IoT Based Landslide and Slope Monitoring System

Ms. Patole Vidya Adinath[1], Ms. Gadakh Jayashri Uttam[2], Ms. Pingale Geeta Suresh[3], Ms. Ipar Divya Yogesh[4]

Abstract

The "IoT-Based Landslide and Slope Monitoring System" aims to provide real-time monitoring and early warning for potential landslide and slope failure events using a hardware prototype integrated with LORA communication technology. The hardware prototype features rainfall and soil moisture sensors to monitor environmental conditions, triggering alarms when critical thresholds are reached. It is also equipped with an LCD display to show sensor readings continuously. The system is designed to be deployed in mountain regions, where it tracks the slope's stability, raising alerts if significant shifts are detected.The user-facing component of the system is an Android application that allows users to register according to their district. In the event of a landslide or slope failure, the app sends targeted notifications to users in the affected area. This ensures timely information is delivered to the appropriate districts, enhancing safety and preparedness in vulnerable regions. By combining physical monitoring with a user-friendly application, the system aims to minimize the risks associated with natural disasters.[1]

Keywords: Android application Disaster preparedness LCD display Landslide monitoring Mountain regions

INTRODUCTION

Landslides and slope failures pose significant threats to communities in mountainous and hilly regions, often resulting in severe property damage, environmental degradation, and loss of life. With increasing climate variability and unpredictable weather patterns, the need for reliable and real-time monitoring systems has become more urgent. [2]Traditional monitoring methods are often limited by manual observation and delayed reporting, which can reduce the effectiveness of early warning efforts. In response to these challenges, this project presents an IoT-Based Landslide and Slope Monitoring System designed to enhance disaster preparedness and risk mitigation through real-time data collection and communication. By integrating rainfall and soil moisture sensors with LoRa (Long Range) communication technology, the system enables continuous environmental monitoring and timely alerts. Coupled with an Android application that delivers targeted notifications based on users' district registration, the solution provides a comprehensive approach to monitoring slope stability and disseminating warnings, aiming to safeguard lives and infrastructure in vulnerable areas.[4]

LITERATURE SURVEY

1. Amruta Amune; Swapnil Patil, "IOT Based Smart LandSlide Detection System,"[1] 2023 - This research proposes a low-fee, electricity-efficient, and reliable Landslide Early Warning System (LEWS) for Himalayan landslides to lessen the probability of such tragedies. It's a landslide monitoring system based on Internet of Things (IoT) protocols, with a Wireless Sensor Network (WSN), records amassing, and analysis unit.

2. Pradeep Singh Rawat, ”Landslide Monitoring Using IoT System with Cloud Platform,”[2] 2023 ˆa This article presented an innovative landslide monitoring system. It is based on the IoT protocols based monitoring system consisting of cloud platform which provides instant alerts of upcoming landslides on the basis of real time data set collected inside the IoT cloud platform. As part of this monitoring system, landslide data is sent directly to the civil protection department and notified to the local population for the awareness and future precautionary safety measures. The results and discussions section shows the real time data visualization of the landslide inducting parameters, including metrological, geophysical and hydrological parameters.

3. Atharva Pargaonkar, ”RRemote Landslide Detection Using Semantic Segmentation,”[3] 2023 - This study focuses on detecting such hazardous landslides in remote locations using a deep learning approach. Techniques like semantic segmentation have been used with the help of U-Net architectures to accurately identify locations where landslides have occurred.

4. Hemalatha Thirugnanam, ”Review of Landslide Monitoring Techniques With IoT Integration Opportunities,”[4] 2022 - This article also aims to provide an overview of landslide monitoring in general to nonspecialist in the field. The major monitoring techniques are classified based on the type (fall, topple, slide, spread, flow, slope deformation), velocity (slow, moderate, rapid), monitoring parameters (meteorological, geological, hydro-geological, physical, geophysical), monitoring phases (spatial, temporal), and early warning systems (spatial, temporal) of landslides.

5. Kishor B. Bhangale, ”IOT Based Landslide Detection in Hilly Area,”[5] 2021 - this article presents the early landslide detection based on various parameters of the hilly area such as moisture, rain level, vibrations and accelerometer sensor outputs. The proposed system provides an alert buzzer to the proximity using Fuzzy logic Controller. The anticipated scheme is implemented for the real time scenario and data is stored on the cloud for the future reference. It provides a simple, feasible and low-cost landslide monitoring and warning system.

6. Marojahan Mula Timbul Sigiro, ”Improving Road Safety in Landslide Prone Areas: Real-time LoRa-Based Landslide Detection and Warning System,”[6] 2023 - Landslide natural disasters are unexpected events that can significantly impact the environment and society. Landslides usually occur on slopes, hills, or mountains. Moreover, roads in the hills are also often affected by landslides.

METHODOLOGY

The project is designed to provide early warnings for landslides and slope failures in mountainous regions. By using sensors to monitor environmental conditions like rainfall and soil moisture, the system can detect signs of instability in the slopes. It uses LORA communication technology to send real-time data, and an Android app delivers alerts to users in specific districts if there is a risk of a landslide. This system helps improve safety by giving people in vulnerable areas timely information so they can take preventive actions.

1. User Classes and Characteristics

- These users will oversee the system’s operation, monitor data from multiple locations, and manage user registrations. They are responsible for configuring critical thresholds for sensor readings, issuing warnings, and coordinating with local authorities during emergencies.
- These users are individuals living in or near mountainous regions prone to landslides. They will use the Android app to register, receive alerts, and access safety information.

- These users will handle the installation and maintenance of the sensors and hardware prototypes. They ensure that the system is functioning correctly, troubleshoot issues, and perform regular hardware checks.

2. Assumption Dependency

✓ System is well perform if proper internet is provided

✓ Sensor should store properly

✓ Notifications

3. User Interfaces

User has to interface with system to access the features and to provide easy communication with system

4. Communication Interfaces

There is a specific network protocol as long as the performance requirement are satisfied

5. Performance

System must follow state-of-the-art interoperability standards so that its integration or communication with external systems can be achieved. System should be developed following Service Oriented Architecture (SOA) and Open standard architecture. System needs to be developed in a way that will allow the creation and support of ˆaWeb Servicesˆa to exchange information between the system and external systems.

Factor of Safety (FoS) for Slope Stability:

$$FoS = \frac{R}{D}$$

Where:

- FoS = Factor of Safety (a value >1 indicates a stable slope, while a value <1 indicates a risk of landslide)
- R = Resisting forces (shear strength of the soil)
- D = Driving forces (shear stress caused by gravity)

OBJECTIVE

1. To provide real-time monitoring of rainfall and soil moisture levels using IoT sensors.

2. To send early warning alerts to users in affected areas through a mobile application.

3. To enhance disaster preparedness by continuously tracking slope stability in mountain regions.

4. To minimize the risks and damages caused by landslides through timely notifications.

5. To utilize LORA communication technology for efficient data transmission in remote locations.

PROBLEM DEFINATIONS

The problem is that landslides and slope failures in mountainous regions can happen without much warning, putting peopleˆas lives and property at risk. Current methods of monitoring these areas are either slow or not accurate enough to detect early signs of danger. There is a need for a reliable and real-time solution that can monitor environmental factors like rainfall and soil moisture to predict potential landslides. This solution should also quickly alert the people living in affected areas so they can take action to stay safe.[12]

DATA FLOW DIAGRAMS

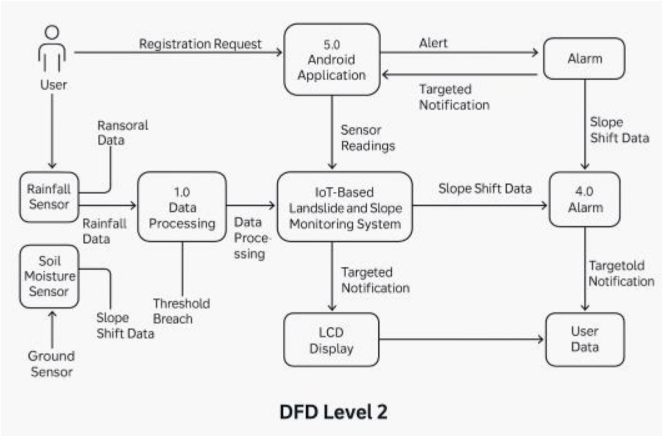

Fig 1: Level2Data FlowDiagram

FUCTIONAL REQUIREMENTS

- The system continuously monitors rainfall, soil moisture, and slope stability using sensors to detect early signs of potential landslides. Data is collected and processed in real-time to ensure timely alerts.
- When the system detects critical environmental changes, it sends early warning notifications to residents in at-risk areas through the Android app. This gives people enough time to take safety precautions or evacuate if needed.[13]
- Users register based on their district, and the app sends alerts specifically to those in the affected areas. This ensures that only relevant people are notified, preventing unnecessary panic.
- The Android application allows residents to easily register, receive notifications, and access important safety information. The app is designed to be simple and easy to use, making it accessible to a wide range of users.

NON FUCTIONAL REQUIREMENTS

Non-functional requirement is a requirement that specifies criteria that can be used to judge the operation of a system, rather than specific behaviours. They are contrasted with functional requirements that define specific behaviour or functions.

ADVANTAGES

1. Early Warning System:
   The system alerts people before a landslide happens. This helps them evacuate safely and quickly, saving lives and reducing panic.
2. Real-Time Monitoring:
   It constantly checks important data like rainfall and soil moisture. This helps detect any unusual changes in the mountain's condition at the right time.

3. Mobile Alerts via Android App:
   People can use a simple app to get alerts on their phones. The app even sends messages based on the user's district, so only the affected areas are notified.
4. Works in Remote Mountain Areas:
   With LORA technology, it can work even in mountain regions where internet or mobile signals are weak. It's designed for tough places where monitoring is usually hard.

APPLICATIONS

1. Hill Stations and Tourist Areas:
   Places like hill resorts or mountain roads can install this system to protect tourists and locals from sudden landslides.
2. Agricultural Slopes:
   Farmers in hilly regions can use it to protect crops and farm workers from landslide damage.
3. Construction and Mining Sites:
   If construction is going on in a hilly region, the system helps keep workers safe by alerting them about unstable ground.
4. Government Disaster Management:
   Authorities can use the data to plan better disaster response and send rescue teams faster.

RESULTS

Fig: 2 Prototype model

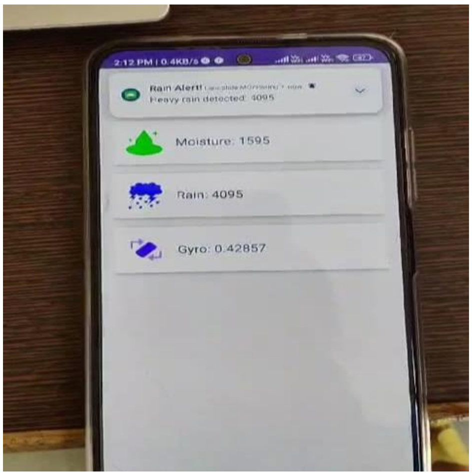

Fig: 3: Android Application

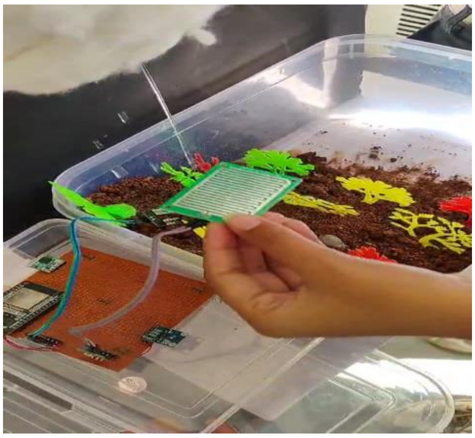

Fig : 4: Rain Sensor

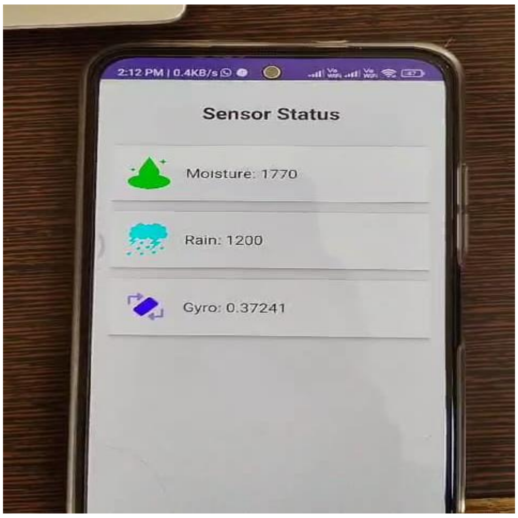

Fig: 5: Values display on application

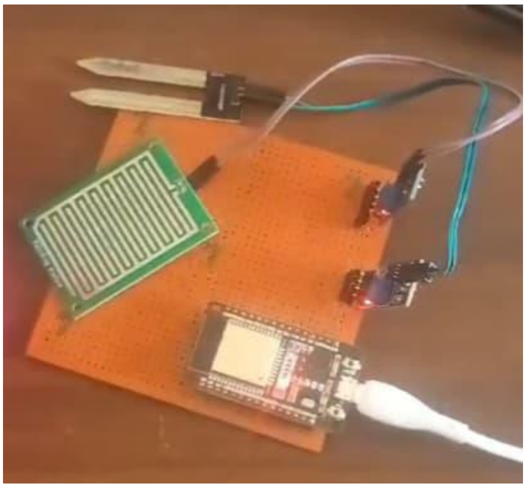

Fig: 6: Hardware Model

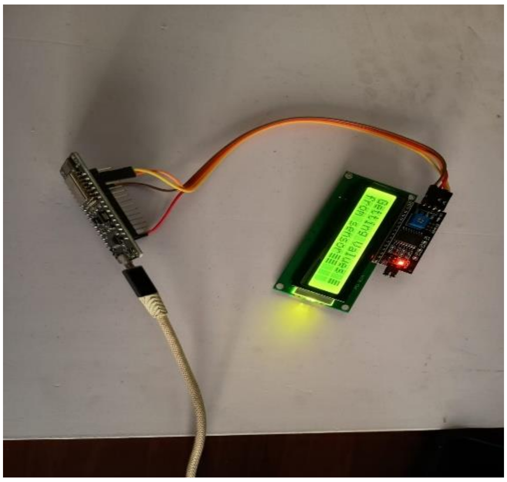

Fig: 7 LCD Display

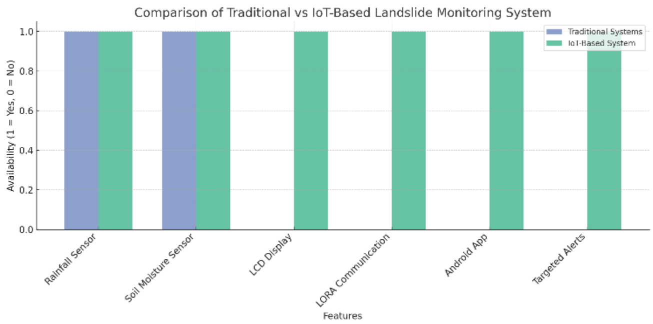

Fig 8 : Comparison Bar chart

Ref(google.com)

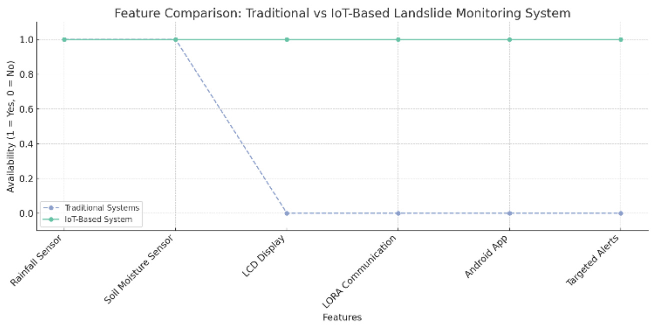

Fig 9: Line chart

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CONCLUSION

In conclusion, the system offers a practical solution for monitoring landslide-prone areas in real-time, helping to prevent disasters and protect lives. By integrating sensors, LORA communication, and a user-friendly mobile app, the system provides early warning alerts to residents and disaster management teams, allowing for timely actions in case of potential landslides. While the system offers significant benefits in terms of safety and preparedness, challenges such as power dependency and initial setup costs need to be addressed for broader implementation. Overall, this system plays a crucial role in improving disaster management and safeguarding communities in vulnerable regions.

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