

Landslide Detection System Using WSN

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Abstract— Nowadays, everyone prioritizes personal safety and protection from natural disaster. A natural disaster might strike the Earth at any time or place, resulting in billions of fatalities as well as economic losses. Although these processes cannot be prevented, some intelligence systems may be able to prevent these losses. One of the main natural hazards among these is a landslide. Although there are other methods for detecting landslides; one of the newer technologies that has given scientists the potential to create real-time monitoring systems is wireless sensor network. The design, development, and deployment of a wireless sensor network (WSN) for real-time monitoring are covered in this project. The landslide detection system uses a vibration sensors, soil moisture sensors and accelerometers. By using these sensors, this proposed technology can give early warnings to save the lives of people and possible property.

Keywords—Wireless Sensor Network, Real-time monitoring, Networks, Landslide

I. INTRODUCTION

A landslide is a major problem faced by people living near the hillsides. The consequences that happen include deaths and loss of property on a large scale. A landslip is a fast-moving mass of rock, soil and other debris. Landslides, which are typically produced by earthquakes or periods of heavy rainfall, pose major geological threats and damage infrastructure. As a result, early detection of landslides is critical [1]. Landslides, a kind of "mass wasting," are down-slope movements of soil and rock caused by gravity, causing annual damage to societal life. Landslides in Kerala during the monsoon season have claimed lives in India in recent years [2]. Natural causes of landslip include increased hydrostatic pressure caused by rainwater saturation, snow melting, increased groundwater level, increased pore water pressure, volcanic eruptions, and earthquakes. Human activities include harsh activities like deforestation, farming, mechanical vibrations, blasting and mining. The slope's stability changes as shear stress decreases and shear strain increases [3]. Landslides occur more frequently in India, particularly in the hill region, than any other geographic phenomenon, resulting in a large number of casualties. Because many people are dying and there is significant infrastructure damage, there is an increased need to create a device to identify the disaster at an early stage. We must monitor landslides on a regular basis and notify the public in advance. . A number

of methods for landslide detection mechanisms have been proposed, but none is as viable as the IoT-based landslide detection system [4]. Furthermore, there are some architecture that identifies and categorizes components based on their benefits and downsides, as well as performance metrics such as efficiency, dependability, quality of service, and network longevity [5]. To safeguard human lives and property in mountainous places, a landslide monitoring system must be established immediately. There is a need to build landslide monitoring and detecting systems that can generate alarms when a landslide happens. These devices may save human lives and property by sounding alarms at critical times [6]. The fundamental observing procedures are grouped by type (fall, slide, spread, stream, incline twisting), speed (slow, moderate, quick) checking boundaries (meteorological, topographical, hydro geological, physical, geophysical), periods of avalanches (neighborhood, fleeting) and early admonition frameworks (nearby, transient) [7]. Remote sensors are one of the state-of-the-art advances that can rapidly answer quick changes in information and send recognized information to an information examination focus in regions where cabling isn't proper. Remote sensor organization (WSN) innovation can quickly catch, process and communicate basic information in high goal progressively [8].

This paper is an endeavor to give a significant level outline of landslide checking strategies and attempts to relate observing methods to the kind of landslides that they might possibly happen, checking viewpoints (ongoing, close to continuous, periodical, site-explicit, and territorial checking), and utilization of these procedures for giving early advance notice and so on. Be that as it may, the geographical development of the landscape, landslide elements, and recurrence should be concentrated on exhaustively with the assistance of specialists. This article isn't a substitution for the master counsel that is important to be completed prior to sending a specific observing strategy for any avalanche application. In this paper the aim is to give a framework that will give constant checking the assistance of various sensors like accelerometer, soil moisture sensor and vibration sensor. These sensors assist in getting and moving data to the servers which with willing be checked by the aide groups ideal. In particular, the accelerometer sends blunder in the event that the hub of the accelerometer changes past

line. When a vibration exceeds a specific specified limit, the vibration sensor notifies the application of the error. The soil moisture sensor likewise has a cutoff set-in advance which when surpassed sends an alert. An application is created and made available to both the residents of that area and the associated organisations. The application shows a recognized sign when all three of vibration, accelerometer or soil moisture sensors surpass their separate thresholds. Every individual will be encouraged to download this application for the security purposes. Assuming the threshold is surpassed cautions will be produced.

II. LITERATURE REVIEW

In In 2009, Ramesh, Maneesha V. published a study [1] showing that WSNs are perfect for monitoring remote or dangerous situations because of their ability to swiftly gather, process, and send vital data in real time with excellent camera quality. Low memory availability compared to other technologies.

In another study in 2018, Aggarwal, Shivam, et al. [2] proposed a method in which the system uses a camera to view its surroundings and recognize moving objects based on the center of mass of moving pixels. The Raspberry Pi device's video stream serves as the system's input which OpenCV a open source library consisting of hundreds of algorithms, is then used to process. The system requires a stable internet connection and may not be effective in areas with poor connectivity.

Ye, C., Li, Y., Cui, P., Liang, L., Pirasteh, S., Marcato, J. & Li, J., et al. in 2019 [4] suggested a framework in which spectral-spatial properties of a landslide are extracted using a deep belief network, and the landslide is then verified using a logistic regression classifier with constraints. The framework requires a large amount of labeled data for training the deep learning model.

Sruthy, M. R., Anjana, R., Archana, R., Dhanya, V., & Hridya, A. H. in their study [8] aimed to detect conditions that lead to landslides and notify citizens well before time. The system uses accelerometer and soil moisture sensors to collect data, which is then transmitted to a microcontroller and Raspberry Pi for analysis. They have used multiple controllers.

Ravi Bhushan Bhardwaj in 2021 proposed a study [3] in which the system uses sensors connected to an Arduino development board, which is connected to the cloud service for monitoring real-time data. An alarm is issued via SMS to the end user's registered mobile number and displayed on the LCD screen if the sensor output exceeds the threshold value. The system relies on the availability of GSM service, which could not be available in remote locations.

Danneels, Gaele, Eric Pirard, and Hans-Balder Havenith in a study in 2007 [9] learned that the maximum likelihood ratio (MLR) and artificial neural network (ANN) classification methods are contrasted. Using the two-fold threshold technique, the likelihood image is segmented at the output into landslide and non-landslide areas. The accuracy of the automated procedure depends on the quality and resolution of the remote sensing images, as well as the selection of the training area and parameters.

R. Dhanagopal, B. Muthukumar in their study in year 2019 [7] discussed that the final goal of their research is to use IoT to create an early landslide detection system that is low-power, fast, and energy-efficient. The sensor gadgets that make up the system are meant to run on an internal battery. This technology has limited scalability.

In 2019, P. K. Mishra, S. Dhar, and M. Kalra [6] presented a cost-effective and efficient surveillance

system for landslide monitoring in real-time using computer vision algorithms and a small computer board Raspberry Pi. The proposed system uses a Visual Background Extractor (ViBe) for moving object detection and median filtering to reduce impulse noise. The three primary phases of the system are object tracking, object detection, and background subtraction. Requires entropy calculation and depends on webcam video.

In a recent study in 2022, S. Bagwari, A. Gehlot, R. Singh, N. Priyadarshi and B. Khan [5] offers a thorough analysis of low-cost sensor-based and LoRaWAN options for Internet of Things landslide monitoring systems. The paper also discusses pixel-based techniques for detecting changes in electromagnetic radiation and the 4 applications of artificial intelligence and fuzzy logic to landslide monitoring and prevention. Challenges faced to make the system more collaborative and flexible.

Hemalatha Thirugnanam, S. Uhlemann, R. Reghunadh, M.V. Ramesh and V. P. Rangan in 2022 proposed a study [10] which compares several monitoring methods, such as photogrammetry, LiDAR, GPS, and seismic approaches, and discusses the benefits and drawbacks of each method as well as the potential integration of IoT. But methods which utilizes manpower are hard to be integrated as IoT edge device.

In 2015, Aibek Musaev, D. Wang and C. Pu. proposed a study [11] in which their system incorporates data from social and physical information services into a multi-service composition technique. Semantics-aware detection, integration, and filtering are the three separate parts of the system. The filtering component removes noise from social sensors and downloads data from physical and social sensors. The integration component creates a list of possible landslide places by integrating the filtered data from social sensors and the data from physical sensors using a Bayesian model integration method. The semantics-aware detection component removes out-of-date results and group's locations associated with the same event. Real data is used to assess the system, and it is contrasted with a reliable source. The integration of the system depends on geo-tagging and had less accuracy.

G. N. L. Ravi Teja, V. K. R. Harish, D. Nayeem Muddin Khan, R. B. Krishna, R. Singh and S. Chaudhary in 2014 [12] published a study which involves the deployment of a heterogeneous network of geo-physical sensors, including pore pressure and moisture content sensors, strain gauges, tilt sensors, and geophones, to monitor changes in soil conductivity, slope gradient, and seismic activity. The data collected by these sensors is transmitted wirelessly to a central node for analysis and interpretation. The system is designed to issue warnings immediately in the event of severe slope failure or damage. The use of wireless sensor networks allows for cost-effective and efficient monitoring of large areas prone to landslides. Potentially slower processing speed as a result of serial controller.

Prapti Giri, K. Ng and W. Phillips in 2019 in a study [13] proposed a flowchart which makes use of IMU sensors to enable efficient monitoring and warning in the present. Two methods are devised to calculate slope movements: one based on changes in the linear acceleration data pattern and the other on sensor noise. Different forms of movement or modes of slope failure are characterized. Small-scale tests are carried out to mimic roll, single-column toppling, translational slips, and rockfall. The information gathered is utilized to create methods for spotting movement and classification standards for different kinds of failures. This technology was unable to pinpoint the landslide's precise location.

M. I. Sameen and B. Pradhan in 2019 proposed a study [14] which entails dividing Landslide Identification and

Mapping (LIM) techniques into three categories: deep learning, object-based, and pixel-based. The authors then suggest a novel technique to increase the accuracy of landslide detection by integrating spectral and topographic data using a residual neural network (ResNet). Adaptive moment estimation (Adam) and a binary cross-entropy loss function are used to train the ResNet. The learning rate strategy is sigmoidal decay with an initial value of 0.001, and the models are trained for 500 iterations with early termination. Using a dataset of Landsat 8 and Shuttle Radar Topography Mission (SRTM) images, the authors assess the performance of their proposed method and compare it with existing LIM techniques. Network parameter optimization and selecting suitable training approaches continue to be difficult tasks.

III. METHODOLOGY

In earlier technologies, attempts have been made to make an affordable system which will be able to detect landslide in advance so as to save property loss and mainly life loss. In this paper there is a similar approach. In this proposed system the main focus is on giving alerts when there is a possibility of landslide. The proposed work consists of three sensors; vibration sensor, accelerometer sensor and soil moisture sensor. The process starts at the sensor-end. An mobile application is made that displays an error as 'detected' when the vibration, accelerometer or soil moisture sensor exceeds the threshold. The data is sent to the master-node using I2C protocol. Then through serial communication it is sent to Esp-32. It is then transferred to firebase and ultimately to the application. In particular, the soil moisture sensor notifies the user through the app that it has been "detected" when the water content drops below a predetermined threshold of 500. The screen shows 'detected' if the vibration sensor picks up vibration. The tilt is detected by the accelerometer. The screen reads "detected" if the value exceeds, or if the accelerometer is tilted beyond, a predetermined value, which is set to "6."

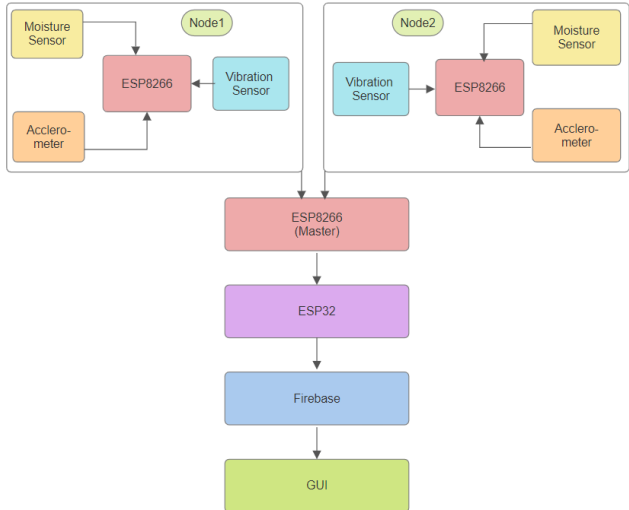


Fig. 1 Block diagram of sensor communication

The block diagram represents the proposed system which includes components like soil moisture sensor, vibration sensor, accelerometer, Esp8266, Esp32, firebase and GUI. This technology eliminates a number of other approaches, including the use of multiple microcontrollers, handling scalability issues, lacking greater accuracy in ANN-based systems, and not having larger memory capacities.

IV. RESULTS AND DISCUSSION

As previously discussed, the application uses three different sensors to detect the possibility of landslides. Each sensor has a different threshold value, so when the value exceeds the threshold, the sensors notify the master node, which in turn notifies the firebase database. At that point, the prompt appears on the app as 'detected'. There are two nodes having three sensors each; vibration, soil moisture and accelerometer sensor. In the below images attached, each image displays 'detected' error sequence-wise. For this some demonstration tests were run on nodes, and the results were visible on the app [Figs. 2 to 7].

Landslide Detection

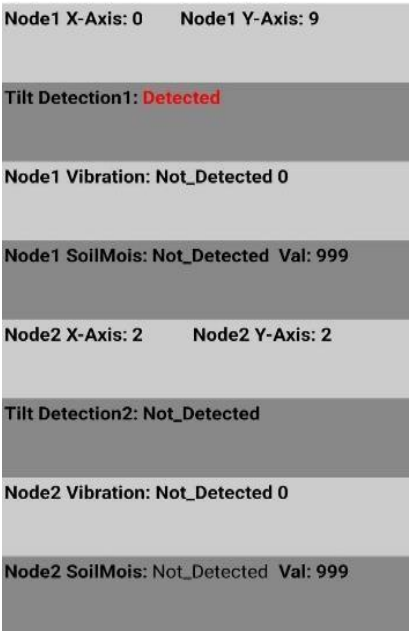


Fig. 2. Node 1: Tilt Detection

Fig.2 shows the 'detected' sign in front of the section representing the tilt detection sensor of 1st node. There is an X-axis value and a Y-axis value that is previously set at 0. If the value goes above the threshold value that is set at '6', the error 'detected' is shown.

Landslide Detection

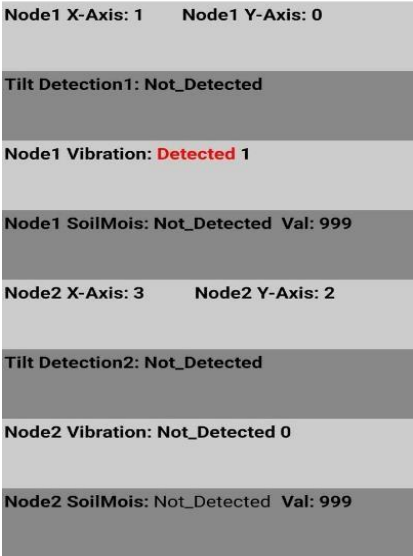


Fig. 3 Node 1: Vibration Detection

Landslide Detection	
Node1 X-Axis: 2	Node1 Y-Axis: 0
Tilt Detection1: Not_Detected	
Node1 Vibration: Not_Detected 0	
Node1 SoilMois: Detected	Val: 297
Node2 X-Axis: 1	Node2 Y-Axis: 2
Tilt Detection2: Not_Detected	
Node2 Vibration: Not_Detected 0	
Node2 SoilMois: Not_Detected Val: 999	

Fig. 4 Node 1: Soil Moisture Detection

Fig.4 shows the ‘detected’ sign in front of the section representing the soil moisture sensor of 1st node. The threshold value set for the soil moisture sensor is ‘999’. When the level of soil moisture goes below the value ‘500’, the error ‘detected’ is shown.

Landslide Detection	
Node1 X-Axis: 2	Node1 Y-Axis: 0
Tilt Detection1: Not_Detected	
Node1 Vibration: Not_Detected 0	
Node1 SoilMois: Not_Detected	Val: 999
Node2 X-Axis: 1	Node2 Y-Axis: 9
Tilt Detection2: Detected	
Node2 Vibration: Not_Detected 0	
Node2 SoilMois: Not_Detected Val: 992	

Fig. 5 Node 2: Tilt Detection

Fig.5 shows the ‘detected’ sign in front of the section representing the tilt detection sensor of 2nd node. Same as the 1st node, there is an X-axis value and a Y-axis value that is previously set at 0. If the value goes above the threshold value that is set at ‘6’, the error ‘detected’ is shown. Fig.6 shows the ‘detected’ sign in front of the section representing the vibration sensor of 2nd node. When the vibration sensor bears a vibration, the error ‘detected’ is shown.

Landslide Detection

Node1 X-Axis: 2	Node1 Y-Axis: 0
Tilt Detection1: Not_Detected	
Node1 Vibration: Not_Detected 0	
Node1 SoilMois: Not_Detected	Val: 999
Node2 X-Axis: 1	Node2 Y-Axis: 2
Tilt Detection2: Not_Detected	
Node2 Vibration: Detected	1
Node2 SoilMois: Not_Detected Val: 999	

Fig. 6 Node 2: Vibration Detection

Landslide Detection

Node1 X-Axis: 1	Node1 Y-Axis: 0
Tilt Detection1: Not_Detected	
Node1 Vibration: Not_Detected 0	
Node1 SoilMois: Not_Detected	Val: 999
Node2 X-Axis: 2	Node2 Y-Axis: 2
Tilt Detection2: Not_Detected	
Node2 Vibration: Not_Detected 0	
Node2 SoilMois: Detected	Val: 297

Fig.7 Node 2: Soil Moisture Detection

Fig.7 shows the ‘detected’ sign in front of the section representing the soil moisture sensor of 2nd node. The threshold value set for the soil moisture sensor is ‘999’. When the level of soil moisture goes below the value ‘500’, the error ‘detected’ is shown.

V. CONCLUSION

In conclusion, the landslide detection system has made great progress in resolving the challenges posed by landslip threats. By combining cutting-edge technologies like machine learning, remote sensing, and data analysis, the developed system shows a great potential to identify and predict landslide events. The utilization of machine learning techniques, specifically deep learning models, has demonstrated efficacy in identifying patterns and anomalies linked to probable landslide regions. giving communities and authorities crucial time to put preventive measures in place. The study also highlights the potential for early warning systems and real-time

monitoring, giving communities and authorities crucial time to prepare for emergencies and evacuate high-risk regions. An all-encompassing strategy for landslide detection and mitigation is made possible by the deployment of an integrated platform that integrates many data sources and analytical tools. It is imperative, therefore, to recognize the constraints and difficulties that arose throughout the process, including data accessibility, model generality, and the requirement for ongoing updates in order to adjust to changing environmental conditions. The development of landslide detection system capabilities will require constant research and cooperation with subject-matter specialists.

VI. FUTURE SCOPE

As we imagine the future of landslide detection system using Wireless Sensor Networks (WSN), integrating position tracking and solar panel batteries promises to dramatically improve the system's efficacy and sustainability.

Integrating GPS or other position monitoring technology into WSN nodes allows for exact geo-referencing of landslide-prone regions. This connection will provide real-time monitoring and precise mapping of landslide events, allowing for more immediate reaction and mitigation

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