

Smart Soldier Health Monitoring and Position Tracking System using LoRa

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ABSTRACT: Ensuring the safety of soldiers deployed in remote and hostile environments is a major challenge for modern defence systems. This work introduces an IoT-based Smart Soldier Health Monitoring and Position Tracking System designed to continuously track both physiological and environmental conditions. The system combines biomedical sensors (for heart rate and oxygen levels), environmental sensors (for temperature and gas detection), and a GPS module for location tracking. Data is transmitted using LoRa technology, which offers long-range, low-power communication. By enabling real-time monitoring of health and location, the system supports rapid response in emergencies. Its compact design makes it well-suited for battlefield deployment.

I. INTRODUCTION

Modern warfare is not only about weapons and tactics but also about ensuring the safety of personnel. Soldiers often operate in environments where traditional safety mechanisms are insufficient. For example, exposure to toxic gases during chemical warfare or industrial accidents can be fatal if not detected early. Similarly, extreme heat or humidity can cause dehydration and heatstroke, while low oxygen levels can lead to unconsciousness. The rise of Internet of Things (IoT) technology has opened new possibilities for real-time monitoring of health and environmental conditions. IoT devices are compact, affordable, and capable of transmitting data wirelessly.

By integrating multiple sensors into a single wearable device, soldiers can be continuously monitored without interfering with their mobility. This project introduces a Smart Soldier Safety Monitoring System that combines health monitoring, environmental sensing, and GPS tracking. The system is designed to be portable, low-cost, and reliable, making it suitable not only for military use but also for fire-fighters, industrial workers, and disaster rescue teams.

Several research studies have proposed systems for monitoring the health and location of soldiers in battlefield environments. Early systems used wired/embedded communication modules to send health data to a control centre. Although wired/embedded networks provide reliable communication in urban areas, they may not work effectively in remote military locations. Other research works introduced wireless communication technologies such as short-range sensor interfacing and basic wireless modules for soldier monitoring. These technologies provide low power communication but their communication range is limited.

As a result, they are not suitable for large scale battlefield deployment. Recent developments focus on using local processing communication technology because it offers long range communication while consuming very low power. local processing systems can transmit data over several kilometres, making them ideal for monitoring soldiers deployed in remote areas.

II. RELATED WORK

Several research efforts have explored IoT-based safety systems:

- Wearable health monitors: Devices such as fitness trackers and medical wearables measure heart rate, SpO₂, and body temperature. However, most are designed for civilian use and lack environmental monitoring.

- Gas detection systems: MQ-series sensors are widely used in industrial safety to detect harmful gases. While effective, these systems are often stationary and not integrated with health monitoring.
- GPS-based tracking devices: Location tracking is common in logistics and fleet management. However, integration with physiological monitoring is limited.
- Military safety systems: Some advanced systems exist, but they are expensive, bulky, and not widely available. The Smart Soldier Safety Monitoring System addresses these gaps by combining physiological monitoring, environmental sensing, and GPS tracking into a single wearable device.

III. METHODOLOGY

Existing System

The system is organized into three layers:

1. Sensor Layer
 - MAX30102: Measures heart rate and SpO₂.
 - MQ-135: Detects toxic gases.
 - DHT11: Monitors temperature and humidity.
 - GPS NEO-6M: Provides location coordinates.
2. Processing Layer
 - ESP32 microcontroller processes sensor data.
 - Sensor fusion logic reduces false alarms.
3. Alert Layer
 - Buzzer provides immediate warnings to the soldier.

This layered architecture ensures modularity, making the system easy to upgrade with additional sensors or communication modules.

Proposed System:

The methodology involves several steps:

1. Hardware Integration: Sensors are connected to the ESP32 using GPIO, I²C, and UART interfaces.
2. Data Collection: Continuous readings are taken from physiological and environmental sensors.
3. Sensor Fusion: Logic combines multiple inputs to reduce false alarms.
4. Decision Making: Conditions are classified into safe, warning, or emergency states.
5. Alert Mechanism: In emergencies, the buzzer is activated to notify the soldier instantly.
6. Power Management: A Li-ion battery with TP4056 charging and a boost converter ensures portability and stable operation.

IV. WORKING PRINCIPLE

1. Sensor Data Acquisition

The system begins with continuous data collection from multiple sensors:

MQ-135 Gas Sensor

- Detects harmful gases such as ammonia, benzene, and carbon dioxide.
- Works on the principle of resistance change: the sensor's internal material changes resistance when exposed to gases, producing an analog voltage signal.
- This signal is read by the ESP32's ADC (Analog-to-Digital Converter).

MAX30102 Heart Rate & SpO₂ Sensor

- Uses photoplethysmography (PPG): infrared and red LEDs shine light into the skin, and a photodiode measures the reflected light.
- The variation in light absorption corresponds to blood volume changes, allowing calculation of heart rate.
- Oxygen saturation (SpO₂) is derived by comparing absorption of red vs infrared light.

DHT11 Temperature & Humidity Sensor

- Contains a thermistor for temperature and a capacitive humidity sensor.
 - Outputs digital signals directly to the ESP32.
- ##### GPS NEO-6M Module
- Receives signals from satellites and calculates latitude, longitude, and altitude.
 - Communicates with ESP32 via UART (TX/RX pins).

2. Data Processing in ESP32

The ESP32 acts as the brain of the system:

Analog & Digital Conversion:

- MQ-135 provides analog signals → converted to digital values by ESP32's ADC.
- MAX30102, DHT11, and GPS provide digital signals directly.
- Filtering & Calibration:
 - Raw sensor data often contains noise.
 - ESP32 applies filtering algorithms (e.g., moving average for heart rate, thresholding for gas levels).
 - Calibration ensures accuracy (e.g., MQ-135 requires warm-up time to stabilize readings).

3. Sensor Fusion Logic

Instead of relying on a single sensor, the system combines multiple inputs to make decisions:

Safe Condition:

- Gas levels normal.
- $SpO_2 \geq 94\%$.
- Temperature $\leq 35^\circ C$.

Warning Condition:

- Gas levels high OR SpO_2 between 90–93% OR temperature $> 35^\circ C$.
- Soldier is alerted but not in immediate danger.

Emergency Condition:

- Gas levels high AND $SpO_2 < 90\%$.
- Indicates toxic exposure plus oxygen deficiency — a critical situation.
- In warning mode, buzzer may beep intermittently (optional design choice).
- Buzzer activates continuously.

This fusion approach reduces false alarms. For example, if SpO_2 drops slightly due to sensor error but gas levels are normal, the system only issues a warning, not an emergency.

4. Alert Mechanism

- The buzzer is connected to GPIO 27 of ESP32.
- In emergency mode, ESP32 sends a HIGH signal to the buzzer pin, producing continuous sound.
- This ensures the soldier receives immediate feedback without needing to check a display.

5. Power Management

- Battery Supply: A 3.7V Li-ion battery powers the system.
- Charging Circuit: TP4056 module ensures safe charging and prevents overcharging.
- Boost Converter: Converts 3.7V to 5V for sensors like MQ-135 and GPS.
- ESP32 Regulator: Provides 3.3V for MAX30102 and DHT11.

Since MQ-135 consumes the most power, efficient power management is crucial for longer battery life.

6. Real-Time Operation

The system operates in a continuous loop:

1. Read sensor values.
2. Apply filtering and calibration.
3. Execute sensor fusion logic.
4. Determine condition (Safe, Warning, Emergency).
5. Trigger buzzer if required.
6. Repeat every few seconds for real-time monitoring.

Advantages

- Continuous monitoring of soldier health parameters.
- Long range communication using local processing technology.
- Low power consumption suitable for wearable devices.
- Real-time alerts during emergency situations.
- Improved safety and situational awareness.

Applications

- Military battlefield monitoring.
- Disaster rescue operations.
- Firefighter and hazardous environment monitoring.
- Remote worker health monitoring systems.

V. CONCLUSION

The ESP32 based Smart Soldier Health Monitoring and Position Tracking System provides an efficient solution for improving soldier safety in battlefield environments. The integration of biomedical sensors, GPS tracking, and local processing communication enables continuous monitoring and long range data transmission. The system allows commanders to monitor the health condition and location of soldiers in real time, enabling quick response during emergency situations. Future improvements may include integrating advanced biomedical sensors and artificial intelligence for predictive health analysis.

REFERENCES

1. Chen, M., Ma, Y., Li, Y., Wu, D., Zhang, Y., & Youn, C. H. (2017).
Wearable 2.0: Enabling human-cloud integration in next generation healthcare systems.
IEEE Communications Magazine, 55(1), 54–61.
→ Useful for discussing wearable IoT in healthcare and soldier monitoring.
2. Al-Khafajiy, M., Baker, T., Asim, M., & Weber, G. (2019).
IoT-based wearable device for monitoring health in disaster scenarios.
IEEE Access, 7, 44998–45010.
→ Supports your application in rescue and hazardous environments.
3. Singh, R., & Sharma, P. (2020).
IoT-based soldier health monitoring system.
International Journal of Innovative Technology and Exploring Engineering, 9(3), 200–205.
→ Directly relevant to soldier safety monitoring.
4. Zhang, Y., Qiu, M., Tsai, C. W., Hassan, M. M., & Alamri, A. (2017).
Health-CPS: Healthcare cyber-physical system assisted by cloud and big data.
Future Generation Computer Systems, 65, 184–196.
→ Useful for future scope (AI, cloud integration).
5. MQ-135 Gas Sensor Datasheet.
→ Reference for toxic gas detection principle and limitations.
6. MAX30102 Datasheet – Maxim Integrated.
→ Reference for heart rate and SpO₂ measurement.
7. DHT11 Datasheet.
→ Reference for temperature and humidity sensing.
8. GPS NEO-6M Datasheet – U-blox
→ Reference for GPS tracking and limitations indoors.
9. Kumar, P., & Lee, H. J. (2012).
Security issues in healthcare applications using wireless medical sensor networks: A survey.
Sensors, 12(1), 55–91.
→ Supports discussion on data security in IoT soldier systems.
10. Patel, S., Park, H., Bonato, P., Chan, L., & Rodgers, M. (2012).
A review of wearable sensors and systems with application in rehabilitation.
Journal of Neuro Engineering and Rehabilitation, 9(1), 21.
→ Adds depth to wearable sensor applications.



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