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Low-Power Lora-Based Soldier Safety Mechanism For Integrated Health Status Monitoring And Gps Location Transmission

[1]Shireen Almas, [2]Pallavi Patil
[1]Student,[2]Professor
[1]VLSI and Embedded Systems,[2]Electronics and Communication Engineering,
[1]VTU CPGS, Kalaburagi,Karnataka,India

Abstract: LoRa (Long Range) technology has emerged as a highly efficient low-power wireless communication standard capable of supporting long-distance data transmission, making it suitable for defense and critical monitoring applications. In modern military operations, continuous health monitoring and accurate geolocation of soldiers are essential to ensure safety and enhance mission outcomes. This study presents a low-power LoRa-based soldier safety mechanism that integrates biomedical sensors with GPS tracking for real-time data acquisition and transmission. The system utilizes sensors to measure vital health parameters such as heart rate, pulse rate, and body temperature, while GPS provides precise geolocation data. All collected information is processed by a microcontroller and transmitted through a LoRa transceiver to a base station for continuous monitoring. In emergency situations, anomalies in health readings or the activation of a panic button generate immediate alerts, enabling faster medical response and tactical decision-making. The proposed design demonstrates a reliable, cost-effective solution to safeguard soldier lives and optimize battlefield strategies.

Index Terms – LoRa, IoT, Soldier Safety, GPS Tracking, Health Monitoring, Wireless Communication, Panic Button, Low-Power System.

I. Introduction

In In modern military operations, safeguarding the lives of soldiers is one of the highest priorities. Soldiers often operate in hostile environments where real-time monitoring of health conditions and location is crucial for survival, rapid medical assistance, and effective mission planning. The absence of timely information regarding a soldier's physical status or exact position can result in delayed medical aid, increased fatalities, and reduced operational efficiency. Therefore, the integration of advanced monitoring systems into defense technologies has become a significant research focus.LoRa (Long Range) technology has emerged as a promising solution for such applications due to its ability to support long-range, low-power wireless communication. Unlike conventional communication methods such as GSM, Wi-Fi, or ZigBee, LoRa provides greater range with minimal energy consumption, making it highly suitable for wearable soldier equipment. By combining LoRa with the Internet of Things (IoT), continuous data transmission of critical information becomes feasible even in remote or infrastructure-deficient battlefields.The proposed system integrates biomedical sensors with a GPS module to create a comprehensive monitoring solution. Sensors measure vital signs such as body temperature, heart rate, and pulse rate, while the GPS module provides real-time location data. The information is processed by an embedded microcontroller and transmitted via a LoRa transceiver to the base station, where it is displayed through a graphical user interface (GUI). In emergency scenarios, abnormal sensor readings or the activation of a panic button trigger immediate alerts, enabling rapid intervention and improved decision-making by the control unit.This approach not only enhances soldier safety but also aids in strategic planning by providing commanders with real-time data on troop health and distribution. The system's low power consumption, long communication range, and cost-effectiveness make it a reliable solution for defense applications. Ultimately, the integration of LoRa with health monitoring and geolocation technologies represents a significant advancement in soldier support systems, bridging technological innovation with battlefield resilience and operational readiness.

II. RELATED WORKS

Article [1]"IoT Based Healthcare Monitoring and Tracking System for Soldiers Using ESP32" by Sujitha V., Deepa S., and Karthik R. in 2022: This study introduced an IoT framework for tracking soldiers' health and location using ESP32 and wearable sensors. The system collected real-time vitals such as heart rate and temperature. GPS data was integrated for geolocation, and results were transmitted wirelessly to a command center. The authors emphasized cost-efficiency and low latency. Experimental results demonstrated reliable soldier tracking even under adverse conditions. The paper also discussed data security challenges. Its contribution lies in combining health monitoring and GPS into a single compact IoT solution.

Article[2]"Soldier Health and Position Tracking System" by Kiran S., Manoj A., and Prasad R. in 2024: This work developed a wearable device to monitor soldiers' biomedical parameters and track their exact positions. The system combined GPS modules with heartbeat and temperature sensors. Data was processed using an Arduino microcontroller and displayed at the base station. LoRa was chosen for long-distance communication to overcome GSM limitations. The research highlighted energy efficiency and extended field usability. Results showed accurate real-time tracking with minimal data loss. This system enhanced military operational awareness and medical responsiveness.

Article [3]"Soldier Health Monitoring and Position Tracking Using GPS and LoRa Module" by V.D. Raskar and Mahesh K. in 2023: This paper presented a LoRa-driven solution to track soldier location and health in real time. Sensors continuously measured heart rate and body temperature. GPS provided precise location details transmitted to the command center. LoRa enabled communication over several kilometers with low power consumption. The study discussed its advantage over GSM in remote terrains. Practical implementation showed robust results in accuracy. The solution ensures enhanced safety and timely medical response in battlefield conditions.

Article[4]"Wearable Computing for Defence Automation" by P.K. Sharma, A. Verma, and R. Singh in 2020: The paper explored the use of wearable computing for military defense applications. Smartwatches equipped with sensors tracked soldier health indicators such as body temperature and pulse. Additional modules measured environmental factors like altitude and position. Data was processed and transmitted wirelessly for centralized monitoring. The research identified key challenges in power management and robustness. It proposed IoT integration for efficient battlefield automation. The paper laid the foundation for future soldier health tracking systems.

Article[5]"Mesh Wearables Meld Microsensors and LoRa Smarts" by K. Clark and R. Fisher in 2024: This Spectrum article described the use of LoRa in wearable mesh health monitoring systems. Instead of traditional bulky devices, microsensors were integrated into lightweight wearables. LoRa enabled efficient long-range data sharing in a soldier network. Health parameters such as pulse and oxygen saturation were monitored continuously. The research demonstrated scalability for multiple soldiers. Battery optimization strategies improved endurance. The study provided insights into future military-grade IoT wearables.

Article [6] "LoRa Based Health Monitoring and Emergency Alarm Device" by Mukhriddin Arabboev and A. Mamatqulov in 2021: The paper presented a health monitoring device integrating LoRa communication with an emergency alarm feature. Sensors monitored heartbeat and temperature parameters. In case of abnormal readings, the system triggered alerts instantly. The use of LoRa extended the communication range significantly. This approach proved energy efficient compared to GSM.

Article [7]"GPS Based Soldier Tracking and Health Indication System" by N. Sinha and R. Mehta in 2020: This study focused on tracking soldiers using GPS and monitoring their health with biomedical sensors.

Heart rate and temperature sensors formed the core of the system. Data was processed using a microcontroller and displayed on an LCD module. The GPS module provided exact geolocation of soldiers to the command station. Wireless transmission was tested using GSM.

III. Problem Statement

In modern battlefield conditions, soldiers often operate in hostile, remote, and infrastructure-deficient environments where communication and real-time monitoring are critical. However, the absence of reliable systems to continuously track soldiers' health parameters and geographical location creates serious challenges. Injuries or health deteriorations frequently go unnoticed due to the lack of immediate medical alerts, leading to delayed assistance and increased fatalities. Conventional GSM or Wi-Fi-based communication systems fail in such scenarios because of limited coverage, high power consumption, and poor reliability in rough terrains. Consequently, there exists a pressing need for an efficient, low-power, long-range monitoring system that ensures continuous health tracking and accurate location reporting of soldiers.

IV. Objectives

The primary objective of this study is to design and implement a low-power, long-range communication system using LoRa technology to enhance soldier safety through real-time monitoring and tracking. The system aims to continuously record vital health parameters such as body temperature, heart rate, and pulse rate using biomedical sensors, and to transmit this information along with GPS-based location data to a central base station. Another objective is to ensure that the system operates efficiently in remote and infrastructure-deficient battlefields, where conventional communication networks are unreliable or unavailable. Additionally, the study seeks to integrate an emergency alert feature, enabling soldiers to manually trigger notifications during critical situations. Overall, the project emphasizes the development of a reliable, scalable, and cost-effective solution to improve operational readiness and facilitate timely medical intervention in defense applications.

V. Methodology

1)Power Supply Design: The system begins with a regulated power supply derived from a 12V, 1.2Ah rechargeable battery, ensuring uninterrupted power for field operations. A voltage regulator circuit stabilizes the input to provide suitable operating voltages for Arduino Mega, sensors, LoRa module, and GPS. The regulated design prevents fluctuations that could cause sensor errors or system resets. Since soldiers may operate in extreme conditions, the power supply is optimized for reliability and endurance. The battery capacity is chosen to allow several hours of continuous usage without frequent recharging.

2)Microcontroller Integration: Arduino Mega serves as the core processing unit, managing all input and output functions. It collects sensor data, processes it, and controls communication with the LoRa and GPS modules. The choice of Arduino Mega is motivated by its high number of I/O pins, sufficient memory, and compatibility with multiple modules simultaneously. Data from the temperature sensor, heartbeat sensor, and fall detection module are processed by the microcontroller before being transmitted. The microcontroller also manages the LCD display, which shows soldier health status in real-time.

3)Temperature Monitoring:A digital temperature sensor is interfaced with the Arduino to monitor the soldier's body temperature continuously. The sensor readings are compared with medically accepted thresholds to identify abnormal conditions such as fever, hypothermia, or sudden fluctuations due to battlefield injuries. The temperature data is digitized and transmitted via LoRa to the base station for monitoring. This feature helps commanders assess soldiers' readiness and health during missions. Continuous monitoring also provides early detection of adverse medical conditions, reducing chances of delayed treatment.

4)Heartbeat Monitoring:A heartbeat sensor is employed to track the pulse rate in beats per minute (BPM). The analog output from the sensor is converted into digital data by the Arduino for real-time processing. The system checks whether the heart rate lies within the normal range of 60–100 BPM. Abnormalities such as tachycardia (rapid heartbeat) or bradycardia (slow heartbeat) trigger alerts. This information is vital for identifying soldiers under stress, fatigue, or injury. The processed data is transmitted wirelessly to the base unit, providing critical medical insights.

5) Fall Detection Mechanism: The fall detection sensor identifies sudden impacts or falls, which may occur due to injuries or loss of consciousness during combat. The module provides a binary signal to the Arduino, which interprets the soldier's movement condition. If a fall is detected, the system triggers an emergency notification to the base station, along with GPS coordinates. This ensures that medical assistance can be dispatched promptly. The inclusion of fall detection increases reliability and extends the system's utility beyond basic health monitoring.

6)GPS-Based Location Tracking: The GPS module is responsible for providing accurate latitude and longitude coordinates of the soldier's location. Data from the GPS receiver is transmitted to Arduino using serial communication, processed, and sent to the base station via LoRa. The tracking allows commanders to visualize soldier positions in real-time on a map, aiding mission planning and rescue operations. In case of an emergency, the exact location of the injured soldier can be pinpointed. This feature reduces search time and ensures faster response in critical conditions.

VI. COMPONENTS USED

1)**LoRa SX1278 Ra-02:**The LoRa SX1278 Ra-02 is a low-power, long-range transceiver module that operates in the 433/868/915 MHz frequency bands. It supports reliable wireless communication over several kilometers, making it ideal for remote monitoring applications. The module uses LoRa modulation to minimize energy consumption while maximizing signal penetration and range. In the proposed system, it transmits health and location data from the soldier to the base station efficiently.

2)Arduino UNO: The Arduino UNO is a widely used microcontroller board based on the ATmega328P chip. It provides multiple digital and analog I/O pins for interfacing sensors, displays, and communication modules. Its ease of programming and compatibility with various libraries make it suitable for rapid prototyping and embedded applications. In this project, it processes sensor inputs, controls the LCD, and manages LoRa communication.

3)LM35 Temperature Sensor: The LM35 is a precision analog temperature sensor that provides a voltage output directly proportional to the measured temperature. It offers accurate readings with minimal calibration and operates over a wide temperature range. Its low power requirement and simple interfacing with microcontrollers make it ideal for wearable systems. In the soldier safety mechanism, it continuously monitors body temperature to detect abnormal conditions.

4)**MAX30102 Heart Rate Sensor:**The MAX30102 is an integrated optical sensor capable of measuring heart rate and blood oxygen levels (SpO2) non-invasively. It uses LED emitters and a photodetector to detect pulse signals through the skin. The sensor communicates via I2C, enabling easy integration with microcontrollers. In the proposed system, it provides real-time pulse monitoring to assess soldier health and trigger alerts in emergencies.

5)**NEO-6M GPS Module:**The NEO-6M GPS module provides accurate positioning data by receiving signals from multiple satellites. It outputs latitude, longitude, speed, and time information via serial communication. Its compact size, low power consumption, and fast signal acquisition make it suitable for wearable tracking devices. In this project, it enables real-time geolocation of soldiers for operational tracking and emergency response.

6)16×2 LCD Display: The 16×2 LCD display is a simple alphanumeric screen capable of showing two lines of sixteen characters each. It interfaces easily with microcontrollers through parallel or I2C communication, providing a visual representation of sensor readings. The display allows soldiers to monitor their own health parameters and system status in real time. In the proposed setup, it presents temperature, heart rate, and alerts directly on the wearable device.

VII. SYSTEM ARCHITECTURE

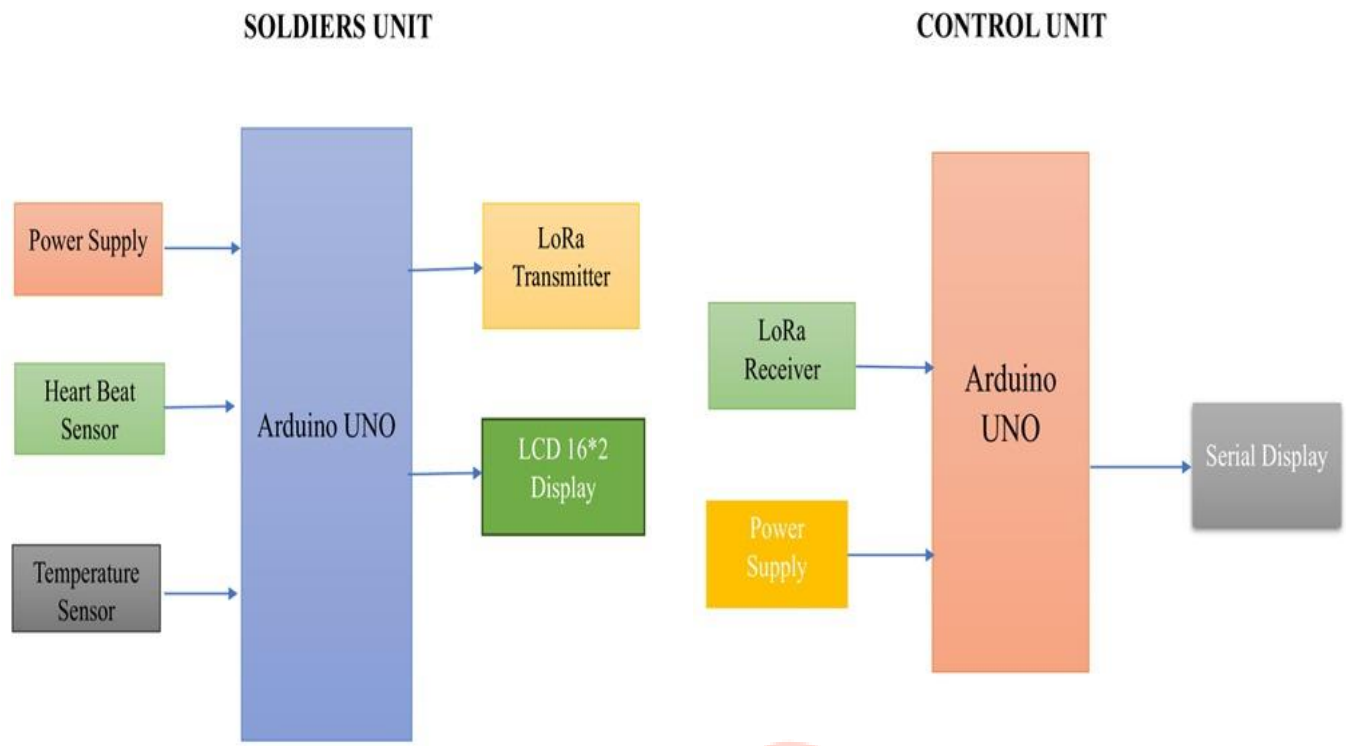

Fig 1:System Architecture

The system architecture of the proposed soldier safety mechanism is illustrated in Fig. 1. The design integrates multiple sensing and communication modules with an Arduino Mega microcontroller, which functions as the central processing unit. A regulated power supply, supported by a 12V @ 1.2Ah rechargeable battery, delivers stable power to all components, ensuring uninterrupted operation even in remote environments.The biomedical monitoring unit consists of a temperature sensor, a heartbeat sensor module, and a fall detection module. These sensors continuously measure vital health parameters such as body temperature, heart rate, and sudden physical impacts indicative of falls. The acquired data is sent to the Arduino Mega for processing and analysis.For location tracking, a GPS module is interfaced with the Arduino, enabling real-time acquisition of geographical coordinates. This allows precise monitoring of the soldier's movement and current position. The processed health and location data are then transmitted to the control unit through a LoRa communication module, which provides long-range, low-power wireless connectivity, making it suitable for battlefield conditions where conventional networks may fail.An LCD display is included in the architecture to provide the soldier with immediate feedback regarding sensor readings and system status. This enhances transparency and ensures that the soldier is aware of the monitoring system's functioning. The modular design of the system enables easy expansion with additional sensors or features in the future.Overall, the architecture emphasizes reliability, portability, and real-time operation, ensuring efficient health and location monitoring while maintaining low power consumption.

VIII. CONCLUSION

In this research, a low-power, LoRa-based soldier safety mechanism was designed and analyzed to enhance the real-time monitoring of soldiers' health and geolocation during battlefield operations. The study successfully demonstrated the integration of biomedical sensors, including temperature and heart rate modules, with a GPS tracking system, all coordinated through an Arduino microcontroller. By leveraging LoRa communication, the system achieves long-range data transmission while maintaining minimal power consumption, overcoming the limitations of conventional communication networks such as GSM or Wi-Fi, especially in remote and infrastructure-deficient environments. The inclusion of a fall detection mechanism and an emergency panic button provides an additional layer of safety, ensuring that medical assistance can be dispatched promptly in critical situations. Furthermore, the incorporation of a 16×2 LCD display allows soldiers to view their health status and system notifications in real time, promoting situational awareness and operational confidence. The modular and scalable architecture of the proposed system enables future enhancements, such as additional health sensors, environmental monitoring units, or improved communication protocols, without compromising reliability or portability. Overall, this research highlights the potential of combining IoT technologies, low-power wireless communication, and wearable sensing devices to create a comprehensive soldier support system. The findings indicate that the proposed mechanism can significantly reduce response times in emergencies, improve tactical decision-making, and enhance overall operational readiness. Ultimately, the study contributes a practical, cost-effective, and technologically advanced solution that prioritizes soldier safety while bridging the gap between real-time health monitoring and battlefield resilience.

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