

LoRa-Based Live Tracking and SOS Alert System for Emergency Location Monitoring in Remote Areas

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Abstract

Remote trekking, mountain exploration, forest travel, and other outdoor activities may take place in areas where cellular communication is weak or unavailable. During accidents, injuries, wildlife encounters, or loss of direction, a user may be unable to communicate an exact location through conventional GSM- or internet-dependent systems. This paper presents a LoRa-based live tracking and SOS alert system that integrates an ESP32 LoRa module, GPS, SOS push button, battery management, solar charging support, and a web-based monitoring dashboard. The sender unit acquires latitude and longitude information and, when an emergency is triggered, forms a data packet containing the location and alert information. The packet is transmitted through LoRa to a receiver unit, which decodes the data and forwards it to a dashboard for map-based monitoring. The revised system description provides a detailed end-to-end methodology, architecture, implementation workflow, and scenario-based functional evaluation. Prototype outputs demonstrate the transmission/acknowledgement process, SOS display, dashboard monitoring, and location visualization. The system is intended as a network-independent emergency communication approach for remote-area safety and can be extended with cloud storage, mobile applications, geo-fencing, satellite communication, and AI-assisted analysis.

Keywords: LoRa, ESP32, GPS tracking, SOS alert, emergency communication, remote-area monitoring, IoT, web dashboard

1. Introduction

Outdoor adventure activities such as trekking, camping, mountain climbing, and forest exploration increasingly involve travel through regions with limited communication infrastructure. In such environments, accidents, injuries, wildlife attacks, landslides, or loss of direction can create situations in which a user cannot communicate an exact location to a rescue team. The submitted manuscript identifies this communication gap as a key motivation for the proposed system.[2]

Conventional emergency tracking systems often rely on GSM networks, SIM cards, or internet connectivity. These approaches can be effective where cellular infrastructure is available, but their usefulness decreases in isolated areas. The proposed work therefore uses LoRa as the communication link between a portable sender



and a receiver. The design combines GPS-based location acquisition with an SOS trigger so that emergency information can be transmitted without requiring a cellular connection between the two units.[3],[5]

The main contributions are: (i) an ESP32-LoRa sender unit for GPS acquisition and SOS-triggered packet generation; (ii) a receiver unit that decodes transmitted information; (iii) a web-based monitoring dashboard for location and alert visualization; (iv) battery management and solar charging support; and (v) a scenario-based functional evaluation of the complete prototype.

2. Literature Review

Previous work has explored GSM, GPS, Wi-Fi, Bluetooth, and LoRa for tracking and emergency communication. GSM-based systems can provide real-time communication but depend on cellular coverage and associated network infrastructure.[2] GPS provides location information but requires a communication channel to transfer that information to a remote monitoring point.[3] Bluetooth is suitable for short-range communication, whereas Wi-Fi generally depends on local network infrastructure.[3]

LoRa-based approaches address the communication problem by providing long-range, low-power wireless connectivity and have been considered for emergency assistance, tracking, disaster management, and related IoT applications.[1],[3],[5],[8] The literature cited in the submitted manuscript also reports LoRa-based tracking and monitoring applications for soldiers, mountaineering, and emergency communication.[6],[7],[10],[11],[13],[14]

Communication technology comparison: GSM depends on cellular network/SIM availability; Bluetooth is primarily short-range; Wi-Fi depends on local network infrastructure; and LoRa is used here as a direct, low-power wireless link between sender and receiver. This qualitative comparison motivates the proposed architecture without introducing unsupported numerical performance claims.

3. Methodology

The proposed system is divided into a sender unit, a LoRa communication link, and a receiver/monitoring unit. The sender is carried by the user and contains the sensing, control, emergency-trigger, and power-management elements. The receiver is connected to a computer and forwards decoded information to the web dashboard. Figure 1 presents the revised publication-oriented architecture.

LoRa-Based Emergency Tracking Architecture

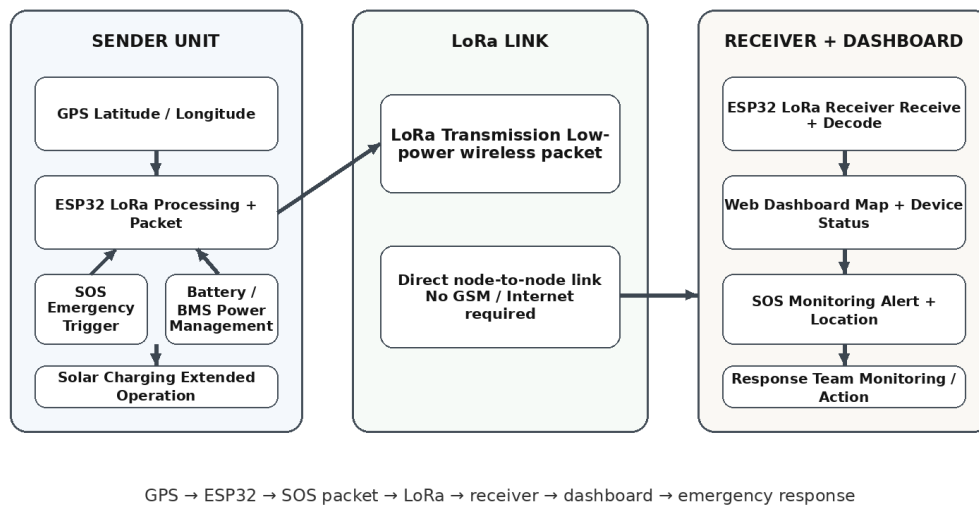


Fig. 1. Revised system architecture of the proposed LoRa-based tracking and SOS monitoring system.

3.1. Sender Unit

The sender unit uses an ESP32 LoRa integrated board, GPS module, SOS push button, lithium-ion battery, battery management system, solar charging support, breadboard, and jumper wires. The GPS module provides latitude and longitude coordinates. The ESP32 processes the coordinates and monitors the SOS input. The integrated ESP32-LoRa design reduces the number of separate communication components and supports a compact portable implementation.[4],[11]

3.2. Emergency Data Generation and LoRa Transmission

During normal operation, the ESP32 receives location information from the GPS module. When the SOS button is pressed, the controller associates the current location with the emergency state and forms a transmission packet. The LoRa module then transmits the packet to the receiver. This direct wireless link removes the need for a SIM card or an internet connection between the sender and receiver.[5],[10]

3.3. Receiver Unit and Web Dashboard

The receiver contains another ESP32 LoRa module connected to a computer through USB communication. The receiver captures the LoRa packet, decodes the information, and extracts the location data. The extracted information is forwarded to the web-based dashboard. The dashboard provides latitude and longitude, device identification/status, emergency alert status, real-time tracking information, and map visualization.

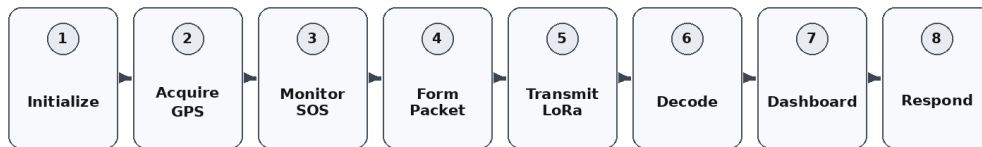
3.4. Power Management

The prototype includes battery management and solar charging support. The battery-management stage is intended to protect the battery against overcharging, over-discharging, and voltage fluctuations, while solar charging is intended to extend operational availability during longer outdoor activities.

3.5. End-to-End Workflow

The complete operational sequence is shown in Fig. 2. The workflow begins with initialization and GPS acquisition, continues through SOS monitoring and packet formation, and ends with receiver-side decoding, dashboard visualization, and emergency response.

Prototype Operational Workflow



Emergency mode: current GPS coordinates are attached to the SOS state before LoRa transmission.

Fig. 2. End-to-end workflow from GPS acquisition to emergency response.

4. System Implementation

The implementation combines the hardware and software elements into a single emergency monitoring chain. The sender-side ESP32 initializes the GPS and LoRa interfaces and continuously processes location information. The SOS input provides the emergency trigger. The receiver-side ESP32 listens for the transmitted packet and passes decoded information to the monitoring application through USB communication.

The web dashboard is used as the visualization layer. The submitted prototype interface includes a real-time GPS dashboard with device activity, emergency status, and map-based location visualization. Figures 3–6 retain the original prototype evidence while using publication-size image exports and consistent captions.

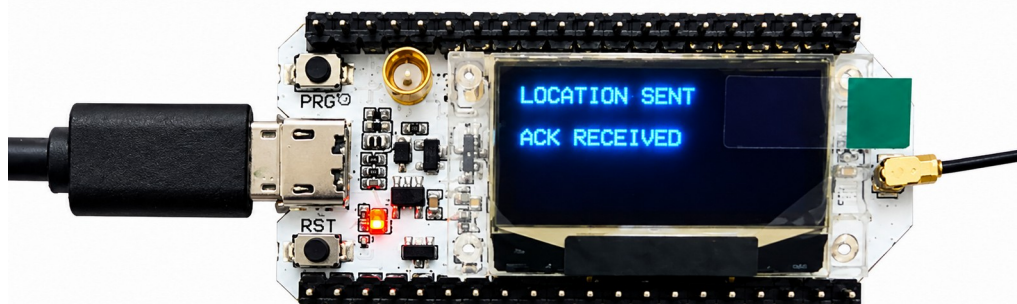


Fig. 3. Sender unit module used in the prototype.



Fig. 4. Receiver/prototype module showing SOS and GPS information.

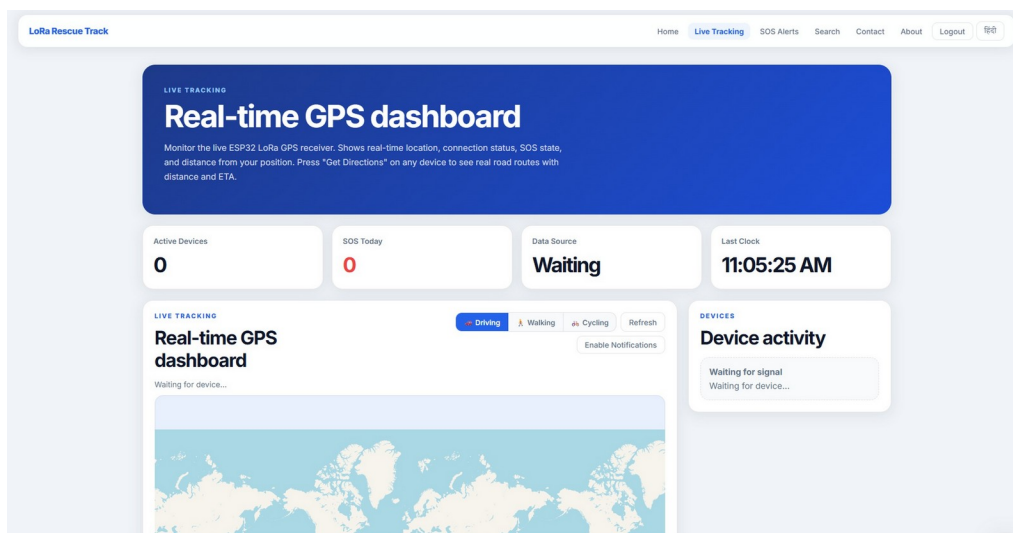


Fig. 5. Web-based real-time GPS monitoring dashboard.

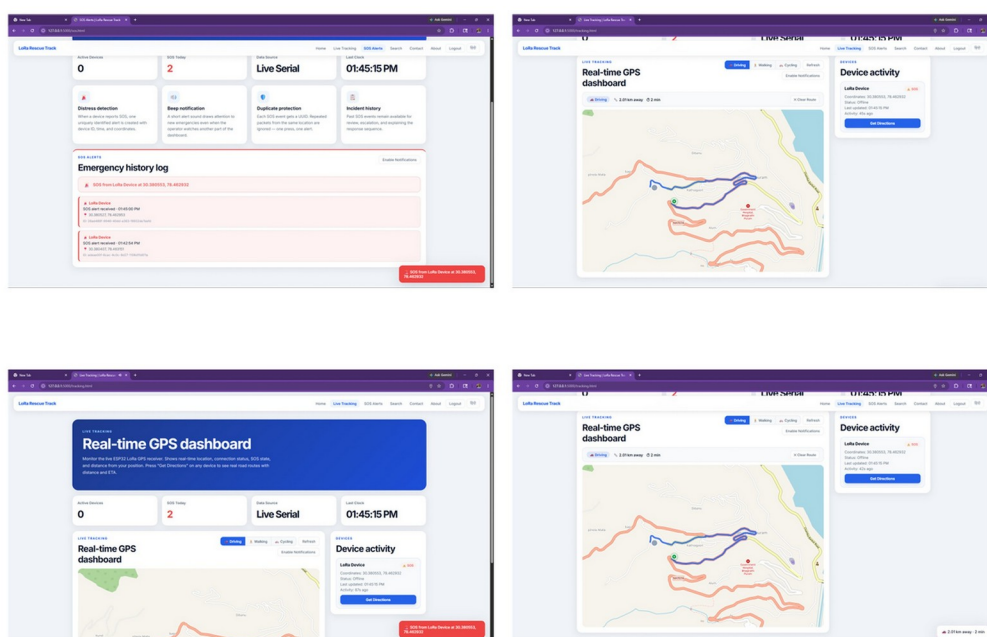


Fig. 6. Prototype dashboard outputs showing location visualization and SOS-related monitoring.

5. Results

The referee requested more detailed analysis and comprehensive evaluation. The submitted work is a hardware/software prototype rather than a dataset-driven study; therefore, a scenario-based functional evaluation is appropriate for the evidence available in the manuscript. The evaluation focuses on whether the major functional stages operate as an end-to-end chain: sensing, emergency triggering, LoRa transmission, reception, decoding, dashboard visualization, and power support.

5.1. Evaluation Scenarios

- 1) Startup/GPS acquisition—initialize the sender and acquire latitude/longitude.
- 2) SOS activation—associate the emergency state with the current location.
- 3) LoRa transmission—send the generated packet to the receiver.
- 4) Receiver decoding—decode the packet and forward the extracted information.
- 5) Dashboard monitoring—display location, device status, alert state, and map information.
- 6) Power support—use battery management and solar charging as part of the portable design; quantitative runtime was not available.

5.2. Functional Analysis

The scenario evaluation indicates that the proposed design addresses the principal functional requirements identified in the introduction. S1 establishes the sensing and processing chain. S2 verifies the emergency trigger concept by associating an SOS state with location information. S3 and S4 form the communication path between the portable unit and the monitoring station. S5 provides the human-readable monitoring layer required by rescue personnel. S6 addresses portability and power support for longer outdoor use.

The output figures provide visual evidence of prototype behavior. The sender/receiver module images show the hardware implementation, while the dashboard images show device activity, map visualization, and emergency-related monitoring. Together, these outputs support the feasibility of the proposed end-to-end architecture rather than only an isolated hardware component.

5.3. Quantitative Evaluation and Current Limitations

A limitation of the submitted experimental record is that it does not report measured LoRa communication range, end-to-end latency, packet-delivery ratio, GPS acquisition time, or battery operating time. These metrics should not be fabricated. Consequently, the present revision reports functional and scenario-based evidence only. For a stronger quantitative evaluation, the system should be tested at multiple distances and terrain conditions and should record communication range, packet loss, latency, GPS availability, battery runtime, and dashboard update time.

The absence of cellular dependency is a central design advantage of the proposed architecture, but actual LoRa performance will depend on deployment conditions and placement of the sender and receiver. Similarly, solar charging support is intended to improve autonomy, but the submitted manuscript does not contain measured solar energy generation or battery-runtime data. These points are therefore treated as evaluation requirements and future work rather than unsupported numerical claims.

6. Discussion

The prototype demonstrates the intended end-to-end information flow from the field device to the monitoring interface. The displayed sender/receiver outputs show that the hardware is capable of presenting location and SOS information, while the dashboard provides a visual representation of the received monitoring information. This supports the feasibility of using an ESP32-LoRa pair as the communication backbone of a remote emergency monitoring system.

Compared with GSM- or internet-dependent approaches described in the literature survey, the proposed architecture reduces dependence on cellular infrastructure by establishing a direct LoRa link between the field unit and the receiver. Compared with Bluetooth-oriented tracking, the design targets longer-range outdoor communication. The trade-off is that the current study does not provide a measured communication-range or reliability benchmark; such measurements are required before making deployment-level performance claims.

From a system-design perspective, the architecture is modular. GPS, emergency triggering, LoRa communication, receiver decoding, dashboard visualization, and power management can be independently improved. This modularity also supports future extensions such as cloud database integration, mobile applications, geo-fencing, advanced mapping, and AI-assisted emergency or route analysis.[8],[15]

7. Conclusion

This paper presents a LoRa-based live tracking and SOS alert system for emergency location monitoring in remote areas. The system integrates ESP32 LoRa modules, GPS tracking, an SOS trigger, battery management, solar charging support, and a web-based dashboard. The revised methodology describes the complete data path from GPS acquisition and emergency triggering to LoRa transmission, receiver decoding, and dashboard visualization.

The scenario-based evaluation demonstrates the functional feasibility of the prototype and clarifies the role of each subsystem. The system is particularly aimed at environments where cellular connectivity may be unavailable. However, the current experimental record does not contain quantitative measurements for communication range, latency, packet loss, or battery endurance; these should be included in future controlled field evaluations.

7.1. Future Scope

The future scope of the proposed system includes quantitative field testing at multiple distances and terrain conditions to evaluate its practical performance. Further studies can focus on measuring the packet-delivery ratio, end-to-end latency, GPS acquisition time, and battery runtime. The system can also be enhanced through Google Maps or advanced mapping integration and geo-fencing alerts for improved location monitoring. Cloud database storage and mobile application support can be incorporated to enable remote access and long-term data management. In addition, AI-assisted route analysis and emergency prediction can be explored to improve safety and decision-making. Finally, satellite communication can be integrated as an additional communication channel for extreme remote environments where conventional LoRa connectivity may not be available.

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