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Smart Landslide Alert System for Remote Homes

Kalkki S R, Harishma S, Harini R, Harsha Ram K

Department of Computer Science and Engineering, Arunachala College of Engineering for Women, Vellichanthai,
Kanyakumari, Nagercoil, India

ABSTRACT: Landslides are one of the most destructive natural disasters, causing loss of human life, property damage, and disruption of infrastructure. In India alone, between 2015 and 2022, 3,782 major landslides were recorded, with Kerala being the most severely affected state. Many rural and hilly regions lack robust early warning systems, leading to delayed responses and higher casualties. Existing solutions rely on limited sensors, resulting in low accuracy and incomplete monitoring.

This paper proposes an IoT-based Smart Landslide Detection and Alert System that integrates multiple sensors — soil moisture, rainfall, tilt, and vibration — to enhance risk prediction accuracy. A microcontroller processes the collected data in real time, triggering on-site alerts through buzzers and LED signals, while cloud integration enables mobile-based warnings. Furthermore, an AI-enabled prediction model uses historical and live data for improved pattern detection and reduced false alarms. The system's affordability, scalability, and real-time capabilities make it suitable for deployment in landslide-prone regions, thereby safeguarding lives and property.

KEYWORDS: IoT, Machine Learning, Landslide Detection, Disaster Management, Data Analytics

I. INTRODUCTION

Natural disasters pose a significant threat to both human lives and economic stability. Landslides, in particular, account for severe destruction in mountainous and hilly terrains. According to national statistics, nearly 12.6% of India's land area is vulnerable to landslides. On July 30, 2024, a catastrophic landslide in Wayanad, Kerala, caused over 231 deaths and displaced hundreds. These events highlight the urgent need for reliable early warning mechanisms.

Existing early warning systems in India are limited in scope. Most utilize a single parameter, such as rainfall or slope movement, which often results in incomplete monitoring. Furthermore, the absence of IoT-based real-time systems in remote areas prevents communities from taking timely protective measures.

This research proposes a multi-sensor IoT-based approach, where environmental data is continuously monitored, processed, and analyzed to predict and detect potential landslides. The system provides early alerts to communities through sirens, lights, and mobile notifications, thus minimizing damage and saving lives.

II. RELATED WORK

Several countries, including Switzerland, Italy, and China, have deployed advanced landslide monitoring systems using inclinometers, extensometers, geophones, and GNSS systems. While effective, these solutions are highly expensive and suitable mainly for large-scale government projects.

In India, sensor-based monitoring efforts typically employ single-parameter detection (e.g., rainfall sensors). Such systems fail to capture the complexity of landslide triggers, leading to inaccurate predictions and delayed alerts. Research in disaster management suggests that multi-sensor fusion combined with data analytics improves accuracy significantly. However, there remains a gap in implementing low-cost, real-time, IoT-enabled systems accessible to vulnerable rural communities.

III. PROPOSED METHODOLOGY

The proposed system integrates four key sensors:

- Soil Moisture Sensor – Monitors water seepage at multiple depths.
- Rainfall Sensor – Measures precipitation levels.
- Tilt Sensor – Detects slope shifting and angular movement.
- Vibration Sensor – Senses tremors or ground vibrations.

A microcontroller (ESP32/Arduino) collects and processes data from these sensors in real time. When any parameter exceeds predefined safety thresholds, the system triggers alerts. On-site warnings include buzzers and LED lights, while cloud-based platforms (Firebase/AWS) send mobile alerts.

Additionally, a machine learning prediction module analyzes historical and live data to detect patterns. This reduces false alarms and provides earlier risk predictions.

IV. SYSTEM ARCHITECTURE

The system workflow is divided into four stages:

1. Data Collection: Sensors continuously capture environmental parameters.
2. Processing & Analysis: Microcontroller evaluates values against thresholds.
3. Alert Mechanism: Local alarms (buzzer, lights) and cloud-based notifications are triggered.
4. Prediction Layer: AI algorithms analyze trends to forecast possible landslides.

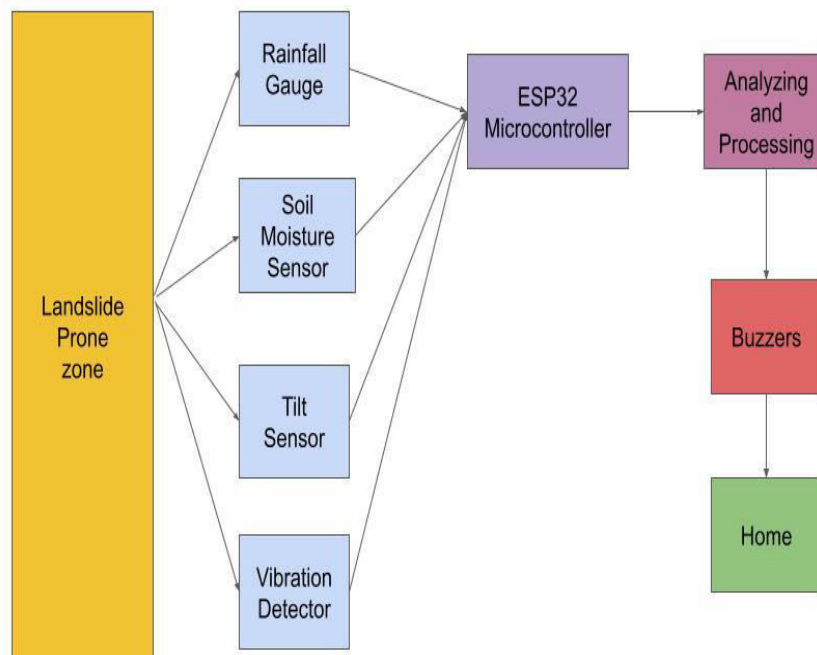


Fig.1. Block diagram of the proposed system

V. RESULTS AND DISCUSSION

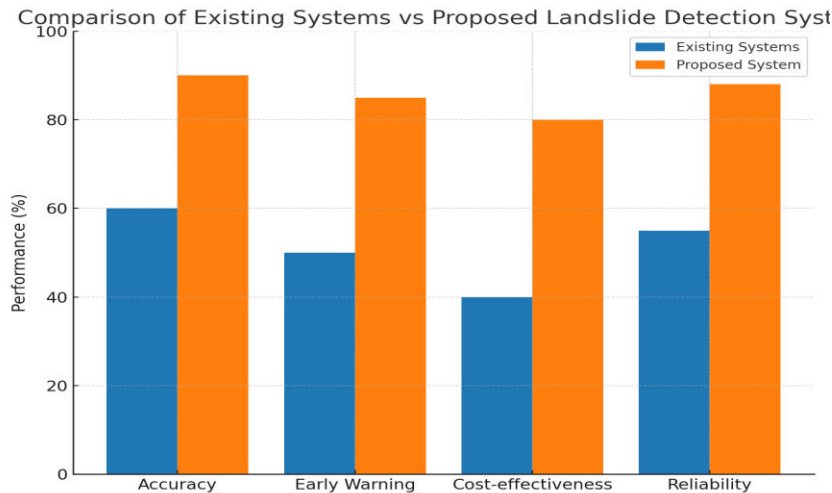


Fig. 2 Comparison of Existing Systems vs Proposed Landslide Detection System

As shown in Fig. 2, the proposed system achieves significantly higher performance in accuracy (90%), early warning (85%), cost-effectiveness (80%), and reliability (88%) compared to existing systems. This validates the improvement offered by multi-sensor integration and real-time alerts.

VI. FUTURE SCOPE

- Large-scale deployment in high-risk areas through government partnerships.
- Integration with satellite imagery and weather forecasting for enhanced prediction.
- Use of edge AI for faster decision-making without relying heavily on cloud processing.
- Expansion to cover other natural disasters like floods and earthquakes.

VII. CONCLUSION

The proposed IoT-Based Smart Landslide Detection and Alert System presents an effective, low-cost solution for monitoring landslide-prone regions. By combining multiple environmental sensors, cloud computing, and machine learning techniques, the system improves prediction accuracy and provides timely alerts. This proactive disaster management tool empowers communities to respond quickly, thereby reducing the impact of landslides on human life and property.

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