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Real - Time Health Monitoring and Position Tracking System for Mountain Climbers

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Abstract: *Mountain climbing poses serious health and safety risks due to physical strain and extreme conditions. This project introduces a smart monitoring system that enhances climber safety using an Arduino Nano and ESP8266, with one as a transmitter and the other as a receiver. Vital signs, temperature, and GPS data are collected and sent via LoRa technology. A Peltier module activates in low temperatures to prevent hypothermia, and an emergency button sends distress alerts. The receiver displays real-time data and triggers alerts, enabling faster emergency response and improving climber survival chances.*

Keywords: Arduino Nano, ESP8266, NEO-6M GPS Module, MPU6050, MAX30100, LoRa Technology

I. INTRODUCTION

Mountain climbing and trekking have grown in popularity due to their physical and mental health benefits, including fitness, resilience, and improved circulation. These activities challenge individuals and are supported by various agencies, fostering a motivated and goal-driven community.

Despite its appeal, mountain climbing poses risks such as low oxygen, extreme weather, and physical and mental strain. Poor nutrition can worsen these risks, especially at high altitudes, leading to issues like abnormal blood pressure and heart rate variations.

Climbers face risks from extreme temperatures, insect bites, and allergic reactions, often requiring urgent medical care. Leaders without mountain medicine knowledge struggle to help. Communication issues worsen these risks. LoRa offers a low-cost, efficient way to bridge communication gaps in remote areas.

Telehealth plays a vital role in supporting climbers by enabling remote monitoring and timely medical intervention where immediate care is hard to access. As interest in trekking grows, integrating technologies like LoRa and telehealth ensures safety amidst the unpredictable challenges of nature.

II. RELATED WORK

Several studies have explored the physiological and psychological demands of high-altitude trekking and mountain climbing, highlighting risks such as acute mountain sickness, hypoxia, and cardiovascular strain (Basnyat & Murdoch, 2003; West, 2004). Research has emphasized the importance of proper nutrition and acclimatization in preventing altitude-related health issues (Butterfield, 1996). Communication in remote environments has also been widely addressed; LoRa (Long Range) technology has been evaluated for its effectiveness in enabling low-power, long-distance communication in rural and mountainous areas (Augustin et al., 2016). Recent advancements in telehealth have shown promise in providing remote medical support, improving outcomes in wilderness and expedition medicine (Tuerk et al., 2021). These technologies, when integrated, offer a robust solution for enhancing safety and real-time health monitoring in challenging terrains.

III. SPECIFICATIONS

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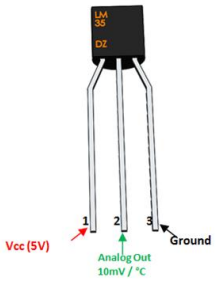
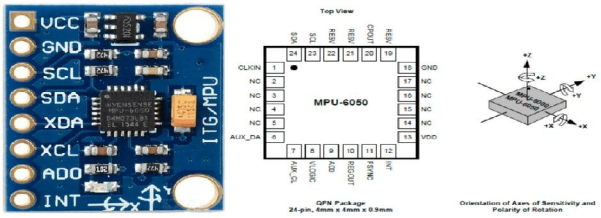
ARDUINO: The Arduino Nano is a compact, versatile microcontroller board based on the ATmega328P. It is designed for embedded systems and electronics projects requiring a small footprint without compromising functionality. With 22 digital I/O pins, an onboard USB interface, and compatibility with the Arduino IDE, the Nano offers reliable performance for prototyping and deployment in space-constrained applications. Its low power consumption and wide community support make it a popular choice for both educational and professional use.

LM35 (TEMPERATURE SENSOR): The LM35 is a precision temperature sensor that provides an analog output directly proportional to the temperature in degrees Celsius. It offers high accuracy and linearity over a wide operating range, typically from -55°C to +150°C. The sensor requires no external calibration, operates on a low power supply, and outputs 10 mV per °C, making it ideal for a variety of temperature-sensing applications in embedded systems and electronic projects**.**



MPU6050: The MPU6050 is a 6-axis motion tracking sensor that combines a 3-axis gyroscope and a 3-axis accelerometer, enabling precise measurement of motion and orientation. It communicates with microcontrollers like the Arduino Nano via the I2C protocol, allowing efficient data transfer for real-time analysis. Widely used in motion detection and fall monitoring systems, the MPU6050 is essential for applications requiring accurate movement tracking, such as health monitoring and safety systems in climbing or other physically demanding activities.



MAX30100(HEART RATE SENSOR): The MAX30100 is an integrated optical sensor designed for pulse oximetry and heart rate monitoring. It combines red and infrared LEDs, a photodetector, and low-noise analog signal processing to accurately measure blood oxygen saturation (SpO2) and pulse rate. By detecting variations in light absorption due to changes in blood volume, the sensor provides real-time physiological data. Compact and energy-efficient, the MAX30100 is ideal for wearable health monitoring systems, especially in applications like climbing, where continuous tracking of vital signs is critical for safety and early detection of health risks.

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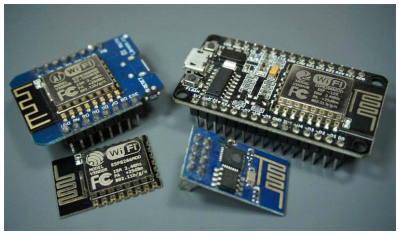
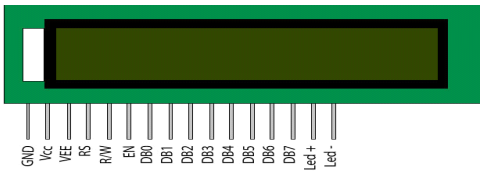
ESP8266 MICROCONTROLLER: The ESP8266 is a low-cost, Wi-Fi-enabled microcontroller developed by Espressif Systems, widely used in IoT applications for its compact design, energy efficiency, and wireless communication capabilities. Equipped with multiple GPIO pins and integrated TCP/IP stack, it enables seamless data transmission and remote monitoring. In safety-critical systems, such as health and location tracking for climbers, the ESP8266 serves as the core processing unit, handling wireless data from sensors and transmitting vital information to display and alert modules. Its real-time responsiveness and connectivity make it ideal for enhancing situational awareness in remote environments.

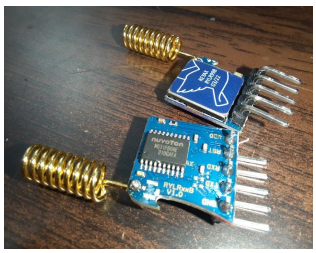


LCD DISPLAY:

The 16x2 LCD (Liquid Crystal Display) is a widely used electronic display module capable of showing 16 characters per line across two lines, with each character represented in a 5x7 pixel matrix. It offers an economical and easily programmable interface for displaying text, special characters, and simple animations. In monitoring systems, the LCD provides a clear, real-time visual output of critical data such as health metrics and GPS location, enabling climbers and support teams to quickly assess vital information and make informed decisions during expeditions.



LoRa Module: The working principle of the LoRa communication system relies on long-range, low-power wireless transmission using spread-spectrum modulation. In this monitoring setup, sensor data from the climber—including heart rate, temperature, motion, and GPS coordinates—is collected and formatted by the Arduino Nano. The LoRa transmitter module then wirelessly sends this data to a distant receiver module, even across rugged terrains and without line-of-sight. The receiver, connected to an ESP8266 microcontroller, processes the incoming data for real-time display and alerting. This reliable, energy-efficient communication enables continuous monitoring in remote environments, making it ideal for enhancing climber safety.



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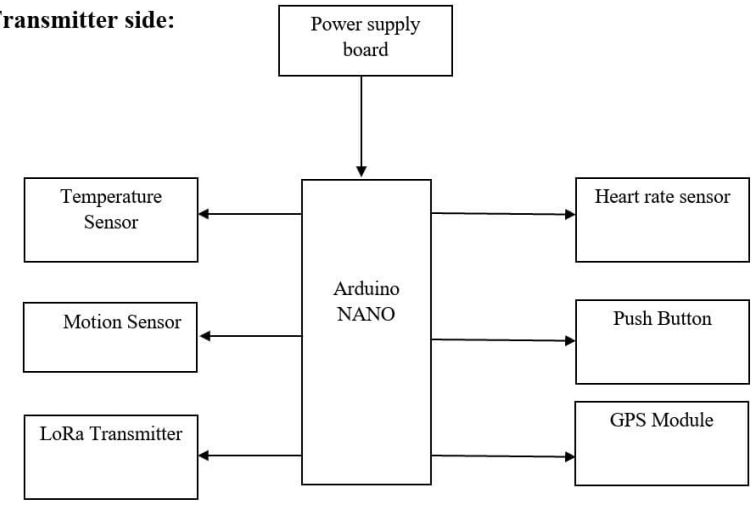
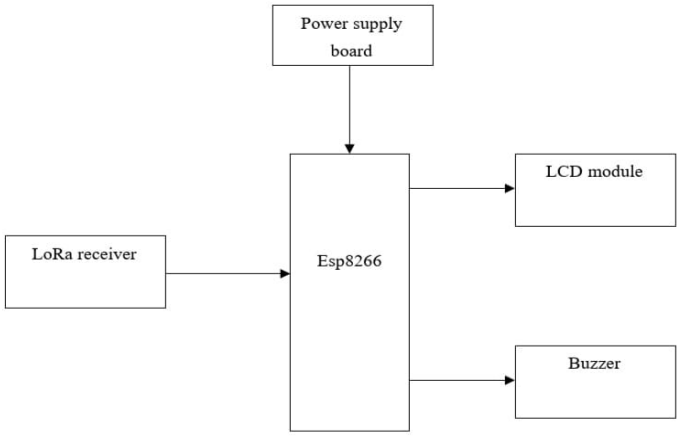
IV. BLOCK DIAGRAM

Transmitter side:



Receiver side:



V. WORKING

The working principle of the Smart Mountain Climbers Health Monitoring and Position Tracking system is based on real-time data acquisition, wireless transmission, and continuous monitoring. The transmitter unit, controlled by a Arduino Nano, collects health metrics (heart rate, body temperature) and GPS coordinates from connected sensors. This data is transmitted via a LoRa module to the receiver unit at the Base Station. The receiver's ESP8266 microcontroller processes the incoming data and displays it on an interface for real-time monitoring. Alerts are triggered if any parameter crosses predefined safety thresholds, ensuring timely intervention. This system enables continuous health and location tracking, enhancing climber safety in remote and high-risk environments.

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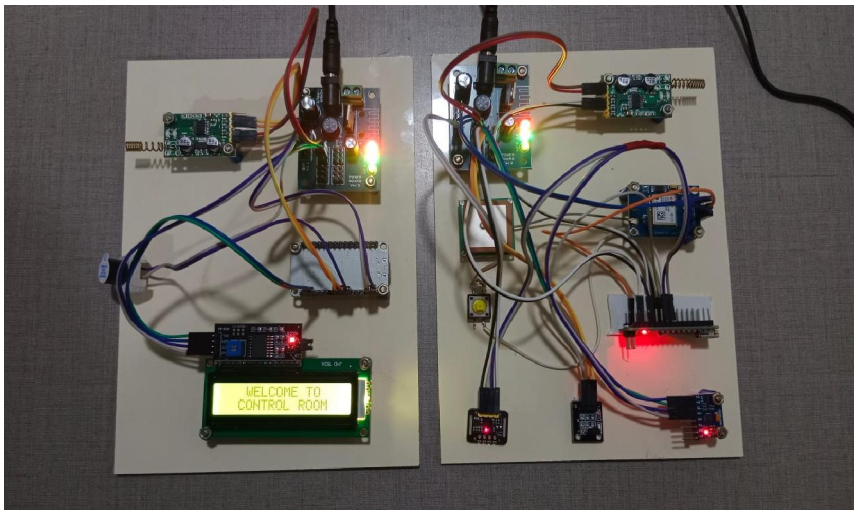
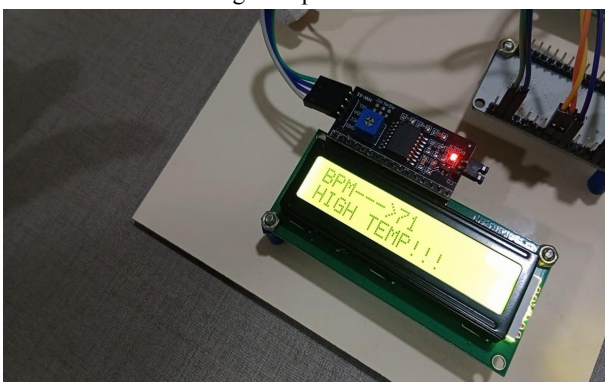
VI. OUTCOME

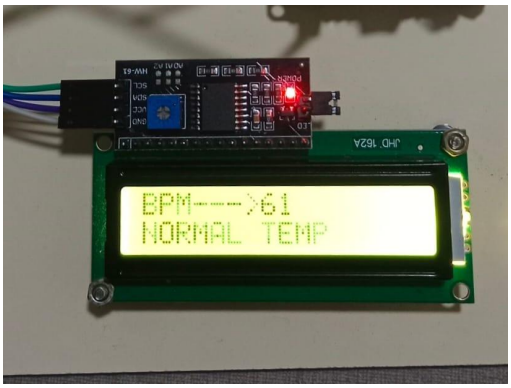
The overall experimental setup is achieved with the use of Arduino nano devices , health sensors, GPS tracking and LoRa technology to enhance the safety of mountain climbers by integrating real-time health monitoring with long range capabilities.



The LCD shows the result when the climber faces high temperature.



The LCD shows the heart rate of the climber when the temperature is normal.



The LCD shows the result when the climber is in abnormal position and also it shows the GPS of the climber.

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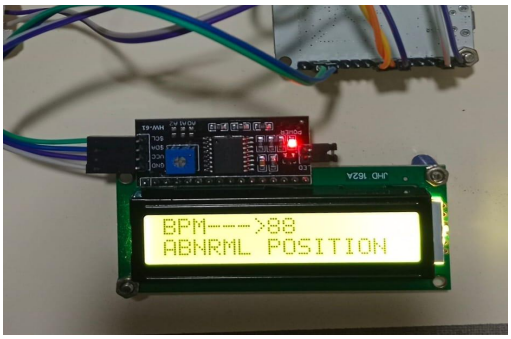

VII. CONCLUSION

The proposed mountain climber safety system demonstrates a practical and effective approach to enhancing the safety and survival of climbers in remote and high-altitude environments. By integrating real-time health monitoring with long-range communication via LoRa technology, the system ensures continuous tracking of vital signs and location, even in areas with limited network coverage. The inclusion of automated temperature regulation, emergency alerts, and real-time data display further improves responsiveness during critical situations. Overall, the system significantly reduces the risks associated with mountaineering by enabling timely intervention and reliable communication, ultimately safeguarding climbers' lives.

FUTURE ENHANCEMENT

By leveraging IoT technology, data can be stored in the cloud, enabling seamless access to information from anywhere, facilitating future scalability and integration.

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