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Design and Implementation of a Smart Unmanned Ground Vehicle (UGV) with 360 Degree Surveillance

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Abstract— **In order to defend both the borders and the population, the current defence of our nation is spending a significant amount of money and manpower to guarantee safety against the growing criminal activities such as the illicit supply of weapons, narcotraffic, and border attacks. Therefore, border surveillance is crucial. The percentage of soldiers losing their lives is rising. A system is being developed for defence and military applications to provide surveillance at LOC (Line of Control) utilising an unmanned ground vehicle in order to improve the quality of monitoring. Our proposed UGV combines IOT with 360-degree surveillance to enhance surveillance quality and aid in making decisions right away without waiting for operator commands. Thus, the UGV serves a variety of purposes to address the aforementioned problems by automatically spotting attackers attempting to infiltrate the LOC, detecting dangerous gases, and detecting underground explosives that go off when disturbed. The aforementioned tasks are carried out via many sensors.**

Index Terms— **IR sensor, PIR sensor, Metal sensor, Gas sensor, Ultrasonic sensor, ESP32, Blynk, ThingSpeak.**

I. INTRODUCTION

The introduction discusses the increasing popularity and usage of unmanned ground vehicles in military organisations due to their ability to perform better in hazardous conditions than humans. It also highlights the significant advancements made in this field and the various integrated systems on military robots. However, the current lack of tools to defend LOCs from attacks is presented as a problem. The proposed solution is a system that can ruthlessly shoot any intruder trying to violate borders or promote unlawful activities, while also offering other features such as bomb detection, identifying hazardous substances live video surveillance, SMS and visualisation The proposed UGV is equipped with multiple sensors for detection and can be remotely operated for inspection and detection.

II. LITERATURE SURVEY

The proposed system's major goals are to effectively cover a large area or structure and lower the risk of fatalities. The prototype has a number of flaws that can be fixed by using better cameras, a single microcontroller instead of two, and a Li-ion battery rather than a lead acid battery to ensure long-lasting performance. The limited viewing angle of the prototype can be resolved with a better camera.[1]

In this research, surveillance is important for monitoring adversaries in border areas. In this case, a robot can be used to monitor the border regions. Armed forces in border regions face various challenges, thus this kind of technology enables them to be aware of the activities of the adversary so they can make wise decisions. Servo motors, a camera module, sensors, a mechanical arm, Arduino, and other components were used to construct this surveillance robot system. The important feature is that we can control the entire system from this live feed thanks to the camera that we utilised to send the footage over Wi-Fi.[2]

The design and development of a multifunctional field surveillance robot for mine detection, poisonous gas detection, temperature and humidity monitoring are the main subjects of this work. The main aspect of the project is the combination of IoT cloud servers with Android phone operation. The movements of the robot were directed by instructions typed into an android application.[3]

The design of a military service robot for multiple applications is the goal of this project. The microcontroller and smartphone are connected using the Bluetooth module. Users of the monitoring programme can view the footage captured by the wireless camera mounted on the car. It is propelled by motors. The project's long-term objectives included the incorporation of several sensors and the autonomy of the vehicle.[4]

In this study, ZigBee is used as a communication technique, and the robotic vehicle can also be operated manually. The driving module of this adaptable robot is placed before the CPU, communication, and sensing modules. Despite the fact that this robot utilises the ZigBee protocol to enable wireless capabilities, methods can still be employed to improve accuracy.[5]

III. METHODOLOGY

The suggested approach aims to build an unmanned ground vehicle that offers 360-degree monitoring, intruder identification, harmful/toxic gas detection, narcotraffic detection, and hidden mine/bomb detection. The model deploys a collection of sensors, including ultrasonic sensors for intruder detection. The laser gun fires in the direction of the intruders and attacks them when an intrusion is detected. The laser gun is rotated by a stepper motor. To control the UGVs movement Blynk application is used. To locate mines and bombs buried underground, metal detectors are used. Intruders who utilise harmful gases are found using gas detection sensors. ThingSpeak, a data visualisation tool, is used to visualise the real-time data. On the operator's mobile, SMS notifications are sent via an app called IFTTT.

1. Initialization of the microcontroller and the sensors.
2. With the help of an in-built Wi-Fi module of ESP32 microcontroller the model is connected to the operator’s mobile
3. Then webhooks are used that send SMS notifications to the operator’s device based on response to events like detection of humans, mines and surgical gases.
4. There are four IR sensors which are used to detect presence of humans at the LOC, one sensor in each direction of North, South, East and West.
5. When there is any detection by the IR sensor, a laser gun attached to the prototype will shoot in the direction of detection.
6. To calculate the distance between model and the encroacher an ultrasonic sensor is used that uses a triggering signal and based on the received echo signal and speed of air distance is calculated.
7. As IR sensors do not provide 360 degree surveillance PIR sensor is used to detect presence of humans in directions other than North, South, East and West.
8. To detect the presence of poisonous gases a gas sensor is used that provides a range of sensitivity.
9. To detect the presence of mines/bombs an inductive proximity sensor also known as a metal detector is used.
10. DC geared motors are used to operate the movement of the model.
11. The Blynk app is used to control the movement of the model and also any detections by the sensors will be accordingly visible in the app.
12. Simultaneously an SMS will be sent
13. On ThingSpeak the activity of the sensors can be visualised over the duration of time.
14. ESP eye camera is used to provide live streaming as seen by the model.

IV. TECHNICAL SPECIFICATIONS

The components used for building the model are listed below:

1. ESP32 – Used as the main controller of the model and has Wi-Fi module and Bluetooth module.
2. DC geared motor – Two motors are used to control two wheels at the back, two castor wheels are used in the front.
3. L298N – This is a high current and a high voltage motor driving device that accepts TTL logics from a microcontroller.
4. Relay – A single channel relay is used to control the laser gun. It accepts input from the ULN driver.
5. ULN2003A – This IC is used for driving loads and relays. It is always used for stepper motor interfacing.
6. Stepper motor – The model uses one stepper motor for driving the laser gun. It is interfaced to the microcontroller via the ULN driver.
7. ESP eye camera – This IC is used for providing live streaming, it has a 2 megapixel camera.
8. IR sensors – The model uses 4 sensors, one for each direction to detect presence of obstacles/intruders.
9. PIR sensor – The model uses one PIR sensor to provide coverage of the detection of alive humans.
10. Ultrasonic sensor – The model uses one ultrasonic sensor to determine the distance between the model and obstacle.

11. Gas sensor – MQ 6 gas sensor is used which is sensitive to LPG , iso-butane, propane, LNG.
12. Metal sensor – An inductive proximity sensor is used to detect the presence of mines/bombs underground.

Software Modules used are as follows:

1. Arduino IDE – The Arduino IDE is used for writing the code that controls the overall behaviour of the model. It is also used to connect to the Blynk app, ThingSpeak website, and IFTTT app.

2. Blynk app - The Blynk platform's main goal is to make developing mobile phone applications very simple. Blynk is available for free for individual usage and prototyping. Blynk Server is accountable for monitoring all hardware-to-smartphone connections. Allows hosting private Blynk servers locally or utilising the Blynk Cloud. For all widely used hardware platforms, Blynk Libraries handle all incoming and outgoing commands and enable communication with the server.

3. ThingSpeak - With the help of the IoT analytics platform service ThingSpeak, users can gather, visualise, and examine real-time data streams online. Users can issue alarms, send data to ThingSpeak, and quickly view live data through the devices..

V. RESULTS AND DISCUSSION

In the results as shown below, live streaming via ESP eye camera, the model and its movement is shown, various sensor detection and its output in Blynk app and ThingSpeak is visible correspondingly SMS notifications are enabled.

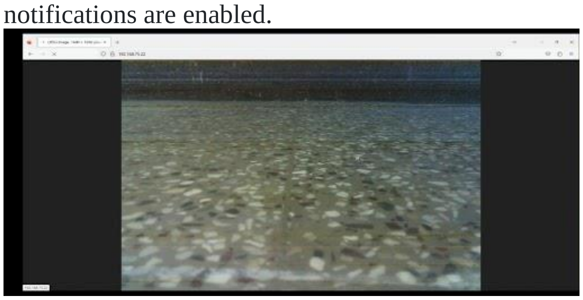

Fig. Live streaming of ESP EYE

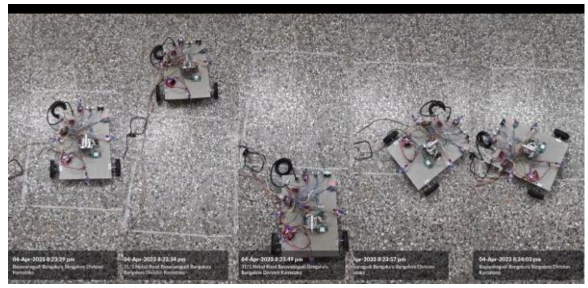

Fig. Model in reference box, movement - forward, backward, right and left respectively.

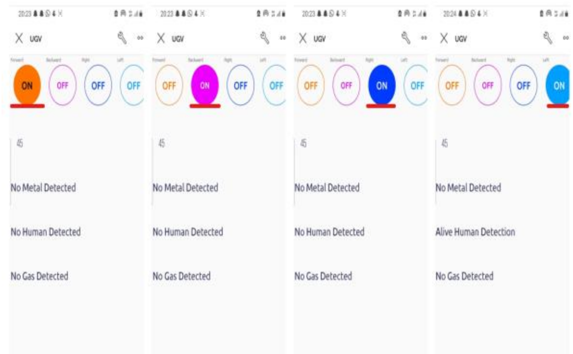

Fig. Model movement control on Blynk app- forward, backward, right and left respectively.

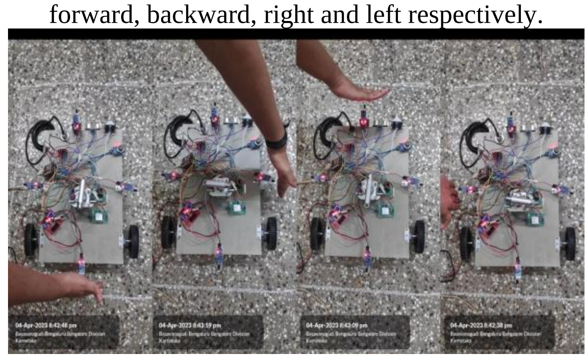

Fig. IR Detection

Fig. IR Detection captured on ThingSpeak

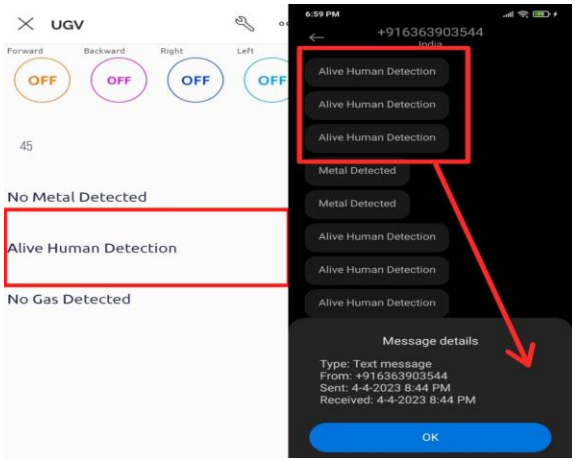

Fig. IR Detection on Blynk and SMS

Fig. Ultrasonic Detection on Blynk

Fig. Ultrasonic Detection on ThingSpeak

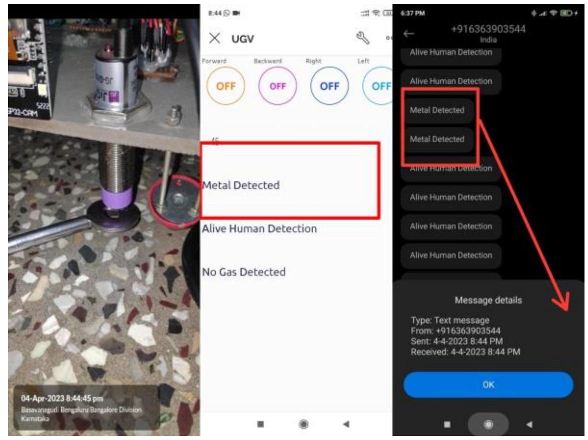

Fig. Metal Detection, Blynk and SMS

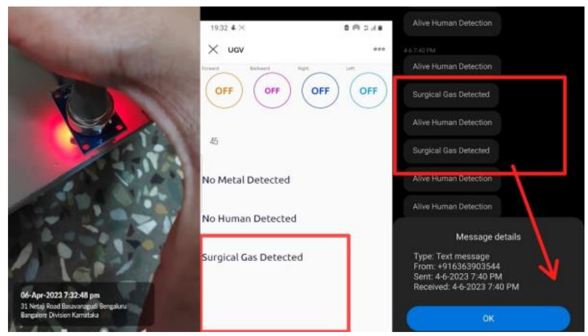

Fig. Gas Detection, Blynk and SMS

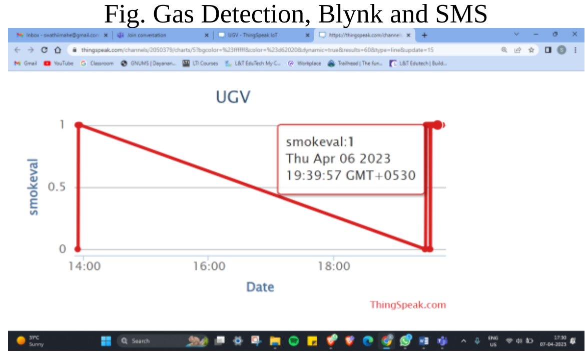

Fig. Gas Detection on ThingSpeak

VI. CONCLUSION AND FUTURE SCOPE

This paper aimed to develop a prototype for detecting human presence, mines/bombs, and surgical gases by initialising a microcontroller and sensors. The prototype used an ESP32 microcontroller with an in-built Wi-Fi module connected to the operator's mobile, and webhooks sent SMS notifications based on events detected. Various sensors were integrated, including IR, PIR, ultrasonic, gas, and metal, which were synchronised with the microcontroller to demonstrate reliable and efficient performance. The prototype was equipped with DC geared motors for movement, and the Blynk app was used for control. ThingSpeak visualised sensor activity over time, and the ESP eye camera provided a live stream of the model's view. Overall, this research project successfully addressed the identified gaps in the literature survey and fulfilled all the project objectives.

The future scope of this project includes several improvements and advancements that can be made to enhance the efficiency and functionality of the prototype. These include:

- Integration of AI and ML: The prototype can be integrated with AI and ML algorithms to enable predictive maintenance and enhance the accuracy of event detection. It enables real-time decision-making based on the sensor data, thus improving the overall performance of the prototype.
- Wireless Power Supply: The prototype can be designed using wireless power supply technology to eliminate the need for wired connections and improve the portability of the prototype.
- Enhanced Sensor Range for Industrial Applications: The current prototype is designed for detecting events in a limited range, and the sensor range can be enhanced to enable its use in industrial applications.

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