

Smart Wearable System for Continuous Soldier Location and Health Monitoring

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Abstract- Smart Wearable System for Continuous Soldier Location and Health Monitoring is a smart, integrated solution designed to enhance soldier safety and mission efficiency. The system continuously measures vital signs such as heart rate, SpO₂, and body temperature using compact biomedical sensors. A GPS and IMU module provides accurate real-time location tracking, while communication ensures secure data transmission to the control center for monitoring and alerts. By combining vital monitoring, geolocation, and thermal regulation, the system supports early risk detection, improved soldier endurance, and better operational decision-making.

Keywords: wearable technology, soldier monitoring, GPS tracking, heart rate, SpO₂, body temperature, biomedical sensors, wireless communication, emergency alerts, defense technology, and mission efficiency.

I. INTRODUCTION

Modern military operations demand advanced technological solutions to ensure the safety, efficiency, and endurance of soldiers operating in challenging and unpredictable environments. [2] Soldiers often face extreme weather conditions, high physical stress, and mission-critical situations where continuous monitoring of their health and location becomes essential. [1], [3], [4] Wearable Internet of Things (IoT) technologies have emerged as a powerful tool to address these needs by integrating compact sensors, communication modules, and intelligent control systems into lightweight, durable wearable devices. [2] [4].

Smart Wearable System for Continuous Soldier Location and Health Monitoring is designed to provide real-time insights into a soldier's physiological state, environmental conditions, and geographic position[5]. By continuously capturing parameters such as heart rate, oxygen saturation, body temperature, and movement patterns, the system enables early detection of fatigue, dehydration, heat stress, and other health risks. [4] The integration of GPS and inertial sensors ensures precise location tracking, improving situational awareness for commanders and enhancing

coordinated operations. Through secure IoT connectivity, all collected data is transmitted to a centralized monitoring platform, enabling timely interventions, informed decision-making improved mission planning. [3] [4] The proposed system offers a compact, low-power, and reliable solution for

continuous health monitoring and location tracking in remote and challenging environments, thereby improving soldier safety, mission coordination, and operational performance. [5]

II. LITERATURE REVIEW

Uma Maheswari et al., [1] Integrated Wearable System for Enhanced Soldier Health Monitoring and Battlefield Awareness. This work present an integrated multi-sensor wearable platform for soldier health monitoring and battlefield awareness. The prototype bundles physiological sensing heart rate, temperature, SpO₂, activity sensing, and situational awareness elements with onboard low-power processing to pre-process data and transmit status to a local hub. The integrated wearable system demonstrated strong sensing accuracy and real-time monitoring capability, it suffers from several important limitations that reduce its suitability for large-scale battlefield deployment.

Bharathi Madavarapu et al., [2] HOT Watch: IoT-Based Wearable Health Monitoring System, This wearable integrates ECG, SpO₂ oximetry MAX30100, and temperature sensing, with onboard ESP8266 processing and Bluetooth-based wireless transmission to a mobile app. Experimental validation reported > 99.4% accuracy against benchmark devices for heart rate and SpO₂, demonstrating viability of a compact, multi-sensor wearable for real-time health monitoring. While the HOT Watch demonstrates high accuracy in monitoring heart rate, SpO₂, and temperature, the system's reliance on short-range wireless communication imposes significant constraints.

Sushil kumar S. Salve et al., [3] Real-Time Soldier Health Monitoring and Position Tracking Using LoRa-Based IoT System. Modern military operations demand robust, real-time communication systems to ensure both mission success and the safety of personnel deployed in the field. Soldiers often operate in remote, high-risk environments where conventional communication infrastructure such as cellular or satellite networks may be unreliable or unavailable.

Low data rate of LoRa makes it unsuitable for high-volume medical data. J. Gaikwad, R. Tele, S. Sawant, P. Nichit, A. Sambare, and G. Rathod, [4] IoT based Soldier Health Monitoring and Position Tracking System, This work present the system is a wearable IoT-based kit for soldiers: it integrates sensors for heart rate, body temperature, GPS, and motion/accelerometer to monitor movements and location. Data from these sensors is transmitted wirelessly to a central monitoring system for real-time monitoring of soldier health and location The system primarily tracks basic physiological parameters such as heart rate and body temperature but lacks advanced anomaly detection features like fall detection, dehydration alerts, or predictive analytics for critical health events.

Sameer A., Yashvin B S, Prajwal K R, Shahil D S,[5] This work presents a prototype wearable system designed to monitor soldier health and location while providing an emergency alert function. The system integrates GPS-based location tracking, basic

physiological sensing of heart rate and body temperature, and an emergency button that allows soldiers to send distress signals to a base station. The concept is feasible, and the system architecture can support simultaneous health monitoring, location tracking, and emergency alerting within a compact, embedded IoT framework.

III. ANALYTICAL CONCLUSION

The Smart Wearable System for Continuous Soldier Location and Health Monitoring successfully demonstrates the integration of IoT, biomedical sensors, GPS tracking, and LoRa communication into a compact and reliable wearable solution for soldier safety. The system effectively monitors vital parameters such as heart rate, body temperature, and SpO₂ while simultaneously tracking real-time location data. By enabling continuous wireless transmission of health and location information to a remote monitoring station, the project enhances situational awareness, emergency response, and operational efficiency in military environments. The inclusion of an SOS alert mechanism and IoT dashboard further improves the reliability and usability of the system. Overall, the project proves that modern embedded and IoT technologies can be effectively utilized to develop an intelligent monitoring system that supports soldier health, safety, and mission management in challenging conditions.

IV. METHODOLOGY

Design Approach

Smart Wearable System is based on integrating IoT and embedded technologies to continuously monitor soldier health and location. The ESP32 microcontroller acts as the main controller, connecting sensors like MAX30100, DS18B20, GPS, and LoRa modules. Health and location data are collected, processed, and transmitted wirelessly to a monitoring station through LoRa communication. Additional features such as an SOS button, OLED display, and vibration motor improve safety and emergency response.

System Architecture Transmitter:

The Smart Soldier Health and Location Monitoring System operates through a structured methodology in which the ESP32 microcontroller serves as the central processing unit, coordinating all sensing, tracking, and alert-based operations.

This block diagram illustrates a comprehensive ESP32- based wearable health monitoring and emergency alert system designed for continuous real-time operation. The ESP32 processor is the core unit that controls, processes, and integrates all connected modules. It continuously acquires the ESP-32 processor for further handling. The ESP-32 acts as the core processing and communication unit of the system. It processes the incoming wireless data, performs necessary validation or conversions, and manages network connectivity.

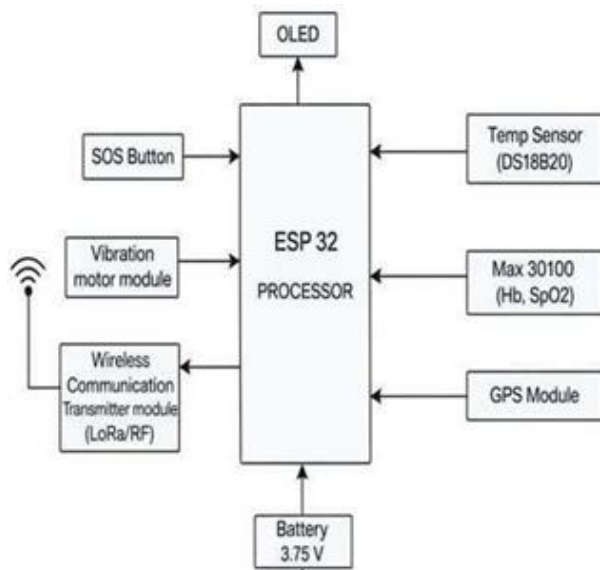


FIG1: Transmitter Block Diagram

Receiver:

The system includes an OLED display to show live sensor readings, system status, and alert messages for immediate user awareness. For safety and interaction, an SOS button allows the user to manually trigger an emergency signal, while a vibration motor module gives haptic feedback to confirm alerts or warn the user when abnormal health parameters are detected. The wireless communication transmitter (LoRa/RF) sends health

data, GPS coordinates, and emergency notifications to a remote monitoring station or control center over long distances with low power consumption. All components are powered by a 3.7 V rechargeable battery, making the system compact, portable, and suitable for wearable applications such as soldier health monitoring, rescue operations, or patient surveillance in remote areas.

The proposed system is designed to enable efficient wireless data acquisition and remote monitoring using IoT technology. Data is transmitted from remote sensing units and received by the LoRa or RF wireless communication receiver module, which is well suited for long- range and low- power communication, especially in remote or outdoor environments. This module ensures reliable data reception even over large distances and sends the collected data.

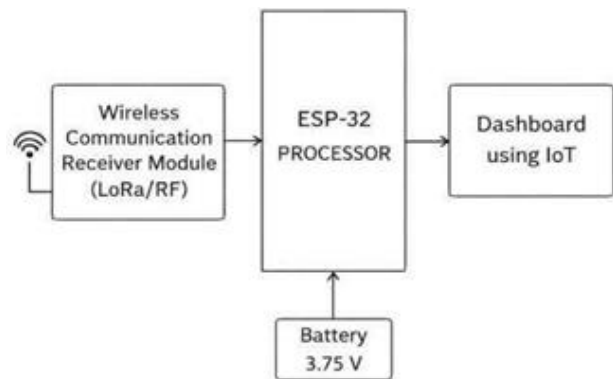


FIG2: Receiver Block Diagram

FLOW CHART

Transmitter:

The Smart Soldier Health and Location Monitoring System operates according to a flow chart based sequence in which the ESP32 microcontroller functions as the main control unit. After the system is powered ON, the ESP32 initializes all connected sensors, the GPS module, and the communication interface. Health sensors continuously measure vital parameters such as heart rate, body temperature, and oxygen saturation, while the GPS module acquires real-time location data.

The ESP32 processes and analyzes the collected data by comparing it with predefined threshold values. The proposed wearable soldier health monitoring system operates in two main stages: initialization and continuous monitoring. When the device is powered on, the microcontroller, health sensors, and GPS module are initialized to ensure proper operation. The soldier's unique ID is collected for identification, and the system checks the network or server connection. If connectivity is unavailable, the system stores data locally and keeps retrying in the background. Once a stable connection is established, the system enters the monitoring loop. During the monitoring phase, the system continuously reads vital parameters such as body temperature, heart rate, and SpO₂ from sensors and filters the values to ensure accuracy. At the same time, the GPS module provides real-time location data, which is checked against a predefined geo-fence.

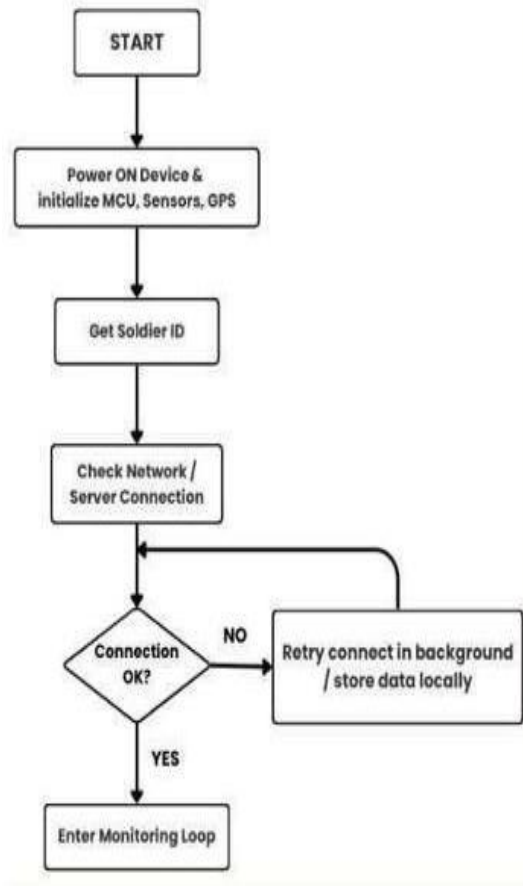


FIG3: Entering Monitoring Loop at Transmitter System

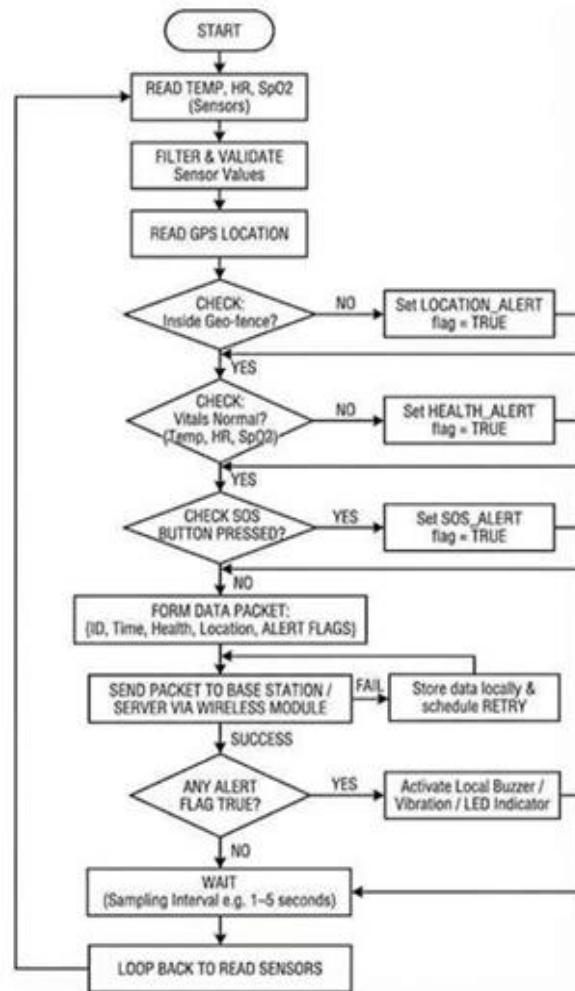


FIG4: Transmitter system Flow chart

Receiver:

During the monitoring phase, the system continuously reads vital parameters such as body temperature, heart rate, and SpO₂ from sensors and filters the values to ensure accuracy. At the same time, the GPS module provides real-time location data, which is checked against a predefined geo-fence. If the soldier moves outside the allowed area or if any vital sign crosses safe limits, corresponding alert flags are set. The system also monitors an SOS button, allowing the soldier to manually trigger an emergency alert when needed.

All collected information, including soldier ID, time, health data, location, and alert status, is packaged and transmitted wirelessly to the base station or server. If data transmission fails, the system securely

stores the data and retries later to prevent loss. When any alert is active, local indicators such as a buzzer, vibration motor, or LED are activated to notify the soldier. The system then waits for a short sampling interval and repeats the process, enabling continuous real-time health and safety monitoring.

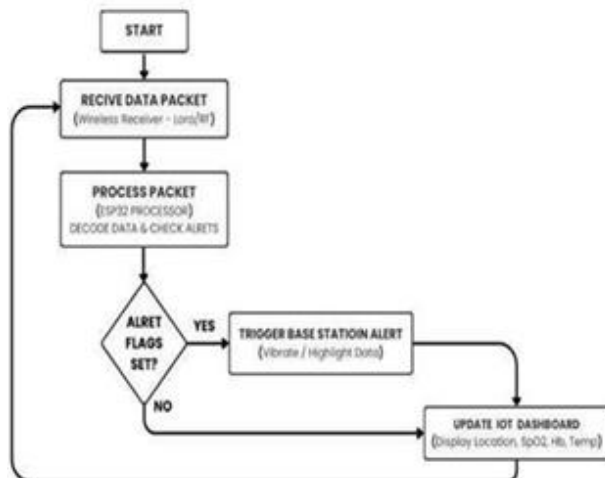


FIG5: Receiver system Flow chart

During this phase, system parameters and threshold values are loaded from memory for accurate decision-making. Self- diagnostic checks are also performed to verify proper functioning of sensors, communication modules, and power supply. Any initialization errors are identified early to prevent system failure. Once all checks are completed successfully, the base station enters normal monitoring mode. Next, the Receive Data Packet stage handles the wireless communication from the wearable device.

V. EXPERIMENTAL RESULTS

Transmitter Circuit:

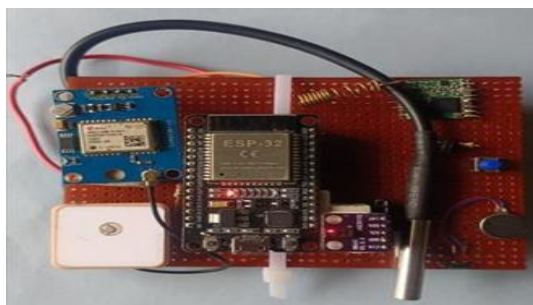


FIG6: Transmitter Circuit

This transmitter circuit appears to be built around an ESP32, which acts as the main controller of the system. The ESP32 reads data from connected sensors, processes it, and then transmits the information. Its built-in Wi-Fi and Bluetooth capabilities make it ideal for IoT-based applications where real-time data needs to be sent to a remote server or device. The circuit includes a temperature and humidity sensor (likely a DHT-type module) connected to the ESP32. This sensor continuously measures environmental conditions such as temperature and humidity. The collected data is then processed by the microcontroller and displayed locally on a small OLED display, which shows values like temperature readings in real time.

A GPS module (visible at the bottom with an external antenna) is also integrated into the system. This module receives satellite signals to determine the device's geographic location (latitude and longitude). The ESP32 combines this location data with the environmental readings, making the system useful for applications like weather tracking, environmental monitoring, or asset tracking. Additionally, there is a communication module (such as GSM or similar) that enables the circuit to act as a transmitter. It sends the collected data (temperature, humidity, and location) to a remote system or cloud platform. The LEDs on the board indicate power status and data transmission activity, helping in debugging and monitoring.

Receiver Circuit:

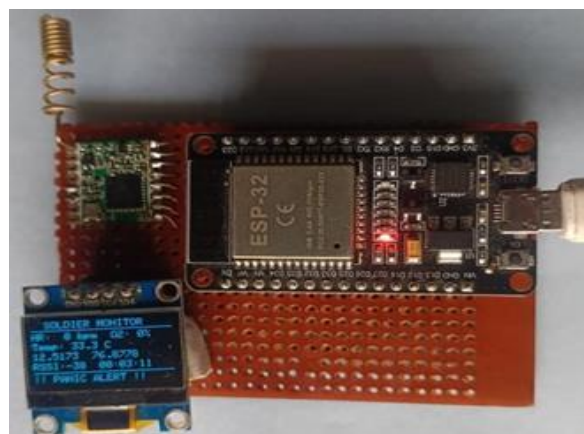


FIG6: Receiver Circuit

The receiver circuit shown in the image is a compact wireless communication system designed to receive, process, and display transmitted data in real time. At the core of the circuit is the ESP32, a powerful microcontroller with built-in Wi-Fi and Bluetooth capabilities. It is responsible for controlling all operations, including reading incoming signals, processing the data, and sending output to the display. The ESP32 is mounted on a general-purpose PCB (perfboard) and powered through a USB connection, with the onboard LED indicating active operation.

The small green module with the helical (spring-shaped) antenna acts as an RF receiver, typically operating in common ISM bands such as 433 MHz. This antenna helps in capturing electromagnetic waves transmitted wirelessly from a transmitter circuit. Once the signal is received, the module converts it into electrical signals and sends it to the ESP32 through digital communication pins.

The ESP32 then decodes this signal, which may contain sensor data, text, or control information depending on the application. On the left side, an OLED display module is connected to the ESP32 using the I2C protocol, which requires only two communication lines (SDA and SCL). The ESP32 processes and interprets the received data using programmed logic. Finally, the processed information is displayed on the OLED screen for user interaction.

RESULTS:



FIG7: Dashboard Display

VI. CONCLUSION

The Smart Wearable System for Continuous Soldier Location and Health Monitoring successfully demonstrates the use of IoT and embedded technologies for improving soldier safety and mission management. The system continuously monitors important health parameters such as heart rate, body temperature, and SpO₂ while also providing accurate real-time location tracking using GPS technology. By integrating LoRa communication, the collected data can be transmitted over long distances with low power consumption, making the system suitable for remote and battlefield environments.

The inclusion of features such as the SOS emergency button, OLED display, and vibration alerts enhances the reliability and usability of the system during critical situations. The IoT dashboard enables centralized monitoring and quick

The IoT dashboard allows remote monitoring and better decision-making.

Overall, the project provides a compact, efficient, and reliable wearable solution that improves soldier health monitoring, emergency response, and operational effectiveness. Future improvements such as AI-based analysis, advanced sensors, and enhanced communication technologies can further increase the performance and intelligence of the system.

Future Scope

The future scope of the Smart Wearable System for Continuous Soldier Location and Health Monitoring is highly promising, as it can be enhanced using advanced technologies to improve soldier safety and operational efficiency. In the future, the system can be integrated with Artificial Intelligence and Machine Learning to analyze real-time health data and predict critical conditions such as fatigue, stress, or medical emergencies. While the current system already monitors vital parameters like heart rate, SpO₂, body temperature, and location, it can be upgraded with advanced biosensors to measure blood pressure, hydration levels, and other health indicators.

Communication can also be improved by replacing or supporting LoRa with 5G or satellite communication, ensuring reliable connectivity even in remote or battlefield environments. Additionally, incorporating energy-efficient designs such as solar or motion-based energy harvesting can extend battery life. Enhanced data security mechanisms like encryption and block chain can protect sensitive military data. Moreover, cloud computing and big data analytics can be used to store and analyze large volumes of soldier data for performance monitoring and strategic planning. Overall, the project can develop into a fully intelligent, autonomous, and secure monitoring system that significantly improves soldier safety and mission success.

Additional biosensors can be included to monitor parameters like blood pressure, hydration level, and ECG for more accurate health analysis. In the future, the project can be integrated with drones, cloud computing, and smart battlefield networks for real-time monitoring, data analysis, and faster emergency response, making the system more intelligent, secure, and efficient.

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