

Landslide Detection and Early Warning System Using Wireless Sensor Network

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Abstract— Landslide is a type of natural disaster that disrupts social life. It occurs most frequently during India's monsoon season, causing major damage and altering the environment condition. An early landslide detection and warning system can be developed with the use of a Wireless Sensor Network (WSN) by establishing several nodes in order to prevent damage and threat. WSN system includes rain gauge, strain gauge, accelerometer and moisture sensor as well as NodeMCU and ESP8266. Each sensor detects ground movement and soil moisture content to carry out its function. The data is transmitted via ESP8266 Wi-Fi module. Early Warning system depend on sensor node used to read different properties of slope and soil condition with particular parameters. The parameters that are received are used for the detection of downhill movement of soil, debris or rocks. The NodeMCU is utilized in the circuit to read the measurements taken by wireless sensors.

Index Terms— WSN, ESP8266 Wi-Fi module, NodeMCU, Sensors.

I. INTRODUCTION

Landslide is defined as variation in downward movement of a mass of rock, rubble or earth down a slope, landslide is a kind of mass wasting which leads to down slope motion of soil and rock with the direct influence of gravity, mudflow, mudslides rock falls are generally called as debris flow and these are the parameters which leads to unusual landslide, when gravity surpasses the capacity of earth substance which creates slope, the outcome of down slope force and component that make low or decreased capacity which leads to slope motion. Landslide can occur due to heavy rainfall, snowmelt, earthquake, volcanic activity and also due to human activity like deforestation and modifying slope of land and mixture disturbance in land instance. Hence a prior warning system for landslide detection can reduce

threat and damage to a low extent.

Particularly for rainfall induced landslide with the aim to reduce the damage a WSN based method can be used to detect and forecast landslide. properly damage, loss of life can be decreased by the early warning and prediction. The WSN system can provide exact information or data by performing real time forecasting landslide induced parameters by constructing a multi sensor WSN based system which records many parameters such as soil moisture, ground vibration and motion detection for rainfall induced landslide. An early warning of three levels can be designed to detect landslide warning signal the system crosses the threshold values; the developed system alerts the end user and information can be transmitted to base station.

II. LITERATURE SURVEY

Mishra et al [1] have developed landslide detection utilizing WSN, which is primarily employed in the creation of real-time monitoring systems. It entails the design and development of wireless sensor networks (WSNs) for real-time forecasting system. Geodetic and non-geodetic procedures are the most common monitoring methods. Landslides have a huge impact on the natural environment of the earth. The importance and utility of non-geodetic techniques are greater. Data is sent across nodes wirelessly building an ad-hoc network, and the base station collects data from the nearest node and sends to the base station using a multifunctional risk information system (IRIS) remote attached to wireless module to scan multifunctional digital sensors. Data is sent from the base station to the computer in the form of packets, which are examined by software installed on the PC. The system can move and accelerate by evaluating data.

Kalpesh et al [2] has proposed using wireless sensors and GSM, landslide detection gives real-time measurements of several restrictions such as moisture, land movement, rainfall volume, and also landslide due to earthquake monitoring by microcontroller. Rain sensors, humidity sensors, vibration sensors, and accelerometer sensors are common devices in electronics that are used to measure data from the environment. Sensor networks and GSM, which are connected via wireless protocol, are useful for mapping, detection, analysis, and prediction in remote areas. Sensors will be relayed to a server in the emergency unit, allowing for landslide mitigation, and GSM will deliver the message service to the server system through wireless.

Kamaleetal[3] have proposed WSN-based real-time monitoring of a rainfall landslide predicting system. Multi sensor wireless system regularly detect the surrounding environment and gather relevant data, which can be sent to the base station, for landslide detection based on the accumulate data and transmits an alert for a possible landslide to the cloud server and it predefines a threshold for initial landslide avoidance. Moisture sensor, load cell sensor, rainfall detection sensor, and accelerometer, which are consolidated to a rod and buried inside the soil, compute the intensity of rainfall, volumetric water measured by the soil moisture sensor, pressure variation determined by the load cell, and accelerometer detects change through sensors.

Hemalatha et al [4] have proposed WSN machine learning (ML) algorithms for real-time monitoring and landslide warning have been successfully reconciled. The WSN identifies landslide triggering characteristics such as pore water pressure (PWP), soil moisture, and motions to be monitored. The obstacles in landslide warning and data-driven are addressed, as well as to overcome them, current PWP and 24 PWP are the two primary algorithms. To overcome schedule inadequacy the system supports vector regression method. It captures the causal relationship between parameters leading, distribution method and laboratory readings for time related changes in framework by achieving reliability through knowledge and forecasting techniques.

Diwaker et al [5] have proposed study of prone to herbal calamities and routinely experience a number of disasters in the form of mass destruction and property loss recommends detection and control to

prevent losses in hilly regions. The WSN technique, which consists of a large number of small sensors used for measuring various parameters, concatenates the sensed information with the sinks via wireless medium, the processed information is sent to the data base center, and the final information is sent to the data center in order to generate an early warning to take proper action. It can aid in the development of wireless sensor architectures, algorithms, and protocols in a variety of studies.

Ravi et al [6] has proposed slide detection based on IOT, the changes in rock mass or soil under gravity can affect both natural and human activities such as deforestation, agriculture, machinery vibrations, blasting mining, and decrease shear stress and raise shear strain by changing the slope's stability. The IOT approach for landslide detection, as well as Arduino and Wi-Fi modules, were used to construct a less expensive and effective warning system. Vibration sensor and moisture sensor are the most commonly used sensors. Data is collected and uploaded to the Arduino cloud performs real time data monitoring and communication to the ultimate user through SMS on their mobile phone when a landslide occurs.

Rahmat et al [7] have proposed an implementation of WSN on ground movement detection system, the system consist of inclinometer used to detect the changes occur, calibration was completed by homemade tilt calibrator with the server, in node transmission system Xbee pro was used and also it needs power supply. GPS used to explore position of node and to detect occurrence of landslide, to build a web server used a code igniter then it starts accessing data. The start topology in a system make communication between the nodes, and starts with the ping from coordinator to nodes, it occurs till data send to coordinator and stored data has been successfully sent to server, then each node show on google map.

Pawan et al [8] have proposed that there are various techniques to find hazard from natural calamities, in past years techniques were not perfect, this led to high threat to human species, In this method GSM module is used to gather information and send data to monitoring station so that data is checked from the previously determined threshold value of a particular system, whenever threshold crosses the system will alert the end user, this can be achieved using hardware and software analysis hence it can act as prevention from damage and destruction.

Aghuset al [9] have proposed WSN warning system in IOT architecture frequently happened in Indonesia, has area topography, climate characteristics, geological structure make country landslide potential area. The communication network between the internet technology which makes a significant spine with the support of substantial for communication, IoT make use of an Arduino ATmega 2560 microcontroller to reserve data from sensor, GSM used to generate the stored data to webserver, which calculates the slope, temperature and soil moisture.

Taroetal[10] have conducted experiment by applying artificial heavy rainfall and detect magnitude and direction of acceleration, based on accuracy highly sensitive electronic inclinometer sensors achieve output, Micro Electro Mechanical System (MEMS), tilt sensor and volumetric water content sensor measures the different behavior of tilt angles observed on slope surface, equipment has developed for practical use by MEMS sensor, based on exactness and susceptible electronic inclinometer sensors performs the output.

Julian et al [11] have proposed landslide warning with GIS analysis of soil movement and rainfall, microcontroller used to process input signals and activate the alarm, LCD used to display the acceleration in x, y, and z axes, soil shifted and rainfall reached 100 mm/day, data logging information and GIS spatial data can be observed remotely and graphics in the form of geographical map with the help of web GIS interface Kampung Gerendong, Desa Putat Nutug, Kecamatan Ciseeng, and Kabupaten Boger all used the system.

Dhanagopalet al [12] have proposed IoT is based on the Energy Efficient Early Landslide Detection (EEELD) concept, which uses less electricity and operates at a high speed and covers a large region for movements such as flows, slope failure, and rock fall. System consists of an Arduino board, humidity and vibration sensor, ZigBee module and LCD screen, and the second prototype consists of a Frequency modulation (FM) transmits to control the message sent to listening nodes, receiver with the help of wireless transmitter receive data from remote sensor, and Arduino board, humidity, vibration sensor, ZigBee module and LCD screen. The society will benefit from a more cost-effective approach since it will protect more lives.

Ravi et al [13] have proposed monitoring system

using WSN, these are the major issues in the environment, causing significant effects on natural habitat, economy, and many resources, three major issues in real time application monitoring fault is one of the application that act as major role by using development technology, by integrating GPS with wireless network helps in identifying the fault occurrence, the electronic nodes are designed by using controller and an electronic node monitoring fault is one of the significant applications that act as advanced technology by integrating GPS.

Kuldip et al [14] have proposed environmental difficulties cannot be stopped in nature, but by introducing some new methods and this damage can be prevented. The most severe natural hazards, a landslide that occurred recently in Pune, necessitated immediate and drastic changes. The best technology for monitoring is WSN transmission, which occurs due to the ZigBee Wi-Fi module, which sends pre-warning SMS to a specific authorized mobile device with the help of ZigBee, where the predetermined readings or threshold values increases in ten second steps and gives an alert audio call to that specific number with a predetermined message.

Pawar et al [15] have proposed the system uses related sensors in that soil moisture sensor helps in measuring moisture content of soil after checking if there are any changes in readings or crossing the initial threshold it gives the sensing or alarm to the local citizen to safeguard. Asia was found to be the most affected continent where 75 percent of landslides occur or the received information is sent to Raspberry Pi (Rpi) using MQTT protocol for controlling purposes and displaying the safe, middle and danger zone notifications, readings are uploaded to the data center for analysis, the group is alerted and an additional 20ms time is required to upload the data from Raspberry pi.

III. METHODOLOGY

A. BLOCK DIAGRAM

The suggested system includes ESP8266 Wi-Fi modules, as well as sensors for correspondence and data recovery. Strain gauge, rain gauge, accelerometer and moisture sensor are the sensors employed. When sensor values exceed the threshold value, an alarm system will be initiated at a remote site.

The data collecting and monitoring unit collects data and controls the use of different sensors NodeMCU from the procurement and control area, resulting in it being used as a transmission unit. This unit contains a number of sensors, including a strain gauge, rain gauge, accelerometer and moisture sensor. Landslide monitoring, forecasting and warning are critical factors in preventing catastrophic devastation of life and property.

Landslides are monitored using three fundamental methods sighting, surveying, and equipment. Each observing approach has its own set of benefits, drawbacks, and application possibilities. One of the successful ways for observing avalanches may be land-based visual observation and inspection of this information on a regular basis. The research encompasses a wide range of actual estimations, including levels, theodolites, electronic distance estimation and the absolute station all of which contribute to the best avalanche portion.

Because of their utilization, remote implementation site unavailability and stability energy, real-time monitoring networks are power constrained. Taking these factors into account, the wireless sensor network at the execution site implements an utterly innovative notion for appropriated placement and assessment, resulting in more precise choices than each signal sensor and the ability to make generally optimal selections.

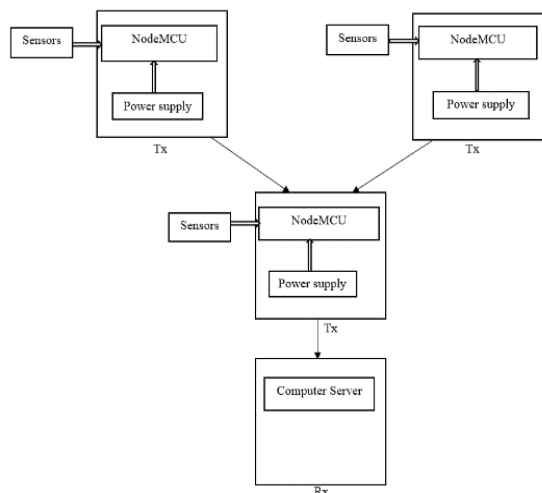


Fig1. Block diagram of WSN Network

Power supply, strain gauge, rain gauge, moisture sensor and ESP8266 Wi-Fi module blocks make up the transmitter circuit. The NodeMCU is linked to the sensors, the signal conditioning circuit is used to

receive the right output from sensors. Because the data acquired by the sensors is in voltage form, we must convert it to the proper format before displaying the results. The controller is designed to provide 5V power to external modules, ESP8266 Wi-fi module is used to transmit data, the range of ESP8266 Wi-fi module is approximately frequency range is adjustable from 100 Hz and 1 kHz.

NodeMCU ESP8266 Wi-Fi module and computer on the receiver side are used to monitor data. The threshold value has been crossed when the alarm system is activated. This system is turned on initially, followed by real-time monitoring. Monitoring occurs once per second, implying that data is checked once every second. The user can set the threshold value on the device. The data is processed by the controller and if it exceeds the threshold, it is checked for maintenance value on a regular basis. If the threshold value is surpassed, the output will be displayed on the LCD.

IV. CONCLUSION

This study describes the real-world deployment of a wireless sensor network for landslide detection. WSN for Landslide Detection is one of the most difficult study topics available in the field of geological research today. The proposed system collects data via a wireless sensor network and then communicates it, the system uses a wireless sensor node and NodeMCU for efficient transport of real-time data to the monitoring station. Advanced data processing is possible to the monitoring center's software and hardware. As a result of the analysis, residents in the area can be alerted landslide warnings and risk assessments. The suggested task is to monitor the risk of landslides and measure the parameters associated with landslides before the occurrence.

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