

Robust Early Detection Mechanism for IoT enabled Landslide Monitoring using Lora Technology

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ABSTRACT: Landslides pose major socio-economic threats to areas that are favored by their geography. Currently existing methods and techniques for monitoring landslides are characterized by significant limitations in terms of both technical (quality and data frequency) and usability (high inferred costs, very high expertise requirement). In this project we are introducing a ground breaking framework for tracking landslides that leverages state-of-the-art IoT technologies. The system consists of a series of autonomous sensing devices fitted with a specially tailored sensor suit to track landslides. The devices take sensory measurements at frequent intervals-while operating at a very low duty cycle-and transmit them for curation and visualization through the Lora network to a data server powered by cloud server. The system follows a modular architecture that is scalable and has been shown to be highly reliable. As a result, proposals are being made to expand its use to other areas.

KEYWORDS: Internet of Things, Sensors, Landslide, LoRa.

I. INTRODUCTION

Landslides in India mostly occur during monsoons, causing great loss of life and property. They cause considerable damage to highways, railways, and pipelines. They generally occur with other major natural disasters such as earthquakes, volcanic activity and floods are caused by heavy rainfall. In many cases, expanded development and human activities, such as modified slopes of land and deforestation, can increase the incidents of landslide. An early warning system for landslide prediction can reduce these losses to an excellent extent. We shall use the wireless sensor networks within the landslide prone areas for estimating the prospect occurrence of landslides.

Wireless sensors are one of the technologies with great advancements that can quickly respond to rapid changes of data and send the sensed data to a data monitoring center via Lora. Sensors are easy for rapid installation, which may be positioned directly upon the landslide body, or within the surroundings, to supply real time data on the landslide activity. Landslide is a frequently occurring natural disaster in hilly regions. Major landslide prone areas in India are the Himalayas, Indo-Burmese Range, Western and Eastern Ghats, Nilgiris, and Vindhya Range. It affects approximately 15% of land area of India, which accounts nearly 0.5 million squarekilometre.

The Internet of Things (IoT) is a term for describing an infrastructure for enabling advanced, ubiquitous services between connected physical and virtual things, based on evolving information and communication technologies in an Internet-like structure. Things in IoT are described as objects embedded with sensors and the ability to communicate, resulting in networks that underpin new innovative business models and processes, whilst reducing the associated costs and risks of existing ones. The techno-social ecosystem of IoT enables a cyber-physical convergence which lies at the heart of broader paradigm shifts, such as Industry 4.0 and Circular Economy. The financial impact of IoT is also profound; by 2025 more than 55 billion IoT devices will be deployed globally and around 15 USD trillions will be invested in IoT in aggregate between 2017 and 2025. Investment areas already cover several sectors of economic activity and use-case verticals such as health care, security, transportation, critical infrastructure, manufacturing, etc.

However, the benefits of IoT are not confined only in reducing the costs and increasing the efficiency of already existing systems, but extend to enabling new innovative services that were not possible to be supported so far. These services not only lead to increased yields but also inform the decision making of end-users. Recent technological advancements and trends have accelerated the deployment and adoption of IoT networks and systems.

The proliferation of Single Board Computers has greatly reduced the CapEx and has increased the versatility of developing and deploying IoT systems. Advancements in wireless communication technologies have also been another

important factor. Low power personal area network (LowPANs) protocols, such as IEEE802.15.4 and Bluetooth Low Energy (BLE) at the physical and MAC layers, and 6LoWPAN and 6TiSCH at the networking layers have enabled IoT systems in indoor environments such as smart buildings and factories. On the other hand, wireless wide area networks for the IoT, such as LoRaWAN, SigFox and NB-IoT enable the deployment of IoT systems over broad geographic areas, thus allowing novel business models and decision making mechanisms for private companies as well as for local and national authorities.

II. RELATED WORK

The term landslide refers to major soil displacements down a slope such as cliffs or mountains. Although, the primary driving force of a landslide is gravity, there are other contributing factors as well, such as soil composition, precipitation, variations of soil and air temperature and human activity. Landslides may have great adverse effects severely affecting human activity and lives, sometimes to the degree of natural disasters. But can be reduced significantly, if we have better understanding of the initiations of landslides and in techniques of slope instability hazard assessments, prediction and mitigation.

Indicative examples are the 2010 Uganda landslide that caused 100 deaths and the 2011 Rio de Janeiro landslide that caused 610 deaths. In this context, landslide monitoring and prediction has been a hot research topic. This addresses the main enabling factor of this promising paradigm is the integration of several technologies and communications solutions. Wireless and wired sensors and actuator networks, enhancing communication protocols and distributed smart intelligent objects are just the foremost relevant. As one can easily imagine, any serious contribution to the advancement of the web of Things must necessarily be the results of synergetic activities conducted in several fields of knowledge, like telecommunications, informatics, electronics and science. In such a posh scenario, this survey is directed to those that want to approach this complex discipline and contribute to its development.

In 2007, forecasting potential slope failure in open pit mines is integral to maintaining safety and mine productivity. Laboratory testing of rain induced landslides in Korean 20 years ago led to an inverse-velocity approach for estimating slope failure time. This approach appears to possess been largely overlooked in mining, but has been successfully applied within the prediction of three large slope failures ranging in size from 1 to 18 million cubic metres. These predictions were forecasted fortnight to 3 months beforehand of failure. This presentation provides a summary within the development of inverse-velocity as a tool for failure prediction and presents four case examples within the successful application of this approach. A methodology is additionally presented that facilitates contingency planning and remediation supported slope movement rate predictions.

In 2013, a full-scale field experiment including artificial rainfall has been examined during an instrumented loess cut slope in a loess plateau, Northwest-China. By the use of Instrumentations including soil moisture probes, tensiometers, piezometers, vacuum sensors, water level sensors, and rain gage were installed within the slope. After monitoring for about 2 years, artificial rainfall was induced at the location in April 2007. This project paper presents the results for soil moisture probes, tensiometers, and water levels to illustrate the surface infiltration process in an unsaturated soil. The result provides the top 0.7 m in loess is an active zone under the process of infiltration and evaporation, when subjected to a maximum rainfall intensity of XMR soil. During the heavy rainfall intensity of 120 mm/day, the depth of the "wetting front" is about 3 m.

In 2017, the precise determination of point coordinates along the traditional Global Positioning System techniques often requires observation times from one to many hours for the detection of landslides. In the previous couple of years, new GPS methods are developed (the fast static and real time kinematic), with higher productivity and good theoretical precision. The main objective of this paper is to determine the performance of those methods in landslide monitoring practice. We present, first of all, the essential principles of the GPS, the equipment and dealing procedures. We often discuss afterwards the applicability of the GPS to the monitoring of landslide surface displacements. Compared with the classical surveying methods, the GPS allows a bigger coverage and productivity with similar accuracy. Furthermore, it can work in all kinds of weather conditions and a direct line of sight between stations is not required.

III. PROBLEMSTATEMENT

Slope failures are generally considered as predictable hazards and economic losses due to such hazards can be reduced significantly, if we have better understanding of the initiations of landslides and in techniques of slope instability hazard assessments, prediction and mitigation. But in spite of its predictability, landslides are continuing in India and cause severe economic losses in many development projects due to in efficiency of land slide assessment in the design of cut and dumped slopes. Land slide has posed challenges and cause serious damages in different infrastructures such as pavements, highway embankments and dams. In India many developmental projects are fail because of land slide in different parts of the country. For example, the road alignment passes through many North Eastern states is characterized mainly through extremely rugged terrain, with steep hill slopes and deep valleys. At this section land

slide is always happening and many of country's budget is wasted here for maintenance purpose in every year. The landslide that occur recently in Shimla around dump site had caused the death of many lives due to dumping of wastes without appropriate design of slopes. Therefore, it is important to determine the causes of the landslides, as this will help in formulating effective remedial measures, effective slope stability analysis and demarcating of the landslide prone zones.

EXISTING PROBLEM

The measurement and recording of data related to the physical characteristics of the earth's surface is a critical phase of any major engineering project. The information, which these terrain investigations provide, is an important element of the initial planning stages of a project. Monitoring the deformation of structures and ground surface displacements during landslides are often accomplished by using differing types of systems and techniques. These included Dielectric moisture sensors for measuring water content of the soil, tilt-meter for measuring movement of soil layers in regards to creep, slow or sudden movements, rain gauge sensors for measuring the effect of rainfall on a slope and ancillary effects such as pore pressure and temperature sensors for physical properties of soil and water change with temperature. Later these information is uploaded to a third party web service for displaying real time data and notifying emergency centres.

However, these systems have many drawbacks. Firstly, many ancient landslide system make use of Sigfox Technology which is outdated in today's world technology. Secondly, the government has to spend huge additional wage on third party web services that monitors and notify the occurrence of landslides. Third, it requires high energy consumption from nearby power generating industries which are difficult to find in rural areas. Fourth, these existing system relies hugely on the large physical form factor of the sensor columns (20 meters in length) rather than wireless transmission of data. Lastly, many existing systems make use of tilt sensors that reads only 2-dimensional values rather than an accelerometer that reads 3D values.

PROPOSED SYSTEM

In the proposed system we have the modules of Lora for remote correspondence and four sensors for information retrieval. The sensors utilized are Soil moisture sensor, Temperature and humidity sensor, Rain gauge sensor and accelerometer sensor. There will be an early warning system at the remote place which will be activated when the sensor values cross threshold value. The information gathering and monitoring unit gathers the information through different sensors and control utilizing microcontroller. The information is then transmitted from the gathering and control segment, consequently it go as transmitting unit. If values are greater nearby government agencies are notified.

The additional advantages of using such system over existing ones are that these make use of cost-effective Lora technology to notify government offices rather than third party web services, uses sleep and awake mechanism to implement required delay, uses wireless Lora technology for value transmission over traditional wired systems and makes use of the latest three degrees of freedom (3DoF) MPU6050 chip based MEMS accelerometers to measure and real-time monitor the inclination instead of tilting sensor.

IV. METHODOLOGY

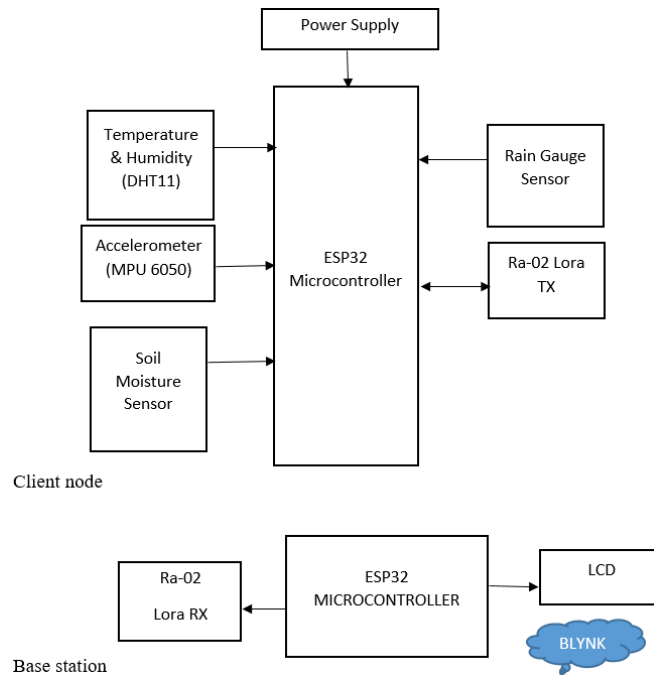
In the proposed system we have two modules of Lora, one for remote correspondence and four sensors and other for information retrieval. The sensors utilized are Soil moisture sensor, Humidity sensor, Rain gauge sensor and accelerometer sensor. The warning system is placed at the remote place which will be activated when the sensor values cross threshold value. The information gathering and monitoring unit gathers the information through different connected sensors and control utilizing microcontroller. The information is transmitted from the gathering and control segment, consequently it go as transmitting unit. In this unit we have the diverse sensor, for example, Soil moisture sensor, Humidity sensor, rain gauge and Accelerometer sensor.

The transmitter circuit consists of power supply, soil moisture sensor, Temperature & humidity sensor, rain gauge sensor, and accelerometer sensor and Lora module blocks. These sensors are connected to the ADC 0 and ADC 1 of microcontroller. The signal conditioning circuit is employed for sensors to urge appropriate output.. The data collected from the sensors is in voltage form thus we convert it in suitable format to display the results.

The power supply has been designed for 3.3 V for microcontroller and 5 V for peripheral modules. The transmitting of data is done using Lora.

The various sensors used at each remote Lora module include:

- Accelerometer: Measuring movement of soil layers in regards to creep, slow or sudden movements
- Rain Gauges: Measures the effect of rainfall on a slope and therefore the ancillary effects such as porepressure.
- Temperature Sensors: Physical properties of soil and water change with temperature, recorded everysecond.
- Dielectric Moisture Sensors: Measuring water content of thesoil.



V. PSEUDOCODE

Algorithm

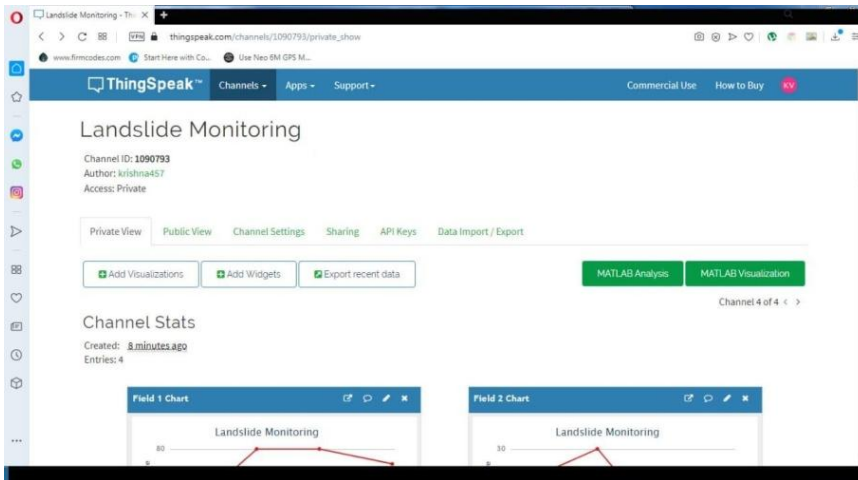
1. Initialize all the sensors
2. BeginLoRa
3. Read values from different sensors from each module
4. Transmit sensors value through LoRa
5. Initialize Lo-Ra receiver
6. Wait for Lo-Ra data
7. Verify if packets are received properly
8. Connect to thingspeak
9. Upload all values to thingspeak
10. Close connection

VI. EXPERIMENTAL RESULTS

Early warning and civil protection could start with reliable analysis of deformation observations of the Earth's surface, followed by landslide risk assessment. The issue is to single out warning signals as early as possible to have more time for preventive action. For potentially endangered areas, where protection works are not feasible or would simply be too costly, these monitoring systems have been installed. However, these systems are dominantly automatic and require no regular field visits to take measurements. Therefore, it is makes easy for us to establish any relation between initiating and controlling factors, thus fully understanding the underlying process mechanism which is essential for any early warningsystem.

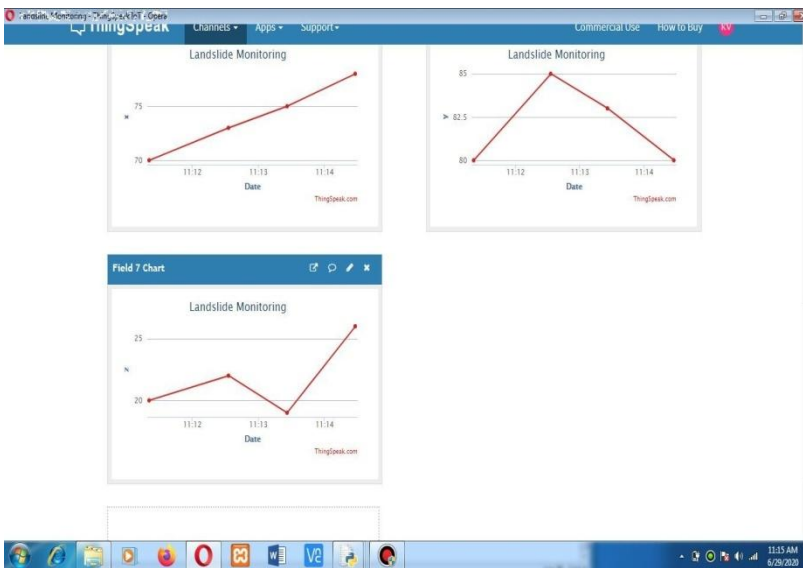
Based on the proposed system we analyse the real-time data collected from different sensors and then plot them against the date as shown in the below graph. At first we read values from different sensors like, temperature, humidity, soil-moisture and rain-gauge and then transmit these to Lora receiver. We then do connection with the ThingsSpeak and where the results for corresponding sensors get plotted with respect to date. After looking the result obtained from the different graphs, we can simply evaluate and monitor the area at realtime.

1. Connecting to ThingSpeak



Here in the above fig we can see project name, channel ID and access point status

2. Executed output of MPU6050



Here we can analyze the output of mpu6050 in the form of graph i.e. X-axis Y-axis and Z-axis respectively

VII. CONCLUSION AND FUTURE WORK

Landslides pose significant socio-economic risks to regions which are favoured by their geography. Already current technologies and strategies for tracking landslides are distinguished by major shortcomings in terms of both technological (quality and data frequency) and applicability (high implied costs, unique skill requirement). Through this study we proposed a revolutionary detection framework for landslides that leverages state-of-the-art IoT technology. The program is extremely robust and flexible although, as compared with current solutions, its implementation and service involves drastically reduced costs.

The system has been deployed successfully providing a modern way to control a landslide site quickly. When an enormous transition takes place in the world, we get to learn the details sooner through LoRa and IOT technologies.

As part of future work, we plan to build improved models of the stress versus strain characteristics of the rocks and also intend to field test the system during the monsoon season in India. We can also implement machine learning concepts for predicting accurate about the weather. Lo-Ra mesh network can be increased from limited node to more than 3 nodes.

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BIOGRAPHY

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