PROGRESS IN ENGINEERING APPLICATION AND TECHNOLOGY
e-ISSN: 2773-5303

PEAT

Vol. 6 No. 1 (2025) p. 528-533
https://publisher.uthm.edu.my/periodicals/index.php/peat

Smart Detector System for Landslide and Soil Movement Using Internet of Things

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DOI: https://doi.org/10.30880/peat.2025.06.01.056

Article Info

Received: 22 January 2025
Accepted: 29 January 2025
Available online: 30 April 2025

Keywords

Landslide, Internet Of Things, Detector System, Real Time Monitoring, Characteristic of Landslide

Abstract

The purpose of this study is to develop a Smart Detector System for Landslide and Soil Movement using IoT technologies to address the limitations of traditional landslide monitoring methods. The system focuses on providing real-time monitoring, early detection, and timely alerts to minimize risks to life, property, and infrastructure in landslide-prone areas. By incorporating advanced sensor networks, such as vibration sensors, and soil moisture sensors, the system continuously monitors raw data environmental factors. Data from these sensors are transmitted to a centralized platform for real-time analysis, leveraging machine learning techniques to detect early signs of potential landslides. This project is built to be flexible, affordable, and easy to use in different locations, making it suitable for many landslide-prone areas. It is expected to improve how quickly and accurately landslides can be detected, while also providing constant monitoring of soil and environmental changes. By using advanced technology and data analysis, the system aims to protect communities and buildings by reducing the dangers and damage caused by landslides, helping these areas become safer and more prepared.

1. Introduction

Landslides are a significant natural hazard that pose serious threats to human lives, property, and infrastructure worldwide, particularly in regions with unstable terrain. Conventional monitoring methods often lack the ability to provide timely alerts or continuous real-time data, limiting their effectiveness in preventing landslide-related disasters [1]. To address these challenges, advancements in technology, particularly the Internet of Things (IoT), have opened new opportunities for improving landslide monitoring and early warning systems [1]. The Smart Detector System for Landslide and Soil Movement using IoT project uses machine learning, real-time data processing, and contemporary sensor networks to improve landslide detection and prediction. To continually monitor important environmental conditions, the system incorporates sensors including vibration sensors, gps neo 6m, and soil moisture detectors. The technology provides timely notifications and allows early detection of landslide threats by sending real-time data to a centralized platform. In order to supplement ground-based monitoring and give comprehensive terrain evaluations, remote sensing technologies such as satellite imaging and LiDAR are also included [1]. The goal of this project is to develop a scalable, affordable, and flexible solution to increase safety and resilience in landslide-prone areas, building on earlier studies in IoT-based environmental monitoring.

In Malaysia, landslides are a serious natural hazard that frequently results in fatalities, property destruction, and disruptions to infrastructure. The Batang Kali landslide on December 16, 2022, which sadly claimed 31 lives including 13 children at an unauthorized camping in Selangor, is a noteworthy case [2]. According to investigations, the catastrophe was mostly caused by continuous, intense rain, underscoring the urgent need for efficient monitoring and early warning systems in areas vulnerable to landslides [2]. The creation of an Internet of Things (IoT)-based smart detector system for soil movement and landslides is suggested as a solution to these problems. The goal of this system is to continuously monitor the environment so that possible landslides may be identified early and communities that are at risk can get timely notifications.

The important topic, "How can IoT-based technologies enhance the early detection and monitoring of landslide risks in Malaysia?" is addressed in this paper [3]. In light of this, the study postulates that combining cutting-edge sensor networks, real-time data transfer, and machine learning methods might greatly increase the accuracy of landslide detection and deliver early alarms to lessen the effects of disasters [3]. The project is to explore this theory in order to create a scalable and reasonably priced Smart Detector System for Landslides and Soil Movement that not only overcomes the drawbacks of conventional monitoring techniques but also adjusts to the particular geographic and environmental circumstances of Malaysia. This invention might lead to a safer and more sustainable future by preserving infrastructure, saving lives, and boosting resilience in areas vulnerable to landslides.

2. Methodology

The Smart Detector System for Landslide and Soil Movement using IoT was created in response to the difficulties presented by conventional landslide monitoring techniques, which frequently fall short of providing timely alarms. Through the integration of IoT technologies, this system sought to enhance landslide detection and early warning by continuously monitoring important environmental conditions. Addressing the problems brought to light by previous landslide incidents in Malaysia, such the Batang Kali landslide, where a lack of early identification resulted in substantial damage and fatalities, was the aim.

2.1 Material

To accomplish accurate landslide monitoring, the Smart Detector System for Landslide and Soil Movement using IoT depended on a mix of carefully chosen materials and components. Because of their precision and dependability in monitoring important indications such soil movement, vibration, and variations in moisture content, these sensors were selected. In order to provide real-time data transfer from distant locations to a central platform, communication tools such as Wi-Fi module were also added. These communication modules were chosen because they are perfect for the Internet of Things-based monitoring system because to their long-range capabilities, low power consumption, and flexibility in challenging settings.

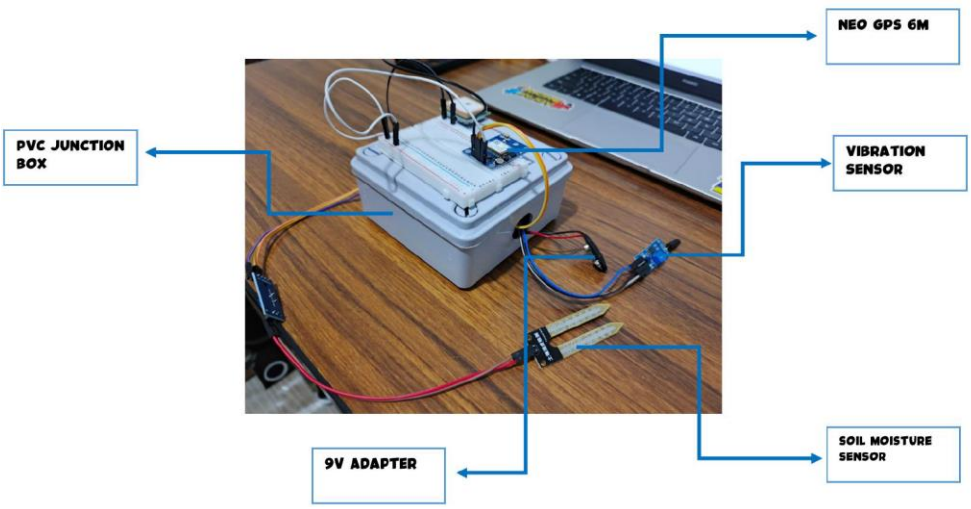

Fig. 1: Project Diagram

Figure 1 shows the prototype of a Smart Detector System for Landslide and Soil Movement utilizing IoT technologies. The system is built within a PVC junction box, which serves as a protective enclosure for the internal circuitry, shielding it from environmental conditions. A 9V adapter powers the system, ensuring reliable operation of all connected components. The setup includes a soil moisture sensor, which monitors the soil's moisture levels—a crucial parameter in predicting landslides. Additionally, a vibration sensor is included to detect any ground movements or vibrations that may indicate an impending landslide. A NEO GPS 6M module has been added into the system to improve its functioning and enable accurate position tracking of the device. This capability is crucial for linking sensor readings to geographic locations and keeping an eye on certain landslide-prone regions. Because of its small size and effective design, it may be used for real-time data collecting and monitoring in high-risk and distant areas. This prototype is a creative step toward enhancing early warning and landslide detection systems.

2.2 Software Development

The Smart Detector System for Landslide and Soil Movement's software development component is centered on effectively organizing and displaying the data gathered by the sensors in the system. In order to do this, the project gathers and processes real-time sensor data using ThingSpeak, a cloud-based IoT analytics platform. All of the data produced by the system is centralized in ThingSpeak, which facilitates the smooth transfer of data from the sensors to a cloud environment for additional analysis and interpretation.

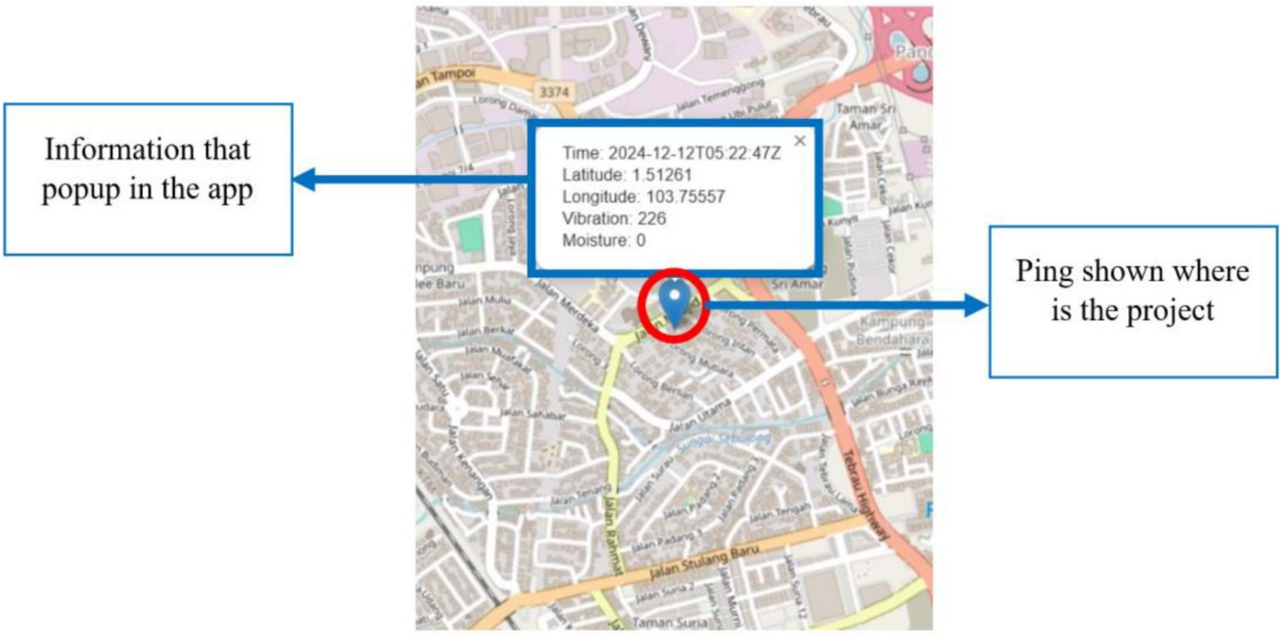

Fig. 2: Project Dashboard Diagram

Figure 2 shows a specific project location on a map-based application interface. Street names and other landmarks are included in the comprehensive map backdrop. The project's exact position is shown with a blue pin with a red circular border. A popup window that displays vital project information, such as the time, latitude, longitude, vibration levels, and moisture measurements, is located next to the pin. The layout and annotations on the map point to the possibility of a real-time project tracking and monitoring tool. The functionality of the program is detailed via two annotations. With the caption "Information that popup in the app," one arrow points to the popup box, highlighting the information that appears when a location is chosen. The blue pin, marked "Ping shown where is the project," is shown by another arrow, which shows how the program indicates the project's actual position on the map. By simply fusing geolocation with comprehensive project data, this graphic design improves usability.

2.3 System Flowchart

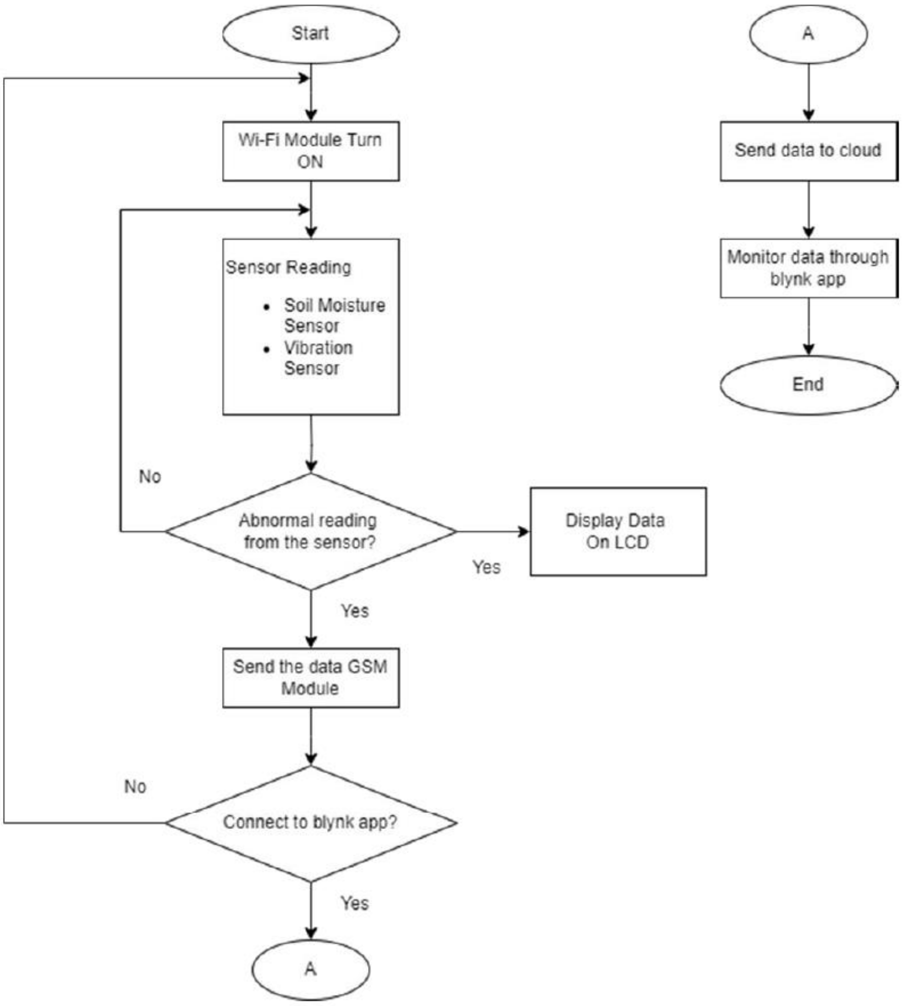

***Fig. 3*: Project System Flowchart**

A flowchart outlining a procedure for data monitoring with sensors, a GSM module, and a mobile application is shown in Fig. 3. As symbolized by the "Start" oval, it starts with the system booting up. The Wi-Fi module is first turned on, and then sensor readings are taken. Among these sensors are vibration and soil moisture sensors. A decision node looks for unusual sensor readings. The data is shown on an LCD if no unusual readings are found. A GSM module transmits the data if anomalies are found. The system's ability to connect to the Blynk app is confirmed by the following decision node. Following connection, the data is sent to the cloud, tracked via the Blynk app, and terminated at the "End" oval. A reference to "A," which denotes a continuation point for certain phases, is also included in the flowchart. The integration of hardware and software for real-time data monitoring and reporting is depicted in this figure.

3. Result and Discussion

Table 1: Raw Data Characteristic Based on Sensors

Sensors	Safe Range	Caution Range	Danger Range
SW1801P Vibration Sensor	200 - 500	600 - 800	900 - 1000
Soil Moisture Sensor	0 - 500	600 - 1000	1100 - 2500

The measurement ranges for the SW1801P Vibration Sensor and the Soil Moisture Sensor are shown in the table. Every sensor is divided into three different ranges: Danger, Caution, and Safe. The safe range for the SW1801P Vibration Sensor is 200 to 500, which denotes typical or acceptable vibration levels. The situation moves into a danger zone, indicating that vibrations are getting more problematic and that additional observation is necessary, when vibrations fall between 600 and 800. Levels exceeding 900 are dangerous since they may indicate excessive vibration that might lead to mechanical or structural problems. The soil moisture sensor ranges should be focused on identifying situations that might result in soil instability or possible landslides in the context of an Internet of Things (IoT)-based smart detector system for landslides and soil movement. The Soil Moisture Sensor's safe range is 0 to 300, which denotes steady soil moisture levels that are neither too dry nor too wet. There is no immediate risk of soil movement or landslides within this range since the soil is stable. The range of concern is between 301 and 700, when soil conditions may become unstable and moisture levels are borderline. This range indicates that soil moisture is getting close to levels that, when paired with other environmental conditions, may cause soil movement.

3.1 ThingSpeak Data

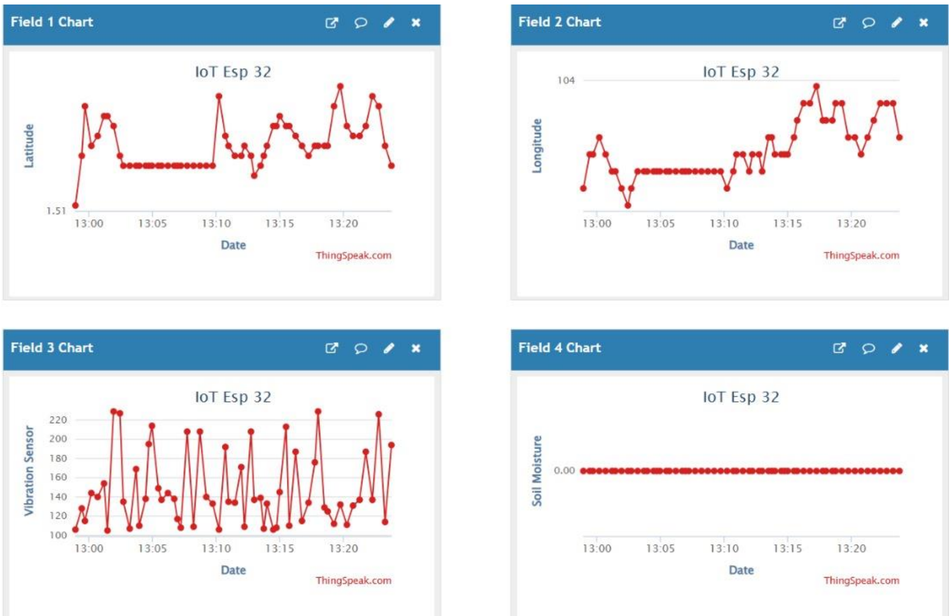

Fig. 4: ThingSpeak Data from Sensors

Figure 4 shows four-line charts produced by the ThingSpeak platform from an ESP32 Internet of Things device. Latitude and longitude are represented by the first two charts, "Field 1" and "Field 2," respectively. These charts illustrate variations over time that reveal shifts in the device's geographic location. Because the gadget travels, the latitude measurements fluctuate about 1.51, and the longitude numbers centre around 103. Sensor data is presented in the other two charts. The vibration sensor readings displayed in the "Field 3 Chart" exhibit a great deal of fluctuation, with values ranging from 0 to 220, signifying dynamic vibration levels. The soil moisture levels shown on the "Field 4 Chart" are continuously 0 during the monitoring period, indicating that there is no detectable moisture. When combined, these figures show how well the gadget can track geolocation and ambient data in real time.

4. Conclusion

It is clear from the introduction that landslides pose serious hazards to people's lives, property, and infrastructure, and that conventional monitoring techniques frequently fall short in terms of timely warnings or in-the-moment monitoring. The examination of the literature shows developments in the integration of IoT and sensor networks to improve landslip early warning systems. Important technologies that have been shown to be useful in real-time monitoring include vibration sensors, and soil moisture sensors. By examining environmental data, machine learning methods like artificial neural networks have shown potential in the prediction of landslides

Acknowledgement

This project paper is supported by Universiti Tun Hussein Onn. The author would like to thank the Faculty of Engineering Technology, Universiti Tun Hussein Onn Malaysia for providing necessary research facility for this study.

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