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Situational Awareness with Friend and Foe Detection and Combat Support System

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Abstract

In modern combat scenarios, soldiers often operate in complex and rapidly changing environments where timely information is crucial for survival and mission success. However, the lack of real-time situational awareness can lead to delayed decision-making, increased vulnerability to threats, and inefficient resource management. Existing systems often fail to integrate data from multiple sources, resulting in fragmented information and inadequate support for soldiers in the field. The system aims to develop a Soldier Combat Support System that enhances situational awareness by providing real-time data analytics, threat detection, and seamless communication among team members. System will integrate information from battlefield sensors, drones, and communication networks, allowing soldiers to access critical insights for informed decision-making. By addressing these challenges, the System seeks to improve operational effectiveness, enhance soldier safety, and optimize mission outcomes in combat situations such as assault or point defence.

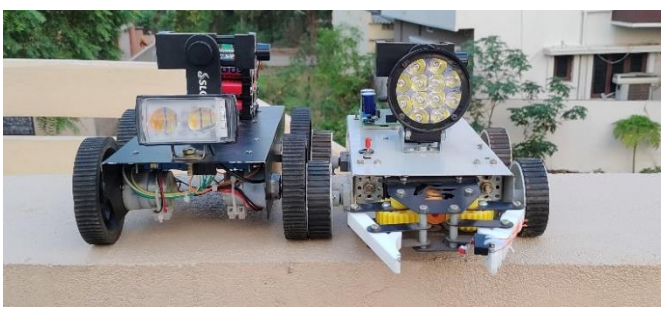
1. Introduction

Modern warfare has evolved into a dynamic and technology-driven domain where soldiers are required to make critical decisions under immense pressure and in ever-changing combat environments. In such scenarios, real-time situational awareness is not just advantageous—it is essential for survival, mission success, and strategic advantage. However, traditional combat systems often lack the ability to deliver timely actionable intelligence to soldiers on the ground. Fragmented data from sensors, delayed communication, and limited automation reduce the effectiveness of conventional battlefield operations. The "Situational Awareness with Friend and Foe Detection and Combat Support System" is an integrated solution designed to address the challenges associated with monitoring and ensuring the well-being of military personnel in dynamic and unpredictable operational environments. This system amalgamates state-of-the-art wearable devices, GPS technology, health monitoring sensors, environmental sensors, and a friend-or-foe

frequency transmission system to provide comprehensive real-time friendly fire deterrence and situational awareness, thereby enhancing modern warfare capabilities. The wearable or mountable devices continuously collect vital health metrics such as heart rate, body temperature, and activity levels, fostering a proactive approach to healthcare management. Simultaneously, GPS technology enables precise and continuous tracking of soldiers' positions on the battlefield. The collected data is transmitted to a centralized monitoring system, where advanced analytics and machine learning algorithms assess soldiers' health trends, detect anomalies, and facilitate timely medical interventions [1]. The system also includes plans for receiver-integrated smart grenades for use in assault operations, increasing strategic capability. Additionally, the system is adaptable for point defence scenarios such as check-posts and cantonment gates, offering versatility in deployment. By significantly enhancing situational awareness, optimizing the use of defence resources, and prioritizing the health and safety of deployed personnel, this innovative system stands at the forefront of leveraging technology to safeguard and empower modern military forces. The proposed solution integrates advanced electronic warfare (EW) technologies with smart detection and safety mechanisms, aimed at significantly improving the safety and operational efficiency of military personnel in dynamic battlefield environments. The system leverages multiple components, each designed to work in tandem to address key threats and challenges in modern combat. Here's a breakdown of the proposed system:

1. Rover-based Protection Unit

A mobile ground unit that moves ahead of or alongside troops, emitting a controlled signal to disable nearby friendly landmines and create a safe path. It enhances troop mobility and safety in mine-infested areas (Figure 1).



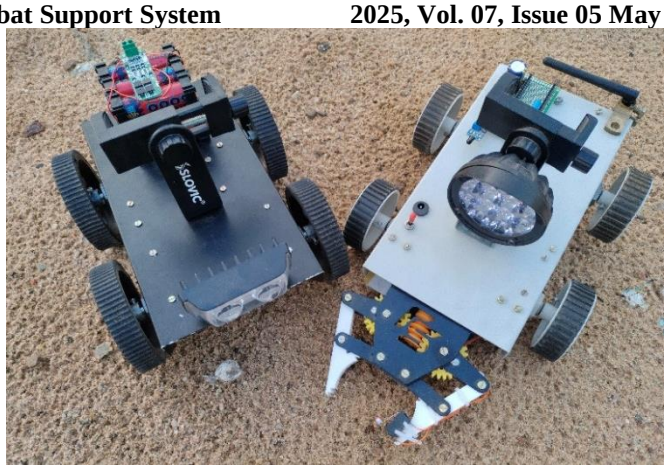


Figure 1 Electronic Warfare Rover

2. Electronic Landmine with Proximity and Signal-Based Detection

A smart landmine equipped with proximity sensors to detect intruders and detonate automatically [2]. It includes a receiver that recognizes friendly forces via predefined signal frequencies, allowing it to deactivate and prevent accidental friendly casualties (Figure 2).

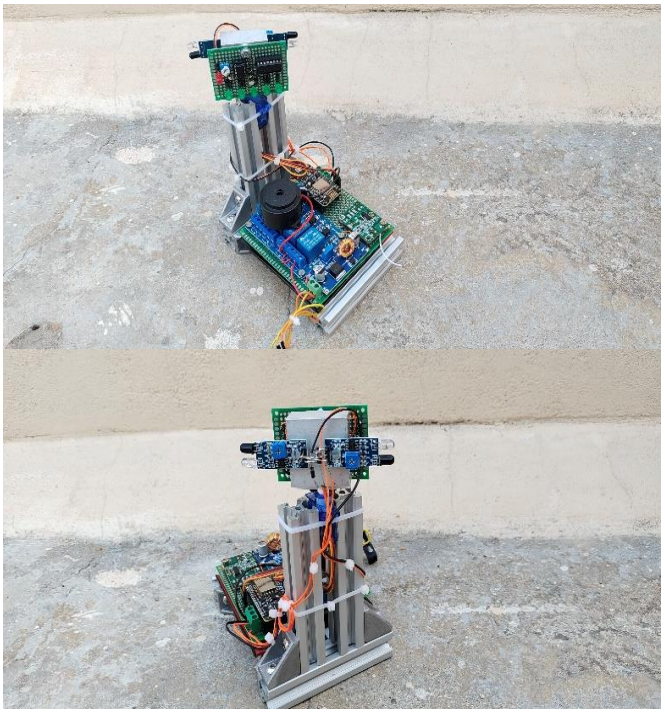


Figure 2 Electronic Landmine

3. Troop Assistor Gadget

A wearable or mountable device for soldiers that monitors vital health parameters (like heart rate and temperature) and transmits a unique frequency for mine deactivation [3]. It aids both in health tracking and mine safety simultaneously (Figure 3).

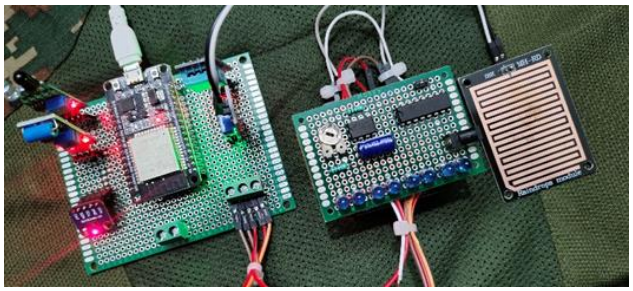


Figure 3 Troop Assistor Gadget

4. GUI Surveillance Application

A centralized graphical interface that visualizes real-time data from sensors, rovers, and troop gadgets [4]. It allows commanders to monitor soldier locations, health stats, and threat zones, improving situational awareness and decision-making (Figure 4).

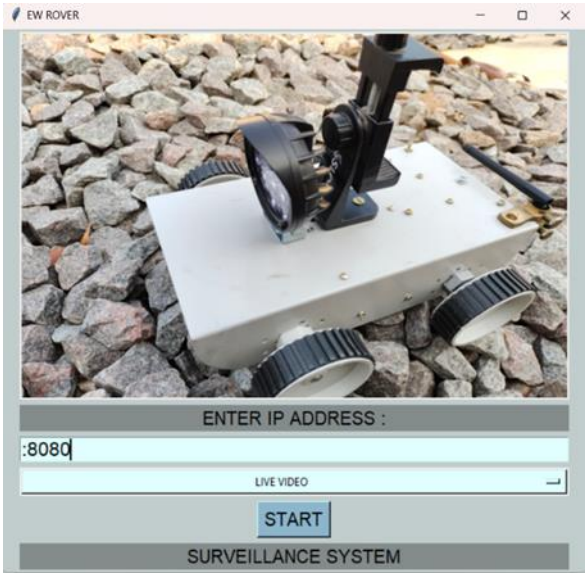


Figure 4 Surveillance System GUI

2. Methodology

The approach for the Situational Awareness with Friend and Foe Detection and Combat Support System relies on the integration of various technologies to create a real-time, efficient, and highly secure combat support solution. The following key steps were involved in the development of the system [5]:

2.1. System Design and Component Integration

The system consists of four main components:

- **Electronic Landmine with Proximity and Signal-based Detection:** A landmine equipped with sensors that detect intruders and friendly soldiers based on specific frequencies, ensuring minimal collateral damage to friendly forces [6].
- **Rover-based Protection Unit:** A mobile unit that generates a radial safe zone for friendly soldiers by emitting controlled radio signals, preventing accidental landmine activation [7].
- **Troop Assistor Gadget:** These wearable devices allow soldiers to track health metrics such as heart rate, temperature, and activity, while also transmitting a specific frequency to deactivate nearby landmines [8].
- **GUI Surveillance Application**: A user-friendly runtime interface that integrates real-time data from sensors and displays situational awareness to the commanders.

2.2. Data Collection

The system collects data through a combination of IoT sensors, including health monitoring sensors for soldier vitals, GPS for location tracking, and environmental sensors for detecting potential threats [9]. This data is continuously transmitted to a centralized server (Table 1).

Table 1 Sensors and their Function

Sensor Name	Type	Function
MAX30102	Optical Heart Rate & SpO2 Sensor	Measures heart rate and blood oxygen saturation levels
DHT11	Temperature & Humidity Sensor	Measures ambient temperature and humidity
Rain Sensor	Weather Sensor	Detects the presence and intensity of rain
Vibration Sensor	Motion Sensor	Detects mechanical vibrations or shocks
IR Sensor	Proximity/Obstacle Sensor	Detects nearby objects using infrared light
GPS NEO 6M	Positioning Sensor	Provides real-time geographical location coordinates

2.3. Data Processing and Analytics

Advanced deep learning algorithms like CNN and statistical techniques analyse incoming data in real-time in Blynk IOT cloud and GUI application to identify threats, anomalies in soldier health, and assess battlefield dynamics [10]. The system provides predictive insights to support decision-making (Table 2).

Table 2 Sensors and Compatible Library

Sensor Name	Common Libraries
MAX30102	MAX30102, Adafruit_MAX30100
DHT11	DHT, Adafruit_DHT
Rain Sensor	Analog input (no special library)
Vibration Sensor	Digital input (no special library)
IR Sensor	IRremote, Digital input
GPS NEO-6M	TinyGPS++, NeoGPS, SoftwareSerial

2.4. Signal-Based Identification

The system uses a frequency-based identification protocol (27mhz Frequency) to differentiate between friendly and enemy forces. This reduces the likelihood of friendly-fire incidents and enables deactivation of the electronic landmine when friendly personnel are detected. 27mhz transmitter and receivers are used (Figure 5).

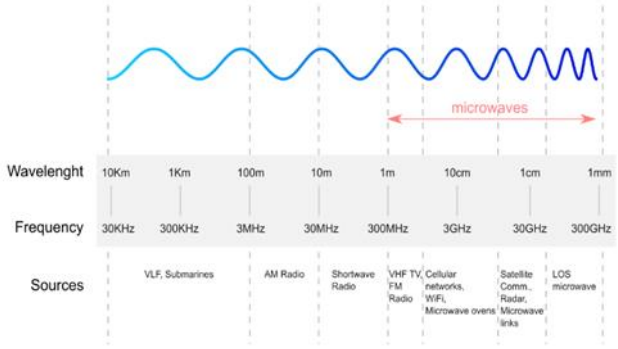


Figure 5 Electromagnetic Spectrum

2.5. Integration with Communication Networks

The data from the IoT devices is integrated with Blynk IoT platform for real-time monitoring and remote control. The communication network facilitates seamless connectivity between soldiers, their wearable devices, and the central server for efficient coordination (Figure 6).

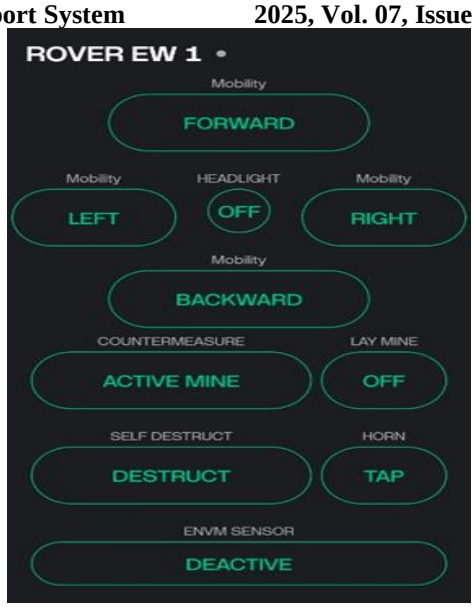


Figure 6 Rover Command and Control Interface

2.6. User Interface Development

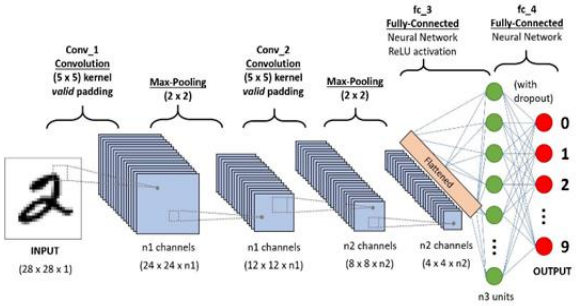


Figure 7 CNN Architecture

A Graphical User Interface (GUI) is designed using YOLO and python for military commanders to view the live status of the field, monitor soldier vitals, and access crucial threat detection data. This interface provides actionable insights for informed decision-making in combat scenarios (Figure 7).

- **CNN and YOLO v8:** are widely used for object detection by identifying and localizing objects within images. The process involves: Feature Extraction: CNNs apply convolutional layers to extract hierarchical features (edges, textures, shapes) from input images.
- **Region Proposal:** Techniques like Region-based CNN (R-CNN) or more recent approaches such as YOLO (You Only Look Once) generate potential bounding boxes around regions of interest (RoI).

- **Classification and Localization:** The network classifies each region as an object or background, while simultaneously refining the bounding box coordinates to precisely localize the object.
- **Final Output:** The network produces a set of bounding boxes with associated class labels, representing the detected objects in the image.

2.7. Testing and Validation

The system undergoes rigorous testing, including field simulations to assess the reliability of the components under various operational conditions. The system is fine-tuned for optimal performance, ensuring minimal delay in threat detection and health monitoring.

3. Results and Discussion

3.1. Results

The implemented system successfully demonstrated real-time monitoring, threat detection, and situational awareness using integrated IoT sensors and communication modules. Data from health, environmental, and positional sensors were effectively transmitted and visualized via the Blynk IoT platform and the GUI application. Each subsystem, including the Troop Assistor and Rover-based Unit, functioned cohesively, validating the system's potential for enhancing operational safety and decision-making in combat scenarios.

Blynk IoT Output:

The Blynk app showed real-time sensor values and alerts remotely, offering easy monitoring and situational awareness on a smartphone (Figure 8).

Figure 8 Blynk Environment Sensor Interface

Serial Monitor Output:

The Serial Monitor displayed live sensor readings like heart rate, temperature, and GPS data, helping in quick testing and debugging (Figure 9).

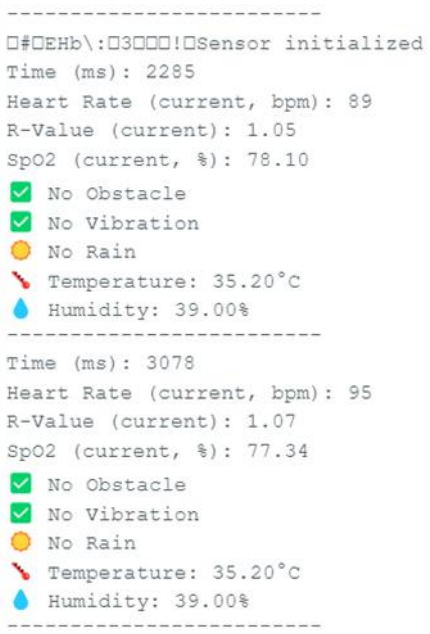


Figure 9 Serial Monitor Output Terminal

GUI Surveillance Application Output:

The GUI surveillance application provided a visual interface showing soldier positions, sensor alerts, and system status, enhancing real-time battlefield monitoring and decision-making (Figure 10).

Figure 10 Real Time wireless Object Detection

3.2. Discussion

The combat support system excels by capturing spatial and interaction-based features that are often missed by traditional surveillance or sensor-isolated systems. The integration of

diverse sensor data—such as GPS, health vitals, and environmental conditions—into a unified communication and monitoring framework significantly enhances situational awareness and decision-making. The use of smart modules like the Troop Assistor and GUI surveillance platform ensures that critical data is prioritized and interpreted effectively, contributing to the system's accuracy, reliability, and robustness in high-risk battlefield environments.

3.3. Key Challenges Include

- **Hardware Integration Issues** – Difficulty in synchronizing multiple sensors and modules.
- **Real-Time Communication –** Ensuring fast, reliable data exchange under dynamic conditions.
- **Power Management –** Limited battery life for wearable/portable devices.
- **Sensor Noise/Inaccuracy** – Risk of false positives or missed detections.
- **Signal Interference** – Potential disruption from jamming or electromagnetic sources.
- **Data Security –** Need to protect against interception or spoofing.
- **Friend/Foe Detection Accuracy** – Misclassification can lead to critical errors.
- **Environmental Effects** – Harsh conditions may affect sensor performance.
- **System Scalability –** Performance may degrade as deployment size increases.
- **Software Stability –** Risk of crashes or bugs in multi-component systems.

3.4. System Description

Inputs: The system takes input from various IoT sensors such as MAX30102 (for heart rate and SpO_2), DHT11 (for temperature and humidity), rain and vibration sensors, IR sensor (for motion/proximity), and GPS NEO-6M (for location tracking). It also receives communication signals for friend/foe detection and user inputs via Blynk IoT or a GUI interface. These inputs collectively enable real-time monitoring and decision-making in combat scenarios.

- **Generalization:** Performance of the System is up to the mark and the behaviour is also observed as normal considering the virtue of absolute coordination among the sub systems which are interlinked for a broader objective.
- **Computational Cost:** YOLO v8 requires GPU acceleration (e.g., NVIDIA RTX 4050, 6GB VRAM), with CUDA support.
- **Interpretability:** While attention weights provide feature importance, complex CNN models can be trained for visualizing in a dialogue window, but further interpretability tools (e.g., Serial Monitor) could enhance structure of incoming data packets.

3.5. Future Enhancements Include

- Integration of AI-powered threat classification to distinguish between different types of intrusions or enemy movements.
- Enhanced Blynk IoT dashboard with role-based access and real-time video feeds from drones or surveillance units.
- Edge computing support to allow local data processing on the battlefield with minimal latency.
- Encrypted communication protocols for secure data transfer between soldiers and command centers.
- Battery optimization and solar charging modules to ensure longer field operation for wearables and sensors.
- Pretrained ML models for improved accuracy in health prediction, friend/foe identification, and anomaly detection.
- AR (Augmented Reality) integration for real-time battlefield visualization through head-mounted displays.
- Support for swarm drone coordination for area surveillance and autonomous threat detection.
- Multi-language voice alert system for on-field instructions and warnings.
- Auto-calibration routines for sensors to adapt to varying environmental conditions.

The system's real-time performance and interactive interface make it suitable for both research and educational applications, enabling users to explore interactions intuitively.

Conclusion

This project developed a situational awareness and combat support system combining electronic

warfare (EW) with IoT-based safety features. It integrates an electronic landmine, a rover protection unit, a wearable troop assistor, and a GUI surveillance app for real-time friend/foe detection. IoT sensors (heart rate, temperature, motion, rain, vibration etc.) connected via Blynk provide health monitoring, location tracking, and threat detection. This system enhances soldier safety, reduces friendly-fire incidents, and supports real-time decision-making. Future improvements will focus on optimizing power efficiency, expanding coverage, and incorporating AI for advanced threat prediction.

Acknowledgements

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