Wearable Tracker to Detect Location & Vital Signs of Victims During Disaster

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Abstract — Disasters such as earthquakes, landslides, floods, and structural collapses make victim detection extremely challenging due to blocked communication paths and lack of real-time information. Traditional rescue operations rely heavily on manual search and delayed reporting, resulting in slow response and higher mortality rates. To address these challenges, this work proposes a *wearable IoT-based tracker* capable of continuously monitoring critical vital signs—heart rate, SpO_2, body temperature, and motion—along with real-time GPS location of victims. Sensor data is processed on an ESP32 microcontroller and transmitted via Wi-Fi to a cloud backend for live visualization through a mobile dashboard. The system enables faster detection, accurate victim localization, automated alerts, and data-driven rescue prioritization, making it highly suitable for real-world disaster scenarios. The proposed solution is *low-cost, rugged, energy-efficient,* and scalable for large deployments.

Index Terms— Disaster Management, Emergency Response, GPS Tracking, Vital Signs Monitoring, Wearable IoT.

I. INTRODUCTION

Natural and man-made disasters frequently cause large-scale destruction, leaving victims trapped under debris, displaced, or injured. In such scenarios, **time-critical rescue operations** rely on quick identification of a victim's physical condition and exact location. However, traditional search-and-rescue (SAR) techniques depend on visual inspection, manual surveying, and communication through intermediaries—all of which significantly delay response time.

Modern IoT and embedded technologies enable compact wearable devices that deliver **continuous health monitoring**, **GPS tracking**, and **wireless communication**, making them highly effective for disaster response. Existing systems focus on either location tracking or health monitoring but rarely combine both in a cost-efficient and field-ready design.

This research presents a **Wearable IoT-Based Disaster Tracker**, designed to deliver *real-time vital data, GPS coordinates,* and *motion status* of individuals stranded during disasters. The proposed system ensures seamless visibility for rescue authorities through a dedicated dashboard, improving **situational awareness**, **rescue coordination**, and **survival probability**.

II. LITERATURE REVIEW

Recent advancements in wearable IoT systems highlight their growing relevance in disaster management:

- **GPS-based disaster tracking systems** demonstrate reliable location extraction but lack physiological monitoring, limiting their usefulness in prioritization scenarios. Systems described in prior IRJET studies focus on RF-based GPS transmission but do not integrate health sensing.
- **Health-monitoring wearables**, such as those equipped with MAX30100/MAX30102 or temperature sensors, have been widely used for fitness and medical monitoring. However, most lack rugged design and do not incorporate geospatial tracking required during disasters.
- **Earthquake early-warning systems** using accelerometers (ADXL series) improve hazard detection but do not provide continuous victim health updates post-disaster.
- **IoT-enabled emergency response frameworks** emphasize the importance of cloud dashboards and automated alerts for improving decision-making during crises.

The review highlights a significant research gap: *There is no unified, low-cost wearable device that simultaneously tracks victim location, vital signs, and motion with cloud-based remote monitoring.*

The proposed system addresses this gap through a fully integrated hardware–software solution.

III. PROBLEM STATEMENT

Rescue teams face multiple challenges during disaster operations:

- **Absence of real-time vital signs**, making it hard to identify unconscious or critically injured victims.
- **Difficulty in locating victims** trapped under collapsed structures without access to GPS data.

- **Poor communication and lack of synchronized data**, leading to inefficient coordination.
- **No structured prioritization**, as rescuers cannot differentiate stable victims from critical ones.
- **Unpredictable and harsh environment constraints**, requiring rugged, low-power devices.

A unified, intelligent, and automated wearable system is essential to overcome these limitations.

IV. OBJECTIVES

The key objectives of this research are:

1. **To design a wearable device** capable of continuously monitoring heart rate, SpO_2, body temperature, motion, and falls.
2. **To integrate GPS tracking** for accurate, real-time location monitoring.
3. **To enable IoT-based wireless transmission** of physiological and positional data.
4. **To develop a cloud backend** for live visualization, alerting, and data storage.
5. **To create a responder dashboard/mobile interface** for efficient rescue coordination.
6. **To deliver a low-cost, compact, and energy-efficient solution** suitable for real-world deployment.

V. SYSTEM ARCHITECTURE

The system comprises three major components:

A. Hardware Module

- **ESP32 DevKitC** – Central microcontroller with Wi-Fi, dual-core CPU, low-power mode.
- **MAX30102 Sensor** – Measures heart rate and SpO_2 using photoplethysmography (PPG).
- **DS18B20 Sensor** – Digital temperature sensor with waterproof capabilities.
- **MPU6050 Sensor** – Detects motion, falls, and sudden impact using accelerometer + gyroscope.
- **NEO-6M GPS Module** – Provides real-time latitude and longitude of the user.
- **Li-ion Battery + TP4056 Charging Module** – Ensures portability and safe battery handling.

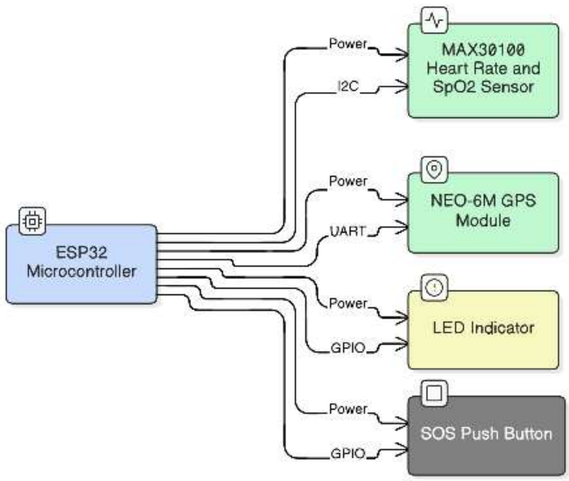

Fig. 1. Hardware workflow of the wearable disaster-response tracker system.

Hardware workflow of the proposed wearable disaster-response tracker. The power supply unit (Li-ion/Li-Po battery with TP4056 charging module) provides regulated power to the ESP32 microcontroller, which in turn interfaces with MAX30102, NEO-6M GPS, MPU6050, and DS18B20 sensors for vitals and location monitoring.

B. Software Module

- **Backend:** Node.js + Express, Firebase Realtime Database
- **Communication:** MQTT/HTTP for lightweight IoT messaging
- **Security:** JWT authentication, AES encryption
- **Frontend:** React Native application for rescuers with live dashboards.

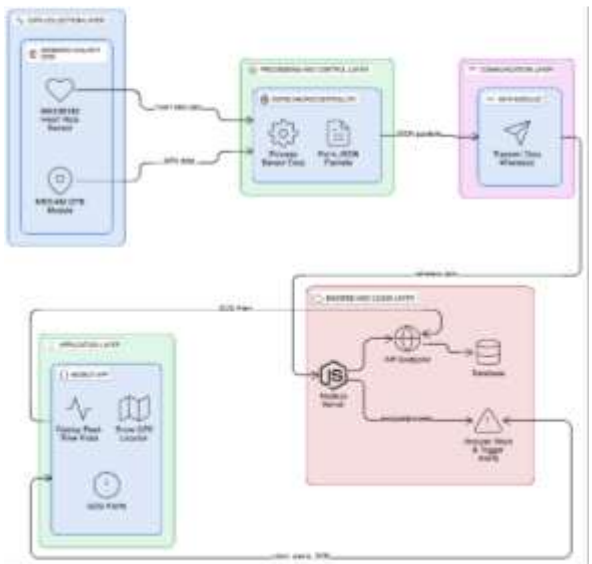

Fig. 2. Functional workflow of the proposed wearable tracker.

VI. METHODOLOGY

1. Sensor Data Acquisition

The ESP32 continuously reads:

- Heart rate & SpO_2 (MAX30102)
- Body temperature (DS18B20)
- Motion and fall data (MPU6050)
- GPS coordinates (NEO-6M).

The ESP32 continuously acquires physiological, motion, and location data from the integrated sensors. The MAX30102 module provides heart rate and SpO_2 values, while the DS18B20 sensor records real-time body temperature. The MPU6050 accelerometer-gyroscope module captures motion patterns and detects potential fall events. Additionally, the NEO-6M GPS module supplies precise geographic coordinates, enabling accurate victim localization during disaster scenarios.

2. Edge Processing

Collected data undergoes:

- Noise filtering
- Peak detection algorithms
- Motion classification
- JSON structuring for optimized transmission.

Once the raw sensor data is collected, the ESP32 performs essential preprocessing operations. Noise filtering techniques remove unwanted signal variations, while peak detection algorithms extract accurate heart rate readings from optical data. Motion data is classified to distinguish normal movement from abrupt fall activity. All processed values are thereafter structured into compact JSON packets to ensure efficient and reliable transmission over the network.

3. Cloud Transmission

Data is sent to the backend via Wi-Fi using MQTT/HTTP protocols.

The refined sensor data is uploaded to the cloud backend using the ESP32's Wi-Fi capabilities. Communication occurs through lightweight MQTT or standard HTTP protocols, enabling low-latency and energy-efficient transmission. This connectivity ensures that vitals, motion states, and location updates are continuously synchronized with the remote server.

4. Backend & Database Functions

- Data validation
- Alert generation based on thresholds
- Firebase storage and synchronization
- Anomaly detection: fall, abnormal vitals, SOS signals.

At the backend, incoming data undergoes validation to eliminate incomplete or corrupted entries. The server processes the vitals to identify abnormalities, triggers alerts for critical events such as falls or unsafe physiological readings, and manages SOS signals. Firebase is used for real-time storage and synchronization, allowing data to be instantly accessible across all client interfaces.

5. Dashboard Visualization

The dashboard displays:

- Live heart rate, SpO_2, temperature
- Motion status & fall detection
- GPS location on an interactive map
- Automatic ranking of high-risk victims

The mobile and web dashboard presents consolidated, real-time information to rescue teams. Heart rate, SpO_2, and temperature values are displayed alongside motion status and fall-detection indicators. GPS coordinates are mapped on an interactive interface, enabling quick identification of victims' locations. The system also incorporates automated ranking logic to highlight high-risk individuals who require immediate attention.

6. Alerting System

Alerts sent through:

- Firebase Cloud Messaging
- Mobile notifications
- SOS triggers.

The alerting mechanism delivers timely warnings to responders through Firebase Cloud Messaging. Mobile notifications are generated when the system detects abnormal vitals, fall events, or manual SOS triggers from the wearable device. This ensures rapid situational awareness and helps prioritize emergency response actions.

VII. RESULTS & DISCUSSION

Prototype testing showed:

- **Accurate GPS tracking** with consistent coordinate updates.
- **Reliable SpO_2 and heart rate readings**, validated against pulse oximeters.
- **Motion analysis accurately detected falls**, sudden impacts, and user inactivity.
- **Cloud dashboard displayed real-time updates** with minimal latency (~1–2 seconds).

The system effectively demonstrated:

- Faster identification of trapped victims
- Clear prioritization based on health data
- Highly stable wireless communication

- Suitability for real-world deployment due to low cost, compact size, and robustness.

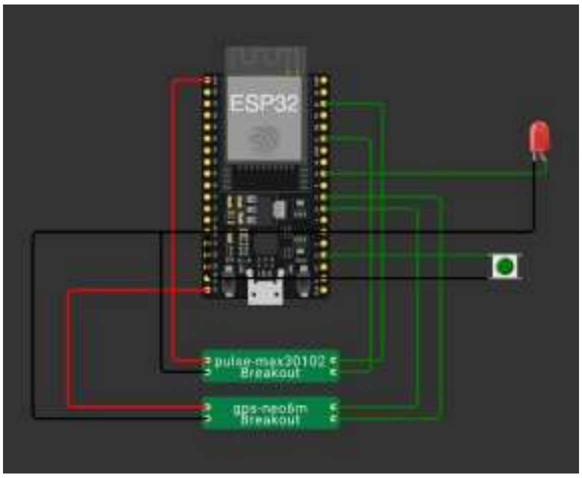

Fig. 3. Circuit schematic showing ESP32 connections with MAX30102 pulse sensor, NEO-6M GPS module, LED indicator, and push-button for system interaction.

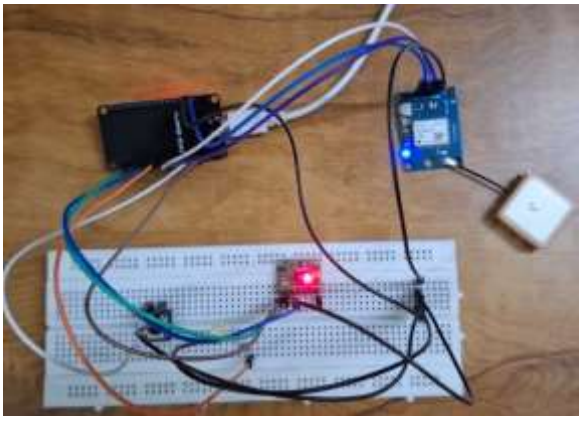

Fig. 4. Prototype hardware setup showing ESP32, MAX30102, and NEO-6M GPS modules interconnected on a breadboard for real-time vitals and location monitoring.

Detailed circuit wiring layout of the wearable tracker, showing power distribution from battery and TP4056 module, signal routing to ESP32 GPIO pins, I²C connections for MAX30102 and MPU6050, UART interface for NEO-6M GPS, and 1-Wire protocol integration for DS18B20 temperature sensing.

VIII. CONCLUSION

This research successfully develops a Wearable IoT-Based Disaster Tracker that merges real-time physiological monitoring with GPS tracking and cloud connectivity. The integrated system offers significant advantages over traditional rescue methods by enabling continuous monitoring, automated alerting, and efficient rescue coordination. The device's low power consumption, portability, and accuracy make it highly practical for large-scale disaster response.

Future enhancements include:

- LoRaWAN based long range communications
- AI-powered victim prioritization
- Solar-based charging for prolonged field use

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