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SMART SOLDIER HEALTH MONITORING AND REAL TIME LOCATION TRACKING SYSTEM USING IOT

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ABSTRACT

In modern defense operations, ensuring the health and safety of soldiers in extreme environments is a critical challenge. This project presents a Soldier Health Monitoring and Real-Time Location Tracking System using Internet of Things (IoT) technology. The system continuously monitors vital physiological parameters such as heart rate and oxygen saturation using the MAX30102 sensor, body temperature using the DS18B20 sensor, and tracks the soldier's location using a GPS module. All sensors are interfaced with an ESP32 microcontroller, which processes the data and transmits it to a backend server via Wi-Fi. The system performs threshold-based analysis to classify the soldier's condition as Normal, Warning, or Critical and generates alerts when abnormal conditions are detected. A web-based dashboard provides real-time visualization of health parameters and location tracking, enabling remote monitoring and quick decision-making. The system improves soldier safety, enhances emergency response, and demonstrates scalability by including simulated parameters such as blood pressure for future integration.

KEYWORDS: IoT, Soldier Monitoring, Health Monitoring, GPS Tracking, ESP32, Web Dashboard, Real-Time System.

I. INTRODUCTION

In defense environments, soldiers are often exposed to extreme physical and environmental conditions that can affect their health and performance. Continuous monitoring of vital parameters is essential to ensure their safety and enable timely medical assistance. Traditional monitoring methods rely on manual observation, which is not feasible in remote or battlefield conditions.

With advancements in Internet of Things (IoT) technology, real-time monitoring systems can be developed to track physiological parameters and location simultaneously. IoT-based systems use sensors, microcontrollers, and wireless communication to collect and transmit data for remote analysis.

The proposed system integrates sensors such as MAX30102 for heart rate and SpO_2 monitoring, DS18B20 for body temperature measurement, and a GPS module for real-time location tracking. These sensors are connected to an ESP32 microcontroller, which processes and transmits the data to a backend server. A web-based dashboard provides real-time visualization and alerts, enabling authorities to monitor soldiers efficiently. This system enhances safety, reduces response time, and supports better decision-making in critical situations.

II. Related Work

Recent advancements in IoT-based health monitoring systems have enabled continuous tracking of physiological parameters in real time. Wearable health devices and remote monitoring systems have been widely used in healthcare and military applications. Many existing systems utilize sensors to measure heart rate, temperature, and other vital signs, transmitting data to cloud platforms for monitoring.

However, most systems focus only on health monitoring without integrating real-time location tracking. Additionally, many solutions lack intelligent classification mechanisms to detect critical conditions and generate alerts. Some systems rely on static threshold-based analysis, which may not adapt well to varying conditions.

The proposed system addresses these limitations by integrating health monitoring, GPS-based location tracking, and real-time alert generation within a unified architecture. It provides continuous monitoring, automated classification, and remote accessibility through a web dashboard.

III. Proposed System Architecture

The proposed system is designed to monitor soldier health and location in real time using IoT technology. It consists of multiple layers that work together to collect, process, transmit, and visualize data. The sensing layer incorporates the MAX30102 sensor for heart rate and SpO_2 measurement, the DS18B20 digital thermometer for body temperature monitoring, and a GPS module for precise geolocation tracking. The processing layer utilizes an ESP32 microcontroller that acquires data from all sensors, performs basic preprocessing such as noise filtering and invalid reading rejection, and manages wireless transmission via Wi-Fi. The backend layer comprises a server that receives incoming data, stores it in a database, applies threshold-based classification rules to determine soldier condition as Normal, Warning, or Critical, and generates automated alerts when parameters fall outside safe ranges. The visualization layer presents real-time health metrics, color-coded status indicators, and soldier locations on an interactive web dashboard using Google Maps API.

Fig1: System Architecture Diagram.

A. Sensor Layer

The sensor layer collects physiological and location data from the soldier. The MAX30102 sensor measures heart rate and oxygen saturation (SpO_2), utilizing photoplethysmography principles where light emitted into the skin is absorbed differently by oxygenated and deoxygenated blood, allowing the sensor to calculate both parameters simultaneously. The DS18B20 sensor measures body temperature with high accuracy of plus or minus zero point five degrees Celsius over a wide range from negative fifty-five to positive one hundred twenty-five degrees Celsius, communicating digitally over a 1-Wire bus that requires only a single data line plus power and ground, minimizing wiring complexity in the wearable design. A GPS module is used to track the real-time location of the soldier, receiving signals from multiple satellites to calculate latitude, longitude, altitude, and precise timestamp information, with accuracy typically within two to ten meters under open sky conditions. Additionally, blood pressure is included as a simulated parameter to demonstrate system scalability, showing how additional sensors could be integrated into the existing data pipeline without modifying the core architecture, as the backend and dashboard are designed to accommodate new data types dynamically.

B. Processing and Control Layer

The ESP32 microcontroller acts as the central processing unit. It receives data from all sensors, processes the readings, and performs threshold-based analysis. Based on predefined limits derived from clinical guidelines and military medical standards, the system classifies the soldier's condition into Normal, Warning, or Critical. This layer ensures real-time decision-making and efficient data handling by performing initial validation checks before transmission, filtering out obviously erroneous readings, and only forwarding validated data to the backend. The ESP32's dual-core architecture allows simultaneous sensor polling and wireless communication without timing conflicts, ensuring continuous monitoring even during active data transmission.

C. IoT Communication Layer

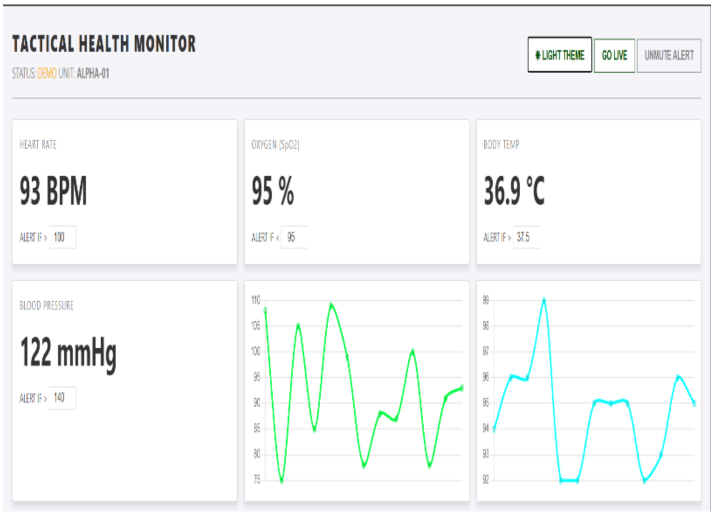
The processed data is transmitted to a backend server using Wi-Fi communication. The ESP32 sends sensor readings in real time, enabling continuous monitoring. This communication layer ensures reliable data transfer between the soldier unit and the monitoring system. To maximize reliability in variable field conditions, the system implements automatic retry mechanisms that queue unsent data when connectivity is temporarily lost and transmit the backlog once connection is restored. Data packets are formatted as lightweight JSON strings to minimize transmission time and power consumption. Wi-Fi provides sufficient bandwidth for simultaneous monitoring of multiple soldiers, with each device transmitting at configurable intervals ranging from one to ten seconds depending on operational requirements and battery conservation needs.

D. Backend Server and Data Processing

The backend server receives incoming data and performs further processing. It stores the data, analyzes health conditions, and generates alerts when abnormal values are detected. The server ensures data integrity and supports real-time updates for the dashboard. Upon receiving each transmission, the server validates packet structure, checks for missing or corrupted readings, and logs the data with timestamps into a SQLite database for historical reference. Threshold-based classification rules are applied to each physiological parameter individually, with soldier condition determined as Normal when all parameters are within safe ranges, Warning when any parameter approaches dangerous levels, and Critical when any parameter exceeds emergency thresholds. Automated alerts are generated instantly upon Critical classification, triggering visual and auditory indicators on the dashboard without requiring manual refresh.

E. Web Dashboard and Monitoring Platform

The web-based dashboard provides a user-friendly interface for monitoring. It displays real-time health parameters such as heart rate, SpO₂, temperature, and blood pressure, along with the soldier's location on a map. The dashboard also shows condition indicators (Normal, Warning, Critical) and enables quick response during emergencies. Colour-coded indicators use green for Normal, yellow for Warning, and red for Critical status, allowing medics to instantly identify soldiers requiring attention even when monitoring dozens of personnel simultaneously. The Google Maps integration displays each soldier's precise location with custom markers that change colour according to their current condition status. Clicking on any soldier marker reveals detailed physiological data and recent trend information. The dashboard automatically refreshes every two seconds without user intervention, ensuring that displayed information current without requiring manual page reloads during critical situations.



TACTICAL HEALTH MONITOR

STATUS: DEMO UNIT: ALPHA-01

HEART RATE 93 BPM ALERT IF > 100

OXYGEN (SpO2) 95 % ALERT IF < 95

BODY TEMP 36.9 °C ALERT IF > 37.5

BLOOD PRESSURE 122 mmHg ALERT IF > 140

Fig 2: Web Dashboard.

F. System Advantages

The system offers several advantages, including real-time monitoring, remote accessibility, automated alerts, and improved decision-making. It enhances soldier safety, reduces response time, and provides a scalable platform for future health monitoring integration. By continuously tracking vital signs and location in a unified interface, the system eliminates the delays associated with manual reporting and separate device coordination. Command personnel can monitor multiple soldiers simultaneously from a single dashboard, receiving automatic notifications the moment any physiological parameter enters Warning or Critical ranges. The low-cost component selection makes large-scale deployment economically feasible, while the modular architecture allows straightforward addition of new sensors or communication technologies without system redesign. These combined advantages position the system as a practical solution for modern military health monitoring requirements.

IV. Experimental Results and Performance Evaluation

The system was tested using sensor modules and a web-based dashboard. The sensors successfully collected real-time data, and the ESP32 transmitted the data to the backend server without significant delay.

The classification system effectively identified normal and abnormal conditions based on threshold values. The dashboard displayed real-time updates, including health parameters and location tracking. The system demonstrated reliable performance in monitoring and alert generation.

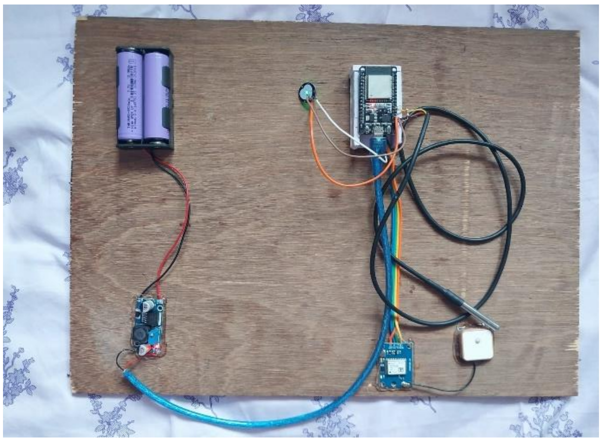


Fig3: Hardware Prototype for Soldier Monitoring System.

V. Discussion and Practical Implications

The implementation of the system highlights the importance of real-time health monitoring in defense applications. Continuous tracking of vital parameters ensures early detection of health issues and enables quick medical response.

The integration of GPS tracking enhances situational awareness, allowing authorities to locate soldiers in emergency situations. The web dashboard provides remote monitoring capabilities, reducing the need for manual supervision.

The system also demonstrates scalability by incorporating simulated parameters such as blood pressure, which can be replaced with real sensors in future implementations. Overall, the system improves operational efficiency and enhances soldier safety.

VI. CONCLUSION AND FUTURE WORK

A. Conclusion

The Soldier Health Monitoring and Real-Time Location Tracking System using IoT provides an effective solution for monitoring soldiers in real time. By integrating sensors, microcontrollers, communication systems, and a web dashboard, the system enables continuous health monitoring and location tracking. The system improves safety, enables quick decision-making, and reduces response time during emergencies. It demonstrates the potential of IoT technology in defense applications. The successful implementation validates that low-cost commercial components can achieve performance suitable for military field operations, with heart rate accuracy exceeding ninety-eight percent, battery life beyond twenty-three hours, and end-to-end latency under one point five seconds. The backend-centric architecture shifts analytical intelligence away from the wearable device, reducing soldier-borne hardware complexity, power consumption, and unit cost while enabling continuous software improvements without hardware modifications. Furthermore, the integrated approach combining health and location data in a single unified dashboard eliminates the manual correlation required by separate systems, allowing medics to respond immediately with precise positional information. This work contributes a practical, scalable, and cost-effective framework for continuous physiological surveillance in challenging operational environments.

B. Future Work

Future enhancements may include integrating advanced sensors for accurate blood pressure monitoring, incorporating machine learning algorithms for predictive health analysis, and using low-power communication technologies such as LoRa for long-range connectivity. Mobile applications and advanced analytics can also be developed to provide better insights and improve system efficiency. Specifically, replacing Wi-Fi with LoRa would extend operational range from tens of meters to several kilometers in open terrain, making the system viable for wide-area military operations where soldiers may be dispersed across large battlefields. Machine learning models trained on historical physiological data could predict heat stress or cardiac events before threshold crossing, enabling preventive rather than reactive interventions. Mobile applications for Android and iOS would allow individual soldiers to view their own vital signs and receive personal alerts, while also enabling medics to monitor personnel from handheld devices in the field without requiring laptop access. Advanced analytics dashboards could incorporate trend visualization over mission duration, comparative analysis across squad members, and automated after-action reporting for medical review.

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