makes their work easier, less costly and more effective.

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