Peak Rescue: A Feedback-Driven Approach to Trek Assist Mobile Application

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ABSTRACT

We demonstrate Peak Rescue, an Acute Mountain Sickness (AMS) feedback-based mobile monitor application suite. Peak Rescue gathers and monitors critical health parameters and environmental data necessary for the assessment of AMS risk during high-altitude trekking. Peak Rescue monitors physiological signal using photoplethysmogram, camera sensor, accelerometer and Global Positioning System (GPS), and oximeter via bluetooth; accepts user input to log current symptoms and health status via a questionnaire administered in the application suite; uses a suite of applications to detect and monitor the health of the user; and suggest actions to take based on the risk assessed in real-time. Peak rescue also provides emergency contact and rescue activation based on the user's physiological conditions, specifically when the readings indicate the user's vital health parameters have fallen outside the normal or acceptable range.

1. INTRODUCTION

The smartphone has become an indispensable tool enabling a variety of mobile health applications that incorporate physiological feedback to monitor user health status and promote wellbeing. Applications like Apple Health and US Army Research Institute's ARMS [1] combine sensor data tracking with risk analysis and recommendations to mitigate health threats in real-time. Building upon this concept, we demonstrate Peak Rescue, an Acute Mountain Sickness (AMS) feedback-based mobile monitor application suite tailored for trekkers and climbers. The hypothesis is that continuous physiological monitoring paired with the sensing, processing, and connectivity capabilities of smart devices can be combined with location-based environmental data to promote safer high altitude trekking by assessing AMS risk. Peak Rescue gathers and monitors critical health parameters and environmental conditions necessary for evaluating AMS risk during ascent, including heart rate variability, blood oxygen saturation, symptoms, exertion, and elevation/ascent rate. The application suite detects and tracks the health state of the user in real-time, provides early alerts when measurements deviate from expected bounds, suggests actions to take when deterioration is detected, and can activate emergency contacts and rescue if the user becomes incapacitated from AMS. The aim is to create an integrated mobile health tracking and emergency response system to improve high altitude trekking safety and promote responsible trekking or hiking.

2. ARCHITECTURE

Figure 1 shows the architecture of Peak Rescue, which has 6 components: a) a weather application programming interface (API) to retrieve geolocation data regarding the weather based on the longitude and latitude entered by the user, b) a set of physiological sensors such as photoplethysmogram (PPG), accelerometer, and bluetooth oximeter, c) measure altitude by using global positioning system (GPS), d) symptom questionnaire to log user's feedback on their current condition, e) an action suggestion module which takes the AMS risk assessment and recommends the best course of actions for the user to take, f) emergency contact activation which can automatically alert emergency contacts/service and initiate rescue if the user's physical condition is outside of the safe range. In our implementation, we use the smartphone's camera sensor to capture PPG data to derive the heart rate of the user, accelerometer to calculate the user's respiratory rate, and an external oximeter device connected via Bluetooth to measure the blood oxygen saturation, as part of collecting the user's physiological data. Peak Rescue also uses data from a weather API for the forecasts throughout a user's trekking schedule and the use of GPS to retrieve altitude information of the specified area, as well as a symptom questionnaire where users can rate their current physical condition based on the symptoms they are experiencing. Based on these parameters, Peak Rescue calculated the Trek Evaluation Score on a range of 0 to 1. The higher the score, the safer it is for the user to continue their trekking. The action suggestion module takes this risk score and recommends the appropriate action corresponding to the algorithms being used.

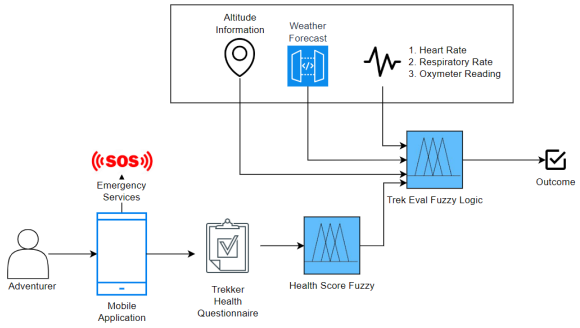

Figure 1: Peak Rescue Application Architecture.

3. THE APPLICATION SUITE

The Peak Rescue application suite consists of a health assessment app which performs analysis on physiological data and user-reported symptoms to determine the risk level of Acute Mountain Sickness (AMS), an action suggestion app which provides recommendations to the user based on the assessed AMS risk level, a weather app to retrieve environmental data, and an emergency contact app to activate rescue services if required.

3.1 Assessment Application

Figure 2 shows the health assessment app, which collects physiological data using the smartphone's photoplethysmogram (PPG) sensor to measure heart rate variability, the accelerometer to calculate respiratory rate, and a connected bluetooth oximeter to read blood oxygen saturation (SpO2). It also retrieves the user's altitude and ascent rate using GPS location data. The user manually inputs a symptom survey rating fatigue, headache, gastrointestinal issues, and other markers of AMS on a severity scale. The app feeds these parameters - heart rate variability, SpO2, respiratory rate, symptoms, exertion level, altitude, ascent rate - into a risk analysis algorithm that calculates a real-time Acute Mountain Sickness Score ranging from 0 (no risk) to 1

(severe risk). The algorithm is calibrated to detect early signs of altitude illness based on medical guidelines for physiological changes at altitude.

3.2 Action Suggestion Application

The action suggestion app takes the quantitative AMS risk score and provides the appropriate recommendation to the user based on their real-time condition. Above a score of 0.8, the user is likely safe to continue ascent with optional precautions like hydrating or supplemental oxygen suggested. Between 0.6 and 0.8, the app recommends descending to the last altitude where the user felt normal as a precaution. Between 0.4 and 0.6, it insists on immediate descent, rest, hydration/nutrition, and cautions against further ascent due to moderate risk of acute mountain sickness. Below 0.4, it activates the emergency contacts app to send the user's location to specified contacts and notify rescue services due to high probability of serious AMS requiring evacuation.

3.3 Weather Application

The weather app utilizes a weather API to retrieve forecasted and real-time weather conditions based on the user's GPS coordinates during their trek. Key variables provided include temperature, precipitation, wind speed, visibility conditions (clouds, fog), and storm warnings. This environmental data allows the health assessment algorithm to account for external risk factors like dehydration, hypothermia, and visibility issues when calculating the AMS risk score.

3.4 Emergency Contacts Application

If the AMS risk score reaches above 0.8 indicating a high probability of acute altitude illness, the emergency contacts app automatically activates to message up to 3 preset emergency contacts via SMS with the user's real-time location and medical condition. It will repeatedly message contacts every 15 minutes with updated GPS coordinates until confirmation of rescue activation is received. The app also has direct one-touch calling/texting to local emergency services to initiate professional evacuation or treatment of severe AMS.

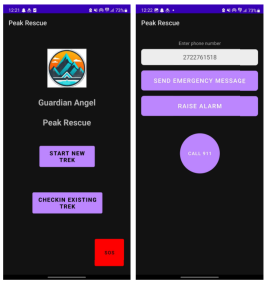

Figure 2: Peak Rescue Application.

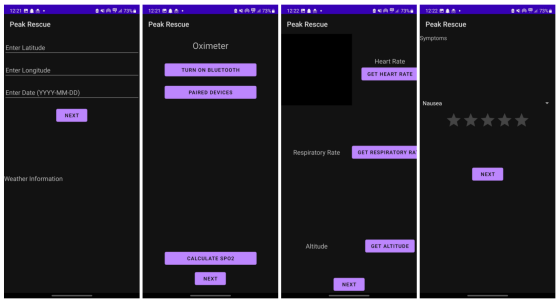

Figure 3: Peak Rescue Data Collection and Assessment.

4. IMPLEMENTATION

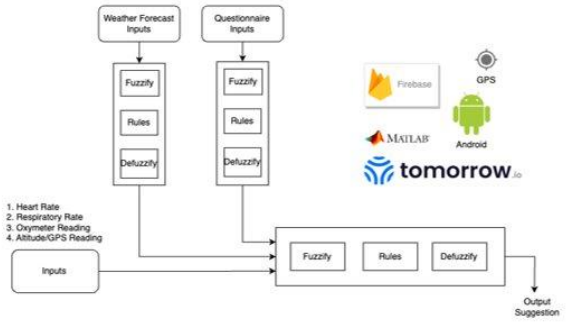

Figure 3: Implementation Diagram

The development of the Mountain Trek Assist project is a collaborative endeavor, emphasizing a modular approach where team members actively contribute to their individual Git branches. The integration of these branches culminates in a cohesive Android application designed to evaluate user symptoms and deliver guidance for responsible trekking practices. Notably, the implementation incorporates fuzzy controllers integrated using the JFuzzyLogic library.[2] This ensures a sophisticated and nuanced approach to assessing and responding to user inputs, enhancing the overall effectiveness of the trekking assistance provided. The main components of the implementation include:

1. Trek Evaluation Fuzzy Controller:
    a. Responsible for assessing trekker well-being based on physiological data.
    b. Utilizes fuzzy logic rules to evaluate symptoms and calculate a trekker's health status.
2. Health Score Fuzzy Controller :
    a. Determines an overall health score based on various health metrics.
    b. Integrates with the Trek Evaluation Fuzzy Controller for a comprehensive health assessment.
3. User Data Collection and GPS Data Processing Component:
    a. Collects user-specific data, including heart rate, respiratory rate, and user information.
    b. Processes GPS data for altitude information.
4. Oximeter (SpO2) Reading Processor and Simulation:
    a. Processes SpO2 readings from an oximeter.
    b. Includes a simulation component for testing and development.
5. Weather Data Retrieval and Offline Accessibility Component:
    a. Retrieves real-time weather data and ensures offline accessibility.
    b. Integrates with other components for comprehensive risk assessment.
6. Weather Fuzzy Controller and SOS Function Component(Figure 4):
    a. Utilizes fuzzy logic to assess weather conditions.
    b. Includes an SOS function for emergency situations.

The implementation of the Mountain Trek Assist project is characterized by a meticulous and collaborative development process, aligning with industry best practices. The modular structure of the implementation allows each team member to contribute to their dedicated Git branches, ensuring code encapsulation and ease of testing. The Trek Evaluation Fuzzy Controller stands as the cornerstone, orchestrating a sophisticated evaluation of trekker well-being through the interpretation of

physiological data. Leveraging advanced fuzzy logic algorithm-Mamdani approach, this component provides a nuanced health assessment, capturing the subtleties of symptoms associated with high-altitude trekking.[3]
Complementing the Trek Evaluation Fuzzy Controller, the Health Score Fuzzy Controller aggregates diverse health metrics, resulting in a comprehensive health score. This collaborative approach ensures a holistic evaluation of a trekker's physical condition, combining the nuanced analysis of symptoms with user-specific factors. The User Data Collection and GPS Data Processing Component play a pivotal role in providing the necessary input for health assessments. This component meticulously collects user-specific data, including heart rate and respiratory rate, and processes GPS data for accurate altitude information, vital for risk assessments.

The Oximeter (SpO2) Reading Processor and Simulation component processes SpO2 readings with precision, crucial for monitoring oxygen saturation levels. Its simulation environment facilitates rigorous testing, ensuring the reliability of the system. The Weather Data Retrieval and Offline Accessibility Component ensures real-time weather data retrieval and offline accessibility, fortifying the system's resilience in remote environments. The Weather Fuzzy Controller and SOS Function Component utilize advanced fuzzy logic to assess weather conditions accurately and provide immediate initiation of emergency procedures when necessary.

In conclusion, the implementation of the Mountain Trek Assist project reflects a commitment to precision, collaboration, and the integration of advanced technologies. The modular development approach, coupled with the utilization of fuzzy logic algorithms, ensures a robust and nuanced evaluation of trekker well-being. The interplay of components, from health assessment controllers to data collection and processing modules, forms a cohesive system designed to promote responsible trekking practices. By seamlessly integrating physiological data, weather information, and user-specific factors, the implementation not only enhances safety through early Acute Mountain Sickness risk detection but also empowers trekkers with timely recommendations and emergency support, fostering a culture of informed decision-making and responsible exploration.

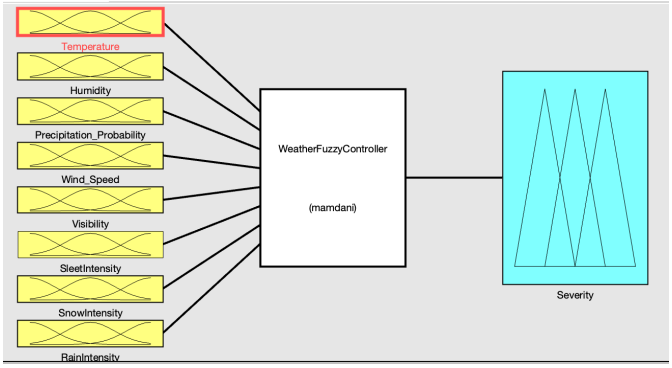

Figure 4: Fuzzy Logic View of the Health Score Evaluator

5. Demonstration

To effectively showcase the Mountain Trek Assist application, a series of realistic scenarios have been outlined, simulating key functionalities. Due to time constraints, not all scenarios have undergone live testing; however, the conceptualization and design of the application ensure its practicality and utility for trekkers worldwide. Here are some envisioned scenarios:

Scenario 1: Initial Setup and Baseline Measurement

User Initialization:

- The app guides the user through a seamless onboarding process, ensuring a smooth setup.
- Users enter their basic information, initiating the creation of a personalized profile.

Baseline Health Measurement:

- The hypothetical user inputs baseline physiological data, creating a reference for ongoing health assessments.
- The system generates a user profile, capturing essential health metrics for future evaluations.

Scenario 2: Ongoing Health Monitoring and Data Input

Trek Commencement:

- The envisioned trekker starts their journey, and the app begins real-time GPS tracking.
- Periodic prompts encourage the input of physiological data, enhancing continuous health monitoring.

Continuous Health Assessments:

- The app, hypothetically, utilizes fuzzy logic to analyze the evolving physiological data.
- The Health Score Fuzzy Controller generates a dynamic health score, reflecting the trekker's well-being throughout the journey.

Weather Updates:

- The system retrieves real-time weather data, ensuring trekkers are informed about current conditions.
- Weather Fuzzy Controller hypothetically contributes to a holistic risk assessment based on weather and health factors.

Scenario 3: AMS Risk Assessment and Recommendations

AMS Risk Indication:

- In this hypothetical scenario, the app detects a potential AMS risk and notifies the trekker.
- Detailed information about the AMS risk and recommended actions is presented.

Timely Recommendations:

- The app hypothetically provides actionable recommendations, guiding the trekker to mitigate the AMS risk.
- Visual cues and notifications offer real-time assistance during critical moments.

Scenario 4: Emergency Situation Handling

SOS Activation:

- In a simulated emergency, the trekker activates the SOS function.
- The system hypothetically initiates emergency procedures, contacting services and notifying predefined emergency contacts.

Emergency Contact Feature:

- Hypothetically, emergency contacts receive real-time updates, allowing for prompt assistance.
- The system ensures that crucial information is conveyed swiftly in critical situations.

Scenario 5: Post-Trek Analysis and Report Generation

Post-Trek Health Report:

- After the hypothetical trek, the app generates a detailed

health report summarizing the journey's physiological data.
- Trends and insights offer valuable information for personal analysis.

Responsible Trekking Insights:
- The app hypothetically provides insights into responsible trekking practices, based on the trekker's decisions.
- Future recommendations aim to enhance safety and well-being on subsequent treks.

While live testing and full-scale demonstrations are pending due to time constraints, the carefully crafted design and conceptualization assure that the Mountain Trek Assist application holds significant potential to be a valuable and useful companion for trekkers worldwide. The envisioned scenarios embody the intended functionality, and with further testing and refinement, the app is poised to offer enhanced safety, informed decision-making, and an overall improved trekking experience.

6. CONCLUSION

In this paper, we demonstrate Peak Rescue, an acute mountain sickness risk assessment and emergency response application suite for trekkers and climbers. The suite consists of health monitoring, action suggestions, weather alerts, and emergency contact activation powered by real-time physiological data analysis. Peak Rescue aims to promote safer recreation at altitude through continuous feedback monitoring and timely interventions when deterioration is detected. With sufficient data collection across diverse trekking populations, future iterations could provide personalized recommendations calibrated to individual risk profiles. Widespread adoption has potential to reduce mountaineering casualties and foster responsible hiking practices through feedback-driven decision support. Our overarching vision is an integrated mobile platform that empowers adventurers to summit safely by understanding how their body responds in real-time to the extremes of high-altitude terrain.

7. REFERENCES

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