LANDSLIDE WARNING AND MONITORING SYSTEM THROUGH SMARTPHONE BY USING OPTIMIZED SOLAR POWERED WIRELESS SENSOR NETWORK

Subodh Prasad[1], Tummalapenta Venkata Sivasai Maheshbabu[1], Ibrahim Khaleel.P[1], R.pragadeesh[1], Dr.P.Avirajamanjula[2]

1 B.Tech.EEE Students 2 Professor

Department of Electrical and Electronics Engineering

PRIST DEEMED TO BE UNIVERSITY, Vallam, Thanjavur 613403

ABSTRACT

Landslides cause significant damages to civil infrastructure. Over the years, methods and technologies have been proposed to determine the risk of landslides and to detect hazardous slope movements. There have been increasing interests in developing and landslide monitoring systems to observe movements using sensors installed on the slope. Although providing accurate data, many landslide monitoring systems are not operating in an automated fashion and lack the ability to analyze the collected data in a timely manner. This paper presents an autonomous landslide monitoring system based on wireless sensor networks by using IOT. Self-contained, autonomous software programs ("software agents") are embedded into the wireless sensor nodes. In cooperation with each other, the software agents are continuously collecting and analyzing sensor data, such as recorded ground acceleration and the orientations of the sensor nodes along the slope. If movements are observed, the collected data sets are automatically transmitted to a connected server system for further diagnoses. Sensors are powered by solar energy. The landslide monitoring system presented in this paper is remotely accessible via the Internet and provides real-time information about the current state of the monitored slope. Laboratory tests have been conducted to validate the reliability and performance of the monitoring system. In this paper propose an IOT based monitoring and risk management of landslides, where data collected by sensors are delivered through the network to a remote unit (RU) for on-line analysis and alerting.

Index Terms- Differential Switching Sensors and Server

I.INTRODUCTION

The term landslide or, less frequently, landslip, refers to several forms of mass wasting that include a wide range of ground movements, such as rock falls, deep-seated slope failures, mudflows, and debris flows. Landslides occur in a variety of environments, characterized by either steep or gentle slope gradients: from mountain ranges to coastal cliffs or even underwater, in which case they are called submarine landslides. Gravity is the primary driving force for a landslide to occur, but there are other factors affecting slope stability which produce specific conditions that make a slope prone to failure. In many cases, the landslide is triggered by a specific event (such as heavy rainfall, an earthquake, a slope cut to build a road, and many others), although this is not always identifiable. Seven types of the requirement are using here solar power with battery, solar power is the sun energy converted into electrical energy. The solar energy is direct in the component and also through the battery. Arduino Uno, Vibration sensor, GYRO sensor, Voltage Regulator, Buzzer, LCD Display, Node microcontroller Unit (MCU). Arduino Uno Microcontroller or Microchip. The vibration sensor is measuring the displaying and Analyzing liner velocity, displacement, and proximity, or acceleration. Gyro sensors also are known as angular rate sensors or angular velocity sensors, are devices that sense angular velocity. Angular velocity. In simple terms, angular velocity is the change in rotational angle per unit of time. Angular velocity is generally expressed in deg/s (degrees per second). The internet of things, or IOT, is a system of interrelated computing devices, mechanical and digital machines, objects, animals or people that are provided with unique identifiers (UUIDs) and the ability to transfer data over a network without requiring human-to-human or human-to-computer interaction. LCD (Liquid Crystal

Display) screen is an electronic display module and finds a wide range of applications. A 16x2 LCD display is very basic module and is very commonly used in various. A "piezo buzzer" is basically a tiny speaker that you can connect directly to an Arduino. From the

Arduino, you can make sounds with a buzzer by using tone

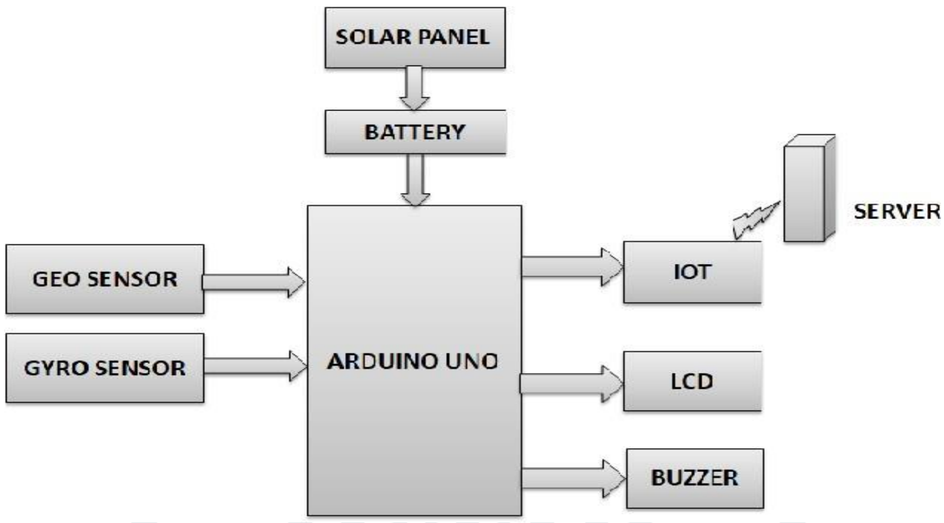
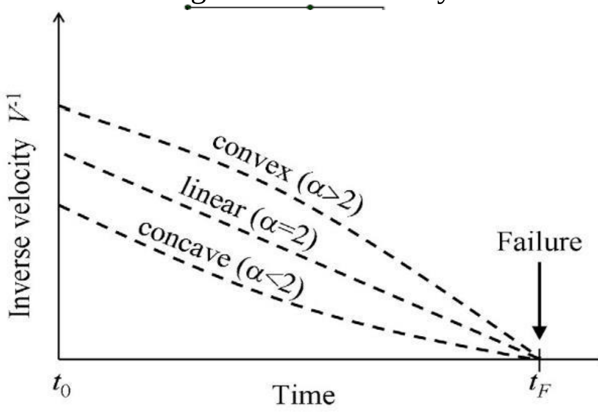
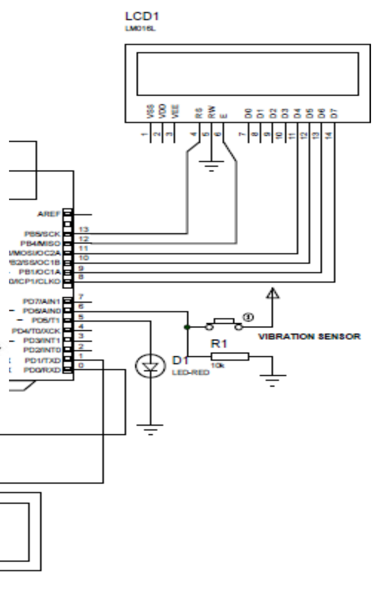


Fig 1. Block diagram

Several methods for slope failure forecasting have been developed (Busslinger, 2009). In this paper, a method based on the inverse velocity of the surface movement is employed. The concept of inverse velocity for predicting slope failure time was developed by Fukuzono (1985), who has conducted large-scale laboratory tests to simulate rain-induced landslides. The conditions in the laboratory were considered to be characteristic of accelerating creep conditions under gravity loading. The assessment of the laboratory data unveiled that the acceleration of surface displacement and the velocity of surface displacement where related, which can be expressed. In the above equation, x is downward surface displacement, d2x/dt2 is the acceleration, dx/DT is the velocity, and A and α are constants depending on the slope characteristics (Fukuzono, 1987). The laboratory tests also led to the recognition that, when plotting the inverse velocity versus time, the values of inverse velocity approach zero, as the velocity of surface displacement increases towards final slope failure (Fig. 1). Plotted graphically, the slope failure time can be predicted at the point at which the trend line through values of inverse velocity crosses the abscissa axis. This relationship between velocity and failure time, as proposed by Fukuzono (1985), can be described by the empirical equation, where V-1 is the inverse velocity of surface displacement and tf is the failure time. Depending on the values of α, the curve of inverse velocity is linear (α = 2), concave (α < 2) or convex (α > 2), as shown in Fig1.

fig 2: Inverse velocity over Time





II. AUTONOMOUS LANDSLIDE MONITORING SYSTEM

The purpose of the landslide monitoring system is to enable early detection of hazardous slope movements. If having identified pre-failure slope deformations, the system automatically informs human individuals about potential landslides. Relevant measurements taken from the observed slope are continuously stored and available for detailed diagnoses of the slope movements. The landslide monitoring system automatically calculates the inverse velocity, and determines whether and when landslides can be expected. The architecture of the implemented prototype system is shown in Figure 2. The system is composed of two subsystems, a wireless sensor network and a server system.

2.1 Implementation of Wireless Sensor Network

A wireless sensor network is comprised of sensor nodes, each has a processor board and a three-axis accelerometer. Mobile software agents are embedded into the wireless sensor nodes to collect acceleration data and to conduct in-situ analyses of the observed slope. A software agent is an autonomous, flexible software program able to complete a specific task without direct human intervention (Wooldridge, 2002). Software agents interact with their environment and respond to environmental changes. Software agents can cooperate with each other to solve complex problems. Time-consuming data analysis and computation tasks can be performed concurrently by several agents to enhance system performance, which is crucial for real-time monitoring systems.

For the modular design of the monitoring system, three classes of software agents are defined and embedded into each wireless sensor node: ManagerAgent, SensorSamplerAgent, and AnalysisAgent. The ManagerAgentenables the communication between the agents embedded in different sensor nodes, as well as between the agents and the server system. The SensorSamplerAgent collects the acceleration data from the slope at a certain sampling frequency and sends the data to the analysis agent. Moreover, the SensorSamplerAgent determines the sensor orientation and reports tilt changes, if identified. The analysis agent determines the motion of the node, thus reflecting deformation in the environment in which the node is installed. For the communication between the sensor nodes and between sensor nodes and the sever system, radio connections are necessary. Because radio communications consume a lot of battery power, the number of data messages should be kept to the minimum. By first sending data to the ManagerAgent, which then forwards it to the recipients of other sensor nodes, the SensorSamplerAgent, and the AnalysisAgent, through the ManagerAgent, communicate with agents situated on other sensor nodes using just one single radio connection (managed by the ManagerAgent)instead of establishing multiple connections.

If a sensor node is in motion, the AnalysisAgent sends a command to the ManagerAgent to inform all other nodes and the server system. As a direct consequence of a detected motion, all nodes increase the sampling frequency and the server system starts analyzing the global situation of the slope. Furthermore, the analysis agent computes the inverse velocity of the sensor node according to the previously described method using the collected acceleration data. The ManagerAgent sends the result of the inverse velocity analysis to the server system. A typical monitoring sequence is shown in Figure 3. Due to the multi-agent architecture, the functionality of the wireless sensor network can easily be extended by adding new analysis agents. This module features an adjustable potentiometer, a vibration sensor, and an LM393 comparator chip to give an adjustable digital output based on the amount of vibration. The potentiometer can be adjusted to both increases and decrease the sensitivity to the desired amount. The module outputs a logic level high (VCC) when it is triggered and a low (GND) when it isn't. Additionally, there is an onboard LED that turns on when the module is triggered.

Acceleration is a process in which velocity is changed with respect to time and it is a vector quantity. Similarly, velocity is speed and direction. There are two ways for explaining the acceleration of anything first one is changed in speed and the second one is a change in direction. Sometimes both are changed simultaneously. If we talk about ADXL 335 accelerometer, then this accelerometer is a device that is used for measuring the acceleration of an object. It measures the acceleration in the form of analog inputs, in three dimension direction such as X, Y, and Z. It is low noise and less power consume device. When it is used for acceleration measure purposes then it is interfaced with any type of controller such as microcontroller or Arduino etc.

2.2 PINCONFIGURES OF GYRO ADXL 335 ACCELEROMETER

Every ADXL 335 accelerometer consists of five pins which are used for different purposes. Its pin configuration is shown in below table and this ADXL 335 accelerometer is connected with any controller according to this table.

CONFIGURES OF GYRO SENSER

- This is VCC pin and is used for power on the ADLX 335 accelerometer. It is connected with 3.3V dc power source.
- This is ground pin and is used for supplying ground to this ADLX 335 accelerometer. It is connected with source ground.
- This is X pin and is used for analog input in x axis dimension. This pin provides analog input signal to controller which is measured by ADLX 335 accelerometer.
- This is Y pin and is used for analog input in y axis dimension. This pin provides analog input signal to controller which is measured by ADLX 335 accelerometer.
- This is Z pin and is used for analog input in Z axis dimension. This pin provides analog input signal to controller which is measured by ADLX 335 accelerometer.

2.3 SERVER SYSTEM

The server system allows human individuals to communicate with the wireless sensor network. The server system is responsible for storing the data and conducting detailed data analyses. In addition, if the server system does not receive the results of the inverse velocity analysis from each sensor node, an attempt to establish a connection to the sensor node is made. If it is not successful, the human experts are informed via email about possible sensor malfunctions. All measured data as well as the results of data analyses can be accessed through a Java application running on the server. Figure 4 highlights the main view of the application showing the functionalities to add or to remove sensor nodes. Data requests can be sent to the wireless nodes to visualize current field data. In addition, the application allows saving data plots in the form of PDF files. In Figure 4, acceleration data is exemplarily shown, collected by two wireless sensor nodes, S1 and S2, during laboratory tests.

2.4 Result

Laboratory tests are conducted to validate the performance of the prototype landslide monitoring system. Specifically, the functionalities of the software agents are analyzed to determine the accuracy of the inverse velocity method applied. To prove the concept, a sand slope is exposed to flooding, which results in soil movement (i.e. landsliding).

2.5 Laboratory test setup

A container is filled with sand as illustrated in Figure 5a. The depth of the container is 42 cm. A sand slope with an inclination of 45 degrees is built with a bulk density of the sand (i.e. the ratio of the mass of the sand particles to the total sand volume) of 1.56 g/cm^3 and a void ratio of 0.7; the void ratio describes how sand particles are packed. A void ratio of 0.7 indicates that the sand is of middle-graded density. The wireless sensor nodes, S1 and S2, are installed on the top and at the toe of the slope surface. Every sensor node hosts the embedded agents.

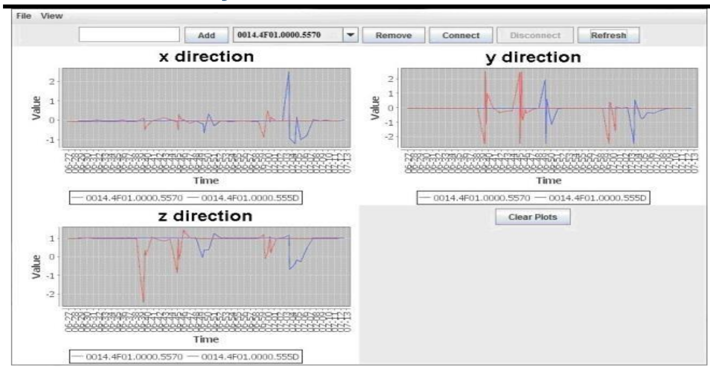


Fig 3 : Proto type control and analysis web application.

To determine the initial slope condition, the embedded agents continuously measure the acceleration and the orientation of a node at a relatively low sampling rate of 0.001 Hz; they analyze the data with respect to changes, condense it, and send it to the server system. To simulate heavy rainfall, water is poured slowly at the top of the slope. After pouring 10 liters of water, the soil is saturated and a slow movement starting at the toe of the slope is observed by the monitoring system. Tension cracks also occur because of the weak foundation material. The movement results in changes in the acceleration data, which are identified by the agents. The sampling rate is automatically increased to 0.01 Hz. Based on the acceleration data, inverse velocity values are calculated and sent to the server system for further analysis and visualization. After a total of 14 liters of poured water, cracks occur at the top of the slope as shown in Figure 5b, leading to another movement at the top of the slope and to total slope failure.

2.6 Results of the laboratory tests

Slope movements have been detected and, based on the inverse velocity method, the failure time has been calculated by the prototype monitoring system. The relevant information has been forwarded from the wireless sensor nodes to the server system. Figure 6 illustrates the inverse velocity calculated by S2 before failure. As can be seen, the inverse velocity decreases as failure time approaches. In summary, the laboratory tests have proven that the landslide monitoring system is capable of autonomously identifying anomalies and pre-failure deformations.

III. CONCLUSION

In this paper, the prototype development and implementation of an autonomous landslide monitoring system based on wireless sensor nodes have been presented using a wireless sensor network. Software agents have been embedded into the wireless sensor nodes to continuously collect and analyze ground acceleration data and orientations of the nodes. Within the laboratory experiments, it has been demonstrated that the software agents react appropriately on environmental changes, e.g. by increasing the measuring frequency if anomalies are identified. The collected data can be sent from the wireless sensor nodes to a server system for further analyses and automated email alerts. A distinct advantage, compared to conventional landslide monitoring systems, is that the presented system observes slopes without permanent human interaction. Furthermore, costs for cable-installation and maintenance are avoided because of the utilization of wireless sensor nodes. Due to the flexibility and adaptability of the software agents embedded into the wireless sensor nodes, a resource-efficient reduction of measured data is achieved. Future improvements can be made, for example, by incorporating soil moisture sensors into the system. Also, the implementation of additional agent functionalities could further enhance autonomous monitoring.

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