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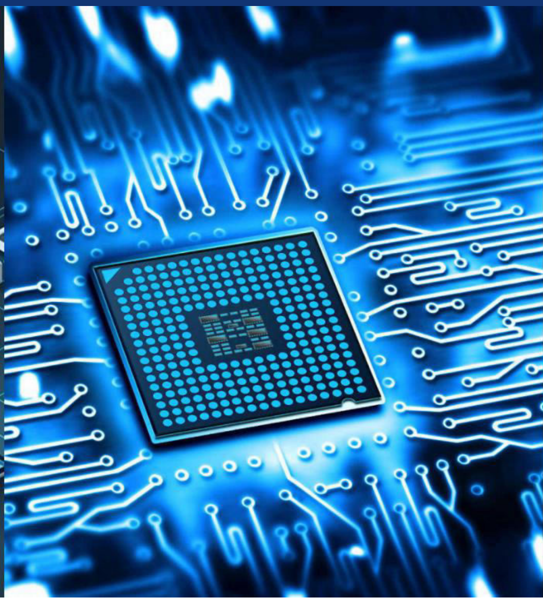


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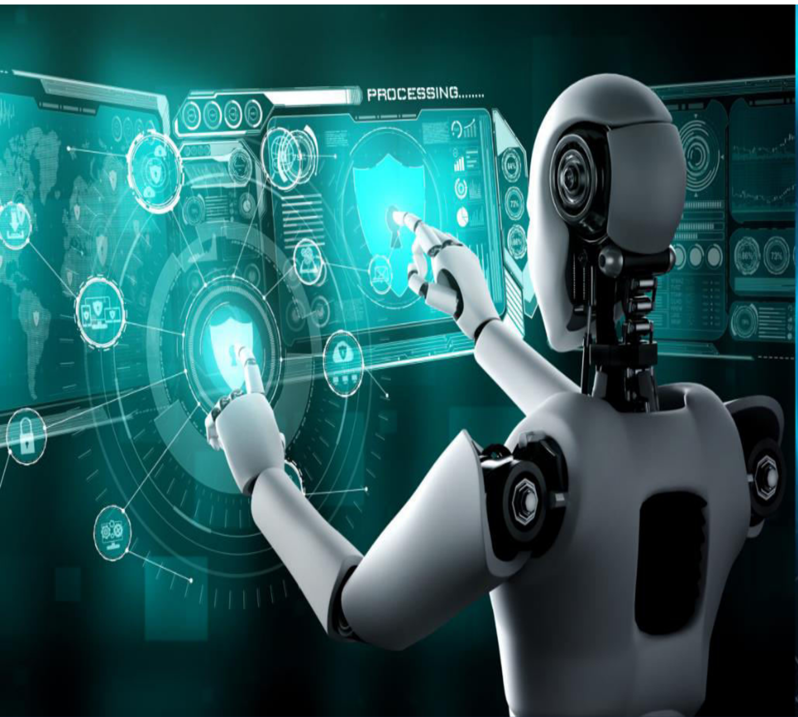

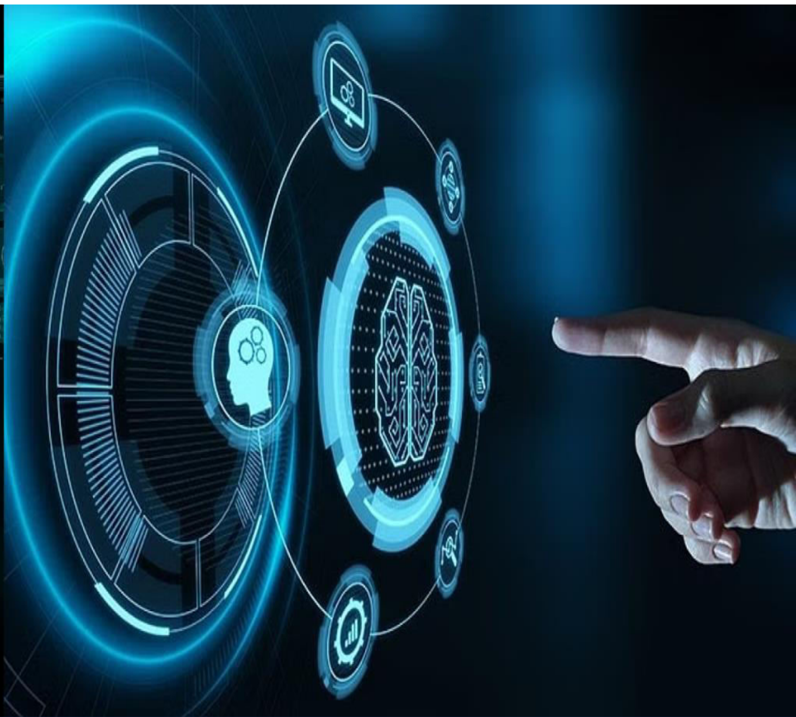

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Warrior Health Condition and Geo-Location Tracking System

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ABSTRACT*:* The safety and well-being of soldiers are critical for the defense of any nation. In challenging and often hostile environments, soldiers face numerous risks, including health emergencies and disorientation. The proposed Warrior Health Condition and Geo-Location Tracking System combines IoT technologies and GPS tracking to address these challenges. The system gathers real-time bioinformatics such as body temperature, heart rate, and oxygen levels using health monitoring biosensors. GPS technology ensures precise location tracking, while wireless communication modules, facilitate seamless data transmission to the base station. The system leverages cloud platforms for storing sensor data, enabling predictive health analytics using machine learning techniques. In emergencies, alerts are generated and transmitted to the command center with the soldier's real-time health status and location, ensuring rapid assistance. The Warrior Health Condition and Geo-Location Tracking System aims to minimize search-and-rescue efforts, enhance decision-making, and ensure the timely response to critical situations, ultimately increasing the survival rate of soldiers on the battlefield while preserving the army's valuable human resources.

KEYWORDS: Sensor-Based Health Tracking, Random Forest Algorithm, Decision Tree Classification, Naïve Bayes Classifier, K-Nearest Neighbors, Cloud- Based Health Data Storage.

I. INTRODUCTION

The health and safety of soldiers are paramount for the success of any military operation. Soldiers operate in challenging and unpredictable environments where the risks of injuries or health issues are high. In such scenarios, having a reliable system to monitor their health and track their location becomes essential. The Warrior Health Condition and Geo-Location Tracking System has been designed, leveraging IoT technology, health sensors and machine learning algorithms. This innovative system continuously monitor soldier's critical health parameters such as heart rate, body temperature, oxygen saturation and ECG readings. The data collected from these sensors is transmitted wirelessly to the central command system using communication technologies. Additionally, the integration of GPS modules allows for precise geolocation tracking of soldiers, enabling command centers to monitor their movements and locate them quickly during emergencies or rescue operations. What sets this system apart is its use of machine learning for predictive health analysis. Algorithms like Random Forest, Logistic Regression, Decision Tree, Naive Bayes, K-Nearest Neighbor, and Support Vector Machine are employed to analyze health data in real-time. These models are capable of identifying anomalies and predicting potential health risks. Once a health issue is detected, the system generates automatic alerts. Commanders can make informed decisions, strategize effectively and respond to emergencies swiftly. This system is not only a tool for safeguarding soldier's lives but also a crucial asset for improving the efficiency and success of military missions. By integrating health sensors, geolocation technology, and advanced data analytics, this system represents a groundbreaking innovation in military technology. It prioritizes the well-being of soldiers, reduces response times during critical situations and ensures that no soldier is left unaccounted for in the heat of battle. This combination of health monitoring and position tracking signifies a major leap forward in enhancing the safety, reliability and operational effectiveness of military personnel.

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II. RELATED WORK

Archana Padikar A, et al., [1] proposed Health Monitoring and Soldier Tracking System using IoT in 2020. The system uses biosensors like heartbeat, temperature, and gas sensors, along with GPS, to monitor soldiers' health and location. Arduino Uno and Node MCU are used to process and transmit the data to the base station. It alerts the base station in critical conditions like heart attacks or gas exposure. Future work aims to enhance sensor accuracy and integrate machine learning for better health predictions.

Brijesh Iyer, et al., [2] proposed a IoT Enabled Tracking and Monitoring Sensor for Military Applications in 2018. The system uses an Arduino board with sensors to monitor vital signs like body temperature and GPS for accurate location tracking. It ensures continuous communication between soldiers and control rooms, enhancing safety during wars. Future improvements aim to monitor more vital signs and use advanced communication protocols for quicker responses. This system focuses on real-time safety and connectivity for soldiers.

Monika V, et al., [3] proposed a IoT and GPS-Based Soldier Position Tracking and Health Monitoring Systemin 2018.This study presents a GPS technology which logs accurate longitude and latitude, while sensors monitor and transmit health data to the base station. The system focuses on being cost-effective, reliable, and lightweight to improve soldier safety. Future enhancements include better wireless communication and additional sensors for advanced health monitoring. This solution ensures continuous tracking and health updates for soldiers.

James Jin Kang, et al., [4] proposed a No Soldiers Left Behind: An IoT-Based Low-Power Military Mobile Health System Design in 2020. The system integrates Low Power Wide Area Networks and Wireless Body Area Networks to monitor soldiers' health and location in real-time. It addresses battery life and data accuracy challenges using a Multilayer Inference System, reducing data size by 97.9% while maintaining accuracy. Wearable sensors ensure reliable monitoring and communication, enhancing mission performance and soldier safety. Future developments may include advanced biometrics and expanded military network applications.

Swarupanand Desai, et al., [5] proposed a Review Paper on Soldier Health Monitoring and Position Tracking System in 2024. The system integrates multi-sensor networks, GPS, GSM, and IoT technologies to monitor vital signs like pulse rate and body temperature while providing precise soldier positioning. Data is transmitted to the military base via GSM modules for quick decision-making and support. It includes a soldier alertness program for activity tracking and an emergency switch for immediate assistance. This lightweight, cost-effective system enhances situational awareness, communication, and soldier safety during missions.

Basheera M. Mahmmod, et al., [6] proposed a Patient Monitoring System (PMS) using IoT in 2024. The system monitors vital signs like body temperature, heart rate, sleep, fall detection, and blood pressure in real-time. IoT enables remote patient monitoring, reducing healthcare costs. The paper reviews PMS, its applications, and challenges in healthcare systems. Future work aims to address open research issues and enhance system capabilities for better healthcare services.

Jhansi Bharathi Madavarapu, et al., [7] proposed HOT Watch, an IoT-based wearable health monitoring system in 2024. The system tracks health metrics such as heart rate, temperature, and oxygen levels using sensors like MLX90614, AD8232, and MAX30100. Arduino technology and Bluetooth connectivity transmit data to a mobile app, with the Pan-Tompkins algorithm used to determine the heart rate. The system also includes GPS to provide location data and alerts users about their health status. The HOT Watch's accuracy is higher than existing wearable devices like Sensor Patch, WS-IoT, and Neo Wear by 1.40%, 0.70%, and 2.47%, respectively.

Heng Yuan and Zhiqing Zhou, [8] proposed an IoT-based AI-assisted telemedicine health analysis system in 2021. The system integrates a cloud fusion health IoT architecture with multimodal information acquisition, including robotics-based sensing and smart clothing. It uses migration learning and continuous conditional random fields for emotion data labeling and classification. The system optimizes user experience and ensures high service quality. The feasibility of the QoS framework is verified through simulations, enhancing telemedicine health analysis.

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Najma Taimoor et al., [9] proposed a survey on reliable and resilient AI and IoT-based personalized healthcare services in 2025. The study explores Healthcare 5.0, which aims for autonomous healthcare services by addressing interrelated health conditions of patients. A three-layer IoT- based architecture using AI and non-AI approaches is analyzed, highlighting its strengths, weaknesses, and security threats. Solutions for personalized healthcare services and methodologies to enhance reliability and resilience are proposed. The survey emphasizes modern HIoT requirements, including personalization and security in healthcare systems.

K. L. Tsui, et al., [10] proposed a System Health Monitoring and Management (SHMM) framework in 2019 using big data analytics. It enables continuous surveillance, prediction, and diagnostics for maintaining system stability across various domains, including mechanical systems and public health. The framework optimizes the use of active and passive data for system control and management. The study also explores SHMM's interdisciplinary connections and its applications in complex systems. Future work focuses on improving data processing efficiency and addressing privacy challenges.

Marjorie Skubic, et al., [11] proposed an automated health alert system in 2015 using in-home sensors for early health assessment. The system captures behavior and activity patterns through embedded sensors, detecting changes as potential health issues. A 1-D alert algorithm generates alerts for clinicians, who validate their clinical relevance, providing ground truth for training classifiers. Over nine months, data from 21 seniors demonstrated effective health change detection using both domain knowledge and supervised learning. The system offers unobtrusive monitoring, enabling early intervention and addressing compliance challenges.

Iqram Hussain, et al., [12] proposed HealthSOS, a real- time health monitoring system for stroke prognostics in 2020. The system utilizes a portable, eye-mask embedded EEG device to monitor brainwaves, enabling classification of ischemic stroke patients and healthy individuals. Data analytics and a medical ontology-based advisor support clinical decision-making. Tested on 37 stroke patients and 36 healthy elderly volunteers, the system demonstrated significant differences in EEG metrics like rsBSI and delta- alpha ratio. Using machine learning, the SVM model achieved 92% accuracy and a Gini coefficient of 95%, proving its effectiveness for early stroke detection and management.

Zhengguo Yang et al., [13] proposed a framework for evaluating the safety of health monitoring systems in the home environment in 2023. The framework integrates system safety requirements, a safety case, and Bayesian networks to address safety concerns in a structured manner. It provides a five-step approach to ensure traceability of unsafe results to safety requirements and supports re-evaluation in case of design or requirement changes. The framework's application is demonstrated with a health monitoring system, highlighting its effectiveness in quantitative safety evaluation. This approach enhances reliability in safety- critical home health monitoring systems.

Julie Barnett et al., [14] proposed *myPace: An Integrative Health Platform for Supporting Weight Loss and Maintenance Behaviors* in 2015. The system addresses obesity by providing a complete weight loss and management platform deployed via smartphone and PC, connecting dietitians and patients. It facilitates sustained behavior change through regular progress updates from patients and tailored advice from dietitians. The platform is based on behavior change theories and human support models like the supportive accountability framework. Initial evaluations using a coaching think-aloud protocol and dietitian interviews revealed positive design features, with further development needed for full acceptance in dietetic practice. Future work aims to enhance patient engagement and system usability.

Fatima Khalique et al., [15] proposed a framework for public health monitoring, analytics, and research in 2019. The framework focuses on acquiring and managing electronic health records (EHR) using standard protocols like HL7 to ensure interoperability. It addresses critical issues such as privacy through anonymization, data fusion from multiple sources, and integration of contextual data. The framework supports public health activities, including surveillance, immunization, and registries, while providing a foundation for AI-based research models.

Muhammad Hassan et al., [16] proposed a hybrid structural health monitoring system in 2024, leveraging IoT with fog and cloud computing. Leaf nodes collect acceleration signals and send them to a fog-based central node for damage detection. If damage is detected, data is forwarded to a cloud server for detailed analysis and localization. The system provides an efficient, reliable, and cost-effective approach for monitoring civil infrastructures. Practical experiments

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validated its effectiveness for critical infrastructure damage detection.

M Zheng and S.Bai, [17] proposed a novel Universal Health Management and Monitoring (HMM) system tailored for resource-constrained environments using the Internet of Things (IoT). The proposed system aims to address challenges in health monitoring and management in environments with limited resources, such as low-power devices, unreliable networks, and restricted computational capabilities.

L. Yu et al., [18] a Personalized Health Monitoring System aimed at improving the wellness of elderly individuals at the community level in Hong Kong. The system focuses on continuous health monitoring, early detection of health issues, and personalized feedback for promoting wellness in an aging population.

J. J.P.C Rodrigues, [19] proposes a article which explores the foundational enabling technologies for the Internet of Health Things (IoHT), a paradigm that integrates healthcare services with IoT to create smart, connected, and efficient healthcare systems. The paper highlights the essential components and challenges in deploying IoHT systems, providing insights into its role in transforming healthcare delivery.

M Al Disi et al., [20] proposed a paper which investigates the application of Compressive Sensing (CS) for efficient ECG signal reconstruction on IoT gateways. It focuses on enabling real-time processing and transmission of ECG signals while addressing constraints related to resource usage, latency, and bandwidth in IoT healthcare systems.

III. DESIGN AND IMPLEMENTATION

The IoT module integrates health sensors like heartbeat, temperature, blood pressure, ECG, and SpO2 with a GPS module to collect real-time health and location data. A microcontroller processes the data and uploads it to the Thing Speak cloud platform for storage and analysis. Alerts are generated in critical health conditions, ensuring timely action. The system is designed to be lightweight and operate with low power, making it suitable for battlefield use. This setup allows continuous monitoring of soldiers' health and location. It enhances operational efficiency by providing real- time data to the base station. The system's design focuses on portability, reliability, and energy efficiency for military applications.

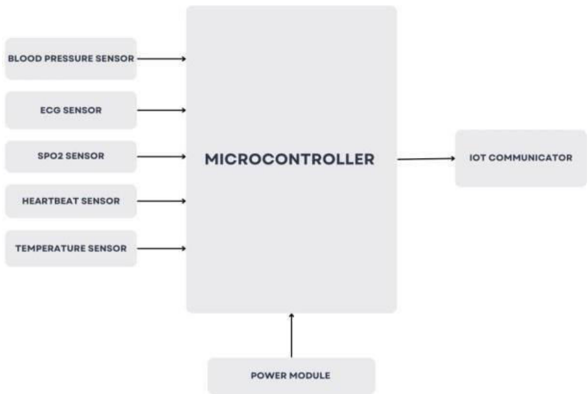

FIGURE 1. Hardware architecture

Implementation of the ML model include the following steps:

Data collection: The first step involves identifying and sourcing data from various platforms. Once the data sources are identified, the system starts collecting the relevant datasets from these sources. After collecting the data, it is stored in a structured format in databases, ready to be processed.

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Data pre-processing: The system goes through the collected data and removes any irrelevant, unnecessary or redundant attributes and relevant features (variables) are extracted from the data. During this process, missing or incomplete data is handled. Finally, the cleaned data is transformed into a suitable format for analysis.

Analysis and prediction: The pre-processed data flows into the analysis and prediction process, and the results are stored for further use. The model performance is evaluated using metrics. Once trained, the model generates predictions based on user input, and the results are displayed. This process enables accurate predictions for informed decision-making.

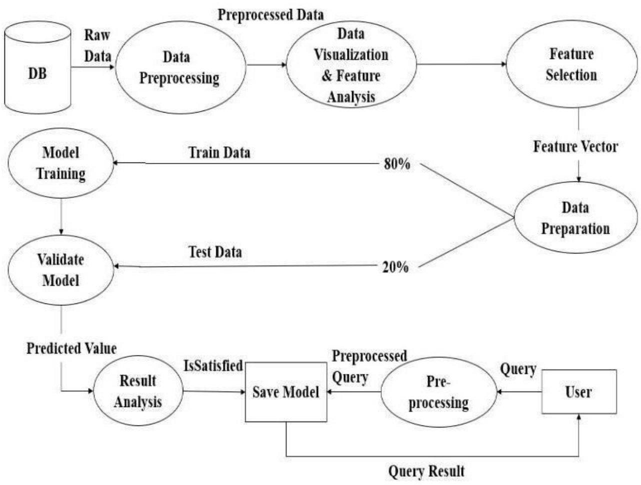

FIGURE 2. Model analysis and prediction

IV. RESULTS

The Warrior Health Condition and Position Tracking System generates alerts when critical health conditions are detected, enabling immediate action. The system enhances safety, mission performance, and situational awareness. Its lightweight and low-power design make it ideal for field use, ensuring efficient and responsive operations in the battlefield. In the figure 8, "Warrior Health Monitoring" web application user interface for predicting health parameters of soldiers, featuring input fields for details like heartbeat, oxygen, BP, temperature, ECG, and age, with options for gender selection. It also includes sidebar navigation options like Soldier List, Add Soldier, Assign Soldier, and Search.

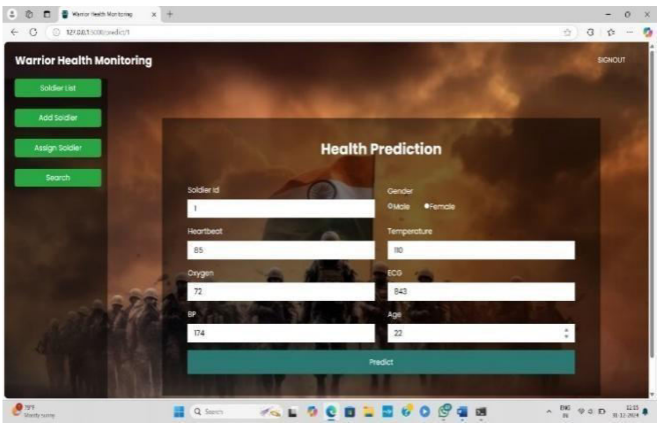

FIGURE 3. User interface

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The image displays a "Prediction" interface from the Warrior Health Monitoring application, indicating that Soldier ID 1 is in a critical condition with a suggestion to consult a nearby doctor.

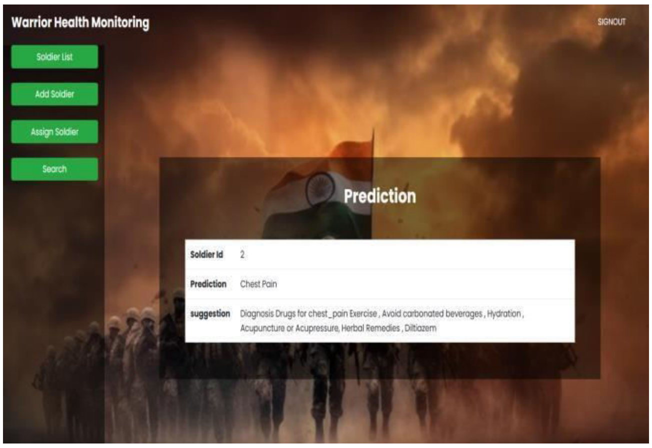

FIGURE 4. Health prediction

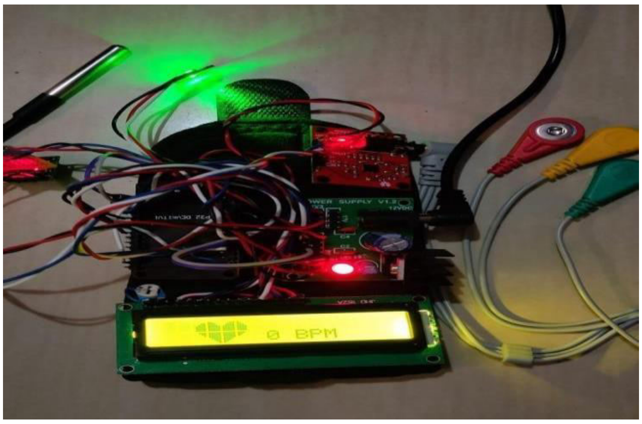

FIGURE 5. IOT System

FIGURE 6. Message to Telegram

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V. CONCLUSION AND FUTURE WORK

In conclusion, the Warrior Health Condition and Location Tracking system offers a significant advancement in ensuring the health and safety of military personnel. By leveraging machine learning for early detection of health issues and real- time tracking of soldiers' health and location via IoT and GPS, the system enhances timely intervention and decision- making. The integration of wearable technology ensures continuous monitoring, allowing for proactive measures during operations. This innovative solution not only improves soldiers' well-being but also strengthens communication and coordination in critical situations, ultimately contributing to the success of military missions.

The Warrior Health Condition and Location Tracking system can be enhanced by integrating more advanced health monitoring technologies, such as real-time biomarker analysis and stress level detection. Expanding the system to support predictive analytics based on broader health data, including fatigue levels and mental health assessments, could improve overall soldier wellness. Additionally, incorporating AI-driven algorithms for more accurate health predictions and GPS-based geofencing for automatic alerts could further increase the system's reliability and responsiveness. The system can also be expanded for use in non-military sectors like disaster response teams, providing broader application for critical health and location tracking. Lastly, enhancing the mobile interface with augmented reality (AR) features could provide intuitive, real-time feedback for both soldiers and commanders in the field.

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