Design and Development of Sensors to Detect Rate of Rainfall and Ground Displacement for Landslide Alert System

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Abstract **-** Landslide activity has become a rising concern due to various natural factors and due to human activity. It is not only the concern of areas having steep slopes, mountains but it can also occur in plain areas. So, there is pressing need to combat with this challenge with latest and efficient technology to create awareness about landslide in advance. We cannot stop natural causes but we can be alert before they occur. So this paper will discuss the combination of GSM wireless technology and sensor network with the proposed direction to alert the people about landslide activity in advance.

Keywords **-** *Rain sensor, displacement sensor and design and implementation*

I. INTRODUCTION

Complex geological and geographical conditions and variations of climate conditions in time and space results in landslide. The sudden increase in external factors like earthquake,heavy rainfall cause landslide [1]. The term landslide is nothing but mass movement of hill slopes comprises of rocks, soil etc.The movement of slopes can either be upward or outward and it can be slow or fast. Landslides mostly related to areas like steep slopes and mountains but it can also occur in area of low relief. Basically there are two main parameter that is an increase of shear stress and decrease in material strength. Erosion, heavy rainfall, vegetation, earthquakes etc. helps in increasing shear stress.Change in state of stability and changes in intergranular forces like pore water pressure, solution decrease the strength of soil. Heavy rainfall and decrease in the strength of soil are the two major factors that will cause landslide. Landslide can occur due to various causes like physical, human etc. Increased urbanization, continued deforestation and increased regional precipitation increase the rate of landslide activity world widely [2].Landslides have always been a major cause of concern. It not only damages engineered structures but also a big loss for human life. So an early warning alert system is needed to detect the landslide activity in advance and to aware the people about it. The aim of this paper to create landslide warning using displacement and rain sensor. It is composed of two sensor rain sensor or displacement sensor to provide continues data on the landslide activity. Rain sensor is used to check the rate of rainfall of Himachal Pardesh. Displacement sensor is used to check the movement in the layers of soil and GSM module is interfaced with microcontroller to aware the people about the landslide activity. The SMS technology also enables the user to dialogue with the module either by means of SMS messages. Also this system comprises of less number of sensors, so the cost of the system is also less [3].

II. RELATED WORK

JianXu et al. (2013) proposes an early warning system for landslides using ZigBee network. It consist of Cortex-M3 architecture of the chip as a core control processor to improve system performance. To process data ZigBee uses CC2530 as the hardware to construct ZIGBEE wireless sensor network and then GPRS system is used send the data and early warning message.as the technological manner to remotely convey data transmission and early warning information. The results show that the system is fullyversatile and good scalability. It also overcome various problems occur in previous having low efficiency and high cost [4].

Leonardo Zan et al. (2002) proposed a system that is consist of number of sensors selected according to characteristics of soil. It has been observed that most of landslides occur due to loss in strength of soil. An early warning monitoring system based on National Instrument Lab View software and an A/D converter with internal processor that collects the data from different sensors such as seismic, pressure transducer and a rain gauge. The system will generate alerts automatically when the other instruments confirm an out of range signal generated by a single instrument [5].

Terzis, A. et al. (2006) introduces a new approach for determining the occurrence of a landslide. This paper introduces a new system which is consisting of number of sensorsto detect landslide activity. It is based on a three-stage algorithm. First sensors collectively detect small movements of a slip surface. Once the presence of movement of surface is detected then in second phase displacement of moved sensor is calculated. Finally the direction of the displacements as well as the locations of the moved nodes is used to estimate the position of the slip surface.After the estimation of location of slip surface a Finite Element Model that predicts whether and when a landslide will occur [6].

Wen Chen et al. (2012) proposed an intelligent visualization system for landslide monitoring, whereas wireless sensor network is deployed for observing and

detecting the dynamic changes of the landslide body at an experiment site. The visualization system is designed and implemented to visualize the spatial distribution of the employed sensors and the data of these sensors. Through the visualization-supported data analysis, the system will be capable of alert for possible critical events such as landslide surface failure. The experimental results show the initial functions and prototype capabilities of the system [7].

Tarolli, P et al. (2006) introduces a new approach for detecting landslide using a terrain stability model. This approach categorizes the location with critical stability index from a terrain stability model on each down slope path from ridge to valley. Any measure of terrain stability maybe used with this approach, which here is illustrated using results from SINMAP. The density of most likely landslide initiation points within and outside mapped landslide scars provides a way to evaluate the effectiveness of a terrain stability measure. This relative density was used to evaluate the utility of high resolution terrain data derived from airborne laser altimetry for a small basin located in the North-eastern Region of Italy. It has been found out appreciable differences between landslide initiation points within and outside mapped landslides and it leads to two conclusions:

- The landslide initiation point approach is very helpful for quantifying the effectiveness of a terrain stability map when mapped landslides do not or cannot differentiate between initiation, run out, and depositional areas.
- If the landslides occurred in complexes that were sometimes more than 100 m wide but the a digital terrain model is best for 10mand if it is used for more than 10m then it will result in loss of resolution that degrades the results [8].

A.Gemitzi et al. (2011) discussed a new methodology to detect landslide prone area using factor analysis and fuzzy membership functions and Geographic Information Systems. A landslide inventory of 51 landslides was created in the mountainous part of Xanthiprefecture and various factors related to landslide activity is calculated. Six conditioning factors like slope angle, slope aspect, land use, geology, distance to faults and topographical elevation are evaluated. By using landslide data fuzzy membership function is defined for each factor. Factor analysis provided weights which is important for landslide occurrence. To produce landslide susceptibility map an overlay and index method is used. In this map it has been observed that 96% of landslides are located in very high and high susceptibility zones, indicating a suitable approach for landslide susceptibility mapping [9].

III. METHODOLOGY

As shown in figure 1, it is composed of two sensors of easy and rapid installation, which can be positioned directly upon the landslide body to get continuous data on landslide activity or on the causes that, could favour it such as Ground displacement and also to detect the rate of rainfall. In case of displacement sensor soil displacements create a pressure on sensor and the output obtained depends upon the voltage received at light dependent resistor. Sensor which is used to detect the intensity of light is composed of light dependent resistor and light emitting diode. If there is any movement detected in the soil then the intensity of light at received light dependent resistor sensor changesand the limits of movement will be stored in microcontroller. If the value of exceed its maximum value then it will send alerts on prestored numbers in EEPROM. Second sensor that is rain sensor is also used to detect the rate of rainfall. Rain sensor is made up of strain gauge with a plate mounted on top surface of strain gauge. Strain gauge is used to calculate the weight of water and limits like maximum value is stored in microcontroller according to area of himachal pardesh. Same as displacement sensor if its value exceeds than its maximum valuethe it will send SMS on prestored numbers. The heart of the system is microcontroller which collects the data recorded by the sensors on the landslide and is linked with GSM to manage both local and telephone alerts. This system works on the mechanism of sensing movements in hills. The limits of movements will be stored. When any motion occurs in land or hill, it will check the predefined stored value. If the value is MAX, it will send SMS on prestored numbers. For this an EEPROM is interfaced with microcontroller to save the telephone numbers and it will send SMS to pre stored numbers in EEPROM. The system is designed to acquire continuous data. It can program the user telephone numbers depending upon the capacity of EEPROM. The alerting procedure is activated when the sensor measuring the sliding movements. For continuous monitoring and detection of ground displacements, system needs continuous power that is provided by solar panel. In case of rain and other weather conditions, we use a battery backup that has been stored in the battery during solar charging.

IV. RESULTS

A full picture of whole system is shown in figure2. It has been observed that an alert message is generated when the water level inside rain sensor is above threshold valueas shown below in figure3.Same case for displacement sensor when the weight on displacement sensor is more than threshold value then it will generate an alert message or display it on LCD as shown in figure 4.

V. CONCLUSION AND DISCUSSION

One of the challenging research areas available today in the field of geophysical research is real time monitoring of landslides. This paper discusses the development of an actual field sensor network based landslide detection system.We have designed a system for landslide detection. This system is developed using AT89s52 microcontroller, rain sensor and displacement sensor. The main components used in this system are EPROM and GSM. We have attached two sensors like rain sensor, displacement sensor. In this paper we use two sensors: 1) rain sensor which is used to detect the rate of rainfall with the help of strain gauge 2)

displacement sensor which is used to detect the movements in soil plates on the accumulation of changes that favour landslides and 3) generating an alert by combining the data from above two sensors. In this system sensors are connected to AT89s52 microcontroller and if any sensor detected any disturbance then it is displayed on LCD and by GSM we got the message. We have done some testing on working of the system in we have observed landslide detection in fig 2 and we obtain message to phone and displayed at LCD. In fig 3, we have observed water level change and message received at receiver section. In fig 4,we have observed movement in soil and message is received through GSM. Our understanding behind these sensor maps is that even if a landslide is imminent at a place then the level of alert raised to reflect that when the limits exceed its value that is stored in microcontroller.In the future, this work will be extended to a full deployment by using the lessons learned from the existing network. Sensor network like displacement sensor can be extended up to high scale for more efficiency.

VI. REFERENCES

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Jaspal Singh graduated in electrical engineering with distinction from Thapar University in the year 1991. Working in MNC GE Medical Systems Asia, he has hands-on experience in the entire range of medical instrumentation and imaging systems. He received his M tech degree in electronic instrumentation from Punjab University, in the year 2007. Thereafter he has worked extensively on development of various electronics & embedded system technologies for healthcare. He has successfully delivered several Govt. of India sponsored projects including pilot 'mobile tele-ophthalmology' implementation. His expertise includes electronics and computing technologies for medicine and biology. He is currently working on sensor and sensor systems, m-health and pervasive computing, etc. for healthcare.

LIST OF FIGURES

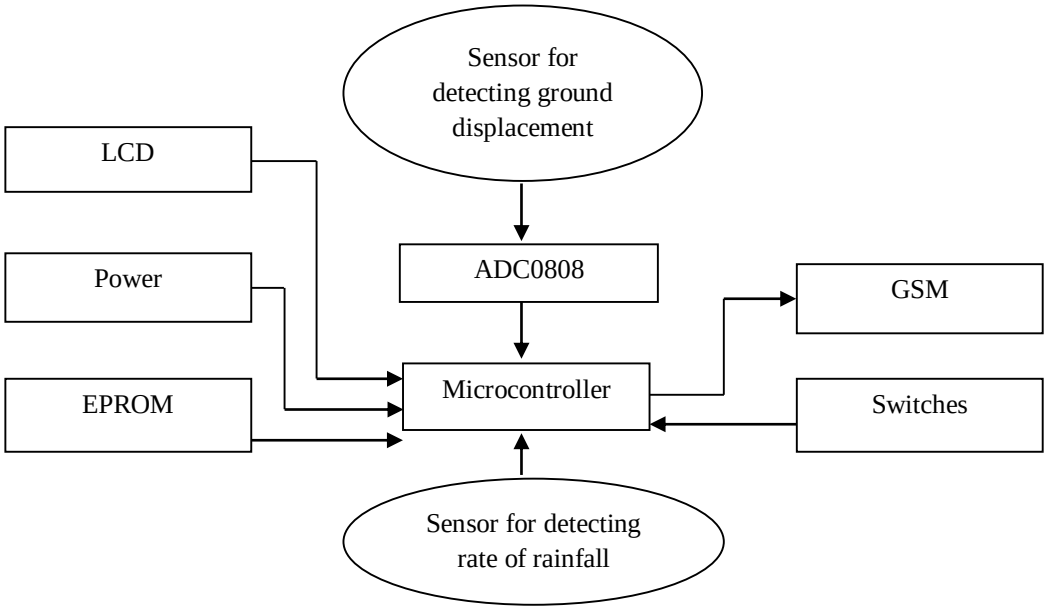

Fig 1: Block diagram of landslide alert system

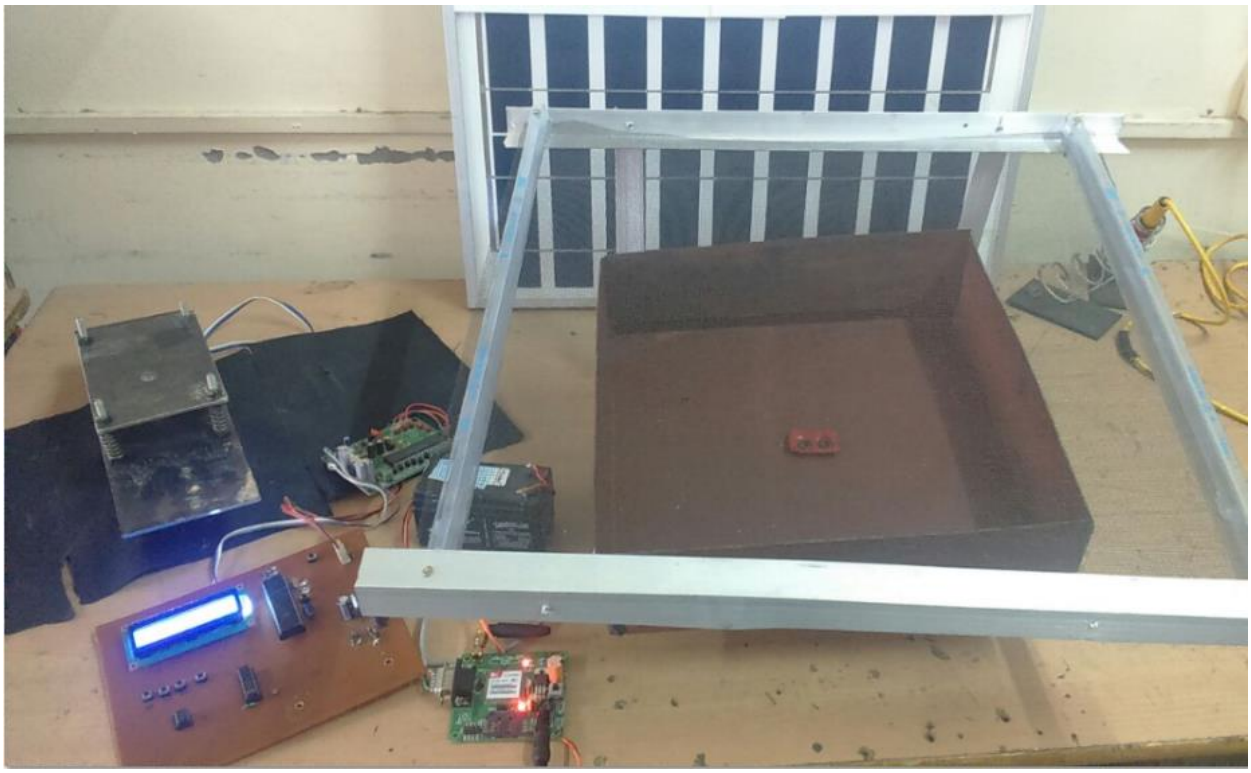

Fig 2: Landslide alert system

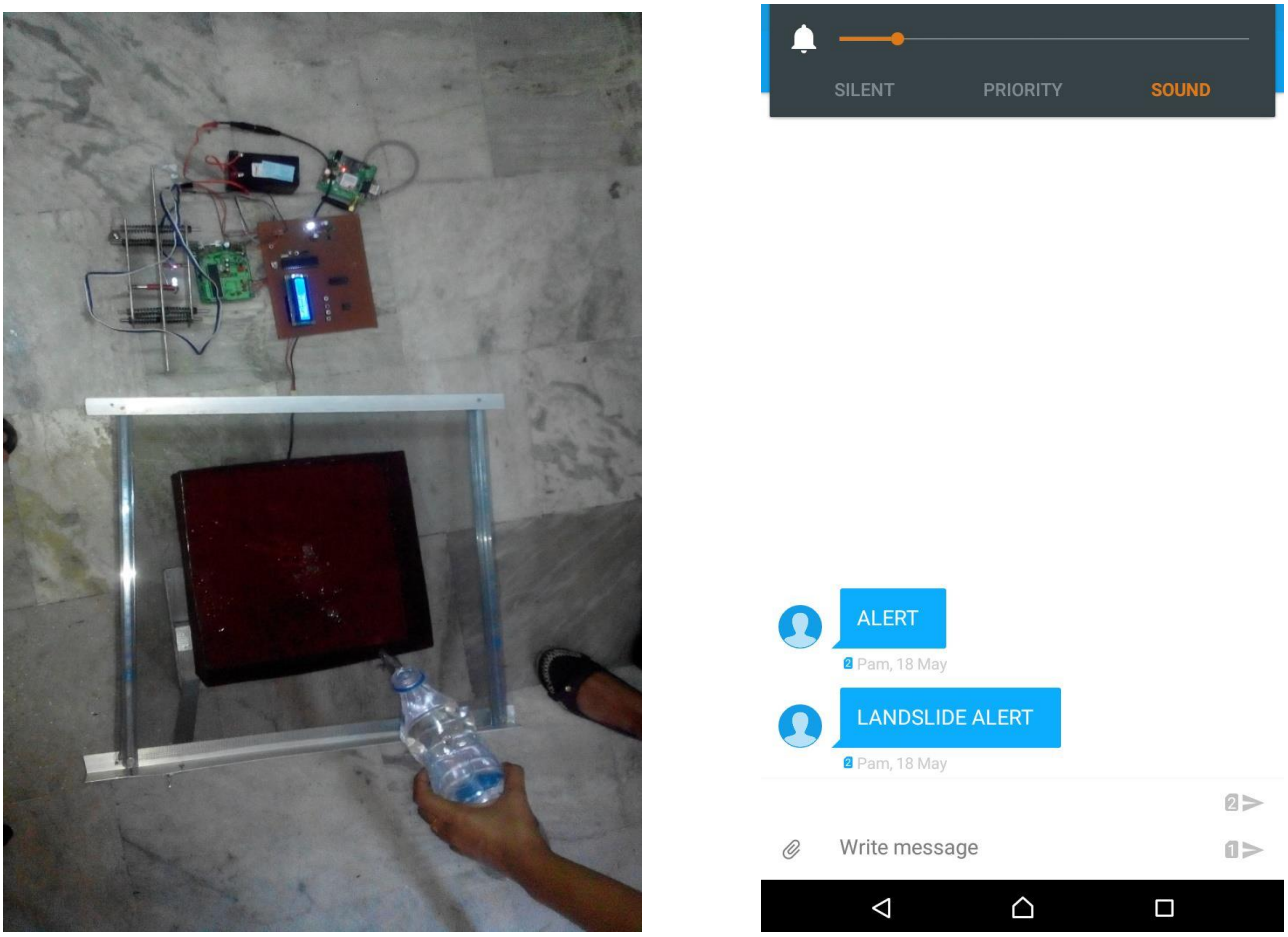

Fig 3: Testing of Rain Sensor

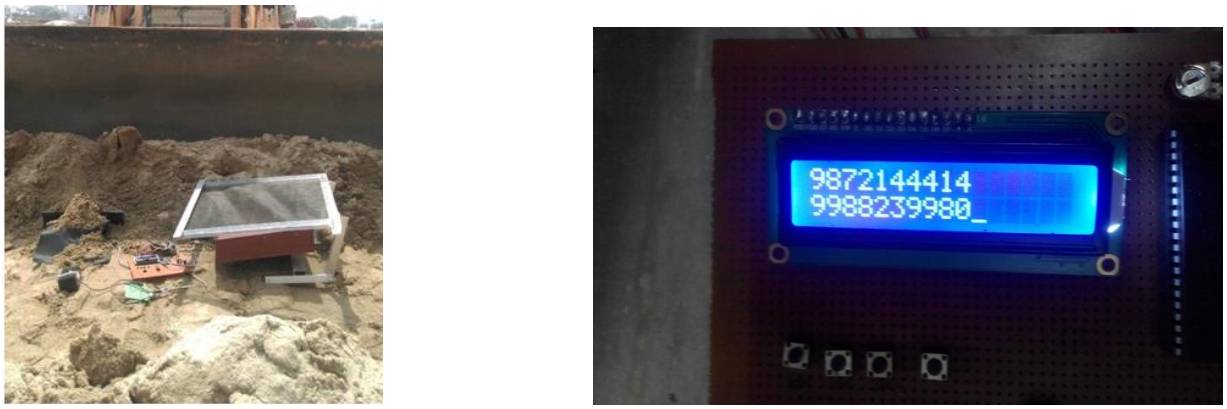

Fig 4: Testing of Displacement Sensor