

# IOT – Based Mountain climber’s healthcare and GPS tracking system

Sumit Kumar<sup>1</sup>, Shivam Yadav<sup>2</sup>, Vishal Verma<sup>3</sup>, Shagun Malhotra<sup>4</sup>

UG Scholars, Computer Science & Engineering Department<sup>1-3</sup>

Assistant Professor, Computer Science & Engineering Department<sup>4</sup>

Sunder Deep Engineering College, Ghaziabad, India

**Abstract:** *This study is about a safety system for mountain climbers. It is a system that uses the internet and special devices to keep climbers safe. The system has sensors that people can wear to check their heart rate, body temperature and oxygen levels. It also uses GPS to track where the climbers are. The system looks at all the information it gets. Sends out alerts if it thinks someone is in trouble. These alerts say where the climber is, so help can get to them faster. The safety system is special because it works well even when it is hard to get a connection. It does things like checking health, tracking location and sending messages all in one. This makes it a lot better than systems that do not work together. The new system makes mountain climbers a lot safer. Helps them get the help they need when they need it. It is really good, for people who climb mountains because it helps them survive when things get bad. Mountain climbers can use this system to stay safe when they are climbing.*

**Keywords:** *Remote Health Monitoring, Real-Time Data Transmission, Wireless Communication (GSM/LoRa/Satellite), Physiological Parameter Monitoring, Smart Wearable Technology, Emergency Response System, Location-Based Tracking System, Cloud-Based Monitoring*

## I. INTRODUCTION

Mountain climbing is widely recognized as one of the most challenging and risky outdoor activities, demanding both physical endurance and mental resilience. Climbers often operate in extreme environmental conditions, including low temperatures, reduced oxygen levels, high altitudes, and unpredictable weather patterns. These factors significantly increase the likelihood of health complications such as hypoxia, fatigue, dehydration, and even life-threatening situations like cardiac stress or altitude sickness. Additionally, the remote nature of mountainous regions makes it difficult for rescue teams to respond quickly during emergencies, often resulting in delayed assistance and increased risk of fatalities.

With the rapid advancement of technology, especially in the field of the Internet of Things (IoT), new opportunities have emerged to enhance safety in high-risk activities like mountain climbing. IoT enables the interconnection of devices, sensors, and communication systems to collect and transmit data in real time. Wearable health monitoring devices can track vital parameters such as heart rate, body temperature, and blood oxygen levels, while GPS modules can provide continuous location updates. When combined into a single integrated system, these technologies can offer real-time insights into a climber’s physical condition and exact location, enabling faster and more effective emergency response.

Despite the availability of individual solutions such as fitness trackers and GPS navigation systems, there remains a gap in developing a unified, reliable, and climber-specific safety system. Most existing devices are not designed to function efficiently under harsh mountain conditions, nor do they provide seamless integration between health monitoring and emergency alert mechanisms. This limitation highlights the need for a specialized system that can operate reliably in extreme environments while ensuring accurate data transmission.

The proposed research focuses on the development of an IoT-enabled health monitoring and GPS tracking system specifically designed for mountain climbing safety. The system aims to integrate multiple sensors with communication



technologies to provide continuous monitoring and real-time alerts. By doing so, it seeks to minimize risks, improve situational awareness, and significantly reduce response time during emergencies. This research not only addresses a critical safety concern but also demonstrates the practical application of IoT in enhancing human survival in extreme conditions.

## II. PROBLEM STATEMENT

Mountain climbers' safety is at risk from a variety of environmental and physical factors which we have difficulty in dealing with at present due to the lack of real time monitoring and communication tools. We see as a great issue the fact that we are unable to continuous monitor a climber's health which may go from fine to very poor very quickly without any visible signs. We see conditions like low oxygen levels, irregular heart rates, or sharp drops in body temp as they may go unnoted until they reach a critical stage. Also we put forth that it is very hard at times to find a climber in an emergency. In mountain settings GPS may not work at all and also we see that traditional ways of communication break down because of a lack of network coverage. This in turn makes rescue very slow and inefficient which in turn reduces the chance of survival.

Also at present we have that which is either a basic level of tracking or health monitoring which does not integrate well and lack real time alert features. We do not have a full solution which puts health monitoring, location tracking, and automatic emergency response together in one reliable package for tough environments.

Also we see a great need for an integrated system which will track health issues, report location accurately and which also has the ability to alert in case of emergency or abnormality. Such a system would greatly improve safety, rescue response, and also reduce the risks associated with mountain climbing.

## III. OBJECTIVES OF THE STUDY

The main objective of this research is to design and develop an IoT-based system that enhances the safety of mountain climbers through continuous monitoring and real-time communication.

The specific objectives include:

- To develop a wearable system capable of monitoring vital health parameters such as heart rate, body temperature, and oxygen saturation.
- To integrate GPS technology for real-time tracking of the climber's location.
- To design a communication system that can transmit data to a remote monitoring station or cloud platform.
- To implement an alert mechanism that notifies emergency contacts or rescue teams when abnormal conditions are detected.
- To ensure the system is reliable, energy-efficient, and capable of functioning in harsh environmental conditions.

## IV. LITERATURE REVIEW

In recent years, significant research has been carried out in the fields of wearable health monitoring, GPS-based tracking systems, and IoT-enabled safety solutions. These studies highlight the growing importance of integrating technology into environments where human safety is at risk. However, most of the existing work focuses on individual components rather than a fully integrated system tailored for mountain climbing.

Wearable health monitoring systems have gained considerable attention due to their ability to track physiological parameters in real time. Many researchers have explored the use of biosensors to measure heart rate, body temperature, and blood oxygen levels. These systems are widely used in healthcare for patient monitoring and fitness tracking. While they are effective in controlled environments, their performance in extreme conditions such as high altitudes and low temperatures is often limited. Issues like sensor accuracy, battery life, and durability remain key challenges when these devices are used in mountain environments.



GPS-based tracking systems are another area that has been extensively studied. These systems allow users to determine their location and navigate through difficult terrains. In rescue operations, GPS plays a crucial role in identifying the position of individuals in distress. However, in mountainous regions, GPS signals can be unstable due to obstacles like rocks, valleys, and dense weather conditions. Some studies have proposed hybrid tracking methods that combine GPS with other communication technologies, but these solutions are still not widely adopted in practical applications for climbers.

IoT-based safety systems have also been developed for various use cases, including vehicle accident detection, elderly care, and industrial worker safety. These systems typically involve sensors, microcontrollers, and communication modules that transmit data to a cloud platform for analysis. In emergency situations, alerts can be sent automatically to predefined contacts. While these systems demonstrate the potential of IoT in improving safety, they are generally designed for urban or semi-urban environments where network connectivity is reliable.

A few research efforts have attempted to address safety in adventure activities, including trekking and mountaineering. These studies suggest combining wearable devices with communication systems to provide real-time monitoring and emergency alerts. However, most of these proposals lack practical implementation details or fail to address challenges such as power consumption, network reliability, and environmental durability.

From the existing literature, it is clear that although individual technologies like wearable sensors, GPS tracking, and IoT communication have been well explored, there is still a gap in developing a comprehensive and reliable system specifically designed for mountain climbing. This research aims to bridge that gap by proposing an integrated solution that combines these technologies into a single system capable of functioning effectively in harsh and remote conditions.

TABLE I: Traditional Methods vs. Proposed IoT-Based System

Features	Traditional method	Proposed Iot-design
<b>System integration</b>	Fragmented: Separate devices for GPS, heart rate, and SOS (often not used together).	Unified: Single integrated platform combining health, location, and communication
<b>Health Monitoring</b>	Manual/Periodic: Climbers check their own pulse or rely on symptoms like dizziness.	Real-Time/Continuous: Biosensors(heart rate, SpO <sub>2</sub> , temp) monitor vitals 24/7.
<b>Emergency Alerts</b>	Manual: Requires the climber to be conscious and able to trigger a signal or call.	Automated: System triggers alerts automatically if health vitals fall outside safe limits.
<b>Location Accuracy</b>	Passive GPS: Signals can be lost in deep valleys; requires manual coordinate sharing.	Active/Hybrid Tracking: Continuous coordinate logging with potential for hybrid communication
<b>Network Reliance</b>	Urban-Centric: Most devices fail or lose functionality without 4G/5G cellular signals.	Adaptive Communication: Utilizes LoRa or Satellite links for remote, off-grid reliability
<b>Environmental Durability</b>	Limited: Consumer-grade wearables often fail in extreme cold or high altitudes.	Ruggedized Design: Specifically engineered for low temperatures and harsh mountain terrain.
<b>Data Utilization</b>	Local Only: Data stays on the device; rescuers have no "history" of the climber's state.	Cloud-Based: Data is transmitted to a remote station for real-time analysis and storage.



### V. PROPOSED SYSTEM

The proposed system is an integrated IoT-based solution designed to enhance the safety of mountain climbers by combining health monitoring, location tracking, and emergency communication into a single platform. The system consists of wearable sensors, a processing unit, a GPS module, and a communication interface that work together to collect, process, and transmit data in real time.

At the core of the system are wearable sensors that continuously monitor the climber's vital parameters. These include heart rate sensors, temperature sensors, and pulse oximeters for measuring blood oxygen levels. The data collected from these sensors is sent to a microcontroller, which acts as the central processing unit. The microcontroller processes the data and checks whether the values fall within safe limits.

The GPS module is integrated into the system to provide real-time location tracking. It continuously records the climber's coordinates, which can be accessed remotely. This feature is particularly useful in emergency situations where the exact location of the climber needs to be identified quickly.

For communication, the system uses wireless technologies such as GSM, LoRa, or satellite communication, depending on the availability of network coverage. The collected data is transmitted to a cloud-based platform or a remote monitoring station, where it can be analyzed and stored. In case of abnormal health readings or emergency conditions, the system automatically triggers alerts and sends notifications to rescue teams or emergency contacts.

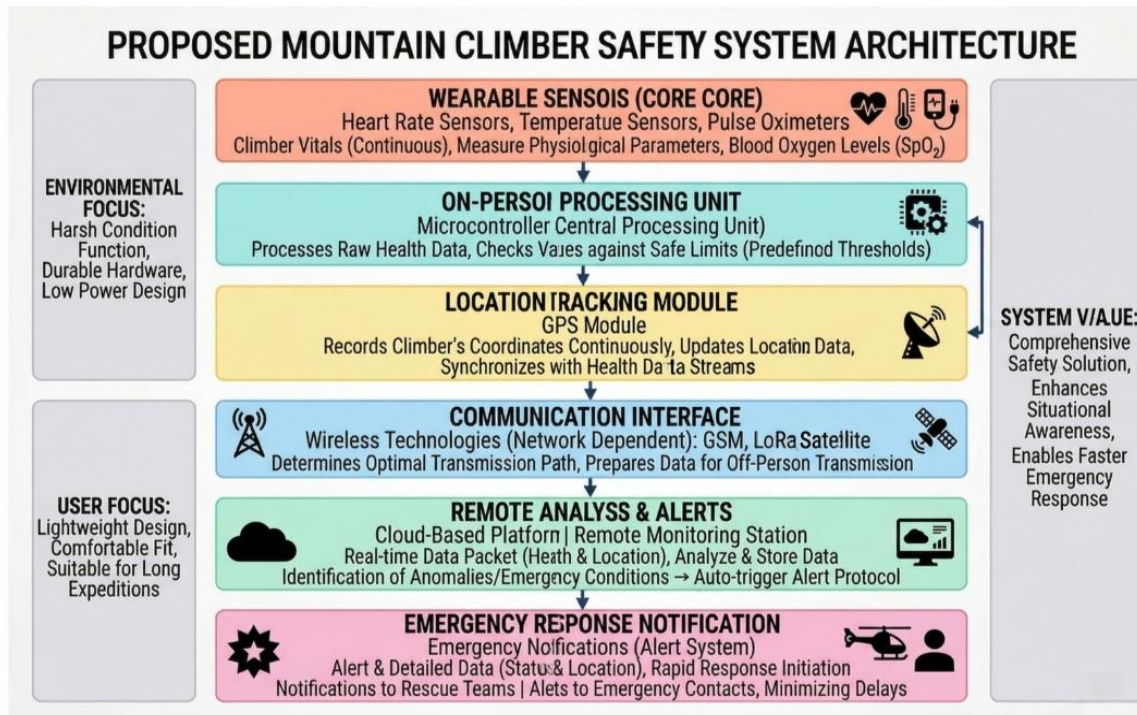


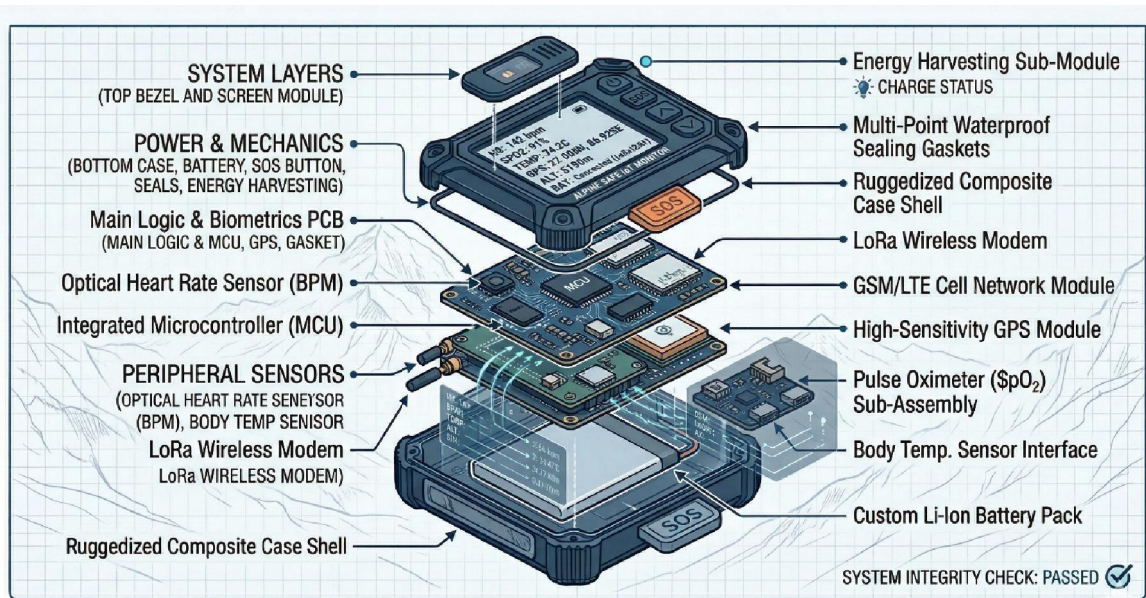
Fig. 6.1: proposed system architecture

An important aspect of the proposed system is its ability to function in harsh environmental conditions. The design focuses on low power consumption, durable hardware, and reliable communication methods to ensure continuous operation even in extreme situations. The system is also designed to be lightweight and comfortable, making it suitable for wearable use during long climbing expeditions.

Overall, the proposed system provides a comprehensive solution that addresses the key challenges faced by mountain climbers. By integrating health monitoring, GPS tracking, and real-time communication, it significantly improves safety, enhances situational awareness, and enables faster emergency response.



**VI. SYSTEM ARCHITECTURE**



**COMPREHENSIVE EXPLODED SCHEMATIC: ALPINE SAFE IoT MONITOR (INTEGRATED DATA & MODULE MAP)**

Fig.7.1: concept of Iot-device architecture

The system architecture is designed to ensure seamless interaction between hardware components, communication modules, and the data processing platform. It follows a layered approach consisting of the sensing layer, processing layer, communication layer, and application layer. Each layer performs a specific function, contributing to the overall reliability and efficiency of the system.

The sensing layer includes wearable sensors responsible for collecting physiological data from the climber. These sensors continuously monitor parameters such as heart rate, body temperature, and oxygen saturation. The accuracy and responsiveness of this layer are critical, as it forms the foundation for detecting potential health risks. The sensors are designed to operate efficiently in extreme environmental conditions, ensuring consistent data collection even at high altitudes.

The processing layer consists of a microcontroller that receives raw data from the sensors and processes it in real time. It filters noise, analyse patterns, and compares the readings against predefined safe thresholds. If any abnormality is detected, the system prepares an alert signal. This layer acts as the decision-making unit, ensuring that only relevant and accurate information is transmitted further.

The communication layer is responsible for transmitting the processed data to external systems. Depending on the environment, communication can be achieved using GSM networks, LoRa modules, or satellite-based systems. This flexibility ensures that the system remains functional even in remote areas where traditional networks are unavailable. Data transmission is optimized to reduce power consumption while maintaining reliability.

Finally, the application layer includes cloud platforms or monitoring interfaces where the data is stored, visualized, and analysed. Rescue teams or emergency contacts can access real-time information about the climber's health and location through this layer. This structured architecture ensures efficient data flow and enhances the overall performance of the system.



**VII. METHODOLOGY / WORKING PROCESS**

The working process of the proposed system begins with continuous data acquisition through wearable sensors attached to the climber’s body. These sensors collect real-time physiological data at regular intervals without causing discomfort or hindrance to movement. The collected data is then transmitted to the microcontroller for further processing.

Once the data reaches the microcontroller, it undergoes filtering and analysis. The system checks whether the measured values fall within normal ranges. For instance, a sudden drop in oxygen levels or an abnormal heart rate is identified as a potential risk. The system is programmed with predefined thresholds, allowing it to make quick decisions without human intervention.

Simultaneously, the GPS module tracks the climber’s location and updates the coordinates continuously. This location data is synchronized with the health data, creating a comprehensive profile of the climber’s condition at any given time. The integration of these two data streams is essential for effective monitoring and emergency response.

After processing, the data is transmitted to a remote server or cloud platform using the available communication network. In normal conditions, the system periodically sends updates to ensure continuous monitoring. However, when an abnormal condition is detected, the system immediately triggers an emergency alert. This alert includes both the health status and the exact location of the climber.

The final step involves notifying emergency contacts or rescue teams through messages, notifications, or alarms. This ensures a rapid response, minimizing delays and increasing the chances of timely assistance. The entire process is automated, reducing dependency on manual intervention and improving overall reliability.

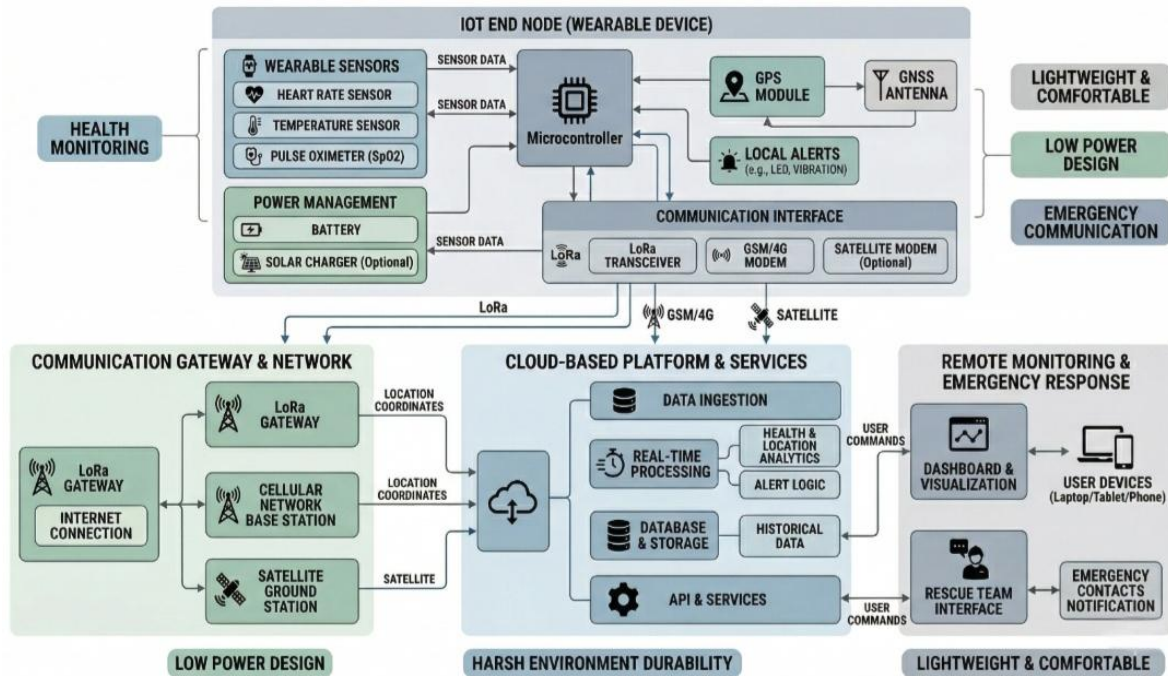


Fig.8.1: working process of device

**VIII. ADVANTAGES AND APPLICATIONS**

The proposed system offers several advantages that make it highly suitable for mountain climbing and other high-risk activities. One of the key benefits is real-time health monitoring, which allows early detection of potential medical issues. This proactive approach helps prevent critical situations before they escalate.



Another major advantage is accurate location tracking. In emergency scenarios, knowing the exact position of a climber significantly reduces the time required for rescue operations. This feature is particularly valuable in remote and difficult terrains where navigation is challenging.

The integration of IoT technology enables seamless communication between devices and monitoring systems. Automated alerts ensure that help is requested immediately when needed, eliminating delays caused by human factors. Additionally, the system is designed to be energy-efficient and durable, making it suitable for extended use in harsh environments.

Beyond mountain climbing, this system can be applied in various other fields. It can be used by trekkers, military personnel, disaster response teams, and workers in hazardous environments such as mining or construction. The flexibility and adaptability of the system make it a valuable tool for improving safety across multiple domains.

### **IX. CONCLUSION**

This research presents the development of an IoT-enabled health monitoring and GPS tracking system aimed at enhancing the safety of mountain climbers. By integrating wearable sensors, real-time data processing, and reliable communication technologies, the proposed system addresses critical challenges associated with high-altitude activities. It provides continuous monitoring of vital health parameters while simultaneously tracking the climber's location, enabling timely detection of risks and efficient emergency response.

The system overcomes the limitations of existing solutions by offering a unified and practical approach tailored specifically for extreme environments. Its ability to function reliably under harsh conditions, combined with automated alert mechanisms, makes it a significant advancement in safety technology. The research demonstrates how IoT can be effectively utilized to reduce risks and improve survival rates in remote and high-risk scenarios.

### **X. FUTURE SCOPE**

While the proposed system provides a strong foundation for improving climber safety, there are several areas where further enhancements can be made. One potential improvement is the integration of advanced data analytics and machine learning algorithms to predict health risks before they occur. This would allow the system to provide preventive recommendations rather than just reactive alerts.

Another area of development is the use of more robust communication technologies, such as satellite-based IoT systems, to ensure connectivity in extremely remote regions where traditional networks fail completely. Improving battery efficiency through renewable energy sources, such as solar-powered devices, can also extend the operational lifespan of the system.

In addition, future versions of the system can include features such as environmental monitoring, including altitude, weather conditions, and air quality. This would provide a more comprehensive safety solution by considering both physiological and environmental factors.

Overall, the future scope of this research lies in making the system smarter, more reliable, and widely accessible. With continuous advancements in technology, such systems have the potential to become an essential part of safety equipment for climbers and other individuals operating in extreme conditions.

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