A SENSOR NETWORK SYSTEM FOR LANDSLIDE DETECTION, MONITORING & PREDICTION OF FOREWARNING TIME

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Abstract: Natural hazards like earthquakes, landslides, tsunami etc. cannot stop. So the only way to reduce the possible damages is the prediction mechanism. The key issues to reduce the possible damages are an accountable disaster prediction and the appropriate forewarned times. Every year, landslides and mudslides are serious geological hazards affecting people, and cause significant damages around the globe. The stability of a slope changed from a stable to an unstable condition is known as landslide or mudslide. This project consists of an ARM based microcontroller board which continuously monitors the angle of a pole that is dug in a highly mudslide affected area, and sends the status of the devices through internet. We can access the status of the devices from any place from a computer with an internet through a Visual basic application. Also, the Forewarning time is calculated and sent through GPRS module present in the system. We are using UDP protocol to send and receive data between the device and the computer. The application at the system is developed in Visual basic.

Index Terms: Advanced Metering Infrastructure, Mudslide Detection, Sensor Network, Data Analysis, Disaster Prevention System

I. INTRODUCTION
Landslides are the natural hazards which includes a wide range of ground movement such as rockfalls, slope failure etc. The reasons for these are variation in water concentration, earthquakes etc. They are geological phenomena causing significant loss of life and billions of dollars in damages each year. Although a basic understanding of the causes and behavior of landslides is available, systems that predict the occurrence of a landslide at a specific site do not exist. The main causes of landslides are: (1) Geological causes: Rainfall and snow fall, Earthquakes (2) Morphological causes: Slope angle, Erosion (3) Physical causes: Volcanic eruption, Ground water changes (4) Human causes: Quarrying, Deforestation. Few major landslides of India are listed as: 22 September 1893 — a huge slide completely blocked the river Birahi Ganga at village Gohna, 11 – 12 July 1996 — massive landslide in Jaldhaka valley and South Kalimpong hills — 32 lives lost, damages to huge property, 9th June 1997 — Widespread devastation of Gangtok town, 7th July 1999 — Kurseong town devastated, 8 August 1998 - major landslide at Malpa, Uttarakhol- 200 people perished. The proposed system can detect, monitor, and predict the forewarning time for landslides using sensor network controlled using a controller chip having an analysis station.

II. BACKGROUND
Previous studies developed many detection and Identification mechanisms for the landslides or mudslides, these techniques include Image enhancement. They are Image differencing,
Vegetation index differencing, Image classification and Image registration. Image enhancement emphasizes the landslides or mudslides in the satellites images. The main problems in these are requires of human experience and knowledge of the observed areas for visual interpretation. Image differencing is a straightforward method and easy to interpret the results by comparing previous data with newer ones. However, this method does not provide an accurate result, because its only a prediction. The selection of thresholds affects the correctness of the result. Vegetation index differencing emphasizes the differences in spectral response. This method reduces the impacts of illumination. However, this technique also enhances the random noise or coherent noise. Image classification is done by minimizing the impact of atmospheric, sensor and environmental differences between multi-temporal images. However, this method requires a sufficient set of the training samples for classification. Image registration detects landslide/mudslide movements with sub pixel accuracy in image. The main disadvantage is its requirements of the high computational cost. Another one but a simple method of change detection and identification uses a local similarity measure based on the mutual information and the image Thresholding. This method uses the mutual information to measure the similarity. It then detects the landslides and mudslides from different images. This method is not suitable for detecting a small area landslide is the another problem.

The deployment cost is the major problem of these techniques. To obtain a “good” prediction, the investment must be sky-high. Usually, the mudslide happens in an area that draws little economical interests. So that, to protect people living in these areas, the detection devices must be inexpensive. Furthermore, the mounting of these devices must be associated with some public utilities system to reach where people are living. Simply, it should have more interactions with common public.

III. SYSTEM ARCHITECTURE

The system architecture is shown in figure 1. Main parts of the system are receiver station and transmitter pole or sensor column which communicate through internet. The sensor columns have two components: The sensing component that is below ground and contains all sensors and computing component that stays above the ground and contains processor and a transmitter. Each sensor column includes a stick with flex sensors and Micro Electro-Mechanical Systems (MEMS) or accelerometer. The sensor columns are placed at regular intervals over the length of the column. It uses User Data-gram Protocol (UDP) for sending and receiving data. UDP is a simple OSI transport layer protocol for client/server network applications based on Internet Protocol (IP). It is a main alternative to Transport Control Protocol (TCP). It is often used in videoconferencing applications specially tuned for real-time performance. It is a minimal message-oriented transport layer protocol. General Packet-based wireless communication service (GPRS) that promises data rates from 56 up to 114 Kbps and continuous connection to the internet for mobile phone and computer users. The higher data rates allow users to take part in video conferences and interact with multimedia web sites and similar applications using mobile hand-held devises as well as notebook computers. The receiver station or analysis station can be a computer with internet. It is always monitoring

![Figure 1: System Architecture (a) Landslide Warning System (b) Sensor Column](image-url)
the poles by checking the status of it. The communication between the controller and the computers is provided by internet.

Message broadcasting uses AMI-associated communication network. AMI has a communication network that consists of many advanced metering and sensing devices. The status of each device within an AMI installation is sent to the data collector, and then forward to the all. This study proposes an inexpensive detection device that is mounted on each electricity pole. The movement or tilting of an electricity pole triggers the mounted detection device to send a message back to the data collector through the AMI communication network. This displacement message is used to calculate the forewarning time and it he mudslide analysis module send that time for to receiver station for broadcasting.

(A) Detection Method

In most of mudslide-damaged residences, the electricity equipments, especially electricity poles, are usually tilted or moved. In order to obtain the displacement, a movement detector attaches to a pole. A simple method is to install flex sensors and MEMS in the pole. Flex sensors are sensors that change in resistance depending on the amount of bend on the sensor. They convert the change in bend to electrical resistance—the more the bend, the more the resistance value. It can measure the tilted angle of pole due to landslide. Flex sensor is shown in figure 2.

Micro-Electro Mechanical Systems (MEMS) or Microsystems Technology is a rapidly growing, emerging technology, and it has a big potential to reshape life patterns in the future like the microelectronics technology. By utilizing this technology, it is possible to integrate both microelectronic circuits and mechanical structures on the same chip, enabling monolithic integration while reducing the micro system size and cost considerably. This technology has an enormous number of application areas, including automotive, biomedical, telecommunication, household appliances, consumer applications and defense applications. Here it used to find the direction of tilt occurred. Figure 4 shows MEMS chip.
present in the system. We are using UDP protocol to send and receive data between the device and computer.

IV. DATA ANALYSIS

The displacement information of the tilted electricity pole is sent to a data collector periodically in the system. The data collector then calculates the forewarning time using these information and forwards to the receiver station. The displacement records needed to calculate the forewarning time includes: time, tilted direction, tilted angle, difference of tilted angles, checking bit, and the tilted severity of an electricity pole. \( \{t_1, t_2, t_3, \ldots, t_n\} \) denotes the set of recording time of each displacement. \( a_n \) denotes the tilted angle. The differences between the continued tilted angles are obtained by \( a_n - a_{n-1} = d_n \) and \( a_{n-1} - a_{n-2} = d_{n-1} \). \( d_n \) denotes a difference between two continuous tilted angles of a pole. When \( d_k \) is not zero, the checking bit \( c_k \) is set and the tilted severity is also calculated according to \( d_k \). If \( |d_k| \leq 2\) the tilted severity \( s_k \) is \( m \). If \( c_k-1 \) is set, \( c_k \) is also set. If \( c_k \) is set and \( d_k \) is zero, \( s_k \) is set to \( s_{k-1} \).

The pairs of checking bit and tilted severity of all electricity poles constructs the alphabets in the proposed mudslide analysis system. The neighboring poles are assigned with adjacent numbers. The pair \( i i c, s \) of time \( ti \) of all numbered electricity poles constructs the Si according to the pole numbers. The mudslide analysis system then builds a suffix tree \( ST_i \) of two adjacent \( Si \) and \( Si+1 \). The longest repeating pattern in the \( ST_i \) of highest tilted severity indicates the most dangerous area that needs to put most attentions.

(A) Forewarning Time Calculation

Obtaining enough forewarning time is the main aim of a disaster prevention system. The data measured system stores the possible titling direction of each electricity pole. With these tilting directions, the database stores the affecting scope of each pole. The system gives each residential area a unique identification. Each affecting scope of an electricity pole than contains a set of residence ID. This system associates each electricity pole and every residence ID of this pole with an offset that indicates the distance between the residence area and the pole. \( \{E_1, E_2, \ldots, E_k\} \) all poles. \( \{R_1, R_2, \ldots, R_i\} \) denotes the residence IDs of an electricity pole \( k \). \( D_{ik} \) denotes the distance between \( R_{ik} \) and \( E_{ik} \). Assume the probability of landslide is \( P(x) \). It is shown in figure 5.

\[
P(x) = 1, \text{ landslide happened} \\
< 1, \text{ otherwise}
\]

At any given time after \( E_k \) has tilted, the first recorded time is \( t_1 \), and \( t_0 \) is subtracting \( \Delta t \) from \( t_1 \). \( \Delta t \) is the period time for retrieving data. The tilted displacement for pole \( E_k \) is \( m \) that is \( \sin \Delta \theta \). Therefore, the tilted velocity for pole \( E_k \) is \( V_k \). \( t_{0k} \) is the time that pole has not tilted for the pole \( E_k \). Figure 6 shows he tilted displacement of pole \( E_k \).
The forewarned time of the pole $E_k$ alerting to the residence $R_i$ denotes $R_{i,AlertTime}$

$$R_{i,AlertTime} = \frac{D_i}{c_k \times h_k \sin \Delta \theta \cdot t_{now} - t_{0_i}}$$

Where, $Ck_i$ is the bit sets, when landslide happens.

V. SOFTWARE

The MDK-ARM (Microcontroller Development Kit) is the complete software development environment for ARM7, ARM9, Cortex-M, and Cortex-R4 processor-based devices. MDK is specifically designed for microcontroller applications and combines the ARM C/C++ Compiler with the Keil RTX real-time operating system and middleware libraries. All tools are integrated into µVision which includes project management, editor and debugger in a single easy-to-use environment. The fully integrated ARM C/C++ Compiler offers significant code-size and performance benefits to the embedded developer, however, MDK can also be used with the GNU GCC Compiler. The Keil RTX is a deterministic real-time operating system with small memory footprint.

Software algorithm of this is given as a flowchart as shown in figure 7. Firstly ARM and needed peripherals should be initialized. Then it needed to read the status of sensors which are used to detect landslide. If flex sensor value changes, it shows the degree of tilt then MEMS reads the tilted direction. Using these sensed data forewarning time is calculated and that time value sends to UART for transmission.

VI. RESULT

When the power on, the system activated and read the values from sensor network. Depending upon that landslide speed calculated and thus forewarning time calculated. Then the processor sends the time value to the data analysis station. Furthermore, the mounting of these devices must be associated with the public utilities system to reach where people are living.

VII. CONCLUSION

The mudslides and landslides have consumed many lives. To address challenges, such as low accuracy, incapability of measuring on a remote, real-time, and expensive of the existing methods to measure the displacement and sliding tilt due
to landslide, a sensor column is used in this paper, which is capable of directly converting the varied sliding deep displacement and tilt angle at any depth to the corresponding output of voltage. So promises to monitor landslide are more convenient and accurate with a relatively simple and low-cost design. Also, the mounting of these devices must be associated with the public utilities system to reach where people are living. So it is a system that ensures prediction of landslides along with detection and monitoring.

REFERENCES


