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IoT based landslide prediction and prevention

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PROBLEM STATEMENT UNDERSTANDING

Landslides are a natural disaster damaging social life every year. It can be defined as the movement of mass of rock, debris down a slope. It occurs due to natural or manmade activities. Asia was found to be the most affected continent where 75% of landslides occurred. India also faced the loss of humans due to landslides which occurred last year during monsoon in kerala. The main aim of the proposed system is to detect those conditions which lead to the occurrence of landslides and notify it well before time so that necessary steps can be taken to reduce or save human loss.

A Landslide, also known as a landslip, is a geological phenomenon that includes a wide range of ground movements. Monitoring is essential to predicting the behavior of landslides and forecasting which storms can trigger large numbers of landslides. This can help save a number of lives and prevent loss of life and property as people will be aware of the upcoming danger slide and can take necessary steps for safety.

Landslides are a geographical disaster that occurs in a short period due to the variations in environmental actions and causes damages in human lives, properties of agriculture. During the rainy season, unlike divisions of India are affected by the landslide natural hazard every year. IOT based technology has the capacity of large scale deployment and real time detecting of landslide losses.
IOT based networks detect the slightest movements of ground or slope instability due to the several reasons such as dielectric moisture, pore pressure and so on that may occur during a landslide.

- **Factors Influencing Landslide Risk**

1) Slope: Coastal bluffs have a relatively steep ocean-facing slope. The angle of a bluff face varies due to factors such as the sediment type and rate of erosion at the base of the bluff. Slope is also affected by the history of slumps and landslides at the site. Some slopes are uniformly straight while others are terraced or uneven due to earth movements. In general, the steeper the slope, the easier it is for gravity to initiate a landslide.

2) Bedrock: Crystalline rock or ledge is much more stable than any sediment bluff and not likely to erode or slide. The elevation of bedrock at the shore and inland beneath a bluff is important in determining landslide risk. Bedrock exposures along the shoreline may slow erosion and make sediment less susceptible to land sliding. Beneath a sediment bluff, bedrock may rise toward the surface and reduce the overall thickness of sediment and thus reduce the risk of deep-seated movement below the ground surface.

- **Natural Conditions**

1) Surface water: The amount, type, and location of surface water can influence bluff slope stability and may contribute to some landslides. Wetlands, ponds, and streams above the bluff can supply water to the bluff face and also to the ground water. The elevation or topography of the land surface determines which way surface water will flow. Water that runs over the face of a bluff can wash sediment to sea, increase the bluff face slope, and weaken the remaining sediment holding up the bluff. Removal of sediment from the bluff face can increase the risk of a landslide.

2)) Ground water: Ground water inland of a bluff comes from surface sources, such as rain or a stream, uphill in the local watershed. Ground water tends to flow horizontally beneath the surface and may seep out the face of a bluff. Seeps and springs on the bluff face contribute to surface water flow and destabilize the bluff face. In addition, a high water table can saturate and weaken muddy sediment and make the ground more prone to slope failure.

3) Earthquakes: Landslides can be triggered by earthquakes. Ground vibration loosens sediment enough to reduce the strength of material supporting a bluff and a landslide results. Most landslides triggered by earthquakes in sediment like that found in Maine have been of Richter magnitude 5 or more. These are relatively rare events, but a few have occurred in historical time.

SOFTWARE AND HARDWARE REQUIREMENT-

A.SENSORS

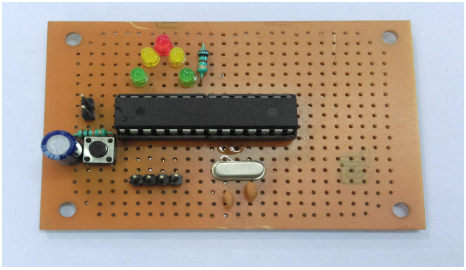
Soil moisture sensor:-
Soil moisture sensors measure the volumetric water content in soil. Soil moisture sensors measure the volumetric water content indirectly by using some other property of the soil, such as electrical resistance, dielectric constant, or interaction with neutrons, as a proxy for the moisture content. This sensor is used to predict the landslide.

Vibration Sensor :-
The vibration sensor Detector is designed for the security practice when vibration sensor sense vibration, it sends a signal to either control panel developed a new type of omnia direction detector with omni directional detection

Temperature sensor:-
This sensor is used in areas like volcanoes where the temperature is the major factor and alive volcanoes can cause landslides in vast areas.

Vibration sensor:-
At the time of earthquake movement of bedrock can be happen and that causes the vibration which can be detected using this sensor. This sensor is used to predict and detect the landslide. The WSN monitored the landslide area. Respective sensor readings are captured and send it to the server. All the threshold are customized according to the sensor and area. Sensor readings are stored at server. Server side programs analyze the data for prediction of landslide. If sensors cross the threshold value, alert system is activated. Alert system is in different form. Big buzzers are activated in the landslide area. There is an advanced alert system using SMS and IoT application. Most of the time landslides happen in highway side areas like Mumbai Pune mega highway. Using the IoT application system alerts the user to avoid the route of landslide. Also IoT applications are used to alert the nearby civil infrastructure.

Gyroscope/accelerometer:-
An accelerometer is an electromechanical device used to measure acceleration forces. Acceleration is the measurement of the change in Velocity or Speed divided by Time. The motion sensor IOT based Landslide Prevention and Detection System 10 in accelerometer used to detect earthquakes. A dynamic accelerometer measures gravitational pull to determine the angle at which a device is tilted with respect to the earth. By sensing the amount of acceleration, users analyze how the device is moving.



Microcontroller ATmega8- It is an 8 bit CMOS technology based microcontroller belonging to the AVR family of microcontrollers developed in 1996. It is built on RISC (Reduced Instruction Set Computer) architecture. Their main advantage is that it doesn't contain any accumulator register and the result of any operation can be stored inside any register, defined by an instruction.

ATmega8 microcontroller consists of 1KB of SRAM, 8KB of flash memory and 512 bytes of EEPROM.

The 8KB flash memory is divided into two parts:-

- The upper part used as application flash section
- The lower part used as boot flash section

In the ATmega8 microcontroller all the registers are connected directly with the Arithmetic Logic Unit (ALU). The EEPROM memory is used for storing the user defined data.

Buzzer for Beep Source- A **buzzer** or **beeper** is an audio signalling device, which may be mechanical, electromechanical, or piezoelectric (*piezo* for short). Typical uses of buzzers and beepers include alarm devices, timers, and confirmation of user input such as a mouse click or keystroke.

Display Unit (Liquid Crystal Display)- A **liquid-crystal display** (**LCD**) is a flat-panel display or other electronically modulated optical device that uses the light-modulating properties of liquid crystals combined with polarizers. Liquid crystals do not emit light directly, instead using a backlight reflector to produce images in color or monochrome LCDs are available to display arbitrary images (as in a general-purpose computer display) or fixed images with low information content, which can be displayed or hidden. For instance: preset words, digits, and seven segment displays as in a digital clock are all good examples of devices with these displays. They use the same basic technology, except that arbitrary images are made from a matrix of small pixels, while other displays have larger elements. LCDs can either be normally on (positive) or off (negative), depending on the polarizer arrangement. For example, a character positive LCD with a backlight will have black lettering on a background that is the color of the backlight, and a character negative LCD will have a black background with the letters being of the same color as the backlight. Optical filters are added to white on blue LCDs to give them their characteristic appearance

GPRS Modem- A GPRS modem is a wireless modem that works with a GPRS wireless network. A wireless modem behaves like a dial-up modem. The main difference between them is that a dial-up modem sends and receives data through a fixed telephone line while a wireless modem sends and receives data through radio waves.

A GPRS modem can be an external device or a PC Card / PCMCIA Card. Typically, an external GPRS modem is connected to a computer through a serial cable or a USB cable. A GPRS modem in the form of a PC Card / PCMCIA Card is designed for use with a laptop computer. It should be inserted into one of the PC Card / PCMCIA Card slots of a laptop computer.

Like a GSM mobile phone, a GSM modem requires a SIM card from a wireless carrier in order to operate.

As mentioned in earlier sections of this SMS tutorial, computers use AT commands to control modems. Both GSM modems and dial-up modems support a common set of standard AT commands. You can use a GSM modem just like a dial-up modem.

Regulated Power Supply- A **regulated power supply** is an embedded circuit; it converts unregulated AC (Alternating Current) into a constant DC. With the help of a rectifier it converts AC supply into DC. Its function is to supply a stable voltage (or less often current), to a circuit or device that must be operated within certain power supply limits. The output from the regulated power supply may be alternating or unidirectional, but is nearly always DC . The type of stabilization used may be restricted to ensuring that the output remains within certain limits under various load conditions, or it may also include compensation for variations in its own supply source

Moisture Strips- A hygrometer is an instrument used to measure the amount of water vapor in air, in soil, or in confined spaces. Humidity measurement instruments usually rely on measurements of some other quantities such as temperature, pressure, mass, a mechanical or electrical change in a substance as moisture is absorbed. By calibration and calculation, these measured quantities can lead to a measurement of humidity. Modern electronic devices use temperature of condensation, or changes in electrical capacitance or resistance to measure humidity differences.

SOFTWARE-

1.Proteus-

The Proteus Design Suite is a proprietary software tool suite used primarily for electronic design automation. The software is used mainly by electronic design engineers and technicians to create schematics and electronic prints for manufacturing printed circuit boards.

It was developed in Yorkshire, England by Labcenter Electronics Ltd and is available in English, French, Spanish and Chinese languages.

The microcontroller simulation in Proteus works by applying either a hex file or a debug file to the microcontroller part on the schematic. It is then co-simulated along with any analog and digital electronics connected to it. This enables its use in a broad spectrum of project prototyping in areas such as motor control, temperature control and user interface design. It also finds use in the general hobbyist community and, since no hardware is required, is convenient to use as a training or teaching tool.

2.Arduino IDE-

The Arduino Integrated Development Environment (IDE) is a cross-platform application (for Windows, macOS, Linux) that is written in functions from C and C++.[3] It is used to write and upload programs to Arduino compatible boards, but also, with the help of third-party cores, other vendor development boards.

The source code for the IDE is released under the GNU General Public License, version 2. The Arduino IDE supports the languages C and C++ using special rules of code structuring. The

Arduino IDE supplies a software library from the Wiring project, which provides many common input and output procedures. User-written code only requires two basic functions, for starting the sketch and the main program loop, that are compiled and linked with a program stub *main()* into an executable cyclic executive program with the GNU toolchain, also included with the IDE distribution. The Arduino IDE employs the program *avrdude* to convert the executable code into a text file in hexadecimal encoding that is loaded into the Arduino board by a loader program in the board's firmware. By default, avrdude is used as the uploading tool to flash the user code onto official Arduino boards.

Arduino IDE is a derivative of the Processing IDE, however as of version 2.0, the Processing IDE will be replaced with the Visual Studio Code-based Eclipse Theia IDE framework

3.Python-

Python is an interpreted high-level general-purpose programming language. Python's design philosophy emphasizes code readability with its notable use of significant indentation. Its language constructs as well as its object-oriented approach aim to help programmers write clear, logical code for small and large-scale projects.

Python is dynamically-typed and garbage-collected. It supports multiple programming paradigms, including structured (particularly, procedural), object-oriented and functional programming. Python is often described as a "batteries included" language due to its comprehensive standard library.

Guido van rossum began working on Python in the late 1980s, as a successor to the ABC programming language, and first released it in 1991 as Python 0.9.0. Python 2.0 was released in 2000 and introduced new features, such as list comprehensions and a garbage collection system using reference counting. Python 3.0 was released in 2008 and was a major revision of the language that is not completely backward-compatible and much Python 2 code does not run unmodified on Python 3. Python 2 was discontinued with version 2.7.18 in 2020

SOFTWARE COMPONENTS-

1. Registration Module-This module is responsible for adding or managing users.

2. LandSlide detection Module-This module is responsible for getting a threshold value and checking the current value getting by sensors and managing the buzzer according to reading values.

3. Device test Module-This module is responsible for only checking if the device is properly working or not.

4. Manage Sensor/Device Module-This module is responsible for a Managing the sensor and device(ON/OFF).

5. SMS Module-This module is responsible for sending a SMS to the governing body when a landslide happens or crosses the threshold value.

WEB APPLICATIONS-

Cloud Server -
A cloud server is a logical server that is built, hosted and delivered through a cloud computing platform over the Internet. Cloud server process and exhibit similar capabilities and functionality to a typical server but are accessed remotely from a cloud service provider.

MQTT Protocol-
MQTT (Message Queue Telemetry Transport) is an ISO standard publish-subscribe based "lightweight" Messaging protocol for use on top of the TCP/IP protocol. It is designed for connections with remote locations where a "small code footprint" is required or network bandwidth is limited. The Message broker (MQTT) is responsible for distributing messages to clients based on landslide related data.

ADDITION AND UPDATES-

Landslides in heavy rainfall areas are making threats to the people living in nearby areas. Also, it becomes difficult to predict about it either. So, combining with partnership of professional laboratories i.e. IS Terre: earth science and LCIS: embedded electronics, telecommunication is aimed to make a new predictive tool which can be used to analyze the area movement using sensors. The basic plan is that the sensors sense the field's movement with minimal cost and power consumption. The monitoring techniques use geolocation using wireless sensor networks which are based on LoRa (Long Range) transmission technology. Inorder to achieve geolocation using a network of sensors, a common technique is used to have a set of fixed (non-mobile) nodes and anchors whose location is already known. The computation of sensor nodes location is done using various techniques. In one such particular technique one anchor is elected to the role of master as it receives information from the other anchors . Another survey is based on the landslide which occurred in Guizhou area in China with major human loss. The threat there increases after rainfall. It introduces ZICM2410 based WSN for monitoring landslides. In this system there are acquisition nodes, base station, monitor host and PC. Several nodes constitute together to form a WSN which collects the information of landslide parameters such as landslide displacement, soil temperature, soil moisture, tilt angle, local rainfall, etc. This system has chosen the SCM2410 Zigbee chip to build a wireless sensor network which is low-cost and can exchange and use the information. It supports multiple network topologies such as point-to-point, point-to-multipoint and mesh network. At the base station, GSM technology is used to transfer the data to the monitor from remote places. The monitor is placed indoors and receives the information from the GSM network and this information is updated to the PC using RS232 interface so that people can look up the monitoring of landslides using the software installed on the PC. PC management software includes two parts as real-time display interface and database management. The system uses VC++ tools to develop the human-computer interface and the SQL anywhere 11 Database platform to design the database . For a landslide monitoring system, the WSN must be designed in such a

way that it should withstand adverse effects of landslides, it should have longer battery life for longer use and high efficiency. In paper , the system uses WSN to collect the data of battery life, radio link and path statistics. The sensor nodes and communication protocols are specifically designed for the network to be self-organizing, fault tolerant and adaptive. This system gives the effectiveness of the network protocols to manage self-organization, node failures, less link quality and unexpected battery life. This system got negligible human intervention when it was implemented on a landslide located in Torgiovannetto (Italy) as an experimental campaign for several months. It revealed a very high level of withstanding against the adverse landslide which makes it suitable for critical landslide scenarios. The collected data in the system is processed at a remote unit for analysis . While monitoring a landslide, the system needs to have enough power to work and should require less power too. This entails one of the major issues while implementing or installing the WSN. Since it's practically not possible to change the battery of a sensor which is in remote areas of mountains. So, in order to save valuable energy of the battery, sensors are made to detect the data in a timely manner. To solve this issue, the technique proposed is called SMARTCONE which helps in monitoring the data of landslides. These SMARTPHONES are synchronously changing their operation modes to collect the parameters and transmit raw vibration simultaneously. The SMARTCONE is based on ARM M0-based extreme low-power 32-b MCU NANO102SC2AN .AN RF transceiver Nordic NRF24L01 with a 3-dBi unidirectional antenna is used to transmit data between the SMARTCONE and it's sever. This system integrates low-power Micro Electro-Mechanical Systems accelerometer ADXL345, a digital low-power temperature and humidity sensor SHT-21 and a GPS module FMP04-TLP for providing its GPS trajectory. A battery fuel gaugeT1BQ2741 is used to monitor the battery and control the power supplies for GPS and RF transceivers. This system consumes 0.5mA at 3.6V in standby mode which is less than that of previous design. These SMARTPHONES simultaneously collect the data and send it to the control room [4]. The major damage is due to the interlayer slide which causes landslides and results in catastrophic losses.

APPLICATION-

1) Can be used by Meteorological Department to have proper security measures

ADVANTAGES -

1) Helps in preventing human loss by evacuating the affected area by predicting the landslides.

2) Can help in saving the economy of the country.

DISADVANTAGES-

1) Can have loss of time by false predictions .

2) The accuracy of the system is not 100%

CONCLUSION AND FUTURE SCOPE-

Real time monitoring of landslides is one of the challenging research areas available nowadays within the field of geophysical research. This paper discusses the event of an actual field deployment of a wireless device network primarily based landslide detection system. This system uses an ad-hoc network composed of wireless sensor nodes, Zigbee for efficient delivery of real time data to the system for monitoring and providing warnings and risk assessments to the inhabitants of the area. This network will be used for understanding the capability and usability of wireless sensor networks for critical and emergency applications.

Monitoring, forecasting and warning of landslides are the essential features for saving the lives and assets from devastation. There are three fundamental ways for monitoring the landslide viz, visual, surveying and instrumentation. Each monitoring technique has its own advantages, Disadvantages and application range. Surveying equipment such as levels, theodolites, electronics distance measurement (EDM), and total station provide some of the prominent landslide features; however, aerial or terrestrial photogrammetric provides contour maps and cross section of landslides. The compilation of photogrammetric data enables a quantitative analysis of change in slope morphology and determination of the movement vectors. Instrumentations may include installing equipment for periodic reading of the different monitoring sensors such as inclinometer, strain gauge, rain gauge, clinometers, extensometer, pore pressure sensor etc. The monitoring techniques also can be divided into two groups: i) Geodetic technique ii) Non-geodetic technique. It focuses on instrumentation monitoring and non-geodetic techniques for detecting the landslide. WSN has the capability of large scale deployment, low maintenance, scalability, adaptability for different scenarios and low maintenance requirements which made it one of the best suited technologies for real time monitoring. A landslide detection system with use of wireless sensor network can detect the slides moments of soil or slope instability due to the several reasons such as dielectric moisture, pore pressure etc. that may occur during a landslide. All this data will be sending and stored in cloud for further analysis for researchers

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