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Landslide Pre-Warning System for Railways in Hilly Areas Using Embedded Systems Network

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ABSTRACT--Landslide is due to mass failures of slope in hilly areas, which includes movement in soil, rock which cause a considerable damage to the natural habitat, environment, economy and other resources. This makes landslide monitoring an essential one in protecting humans and other living beings. In recent years, the frequent occurrence of landslide disasters causes great harm to people's live and properties. We can't stop the natural calamities but we can be alert the people to not use the path Wireless Sensor Network (WSN) technology which is utilized in hilly area to protect people where geological hazards occur easily. This paper includes geophone sensor, moisture sensor and slope angle detector distributed on the hillside. The sensor outputs are analysed and the data are fed to the controller. Thus when there are maximum possibilities for landslide, a warning is to be sent using Global System for Mobile Communication (GSM) or Zigbeeand hence precautionary steps can be taken by the railway department to safeguard the entire people in the place. The paper is intended to give an early warning to railways which travels in hilly areas. If landslide occur on the path of the rail message is sent to the train driver and the traffic control station, such a way the train can be stopped in a safer location such a way the people in the train were not under stress due to train stoppage in mid way of hills.

I.INTRODUCTION

Natural disasters are increasing worldwide due to global warming and climate change. Landslides are simply defined as down slope movement of rock, debrisunder the influence of gravity. This sudden movement of material causes extensive damage to life, economy and environment.However, this disaster is largely unpredictable and occurs within very short spans of time. Therefore, technology has to be developed to capture relevant signals with minimum monitoring delay.

Wireless sensors are one of the technologies which can quickly respond to rapid changes of data and send the sensed data to the receiver section in areas where cabling is not available. A wireless sensor network consists of various sensors which are distributed spatially to monitor physical or environmental conditions such as temperature, sound, vibration, pressure, humidity, motion pollutants. Wireless sensor networks have many applications such as monitoring, surveillance, tracking for smart environment. Combination of wireless sensor network and landslide monitoring becomes the focus of research in the world. A number of research institutes and companies have taken a lot of hard work and gained some achievements in scientific research and corresponding products.

In this paper a heterogeneous wireless sensor node is being used which consists of geophone and moisture sensor. As the predominant reason for the occurrence of landslide is due to rainfall and seismic vibrations of the earth. Hence these are taken into account and depending upon the probability accordingly necessary actions can be taken.

II.LITERATURE REVIEW

Maneesha.V.Ramesh et al (2013) [1].This research has developed a novel wireless geophone placement strategy that helps easier detection of landslide signals by reducing the noise impact on raw geophone signals. This work has enhanced the current state of art by integrating existing signal processing techniques with detection and removal of footsteps and vehicle movement noises. This research has developed a real time warning system and analysis system for rainfall induced by using a wireless sensor geophone network. Each wireless node is connected with a geophone sensor for detecting seismic vibrations. When an event is detected real warnings can be given to the people.

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Y.Srinivas et al (2014) [2]. In this paper they have used three sensors of Angle sensor which gives the readings of slope angle if there is any movement in landslide and they have Liquid level sensor which collects the depth of water at the mountains. Temperature sensor gives the changes in the temperature. These all nodes of sensors are connected to the LPC 2148 ARM processor for collection of data. As the data is collected then Global Positioning System (GPS) gives latitude and longitude and all the readings are given to Zigbee for transmission. As the information is obtained at the receiver side by Liquid Crystal Display (LCD) at receiver station or by Short Messaging Service (SMS) they can alert the people and save lives and property. Thus this design combines GSM wireless communication technology and Wireless Sensor Network

B.Aneesha Begum et al (2015) [3].In this paper they have developed A Disaster pre-warning system the railway track in hill stations, where the railway transport is affected due to heavy rainfall and frequent landslides. Integrating Micro Electro-Mechanical System (MEMS), Flex, Position Infrared Sensor (PIR) and Moisture sensor forming a heterogeneous wireless network helped in identifying the abnormalities and this paperalso includes development, deployment and data retrieval of the sensors information using WSN along with the specification of the location of occurrences of landslide with the help of GPS.

Sagar.D.Solanki et al (2014) [4]. In this paper they have incorporated a technology which has to capture relevant signals with minimum monitoring delay. Hence they have employed wireless sensors which can quickly respond to changes of data and send the sensed data to a data analysis centre in areas where cabling is inappropriate. The heart of this paper lies with the use of GSM,Zigbee and Sensors. Every sensor has Zigbee transmitter (Tx) mounted on it. When landslide happens sensor sense that and transfer data through router to the co-ordinator. Co-ordinator has GSM and Zigbee receiver (Rx). It receives the information transmitted by GSM to the control centre. GSM in the control centre receives this and transfer this information through GSM to the rescue team. They also check the status of the sensor by sending message.Thus they warn the main centre about the occurrence of landslide and hence pre-cautionary actions can be taken.

PROPOSED METHODOLOGY:

Collaboration of geophone and moisture sensor for pre-warning of landslide for railways in hilly areas is very helpful to protect people and avoid accidents. The output values from geophone and moisture sensor are compared with a preset value. The preset value is fixed by carrying out trial and error recordings of these two sensors in different scenarios. Then the output from these two sensors are compared. There exists three kinds of situation depending upon the satisfaction of the condition of situation, corresponding message will be displayed which is then transmitted using Zigbee or GSM to the control station depending upon the distance of transmission. Hence respective pre-cautionary actions can be carried out and people can be safeguarded.

III.BLOCK DIAGRAM

The overall block diagram for Landslide pre-warning system for railways using embedded systems network consists is depicted in the Fig1. It consists of the following components geophone sensor, amplifier, Schmitt trigger, microcontroller, moisture sensor, zigbee and LCD.

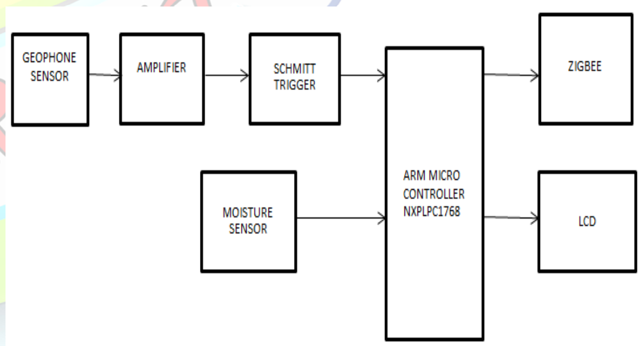

Fig 1 Overall Block Diagram

GEOPHONE SENSOR:

A geophone is a device that converts ground movement (displacement) into voltage. These sensors produce the output voltage based on piezo electric effect that is, when force is applied on the opposite sides of a crystal equivalent voltage will be produced on the other two sides. Thus the seismic vibrations which are responsible for causing the landslide can be analyzed with the help of this device.

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Fig 2 Geophone Sensor

MOISTURE SENSOR:

The primary reason for the occurrence of landslide is rainfall. When moisture content in the soil increases the porosity of the soil increases which decreases its ability to hold the soil together resulting in landslides. Hence the moisture content of the soil must be continuously monitored. This is done with the help of moisture sensor. The moisture sensor can read the amount of moisture present in the soil surrounding it. This sensor uses the two probes to pass current through the soil, and get the moisture level. More water makes the soil conduct electricity more easily (less resistance), while dry soil conducts electricity poorly (more resistance).

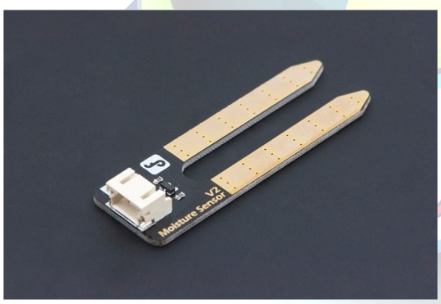

Fig 3 Moisture Sensor

AMPLIFIER:

The geophone sensor output is in the range of mV.Hence for increasing the ease in the analyzation, its output must be amplified before feeding it to the microcontroller.

SCHMITT TRIGGER:

The amplified output of the geophone sensor is converted into pulses with the help of Schmitt trigger. This converts any input sine wave into output square wave. Thus whenever the microcontroller receives the pulses as an interrupt corresponding actions are taken.

ARM MICROCONTROLLER:

The micro controller used is LPC 1768 which is an Advanced RISC Machine (ARM) Cortex-M3 core controller. This microcontroller is used for embedded applications featuring a high level of integration and low power consumption. It incorporates a 3 stage pipeline and uses a Harvard architecture. It is designed for prototyping all sorts of devices especially those including Ethernet, Universal Serial Bus (USB), and the flexibility of lots of peripheral interfaces and FLASH memory. It is packaged as a small Dual Inline package for prototyping with through holestripboard and breadboard, and includes a built-in USB FLASH programmer. The microcontroller is programmed to compare the output of the geophone and moisture sensor with a preset value. The output of these two sensors are in turn compared depending upon the satisfaction of the test conditions the occurrence the respected situation will be displayed in the LCD and also transmitted through GSM or Zigbee.

GSM:

Global System for Mobile communication (GSM) is a digital mobile telephony system. GSM uses a variation of Time Division Multiple Access (TDMA) and is the most widely among other digital wireless telephony technologies GSM digitizes and compresses data, then sends it down a channel with two other streams of user data, each in its own time slot. It operates at either the 900 MHz or 1800 MHz frequency band. Here when the microcontroller detects the possibility of a landslide then using gsm warning signal is sent to the railway authority.

ZIGBEE:

Zigbee is an IEEE 802.15.4 based specification for a suite of high-level communication protocols used to create personal area networks with small, low power digital radios. The technology defined by the Zigbee is intended to be simpler and less expensive than other wireless personal area networks. The CC2500 is a low cost true single chip 2.4 GHz transceiver designed for very low power wireless applications. The CC2500 is intended for the industrial, scientific and medical as a

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short range device with a frequency band of 2400 to 2483.5 MHz. The cc2500 provides extensive hardware support for packet handling, data buffering, burst transmissions, clear channel assessment, link quality indication. The main operating parameters and the 64 byte transmit/receive First In First out (FIFO) can be controlled through a Serial Pheripheral Interface (SPI). In a typical system, the cc2500 will be used together with a microcontroller and a few additional passive components.

DESIGN OF AMPLIFIER:

The output voltage obtained from the geophone sensor is in the level of mV. For analysation purpose it's output must be amplified. The amplifier is designed as below with the gain of around 450.

R2= Input resistance

R3= Feedback resistance

R2= 6.7K Ω

R3= 3M Ω

Gain= $\frac{Vout}{V\,in}$ = $1 + \frac{R3}{R2}$ ……... (1)

Substitute R2 and R3 in equation (1)

Gain= $1+\frac{3\times10^{6}}{6.7\times10^{3}}$

Gain= 448.7

IV.TESTING OF GEOPHONE SENSOR AND MOISTURE SENSOR

AUDACITY RESULTS:

Audacity is used to record and post process the audios. Hence the impact of vibrations on the geophone sensor was seen using this software . The sensor was buried inside the ground within a depth of 25cm. The vibrations were given externally and the responses were recorded.

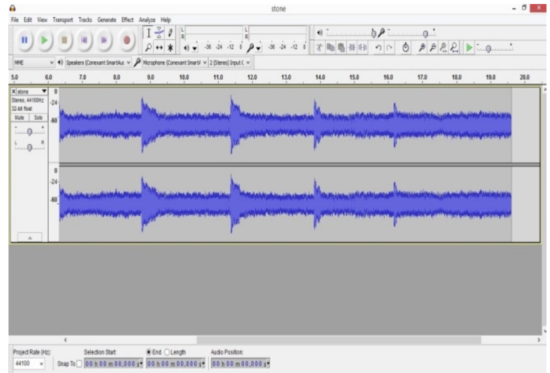

Fig 4 Audacity Output For Loading With Stone on Geophone Sensor

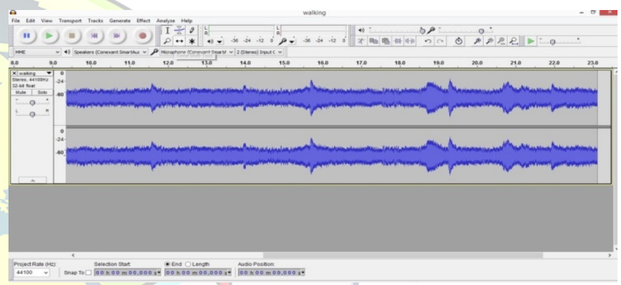

Fig 5 Audacity Output for Walking on Geophone Sensor

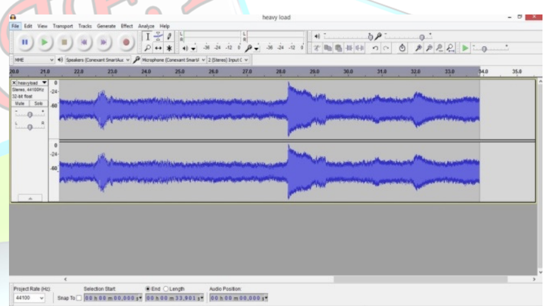

Fig 6 Audacity Output for Heavy Load on Geophone Sensor

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Fig 7 Hardware Setup while recording the values from Geophone and Moisture Sensors

V.RECORDINGS OF GEOPHONE AND MOISTURE SENSOR IN VARIOUS SOIL

The geophone sensor was buried in the soil within the range of 25cm and the moisture sensor was also placed in the soil. A set of readings were taken in different soil conditions namely dry condition, damp condition and wet condition. These readings were helpful in fixing the preset value in the microcontroller and hence it can the type of situation can be predicted.

Table 1 Output Values of Geophone and Moisture Sensor in Dry Soil

SOIL TYPE	MOISTURE SENSOR (V)	VOLTAGE DUE TO VIBRATION ON GEOPHONE SENSOR (V)				
		NORMAL WALK	HEAVY JUMP	LOAD WITH LIGHT FORCE	LOAD WITH HEAVY FORCE	LOADING USING STONE
DRY SOIL	0.02	0.80	1.20	2.26	2.82	1.30
	0.03	0.83	1.25	2.30	2.96	1.32
	0.02	0.90	1.29	2.34	2.93	1.29
	0.01	0.956	1.32	2.38	2.84	1.34
	0.02	0.732	1.34	2.40	2.99	1.31
AVERAGE	0.02	0.84	1.28	2.34	2.91	1.31

Table 2 Output Values of Geophone and Moisture Sensor in Damp Soil

Table 2 Output Values of Geophone and Moisture Sensor in Damp Soil

SOIL TYPE	MOISTURE SENSOR (V)	VOLTAGE DUE TO VIBRATION ON GEOPHONE SENSOR (V)				
		NORMAL WALK	HEAVY JUMP	LOAD WITH LIGHT FORCE	LOAD WITH HEAVY FORCE	LOADING USING STONE
DAMP SOIL	3.70	0.54	1.02	1.36	1.62	1.40
	3.69	0.56	1.16	1.32	1.56	1.43
	3.73	0.43	1.10	1.39	1.63	1.36
	3.72	0.60	1.18	1.40	1.72	1.44
	3.73	0.62	1.20	1.33	1.80	1.41
AVERAGE	3.71	0.55	1.13	1.36	1.66	1.41

Table 3 Output Values of Geophone and Moisture Sensor in Wet Soil

The output voltage obtained from the geophone sensor is in the level of mV. For analysation purpose it's output must be amplified.

Table 3 Output Values of Geophone and Moisture Sensor in Wet Soil

SOIL TYPE	MOISTURE SENSOR (V)	VOLTAGE DUE TO VIBRATION ON GEOPHONE SENSOR (V)				
		NORMAL WALK	HEAVY JUMP	LOAD WITH LIGHT FORCE	LOAD WITH HEAVY FORCE	LOADING USING STONE
WET SOIL	4.20	0.56	1.21	1.36	1.63	1.45
	4.19	0.44	1.18	1.33	1.57	1.44
	4.20	0.63	1.10	1.38	1.68	1.45
	4.21	0.52	1.03	1.42	1.73	1.46
	4.19	0.62	1.24	1.36	1.82	1.48
AVERAGE	4.20	0.55	1.15	1.37	1.69	1.46

The table 1, 2 and 3 shows the average output voltage for moisture as well as geophone sensor subjected to different level of vibrations during dry, damp &wet condition respectively. Thus it's clear from these tables that the voltage obtained from the geophone sensor increases with the intensity of the force applied. Depending upon these values a count value is fixed in the microcontroller for geophone as well as for the moisture sensor. When the preset condition is violated then depending upon the existing condition results will be displayed on the LCD.

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HARDWARE RESULTS

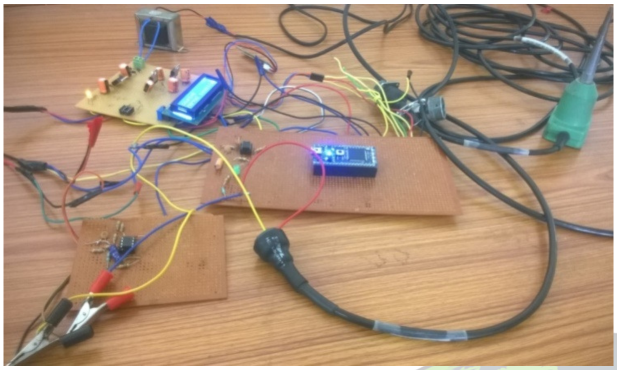

Fig 8 Hardware Model

The figure 8 shows the overall hardware which consists of the amplifier, schmitt trigger and arm microcontrolleralong with geophone and moisture sensor. In this paper we have considered three situations namely normal condition, chances for landslide occurrence and the third one is that the occurrence of landslide is definite.

Case 1: The normal condition prevails when the output from the geophone as well as the moisture sensor has not crossed the preset value that is typically a dry condition exists and there are no chances for landslide to occur. The LCD display during Case 1 is displayed in Fig 9.

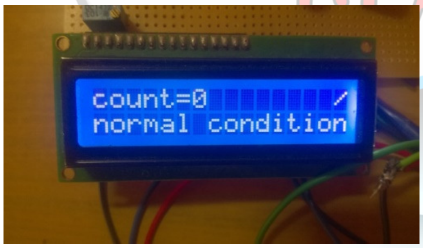

Fig 9LCD display during Case 1

Case 2: The situation is that there may be chances for landslide to occur. This happens when either there is a trigger from the geophone sensor or the moisture sensor and it's value must have crossed the preset value. For example there may be trigger from the geophone sensor but it wouldn't have crossed the preset value and the only output will be from the moisture sensor and vice versa. Hence there are only chances of landslide to occur.The LCD display during Case 2 is displayed in Fig 10.

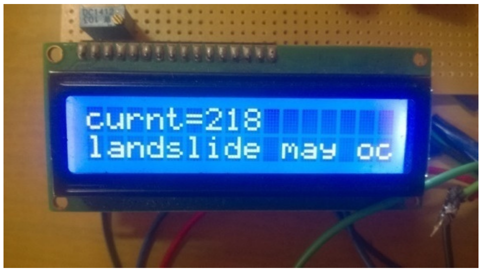

Fig 10 LCD display during Case 2

Case 3: The third situation is that there are definite chances for landslide to occur. This condition prevails when both the output from the geophone as well as the moisture sensor has crossed the preset value. Hence it is predicted that there are definite chances for landslide to occur. The LCD display during Case 3 is displayed in Fig 11.

Fig 11 LCD display during Case 3

VI.CONCLUSION

A reliable solution which can quickly sense and monitor the changes of moisture content and seismic vibrations which are responsible for causing landslides are recorded. This helps in pre-warning of the landslides for railways especially in the hilly areas . The power consumed is very less which makes it a cost effective solution. The prototype is easily portable which makes it even more reliable to be operated in the remote hilly areas.

In order to make it even more real time oriented system and increase the accuracy rate a slope angle

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sensor can be introduced. The output from geophone sensor can be processed and filtered even more effectively to increase the effectiveness of the system. These sensors can be grouped to form several nodes such that each node consists of heterogeneous sensor network and the net output from all the nodes can be collaborated together.

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