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An Automated Landslide Detection System

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Abstract: *Natural disasters like landslides can be proved to be great harm to man- kind. Landslides pose significant socio- economic threats to areas whose geography favors them. This harm cannot be prevented but by careful planning and emergency steps of spreading alert we can often reduce the consequences of these disasters. Recent technological advances in communication medium made new trend in monitoring system. Currently existing landslide monitoring methods and techniques are characterized by significant limitations both in technical terms (quality and frequency of data) and in terms of usability (high inferred costs, requirement of very high expertise).In this work we present an innovative landslide monitoring system that leverages state- of-the-art IoT technologies. The main purpose of this is to implement an automated landslide detection system for detecting land slide. This project aims to detecting landslide at the initial stage. If any landslide occur then an alert message send to the concerned authorities and people in the prone areas. Not only the information about the landslide occurrence but also focuses on monitoring water level, earth vibration via a sensors, and generate alert signals when the values cross the pre-defined threshold values provided to the sensors. The system consist a set of autonomous sensing devices equipped with a sensor suit specifically tailored for monitoring landslides. It also includes public address (PA) system to broadcast the message to local peoples nearby the place. The module can also send the weather condition to the android user. The transmission range of LoRa modules made by us was positive giving us the security that this technology is stable and ready for use in networks of long distance sensors. This app will be very useful to the community and can be used as a primary precaution action to save many lives.*
Index Terms*—IoT, LoRa, WSN, Landslide*

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I. INTRODUCTION

Technological advances have provided variety of tools which if properly assembled can give good estimation tech- nique. Each technique developed can have its own advantages and disadvantages which technique to use depends largely on area under consideration because of large permutations and combinations of triggering factors.Disasters detection systems have been recently developed to detect the emergency infor- mation before disasters strike. Recent and novel advances as optical sensor, wireless sensor networks, had been applied to predict and detect of disasters such as floods, volcano, earthquake and landslides, etc.Overall loss experienced by India until now because of landslide alone is 400 million. Improved technologies or data base management and data representation are present today. Communication technologies consuming lesser power more range and lesser bandwidth are very useful. Disaster monitoring systems must be able to broadcast warning messages to warn people. When a disaster appears, the significant issue that must be solved is to protect human lives.

II. LITERATURE SURVEY

A. Real-Time Forest Fire Detection with Wireless Sensor Net- works

This method includes a wireless sensor network paradigm for real-time forest fire detection. The wireless sensor network can detect and forecast forest fire more promptly than the traditional satellite-based detection approach.

Disadvantages:

- Very costly depending on the system used.
- Time consuming.
- Hard to develop a model from a fuzzy system.
- Requires more fine tuning and simulation before opera- tional.

B. Landslide Monitoring System Implementing IOT using video camera

Video streaming mainly studies the video coding, video transmission optimization at different layers (such as MAC, and application layer), loss recovery, emerging video services, video over different kinds of networks [11–15]. This is an in- terdisciplinary topic and basically covers the research contents in the communication society, signal processing society, etc. It uses novel standalone computer based system which contin- uously monitors a given region by an inexpensive video cam- era.Apply image processing techniques to detect Landslides and upload images on a web server and to notify stakeholders on their mobile device.The camera captures frames and based on the previous data,moving objects are detected.

C. Collision-free Groups For Detecting Large-Scale Land- slides

The congestion problem by broadcast is a challenging in the dense WSNs for detecting landslides since it is difficult to know the landslide location, size,and area in advance. For ex- ample, when large-scale landslide occurs, a lot of notification packets are broadcasted simultaneously, which leads to serious congestion and almost all of them are lost. Furthermore, if transmission timings of detection nodes start to be coordinated after detecting landslides, it might fail because any negotiation among neighbors cause congestion by message exchanges and loss of network connectivity due to slide with landslides. Therefore, we need to determine the transmission schedule in advance before landslide occurs, which is regardless of landslide size and location.

D. Ad Hoc Wireless Sensor Network Architecture for Disaster Survivor Detection

Here, they propose a Model for the detection of Disaster survivor based on extremely critical Disaster situation where this architecture can help to find and locate the people effi- ciently in critical circumstances.

Wireless Ad hoc sensor nodes are playing a vital role in wireless data transmission infrastructure. Due to its compact size and energy efficient structure these nodes can be successfully deployed in wireless Ad hoc infrastructure where these nodes can be efficiently transmit the disaster related sensed data to Sink nodes via Ad hoc relay stations.The emphasis of the research focuses on earth quake based disasters. Our proposed Model can also be successfully integrated with Tele medicine based infrastructure for emergency response authorities to take necessary measures in a limited span of time.

Disadvantages:

- Additional cost to purchase AP hardware.
- Difficult Network Management.
- Limited Network Access.

E. Principles of Optical Sensors for Disasters Detection Sys- tems

FBG sensors are applied to measure and detect variation of parameters of environment changes. The variation of strain and humidity is translated into a modulation of grating structure of FBG that is known by a periodic refractive index modulation in the core of optical fiber. The measurement of humidity and strain is detected by monitoring the variation of wavelength. FBG's control systems due to the reflected signals which can predict eventual disasters caused by temperature or strain changes.

Raman optical time domain reflectometry is based on the spontaneous Raman (stokes and anti-stokes) back scattering. ROTDR systems for distributed temperature measurements are now available commercially. In a ROTDR system a short laser pulse injected into the optical fiber and back scattered sponta- neous Raman light is detected with high temporal resolution. The back scattered Raman (stokes and anti- stokes) photons contains information about the temperature distribution and loss along the optical fiber.

F. Adaptive Video Streaming in Hybrid Landslide Detection System

There are different kinds of sensors used in this system in- cluding multiple incline meter sensors, weather sensors such as humidity sensors, temperature sensors. The sensor data is sent to the control center via WiSUN. After reading and analyzing the received sensor data, the control center can obtain the knowledge of what is happening in the scene. Edge processing in this system is enabled to help reduce the response time of the disaster detection, where the edge processing is making the decisions at the intermediate node before the data arrives at the control center. The edge processing results can be directly sent to the sensors to change the sensor. An automated landslide monitoring system using Iot transmission frequency if needed, the results can also be acquired by the control center.There are multiple kinds of sensors used and the sensors are not synchronized. The sensors keep capturing the data from the environment but only transmit part of the captured sensor data periodically instead of all the time and all the data, in order to save power. During each transmission, couple of consecutive data samples are transmitted. Weather sensor and humidity sensor will tell the information about the weather and humidity of the soil, which is important information for landslide detection.

G. Remote Sensing Image Thresholding For Landslide Motion Detection

OPTICAL (visible-infrared) remote sensing has hardly been used so far for direct landslide monitoring. A major reason for this has been the insufficient spatial resolution provided until very recently by most spaceborne earth observation systems. Efforts have thus mainly concentrated on mapping possible indirect indicators of landsliding such as land cover pattern disruption and hummocky slope surfaces.Several automatic thresholding algorithms are compared, and a variety of filters are employed to eliminate much of the undesirable residual clutter in the thresholded difference image, mainly as a result of natural vegetation and man-made land cover changes.

This has enabled us to discriminate most ground surface changes related to landslide movement. The application of thresholding methods to difference images derived from digital aerial photographs has proved useful to map ground surface changes related to landslide motion.Some constraints to this method were however found that are mainly due to the single-band wide spectral range of aerial photographs, lack of image calibration, and especially to possible man-made and natural changes occurring during the long time elapsed between the available photos. The latter, in particular, may mask actual movement in some landslide sectors. This can however be partly overcome by making assumptions based on image analysis and field checking.

Disadvantages:

- Lack of image calibration

H. Node Grouping Algorithm For Landslide Detection

After the network construction, the proposed method divides all sensor nodes into collision free groups.As mentioned in Collision-Free groups for detecting large-scale landslides, it is desirable to maximize the number of nodes in a group to increase the number of nodes can transmit simultaneously. Unfortunately, actual node placement is not necessarily on the grid due environmental factors such as topography.Therefore, our algorithm for creating node groups is designed so that collision-free groups can be formed one by one from the sink node as a start point. The node which newly joined a group, as the coordinator, calls for participation in the group for neighbor nodes. After that, it chooses up to four nodes that satisfy the condition to join the group, i.e., all of them and the coordinator are at least d_{min} more away from each other. To confirm the condition, the coordinator utilized information among two-hop neighbors, which are exchanged before this algorithm runs. The above sequence is repeated until there are no more nodes that join the group. In addition, our algorithm utilizes RSSI instead of physical distance between nodes since RSSI can estimate the physical distance. The time-sequence of our algorithm. After building the network, the sink node initiates to form groups; it broadcasts a message that notifies the creation of group with group identifier *gid*, which is referred to as a construct message. On receiving it, nodes that do not belong to any groups reply a join message as notifications for participation of the group. The join messages are sent after waiting for a uniform random duration, which is intended that the position of nodes in different groups become not close between groups with close *gid* When the sink node receives the corresponding join messages, it replies a accept message to the nodes which are satisfied the above condition and a reject message to the other nodes.

After enough time has passed since the sink node sent the construct message of group with *gid*, it increments *gid* by one and sends a new construct message. The sink node repeats this operation until *gid* reaches the expected maximum number of groups. After that, the nodes start to call participation in the group for neighbor nodes. When the reject message is received or there is no replay for a certain period of time, the node gives up on joining this group. On the other hand, the roll of coordinators finishes when enough time has passed since they sent the construct message.

III. TYPES OF DISASTERS

To quantify the disasters systems in the case of flooding, knowing the level of river couldn't help us, however knowing which regions will flood due to that river level, how long those areas have before flooding, and how likely the flood will occur at that stage provides the information that can then enable a warning. None of this deals with the fact that the system operates a real environment and must survive that environment. Some of the physical measurement components exist outside, requiring that they endure the elements, resist theft and damage, and operate with limited maintenance.

A. Earthquake and Landslides

Almost, areas affected by landslides and earthquakes are very wide and large, nevertheless they are restricted to well- known regions. Several researches shows that the use of optical fiber sensors may provide better results by detecting stress changes in building or in environment regions.

Earthquakes and landslides are frightening and destructive natural disasters. An earthquake is the sudden, rapid shaking of the earth caused by the breaking and shifting of rock deep underground. If an earthquake occurs in a populated area, it has the potential to cause many deaths and injuries along with extensive property damage.

Landslides and debris flows occur in all U.S. states. In a landslide, masses of rock, earth or debris move down a slope. They can be activated by storms, earthquakes, volcanic eruptions, fires and human modification of land. Landslides and debris flows can move rapidly, striking with little or no warning at avalanche speeds. They also can travel several miles from their source, growing in size as they pick up trees, cars, and other materials.Because of the suddenness and unpredictability of earthquakes and landslides, it is important for you and your family to prepare ahead of time.

B. Fire

More generally, to predict fire risks, we can use earth observation satellites in several phases: fuels mapping, risk assessment, detection, monitoring, map- ping, etc. The devel- opment of fire disaster system depends on many factors: fuel (condition, moisture, etc.), also weather for example the wind speed and its directions, temperature, pressure, strain), etc.

The most common hazard in forests is forests fire. Forests fires are as old as the forests themselves. They pose a threat not only to the forest wealth but also to the entire regime to fauna and flora seriously disturbing the biodiversity and the ecology and environment of a region. Forest fire causes imbalances in nature and endangers biodiversity by reducing funal and floral wealth. Traditional methods of fire prevention are not proving effective and it is now essential to raise public awareness on the matter, particularly among those people who live close to or in forested areas.

C. Floods

Floods disasters are always responsible for the loss of valuable and precious lives, also floods produce the destruction of large amounts of building, bridges, and tunnels every year in poor and developing countries. To predict floods, it’s recommended nowadays to use optical flooding sensor, these sensors are considered the ideal one for road flooding detection. Applying optical sensor in rivers, reservoirs and drainage pond, we can measure and warn the water level.

Floods can also occur in rivers when the flow rate exceeds the capacity of the river channel, particularly at bends or meanders in the waterway. Floods often cause damage to homes and businesses if they are in the natural flood plains of rivers. While river line flood damage can be eliminated by moving away from rivers and other bodies of water, people have traditionally lived and worked by rivers because the land is usually flat and fertile and because rivers provide easy travel and access to commerce and industry.

IV. IOT TECHNOLOGIES AND DISASTERS DETECTION SYSTEMS

In IoT technologies, gathering and collecting large amounts of data from many networks may be difficult and can cause a serious routing problem. The collected data including images and videos often cause traffic congestion in the central network area. In various IoT applications, the sensed information should be sent to the gateway or the base station for further manipulations and operations. Thus, disasters detection sys- tems can use IoT technologies to detect them. In this section we introduce a classification of routing protocols and then we discuss challenge of these protocols.

A. WSN

Wireless Sensor Network or WSN are considered a special type of Ad hoc networks with a lot of nodes that are micro- sensors capable of collecting and transmitting environmental data in an autonomous way and the fixed communication infrastructure and centralized administration are absent and the nodes play both the role of the host and the routers.It responds to the emergence in recent decades of supply and increased need for diffuse and automatic observation and control of complex physical and biological phenomena, in different fields. The sensors are loaded with readings and route information from the covered area to the collection point also called sink. The sink recuperates the information sent by the different sensors and transmits it to the Processing unit. The randomly arranged sensors form the coverage area.

There are two methods to collect information from a sensor network one is according to a request that is, when we want to have the state of the coverage area at a time, the sink emits broadcasts to the whole area in order to the sensors trace their last statement to the sink. The information is then routed through a multi-hop communication, the second is according to an event, this last occurs at a point in the coverage area sensors located nearby go back up then the information collected and send it to the sink.

B. Radio frequency identification (RFID)

RFID technology is applied to acquire information about “things” employed in our smart systems. RFID systems have been used in IoT applications to better track the status of things such as their movements, location, temperature. There are three types of tags (Passive, Active and semi-passive) which can be used in IoT applications. RFID is actually considered as a new method of authentication for IoT application. An RFID system will provide two basic functions for the Inter- net of Things: identification and communication. Its general operating principle is as follows : The reader initiates the communication by broadcasting a request. The neighborhood’s radio tags respond to the latter by providing their identifier and stored data. To manage the access to the medium sharing techniques of the latter using collision avoidance based on the ALOHA ”slotted”are used. They allow radio tags to randomly differ their response.

C. Bluetooth

BLE called also Bluetooth Smart used as a short-range radio with a minimal amount of energy and power (a transmission power of BLE can be between 0.01mW to 10mW). In 2006, Nokia Research Center present Bluetooth smart under the name of “Wibree” and it has been later adopting by SIG “Special Interest Group” with the standard “Bluetooth Core Specification” to get BLE. BLE is used in WPAN “wireless personal area networks” it’s considered as a good candidate for IoT applications. BLE may operate for a long time with various versions. BLE range may cover about 100-meter flower ten times than classical Bluetooth; however, its latency is fifteen times shorter.

D. ZigBee

Zigbee is considered as a mesh network used for low- power operation. Zigbee has been designed based on the IEEE
802.15.4 PHY and MAC standards. ZigBee commands in three bands: 868 MHz, 915 MHz, and 2.4 GHz. 802.15.4 operates with a rate bit from 20 to 250 kbps.
Zigbee provides data and management services. ZigBee is a wireless technology similar to Bluetooth low power (LR- WPAN), managed by the ZigBee Alliance industry commu- nity, relatively recent based on the IEEE 802.15.4, aiming to provide a simpler protocol, less expensive and to overcome the problem of too high energy consumption as Bluetooth.

E. LoRa Technology

LoRa (short for long range) is a spread spectrum modulation technique derived from chirp spread spectrum (CSS) technol- ogy. Semtech’s LoRa devices and wireless radio frequency technology is a long range, low power wireless platform that has become the de facto technology for Internet of Things (IoT) networks worldwide.LoRa devices and the open LoRaWAN protocol enable smart IoT applications that solve some of the biggest challenges facing our planet: energy management, natural resource reduction, pollution control, infrastructure efficiency, disaster prevention, and more.

V. METHODOLOGY

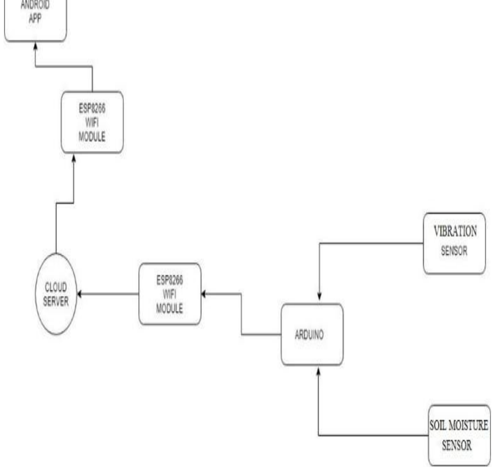

Fig. . Flow Chart

VI. IMPLEMENTATION

Natural disasters like landslides can be proved to be great harm to man- kind. Landslides pose significant socio-economic threats to areas whose geography favors them. This harm can- not be prevented but by careful planning and emergency steps of spreading alert we can often reduce the consequences of these disasters. Recent technological advances in communica- tion medium made new trend in monitoring system. Currently existing landslide monitoring methods and techniques are characterized by significant limitations both in technical terms (quality and frequency of data) and in terms of usability (high inferred costs, requirement of very high expertise).In this work we present an innovative landslide monitoring system that leverages state-of-the-art IoT technologies. The main purpose of this is to implement an automated landslide detection system for detecting land slide. This project aims to detecting landslide at the initial stage. If any landslide occur then an alert message send to the concerned authorities and people in the prone areas. Not only the information about the landslide occurrence but also focuses on monitoring water level, earth vibration via a sensors, and generate alert signals when the values cross the pre-defined threshold values provided to the sensors. The system consist a set of autonomous sensing devices equipped with a sensor suit specifically tailored for monitoring landslides. It also includes public address (PA) system to broadcast the message to local peoples nearby the place. The module can also send the weather condition to the android user. The transmission range of LoRa modules made by us was positive giving us the security that this technology is stable and ready for use in networks of long distance sensors.

This app will be very useful to the community and can be used as a primary precaution action to save many lives.

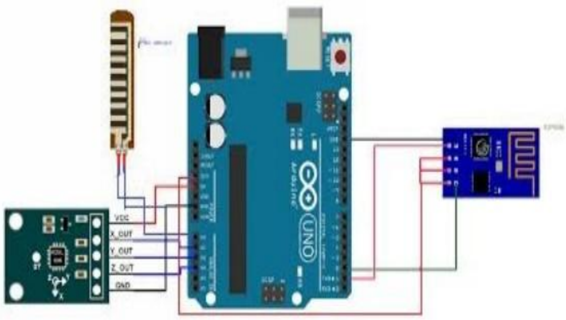

Fig. . Desgin Diagrams

VII. CONCLUSION

The landslide detection system is successfully implemented as a prototype.The monitoring techniques uses geolocation using wireless sensor networks which is based on LoRa (Long Range) transmission technology. All the sensors and other stuff works as per the expectations. The sensors effectively sense the surrounding conditions and give the readings. Based on readings, the prediction of landslide is achieved successfully. The system senses data and transmits it continuously.The In- ternet has changed drastically the way we live, moving interac- tions between people at a virtual level in several contexts spanning from the professional life to social relationships. The IoT has the potential to add a new dimension to this process by enabling communications with and among smart objects, thus leading to the vision of “anytime, anywhere, any media, anything” communications.

Had an early detection system been in place, many lives and valuable properties could have been saved. This is actually a global problem and not confined to the borders of our country alone. Although an earthquake or tsunami cannot be prevented, the impact of them can be mitigated through community preparedness, timely warnings and effective response.

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