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ORIGINAL ARTICLE

Live Soldier Health Monitoring System

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Abstract

A wearable IoT device for real-time soldier health surveillance is presented in this paper. Physiological parameters including heart rate, blood-oxygen saturation, and body temperature are continuously acquired through an embedded sensor array interfaced with an ESP32 microcontroller. Geographic location, movement speed, and field position are tracked via an integrated GPS module. Aggregated telemetry is relayed to a cloud dashboard over Wi-Fi under standard operational conditions; when network coverage is unavailable, A secondary GSM channel autonomously delivers critical data to a command terminal via SMS. The layered communication strategy substantially improves resilience in contested or remote environments, yielding a compact, low-cost platform suitable for large-scale military deployment.

Keywords: Soldier Health Monitoring, Wearable Sensors, GPS Tracking, Dual Communication, Cloud Integration

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Introduction

Contemporary military operations require continuous, realtime knowledge of each soldier's physical condition, geographic coordinates, and movement speed. Conventional field equipment provides only radio-based positional data and lacks integrated physiological telemetry, leaving medical emergencies undetected until a casualty is physically located.

Literature Survey

Military wearable technology has evolved from simple GPS beacons to multi-parameter physiological sensing platforms. Kumar *et al.*(1) showed that unified IoT sensor frameworks reduce field emergency response times; however, their architecture assumes persistent internet connectivity—a condition rarely guaranteed in combat zones. The MAX30102 pulse oximeter has been validated for linked to a cloud dashboard and a GSM SMS failsafe & ensures telemetry reaches command infrastructure even when field network coverage degrades, eliminating the single point of failure found in internet-only solutions.

The proposed system addresses this gap by fusing biometric sensing, environmental monitoring, and GPS-based tracking into a single wearable unit centered on the ESP32 microcontroller.

System Block Diagram

IoT-based Live Soldier Health Monitoring System. Input sensors feed data into the ESP32 central processing unit, which routes telemetry through two independent communication pathways: a Wi-Fi link to the Ubidots IoT cloud platform from which data is forwarded to a personal web dashboard and a SIM800L GSM Module that delivers speed and position tracking, and dual-channel communication redundancy.

SMS alerts directly to a mobile phone at the command center when cloud connectivity is unavailable. Most prototypes offer no fallback when Wi-Fi or cellular data fails, and (2) confirmed that single-channel soldier trackers are vulnerable to outages in urban canyons and remote terrain. Commercially available military wearables still predominantly target either location or health monitoring in isolation, at prohibitive per-unit cost(3). The proposed system directly addresses all three deficiencies through multiparameter sensing, GPS-based (Fig. 1) presents the end-to-end architecture of the proposed

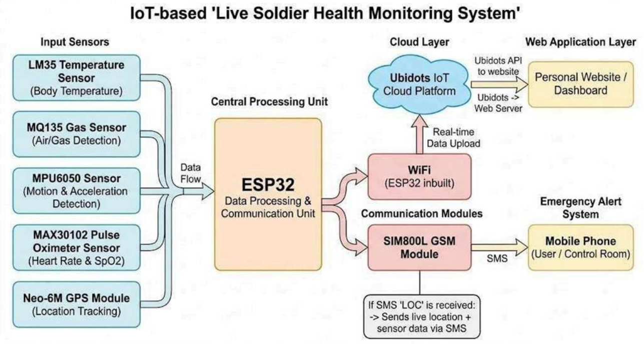


Fig. 1: Block diagram of the IoT-based 'Live Soldier Health Monitoring System'

Table 1: Hardware Component Specifications and Sensor Ranges

Component	Interface	Measurement Range	Resolution /Accuracy	Purpose
ESP32	Main Board	—	240 MHz dual-core	Processing and Wi-Fi communication
MAX30102	I2C	SpO_2: 0–100%; HR: 0– 300 bpm	±2% SpO_2, ±3 bpm	Heart rate and SpO_2 monitoring
LM35	Analog	−55°C to +150°C	10 mV/°C (±0.5°C)	Body temperature measurement
MQ135	Analog	10–300 ppm (NH_3, NO_x, CO_2)	±5 ppm	Air quality and gas detection
MPU6050	I2C	Accel: ±2g to ±16g; Gyro: ±250–2000°/s	16-bit ADC	Motion and fall detection
Neo-6M GPS	UART	Lat/Long; Speed: 0–515 m/s	2.5 m CEP	Location and speed tracking
SIM800L	UART	GSM 850/900/1800/ 1900 MHz	AT command protocol	Emergency SMS communication

(Table. 1) enumerates the hardware components along with broad spectrum of hazardous compounds—including their communication interfaces, measurable parameter ranges, ammonia (NH_3), nitrogen oxides (NO_x), benzene, alcohol, and resolution characteristics. The MQ135 gas sensor is smoke, and carbon dioxide (CO_2)—making it well suited to particularly noteworthy for its ability to detect a both combat and industrial monitoring scenarios.

Methodology

A. Hardware Configuration

The ESP32 acts as the central hub, interfacing with the MAX30102 (SpO2/HR, I2C), LM35 (temperature, analog), MQ135 (gas, analog), and MPU6050 (motion/fall, I2C) for biometric and environmental sensing. A Neo-6M GPS module (UART) provides real-time location and speed, while a SIM800L GSM modem (UART) handles emergency SMS. All components are integrated on a custom PCB for compactness and field durability, as shown in (Fig. 2).

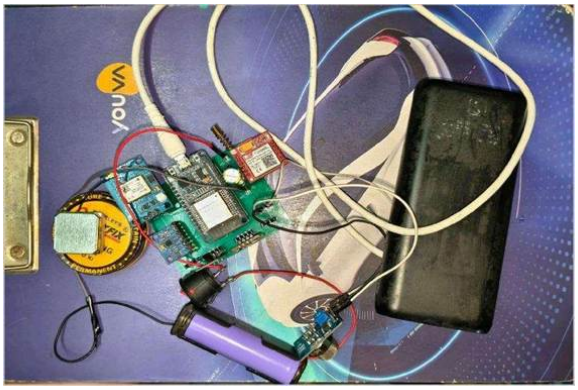


Fig. 2: Assembled prototype showing the ESP32, SIM800L GSM module, Neo-6M GPS, battery pack, and interconnecting PCB wiring

B. Operational Workflow

On startup the firmware initializes all peripherals, acquires a GPS fix, and connects to Wi-Fi. The main loop then executes continuously: (1) read all sensors; (2) compute health and environmental indices; (3) obtain GPS location and speed; (4) publish a telemetry packet to Ubidots; (5) evaluate the MPU6050 output for a fall signature—dispatching an autonomous GSM alert if triggered; (6) poll the GSM buffer for location-request messages and respond if present; (7) repeat.

Software Architecture and Design

The firmware is organized into four layers running on the ESP32. The *Acquisition Layer* reads all sensors and converts raw values (e.g., MPU6050 output to m/s^2). The *Analytics Layer* implements fall detection: a sustained acceleration spike followed by near-zero motion triggers an immediate GSM distress alert without operator input. The *Cloud Synchronization Layer* packages sensor data as a JSON payload and pushes it to Ubidots via Wi-Fi on a configurable schedule. The *FailSafe Communication Layer* manages the SIM800L via AT commands, Handling both autonomous fall alerts and on-demand location responses.

Results and Discussion

Functional validation was carried out under controlled laboratory conditions designed to replicate plausible field scenarios, including simulated network outages and induced fall events. All subsystems performed within acceptable bounds across repeated trials. The Ubidots dashboard (Fig. 3) confirmed live reception of multi-parameter telemetry, displaying per-unit heart rate, SpO2, Temperature, and GPS coordinates alongside color-coded triage indicators (Normal / Warning / Critical). Emergency SMS messages containing geographic coordinates and current vital readings were successfully received at the command terminal within the measured latency windows. (Table. 2) Summarizes key performance figures recorded during the evaluation.

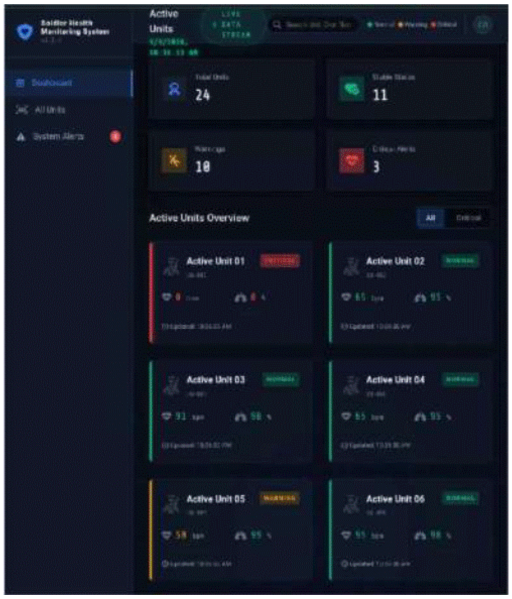
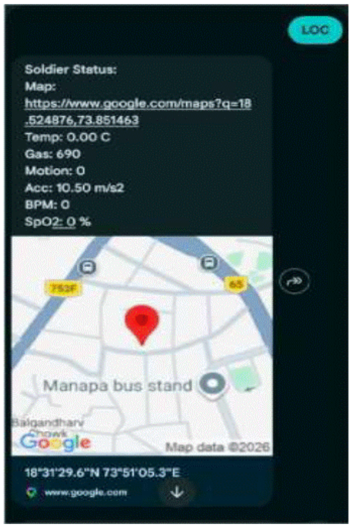


Fig. 3: Live monitoring dashboard: active unit overview with real-time heart rate, SpO_2, and triage status

Under simulated connectivity failure, the GSM modem reliably assumed the communication role without manual intervention, confirming the failsafe design. The sub-one second fall-detection response is operationally significant where delayed intervention is life-threatening. primary limitations are power consumption—simultaneous Wi-Fi, GPS, and GSM operation constrains battery life—and sensor accuracy dependence on calibration; both are addressable through duty-cycling and a pre-deployment calibration protocol in future revisions.



Soldier Status:
Map:
https://www.google.com/maps?q=18.524876,73.851463
Temp: 0.00 C
Gas: 690
Motion: 0
Acc: 10.50 m/s2
BPM: 0
SpO2: 0 %

18°31'29.6"N 73°51'05.3"E

Fig. 4: SMS payload received at command terminal: GPS coordinates, temperature, gas level, acceleration, BPM, and SpO_2

Table 2: Measured System Performance Metrics

Parameter	Sensors Involved	Measured Value	Description
Full Sensor Cycle Time	MAX30102, LM35, MQ135, MPU6050	~0.5 s	Duration to acquire and preprocess one complete sensor frame
GPS Acquisition Latency	Neo-6M GPS	< 2 s	Time to obtain a valid location and velocity fix after power-on
Cloud Upload Period	All sensors (via ESP32 Wi-Fi)	< 10 s	Interval between successive telemetry packets delivered to Ubidots
Fall-Detection Trigger Latency	MPU6050	< 1 s	Elapsed time from fall-event onset to GSM alert dispatch
SMS End-to-End Delivery	SIM800L GSM	~5.1 s	Total time from GSM transmit command to confirmed reception at command terminal

Practical Implications and Future Scope

The System targets three application domains: (i) combat units needing continuous health visibility under limited connectivity; (ii) disaster search-and-rescue teams operating in degraded infrastructure; and (iii) hazardous industrial facilities requiring gas monitoring and fall detection. The Custom PCB allows integration into standard load-bearing military gear without additional Bulk.

Future iterations will replace Wi-Fi with LoRa for multikilometre range in GSM-denied environments, add on-device ML-based predictive health alerting, and implement end-to-end payload encryption to protect sensitive biometric and location data in adversarial environments.

Conclusion

This paper presented an ESP32-based IoT wearable device that unifies physiological sensing, GPS tracking, environmental monitoring, and fall detection with a redundant Wi-Fi/GSM communication backbone. Experimental evaluation confirmed reliable GSM failsafe operation during simulated outages and sub-one-second fall-detection response—both operationally critical for field deployment. The MAX30102 (±2% SpO_2) and Neo-6M GPS (2.5 m CEP) meet field-grade accuracy requirements, while the custom PCB keeps the platform compact and affordable compared to existing military-grade systems.

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