Monitoring Systems for Mountain Climbers using IoT

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Abstract - **Using IoT technology, the Mountain Climbers Monitoring System offers a novel way to solve safety problems in mountain climbing. This system is designed to monitor climbers' vital signs in real-time, follow their whereabouts, and evaluate the surrounding environment in order to improve safety and speed emergency response in remote alpine areas. Important components include sensors such as temperature sensors, accelerometers, pulse rate sensors, and GPS modules to track the physiological characteristics of climbers, as well as an integrated Internet of Things architecture to send data in real-time to a central monitoring platform. The data collected and transmitted by climbers may be used in the Mountain Climbers Monitoring System with Node MCU, a well-liked open-source development board built on the ESP8266 Wi-Fi module. The Mountain Climbers Monitoring System may use LoRa (long-range) technology to send data from wearable devices to the central monitoring platform. The data is collected from the transmitter's end LoRa, and the data is transmitted to the receiver's end LoRa. The data is shared on the IOT open-source webpage Blynk. If there are any abnormalities found, the alarming message is displayed on the LCD on the receiver's end. Machine learning models such as KNN, decision trees, Naive Bayes, logistic regression, random forests, and SVM are used to test the real-time data on trained data.**

Keywords: **LM35, accelerometer, pulse rate, Node MCU, LoRa, Peltier, LCD, GPS Module, SVM, Decision Tree, KNN, Logistic regression.**

I. INTRODUCTION

Monitoring systems for mountain climbers are essential resources for improving performance and safety in alpine settings. These advanced technologies integrate real-timedata collection, GPS tracking, and biometric sensors to provide climbers with essential information on weather conditions, altitude, and vital signs. Precise decision-making is made possible by these technologies, which are designed to protect climbers. Mountain climbers may negotiate difficult terrain more skillfully and safely by utilizing ingenuity. These devices change the face of mountaineering by monitoring physiological factors and providing insightfuldata, all while highlighting efficiency and safety in the goal of climbing.

In this paper, we explore how machine learning (ML) algorithms and IoT can be used to create advanced monitoring systems designed with mountain climbers in mind. These solutions promise to improve safety measures and provide vital predictive skills by combining IoT sensors with ML-driven analytics. This allows for proactive reactions to possible threats and crises in isolated mountainous areas.

II. LITERATURE SURVEY

Ardina et al. have developed a GPS navigation system that may be utilized on mountains without cellular service. Mountain climbers utilize the navigation system tool when ascending. This technique offers the advantage of tracking the whereabouts of mountains [1]. Vinoth kumar et al. have proposed a health and position tracking system that uses the Global Positioning System (GPS) to determine the climber's current location and to measure their heart rate and temperature [2]. This system addresses the drawbacks of the methods that mountain climbers now employ. The gadget is also connected to the Global System for Mobile Communication (GSM) module, which facilitates easy network access and a message interface. In order to continually provide the rescue team with information, climbers' position, and health data will be transmitted via GPS and messages via GSM. In addition, it has extra features, including a climber awareness program that periodically tracks the activity of climbers. In case of an emergency, the climber also comes with an emergency switch. Riaz et al. have designed a flexible composite material based on silk- glycerol hydrogel, may be utilized to build reliable wearable self-power sensors [3]. The suggested hydrogel exhibits strong triboelectric (maximum current output of 12.5 nA) and mechanical (minimum stretchability of around 130% and Young's modulus of approximately 0.08 MPa) characteristics.

Huang et al. have proposed an active technique, unmanned aerial vehicles (UAVs) utilize their cameras to recognize faces andfind target users while hovering over disconnected cluster heads to store, transport, and convey messages. The rescue website will display all of the communications and camera-initiated video streaming when they have been routed through self-organized networks. In order to monitor a moving target in difficult terrain, the article focuses on organizing a UAV swarm [4]. Nadour et al. have developed to efficiently eliminate the swarm while taking the climber's surroundings into account. The method preserves formation compactness, target visibility, and collision avoidance [5]. Poikayil et al. offer a user-controlled suit to adjust body temperature to overcome the issues caused by changing weather. It offers outdoor enthusiasts who encounter temperature extremes an effective way to prevent health problems brought on by harsh weather [6].

Ishisaka et al. have developed the mobile device that climbers carry and the gadget thatlocates the mobile devices makes up this system. The mountain resort has the detection equipment installed. The climber's mobile device uses a GPS satellite to determine its location [7]. Aziz et al. have proposed to create a Mount Climber emergency power pack that integrates a GPS navigation system. This power pack stores energy in a power bank for use in an emergency by utilizing renewable energy sources, such as solar and wind energy [8]. Rathbum et al. have presented the Climbing Assistive Exoskeleton (CAE), which is intended to minimize finger stress in climbers in to improve climbing endurance and preventinjuries. The glove-like device targets a 20–40N force reduction in finger-related climbing strain using resistance bands, a motor, and real-time feedback [9]. Reddy et al. have presented the Mountaineering Team-Based Optimization (MTBO) method for handling challenging Economic Load Dispatch (ELD) problems. When it comes to optimizing global solutions for ELD, the MTBO algorithm shows exceptional efficiency, resilience, and ease of implementation [10]. Tee et al. have used the random forest, SVM, and KNN techniques to train the models. Model performances are compared using various combinations of mobile sensors to see how they impact the models' ability to recognize stimuli [11].

Shaikh et al. have analyzed to uncover power consumption patterns. The Schick-Lear Python library's linear mode algorithms are used for intelligent power regulation and energy consumption. With an improvement in RMSE performance of 35% in the lead-time strategy and 33% in the per-day approach, predictive models show their effectiveness.[12]. Alhenawi et al. have ensured path security by considering secure slope angles. Evaluation involves varied dataset sizes, measuring runtime, speedup, efficiency, and cost. Results demonstrate parallel ACO's superiority over sequential ACO ($p<0.05$). Comparison with a recent parallel A* algorithm using Apache Spark shows significant performance advantages for the parallel ACO algorithm [13]. Song et al. have discussed the evolution and various uses of pole-climbing robots. It provides a comprehensive overview of their mechanical design, driving mechanisms, advantages, disadvantages, and real-world applications.[14].

Hossain et al. have developed a smart heath monitoring system using IOT. The advantages and disadvantages of IOT-based smart health monitoring systems are discussed. The goal is to effectively and consistently monitor multiple patients in a hospital ward, as well as patients who are located remotely. By offering the infrastructure to incorporate AI in cyber-physical systems for in situ analysis, Manufacturing Data and Machine Learning (MDML) aims to standardize the research and operational environment for advanced data analytics and AI-enabled automated process optimization [15].

Elias et al. have demonstrated the integration of MDML with ML models to direct an experiment, handle various IoT data streams, and use numerous computer resources [16]. Anderies et al. have demonstrated how Node MCU ESP 8266-based systems connected with Blynk may be used for automated agricultural irrigation. Numerous earlier studies examined how well the LoRa network performed in urban and hilly settings. The terrain's height has an impact on the packet transmission rate in hilly regions. The building's placement has an impact on urban regions [17]. Ko et al. have conducted various tests to confirm the LoRa network performance in relation to varying PHY settings in open areas and tree farms [18]. Reddy et al. have discussed the studies of the LoRa (Long Range) technology that has a long range, operates at low data rates, and offers intriguing fixes for issues with IoT (Internet of Things) applications. There are several benefits, restrictions, and possible uses listed [19]. Kumar et al. have demonstrated the usage of Peltier and its applications in different situations [20].

III. PROPOSED MODEL

The proposed model Figure 1 tries to overcome the difficulties the climbers face with the network signals in the mountaineering regions. Instead of using the GSM module, the paper proposes LoRa for transmitting the data through the receiver side.

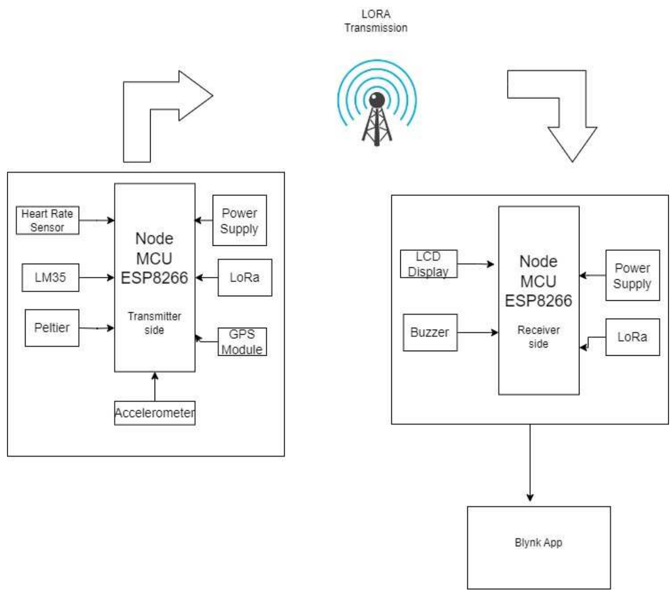

Fig.1 Proposed model

The collected data is passed to a machine learning model to get a prediction of the condition of the climber

A. Methodology

The architecture of the proposed model has a receiver and transmitter side. The data from sensors is collected and controlled by the Node MCU. The data from the transmitter side is transmitted through LoRa to LoRa on the receiver's end. The receiver's end has an alarming system alert in case of any abnormal activities.

B. Transmitter side:

The transmitter side has many sensors that sense the data such as temperature, heart rate etc. from the climber. The NodeMCU acts as a microcontroller that helps in processing the data from all the sensors. The NodeMCU is then connected to the LORA for transmission.

Table I describes the components used on the transmitter side. Table 1 also describes the models of each sensor and also the quantity of the sensor modules used.

Table I. Components of transmitter side

S.No	*Device*	*Model used*	*Quantity*
1	Temperature Sensor	LM35	1
2	Accelerometer	ADXL335	1
3	Heart rate	HW827	1
4	GPS Module	GY-NEO6MU2	1
5	Node MCU	ESP8266	1
6	LoRa	SX1278	1
7	Peltier	TEC1-12706	1

- *Sensor Integration*: Node MCU is fitted with a several sensors, including GPS, temperature, heart rate, and an accelerometer to gather information about the environment and position that is pertinent to the application.
- *LoRa Integration:* A LoRa transceiver module, such as the SX1278, is linked to the Node MCU long-distance wireless data transmission handled by the LoRa module.
- *Data Gathering and Transmission:* The Node MCU gathers sensor data and formats it appropriately for long-range communication, which is made possible by applying LoRa modulation to this data. Next, the Node MCU uses LoRa modulation to transferthis data packet.
- *Transmission Control:* To maximize communication dependability and power consumption, the Node MCU regulates the frequency and timing of data. It does this by making sure that data is transferred on appropriate LoRa channels and at acceptable intervals.

C. Receiver side

Table II describes the components used on the receiver side

Table II. Components of receiver side

S.NO	*Device*	*Model used*	*Quantity*
1	Node MCU	ESP8266	1
2	LoRa	SX1278	1
3	LCD Display	16x2 Alpha numeric display for 8051	1
4	Buzzer	95DB	1

- *LoRa:* Upon receipt of a LoRa transmission, the Node MCU swiftly processes the incoming data packet using LoRa demodulation.
- *Integration with the Blynk App*: The Node MCU is also wirelessly linked to the Blynk IoT platform. Blynk offers an intuitive user interface for controlling and monitoring Internet of Things devices. Because of the Node MCU's programming, users may access and interact with the device remotely using the Blynk app.
- *Real-Time Control and Monitoring:* Users may watch live data from the Node MCU using the Blynk app. In addition to monitoring environmental conditions and receiving warnings or notifications based on specified criteria, they may view sensor readings. The Blynk app could additionally have tools for tracking data and logging history.

D. IOT Modules

- *GPS Module:* Enables real-time location tracking to aid navigation and emergencies.
- *Heart Rate Monitor:* Monitors climbers' heart rates for health and safety purposes, helping to prevent overexertion.
- *LoRa:* The LoRa Module allows you to communicate with the LoRa WAN wireless network, a network made for the IoT.
- *Temperature Sensors (LM35):* Monitor environmental conditions to help climbers prepare for changing weather and avoid extreme conditions.
- *Node MCU:* NodeMCU is a firmware and development kit that is open-source and designed for the ESP8266 Wi-Fi module. It facilitates the rapid development of IoT applications by offering a scripting language based on Lua. NodeMCU enables fast creation of connected devices and IoT applications by providing built-in Wi-Fi, GPIO, and compatibility with a range of sensors.
- *Battery Management System:* Ensures reliable power supply for all modules during extended climbs by optimizing energy usage.
- *Peltier:* The Peltier module, also known as a thermoelectric module, is a device used for controlling temperature by producing heating effects. Applying an electric current to the module allows for the manipulation of the surface temperature, effectively maintaining it at the desired level.
- *Accelerometer:* Incorporates sensors to detect sudden falls or impacts, triggering automatic alerts for potential emergencies.

E. Machine Learning

Machine learning plays a vital role in enhancing monitoring systems for mountain climbers. Real-time trends, abnormalities, and possible hazards may be detected by machine learning algorithms through the analysis of data gathered from several sensors, including temperature sensors, heart rate monitors, and GPS.

We have used machine learning models such as KNN, Decision Tree, SVM, Random Forest, Naive Bayes, and logistic regression models to test the real-time data received from the heart rate and temperature sensors against the trained data. The models are compared against each other based on their accuracy.

A confusion matrix is a performance evaluation tool in machine learning. It organizes predictions from a classifier into a table, comparing them against actual outcomes. It consists of four values: true positives, true negatives, and false positives and false negatives, offering insights into model accuracy and errors.

- *K-Nearest Neighbors (KNN):* KNN is a simple supervised machine learning algorithm utilized extensively for both regression and classification tasks. Figure 2 is the confusion matrix for KNN.

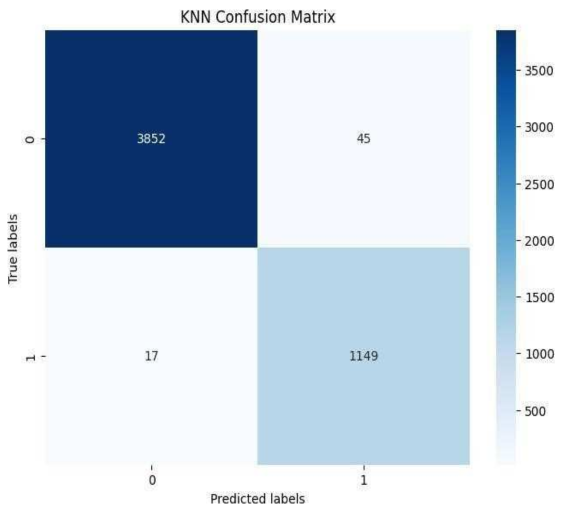

Fig.2 KNN Confusion Matrix

- *Decision Tree:* Decision trees stand as versatile supervised learning models widely employed in both classification and regression tasks. These models partition the feature space into distinct regions based on feature values, employing sequential decision-making to reach final predictions. Figure 3 is the confusion matrix for the decision tree.

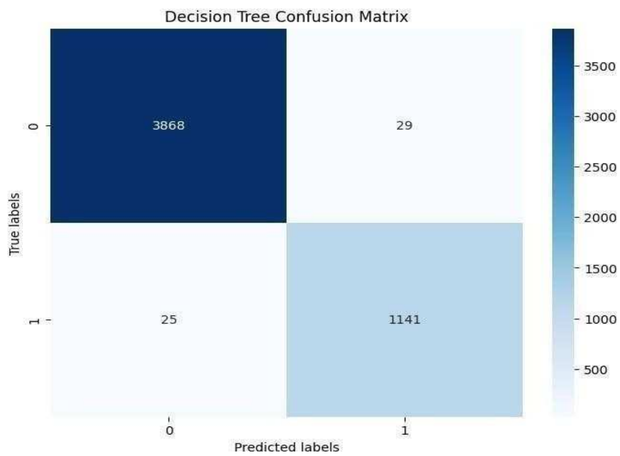

Fig.3 Decision Tree Confusion Matrix

- *Support Vector Machine (SVM):* SVM is a type of supervised machine learning technique that is commonly employed for problems involving regression and classification. The algorithm identifies the most effective hyperplane that can distinguish distinct classes by maximizing the distance between them. Support Vector Machines (SVM) are effective in analyzing data with a large number of dimensions and are capable of handling both linear and non-linear connections using kernel functions. Figure 4 is the confusion matrix for SVM.

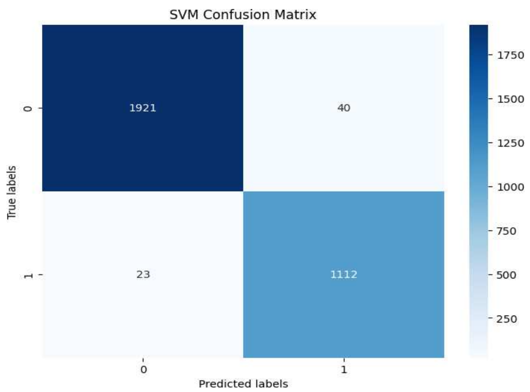

Fig.4 SVM Confusion Matrix

- *Random Forest:* This method entails constructing multiple decision trees during training and aggregating their predictions through voting (for classification) or averaging (for regression). Figure 5 is the confusion matrix for a random forest.

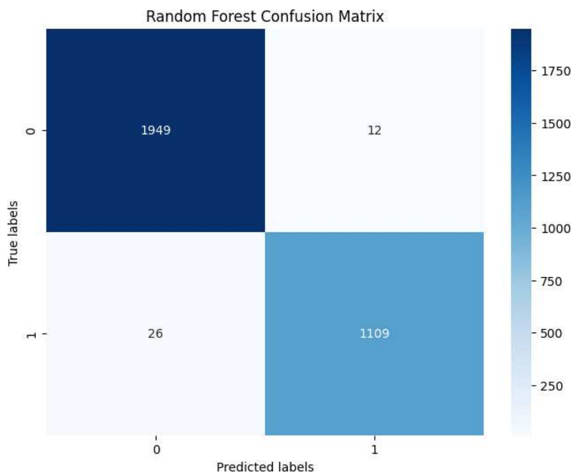

Fig.5 Random Forest Confusion Matrix

- *Naive Bayes:* Naive Bayes is a simplistic yet formidable probabilisticclassifier grounded in Baye's theorem and the assumption of feature independence. Fig 6 is the confusion matrix for Naive Bayes.

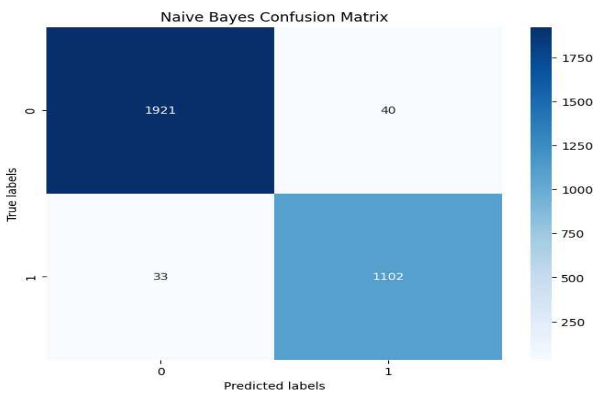

Fig.6 Naïve BayesConfusion Matrix

- *Logistic Regression:* Logistic Regression represents a ubiquitous supervised learning algorithm primarily employed in binary classification tasks. It models the probability of binary outcomes using the logistic function, mapping input features to probabilities ranging from 0 to 1 and enhancing model generalization. The Figure 7 is a confusion matrix for logistic regression.

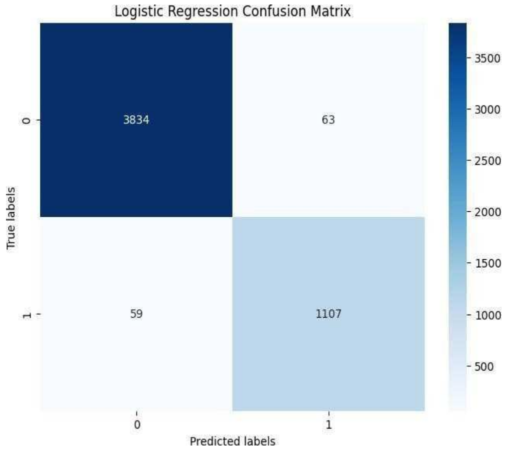

Fig.7 Logistic Regression Confusion Matrix

F. Blynk App

Blynk is a versatile mobile application that can be seamlessly integrated into monitoring systems for mountain climbers utilizing IoT (Internet of Things) and machine learning technologies. Its user-friendly interface and customizable widgets make it an ideal platform for displaying real-time data and facilitating communication between climbers and their support teams. Here's how the Blynk app enhances the monitoring system for mountain climbers in Figure 8.

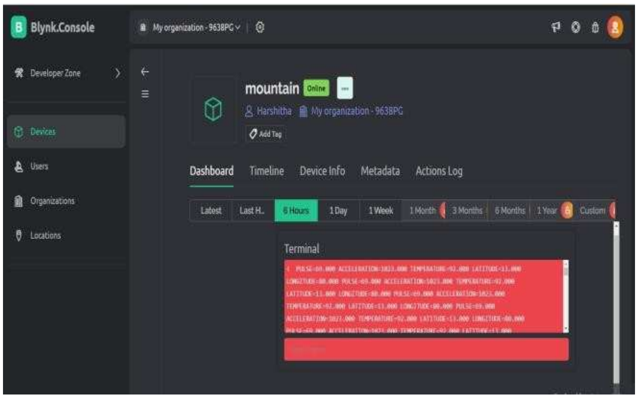

Fig 8 Blynk App template

IV. Prototype

The prototype for monitoring systems for mountain climbers using IoT (Internet of Things) technology, specifically LoRa (Long Range) and Node MCU represents a cutting-edge solution for enhancing safety and efficiency during mountain expeditions.

A. Transmitter side

Fig. 9 shows the transmitter side transmitting the climber's physiological data to the receiver's end.

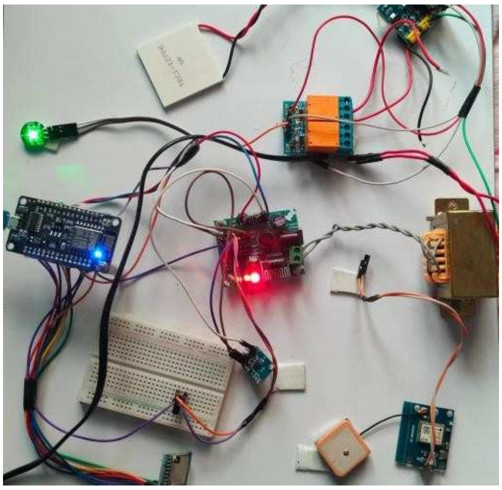

Fig.9 Transmitter side prototype

B. Receiver side

The receiver side Figure 10 receives the data from the transmitter side; the data is updated on the Blynk IOT platform.

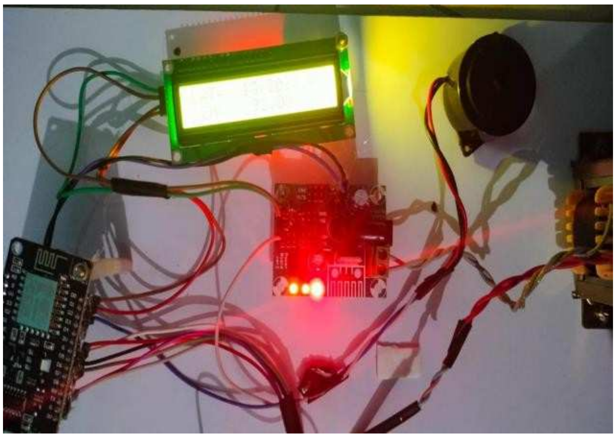

Fig.10 Receiver side prototype.

V. RESULTS

The accuracy of machine learning models is measured by their ability to correctly predict outcomes compared to the total number of predictions made. The accuracy is determined by dividing the number of right predictions by the total number of forecasts. Higher accuracy values indicate better performance. Table III shows the results obtained from themachine learning models.

Table III. Machine Learning Results

S.No	*ML Model*	*Accuracy*
1	KNN	98.74
2	Decision Tree	98.70
3	Navie Bayes	97.64
4	Logistic Regression	98.77
5	Random Forest	98.77
6	SVM	97.96

The transmitter side transmits the climber's physiological data to the receiver's end. The receiver side receives the data from the transmitter side; the data is updated on the Blynk IOT platform. Figure 11 shows the latitude and longitude display of the climber using the GPS sensor. Figure 12 displays the climbers health such as the heart rate, temperature and accelerometer information.

Fig 11 Latitude and longitude display

Fig 12 Climber health display

VI. CONCLUSION

The proposed model is able to provide remote communication through a LoRa device. Thus, the rescue team is able to rescue the climber during any abnormal conditions. The data was collected from the climber in real time. The proposed model also uses a machine learning model to provide predictions of the climber's health. Further, the data can also be used at the base camp for data analysis. The integration of IoT and machine learning technologies into monitoring systems for mountain climbers represents a significant advancement in enhancing safety and efficiency during expeditions. Random forest and logistic regression performed slightly better than other models with an accuracy of 98.77%. By leveraging real-time data collection and analysis, these systems offer climbers access to crucial information regarding physiological parameters and emergency response mechanisms. The synergy between IoT sensors, data analytics, and machine learning algorithms empowers climbers to make informed decisions, mitigate risks, and navigate challenging terrains with greater confidence. Moreover, the ability to monitor individual health metrics and provide personalized recommendations fosters a proactive approach to ensuring climbers' well-being. Astechnology continues to evolve, monitoring systems for mountain climbers will undoubtedly continue to evolve, further enhancing the safety, accessibility, and enjoyment of outdoor adventures.

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