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A WAR FIELD ROVER

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Abstract - This project presents the design and implementation of a Wi-Fi-enabled autonomous and manually controlled war robot, aimed at enhancing battlefield surveillance and safety. The robot integrates multiple sensors including ultrasonic for obstacle detection, metal sensors for landmine identification, and serial-based color recognition for enemy or zone detection. It operates in two modes—manual and automatic—allowing flexible control via serial commands. Real-time alerts are transmitted through a Telegram bot, enabling remote monitoring and quick response. The system is built using an ESP32 microcontroller, with feedback displayed on an LCD and actions triggered through motors, LEDs, buzzer, and laser. This intelligent robotic platform demonstrates practical applications in defense, disaster zones, and hazardous environments, combining embedded systems, IoT communication, and sensor fusion for smart navigation and threat detection.

Keywords: War Robot, ESP32, Telegram Bot, Ultrasonic Sensor, Metal Detection, Color Recognition, IoT, Embed-ded Systems

Index Terms—component, formatting, style, styling, insert

I. INTRODUCTION

In modern defense and surveillance systems, robotics plays a crucial role in enhancing operational efficiency and reducing human risk. This project presents the development of a Wi-Fi-enabled war robot capable of operating in both manual and autonomous modes.

The robot is designed to navigate complex environments, detect obstacles using ultrasonic sensors, identify landmines through metal detection, and recognize color-coded signals for threat classification.

It integrates an ESP32 microcontroller with various sensors and actuators, including a laser, buzzer, RGB LEDs, and an LCD display for real-time feedback. A key feature of the system is its ability to send alerts via Telegram, enabling remote monitoring and quick decision-making.

The robot's dual-mode functionality allows flexible control, making it suitable for applications in military reconnaissance, hazardous area inspection, and disaster response. This project demonstrates the fusion of embedded systems, IoT communication, and sensor-based automation to build an intelligent and responsive robotic platform.

II. RELATED WORKS

Several research efforts have contributed to the development of autonomous robotic systems for defense and surveillance applications. In the study by military robot and patrolling [1] Luckshika M K ,Santhiya Devi S, Nivetha V M,and B Shumugapryia of Internet of Things based military Patrol Vehicle with a NodeMCU,GPS and camera to enhance.[2] Indhumathi G,Sushma S Jagtap,Saranya G,Nizamudeen S,Rahul A K,Ricardeio Vinfred R of Mine Detection Rover With WIFI Control and which approach for buliding robot landmine detection system with ESP-cam.[3]Hirshav Karmakar,Ritam Majumder,Mrinmoy Sarkar of the Spy Rover an IOT Based Surveillance Robot which SPY Rover is that ulitizes serval IOT and communication protcols to gather data and live footage to send realtime.[4]Gayathri.S,Shanthakumari G,Suvarna Lakshmi s and Soundharya R of Autonomous Surveillance Robot of video sujrveillance rover for Military applications.[5] Ruba M,Deebika Sri V,Girinath V P,Ponkarthika M,Santhini C and Hemalatha R of a design and implementation of smart internet based real time control of rover with artifical intelligence

Recent research on ESP32-based war-field rovers focuses on land-mine detection, real-time surveillance, and autonomous navigation. Many prototypes use ESP32-CAM for live video streaming and sensors such as metal detectors, IR, ultrasonic and magnetometers to detect mines and obstacles.These rovers aim to improve soldier safety by enabling remote monitoring and reconnaissance in hazardous zones.

A. Abbreviations and Acronyms

The following abbreviations and acronyms are used throughout this report to represent commonly referenced terms and technologies. **ESP32** refers to Espressif Systems

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Pro-grammable 32-bit Microcontroller, which serves as the core processing unit of the robot. **LCD** stands for Liquid Crystal Display, used for visual feedback. **LED** denotes Light Emitting Diode, utilized for color indication. **Wi-Fi** is Wireless Fidelity, enabling internet connectivity. **IoT** represents the Internet of Things, highlighting the robot's networked capabilities. **BOT** refers to the Telegram Bot used for remote alerts. **RGB** stands for Red Green Blue, the color model used in detection.

B. Equations

This section outlines the key equations used in the design and operation of the war robot.

Ultrasonic Distance Calculation:

$$\text{Distance (cm)} = \frac{\text{Time } (\mu s) \times 0.034}{2} \qquad (1)$$

This equation calculates the distance to an object using the time taken for the ultrasonic pulse to return. The factor 0.034 represents the speed of sound in cm/µs, and division by 2 accounts for the round trip.

- **Speed of Sound in Air:**

$$v = 331 + 0.6T \qquad (2)$$

Where v is the speed of sound in m/s and T is the temperature in Celsius. This is useful for calibrating ultrasonic sensors in different environments.

- **Ohm's Law (for sensor interfacing):**

$$V = IR \qquad (3)$$

Where V is voltage, I is current, and R is resistance. This is fundamental in designing circuits for sensors and actuators.

- **Power Consumption:**

$$P = VI \qquad (4)$$

Where P is power in watts, V is voltage, and I is current. This helps estimate battery requirements and energy efficiency.

- **Telegram Bot Message Flow (Conceptual):**

$$\text{Alert}_{\text{Telegram}} = f\,(\text{Sensor}_{\text{Trigger}},\ \text{Condition}_{\text{Threshold}}) \qquad (5)$$

This represents the logic where a Telegram alert is sent when a sensor detects a condition beyond a defined threshold.

B. Design Flow

1) Initialize all hardware components and establish Wi-Fi connection.
2) Select operating mode (manual or automatic) via serial input.
3) In automatic mode:
   - Measure distance using ultrasonic sensor.
   - Stop robot if obstacle is detected.
   - Check for metal detection and send alert if land-mine is found.
   - Read color input and respond accordingly (e.g., enemy detection).
4) In manual mode:
   - Respond to directional commands (forward, re-verse, left, right, stop).
   - Continuously monitor for metal and color signals.

Send alerts via Telegram bot for critical events.

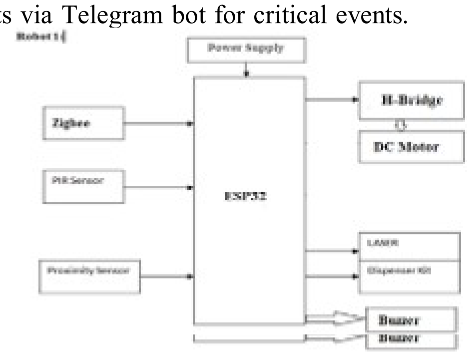

Fig. 1. Block Diagram of War field Rover

III. DESIGN OVERVIEW

The design of the war robot integrates multiple hardware and software components to achieve autonomous and manual control for surveillance and threat detection. The system is built around the ESP32 micro-controller, which serves as the central processing unit. The robot operates in two modes—manual and automatic—selected via serial commands. In manual mode, directional control is achieved through user input, while in automatic mode, the robot navigates based on sensor feedback.

The robot uses an ultrasonic sensor for obstacle detection, a metal sensor for landmine identification, and serial-based color recognition to classify zones or threats. A Telegram bot is integrated to send real-time alerts to a remote user. Visual feedback is provided through an LCD display, and actions are triggered using motors, RGB LEDs, a buzzer, and a laser. The design emphasizes modularity, real-time responsiveness, and remote communication.

A. System Architecture

The system consists of the following modules:

- **Control Unit:** ESP32 microcontroller
- **Sensors:** Ultrasonic sensor, metal detector, color input via serial
- **Actuators:** DC motors, RGB LEDs, buzzer, laser

- **Display:** 16x2 Liquid Crystal Display (LCD)
- **Communication:** Wi-Fi and Telegram Bot API

IV. Implementation and Results

A. Hardware Configuration

The war robot is built using an ESP32 micro-controller, which serves as the central control unit. The hardware components integrated into the system include:

- **ESP32**: Controls all sensors, actuators, and handles Wi-Fi communication.
- **Ultrasonic Sensor (HC-SR04)**: Measures distance to detect obstacles.
- **Metal Detector**: Identifies landmines or metallic threats.
- **RGB LEDs (Red, Green, Blue)**: Indicate color-based zone detection.
- **Laser and Buzzer**: Triggered during enemy detec-tion for alerting.
- **DC Motors with Motor Driver**: Enable movement in forward, reverse, left, and right directions.
- **Liquid Crystal Display (LCD 16x2)**: Displays real-time status and sensor feedback.
- **Power Supply**: Provides regulated voltage to all components.

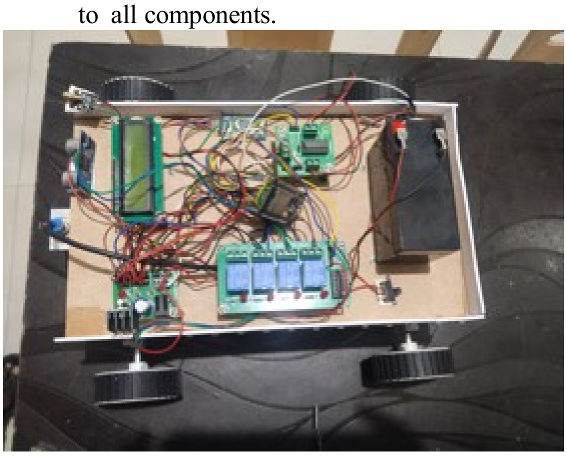

Fig. 2. Military hardware System

B. Software Configuration

The software is developed using the Arduino IDE and programmed in C++. Key libraries used include:

- WiFi.h and WiFiClientSecure.h for network connectivity.
- UniversalTelegramBot.h for Telegram bot integration.
- LiquidCrystalI2C.hfor LCD control.
- ArduinoJson.h for handling JSON data in Tele-gram messages.

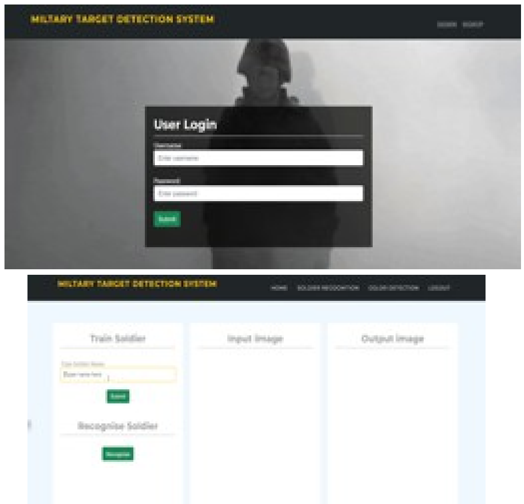

Fig. 3. Military Software System

C. Communication Setup

The ESP32 connects to a local Wi-Fi network using pre-defined SSID and password. Upon successful connection, it initializes a Telegram bot using the Bot Token and Chat ID. Alerts such as landmine detection, enemy presence, and color recognition are sent to the user in real time via Telegram.

D. Operating Modes

The robot supports two modes of operation:

- **Manual Mode**: Controlled via serial commands for directional movement (Forward, Reverse, Left, Right, Stop).
- **Automatic Mode**: Navigates autonomously using sensor feedback and decision logic. It detects obsta-cles, identifies metals, and responds to color-coded signals.

E. Testing Environment

The robot was tested in a controlled indoor environment with simulated obstacles, colored zones, and metallic objects to validate sensor accuracy and response mechanisms. Wi-Fi connectivity and Telegram alerts were verified using mobile devices.

Sensor	Type	Function
Ultrasonic Sensor	HC-SR04	Obstacle Detection
Metal Detector	Inductive Type	Landmine Identification
Color Input	Serial RGB	Zone/Threat Classification

PIR Sensor	Passive Infrared	Motion Detection
Proximity Sensor	IR-based	Short-range Object Detection

TABLE I

SENSOR SPECIFICATIONS USED IN WAR ROBOT

Component	ESP32 Pin
Ultrasonic Trigger	GPIO 32
Ultrasonic Echo	GPIO 33
Metal Sensor	GPIO 4
Red LED	GPIO 14
Green LED	GPIO 27
Blue LED	GPIO 26
Laser	GPIO 25
Buzzer	GPIO 2
Motor Driver Inputs	GPIO 5, 18, 19, 23

TABLE II

PIN CONFIGURATION OF ESP32 WITH PERIPHERALS

V. CONCLUSION

A. Experimental Observations

The war robot was tested under various conditions to validate its functionality in both manual and autonomous modes. The following results were observed:

- The robot successfully connected to Wi-Fi and ini-tialized the Telegram bot for remote alerts.
- In manual mode, directional commands (Forward, Reverse, Left, Right, Stop) were executed accurately via serial input.
- In autonomous mode, the ultrasonic sensor reliably detected obstacles within a range of 30 cm and halted movement accordingly.
- The metal detector identified metallic objects sim-ulating landmines and triggered alerts through the buzzer, LCD, and Telegram.
- Color detection via serial input responded correctly to Red, Green, and Blue signals, activating corre-sponding LEDs and sending notifications.
- Enemy detection simulated by the character 'U' activated the laser and buzzer, displayed alerts on the LCD, and sent messages via Telegram.

B. Performance Summary

Feature	Test Condition	Result
Wi-Fi Connectivity	Indoor, 2.4 GHz Network	Successful
Obstacle Detection	Object at 25 cm	Robot Stopped
Metal Detection	Simulated Landmine	Alert Triggered
Color Recognition	Red, Green, Blue Inputs	LED and Telegram Response
Enemy Detection	'U' Input via Serial	Laser, Buzzer, Telegram Alert
Manual Navigation	Serial Commands	Accurate Movement

TABLE III

SUMMARY OF FUNCTIONAL TEST RESULTS

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