A THEORETICAL FRAMEWORK FOR LANDSLIDE MONITORING AND EARLY WARNING GENERATION

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ABSTRACT
Landslides are a geomorphological process intricately linked to the landform, material, structural, hydrological, climatic and vegetative conditions within which they occur. Due to the increase in the number of population and industrialization, people need to live in landslide prone areas. There are many causes of landslides such as rainfall, rising pore water pressure or accelerating movement, earthquakes, volcanic activity, human work, flood, erosion, snowmelt and change in reservoir level etc. Due to the availability of powerful data acquisition devices, nowadays, we can easily capture huge volume of geometrical information. Proper analysis of such large volume of data can help us to take proper decisions and action plans. However, according to our knowledge, there is no work that performs the analysis of huge volume of such data under cloud computing framework. Considering this fact, in this paper, we provide a theoretical framework to analyze landslides related geometrical data with an aim of landslides monitoring and early warning generation. We hope that proper implementation of this framework will help us to obtain more accurate and precise information about landslides and the authority will be able to take more accurate and efficient action plans.

Keywords: Landslides; cloud computing; data transformation

INTRODUCTION
Nowadays we have many powerful data acquisition devices. As a result it is possible to capture large volume of geometrical information. Information obtained from landform, rainfall, rising pore water pressure or accelerating movement, earthquakes, volcanic activity, human work, flood, erosion, snowmelt and change in reservoir level etc. can be treated as geometrical information. Proper analysis of such large volume of data can help us to take proper decisions and action plans. However, according to our knowledge, there is no work that performs the analysis of huge volume of such data under cloud computing framework. Considering this fact, in this paper, we provide a theoretical framework to capture and analyze landslides related geometrical data for proper monitoring of landslides related issues and provide early warning so that the possibility of landslides can be minimized and proper actions can be taken accordingly.

Most of the tasks related to landslides monitoring so far are site-based and driven by development projects to test the stability of the sites for civil constructions. Conventionally this has been approached by stability analysis of the site, generally determined from the balance of shear stress and strength and expressed as a factor-of-safety. This type of assessment is not well-suited for the general people. Although, several initiatives [1, 2] have been taken for landslides detection and warning generation, they cannot detect and generate warning up to a satisfactory level. This is due to their limited capacity of acquiring and processing large volume of data. The availability of different sensor devices, cloud storage and big data analyzing tools creates an opportunity for us to gather, store and analyze large volume of heterogeneous data to identify important and useful patterns. This can help us to develop a system for accurate assessment about the possibility of landslides. The system generated results can then be evaluated and decisions can be made on whether the level of risk is intolerable, tolerable, or acceptable and actions can be taken accordingly.

Landslides generate a small but important component of the spectrum of hazard and increasing risk that faces mankind. If there were a choice, people would inhabit and rely for their wellbeing on the safe

places of the earth – away from the threat of landslide. However, mankind has been placed progressively at the mercy of nature through population pressure, increasing demands for resources, urbanization and environmental change. It is the intersection of humanity with landslide activity that has recast a natural land-forming process into a potential hazard. Furthermore, economic globalization has enhanced reliance on communication and utility corridors. Fuel lines, water and sewage reticulation, telecommunication, energy, and transport corridors, collectively referred to as 'lifelines' in hazard studies, are highly vulnerable to landslide disruption.

Landslides present a threat to life and livelihood throughout the world, ranging from minor disruption to social and economic catastrophe. Spatial and temporal trends in the level of this threat have driven the current international and national concerns on the issue of hazard and risk reduction. However, these trends are difficult to determine accurately because of the variable quality and consistency of record keeping. These problems arise from a range of factors including: variability and improvements in observational techniques, changes in population density, the mix of different agencies involved and the variability of recording protocols, as well as heightened economic and social awareness. As well as economic loss, landslides have also caused numerous humanitarian disasters throughout history.

METHODOLOGY

Our framework for landslides monitoring and early warning generation comprises three main components. These are design, monitoring, and forecasting. The key tasks in the design phase of our landslide monitoring and early warning system include determining the needs and vulnerabilities of the population at risk, identifying any impediments to the population taking action if a warning is issued, and characterizing the geologic and meteorological setting and conditions that lead to landslide initiation. These conditions are referred to as the geo-indicators. Monitoring, which includes instrument installation and data communication and analysis, is a crucial activity. Forecasting represents the core element of the system as it includes the definition of thresholds, models and all the activities that lead to a warning. It is also the most problematic one, not just for the intrinsic difficulty of predicting natural events, but also for severe social and legal implications. An excessively high threshold value means that the lead time left for the emergency plans will be short and, in the worst case, that the event itself could be missed. Conversely, a threshold that is too conservative may lead to false alarms and to all the related problems.

In other words: acceptable risk criteria and tolerability of false alarms are two sides of the same coin; their definition helps to determine the possible range within which the value of the threshold can be set. In any case one has to keep in mind that the possibility of false alarms can be reduced, but cannot be completely nullified; therefore civil protection plans should encompass this chance as well. Figure 1 shows the three components of our proposed system.

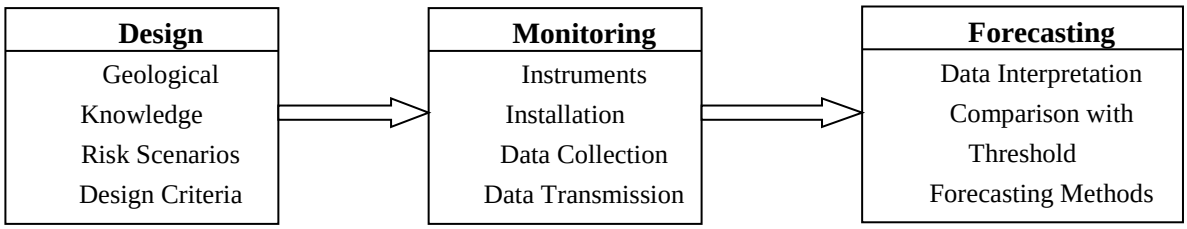

Fig. 1: Components of the proposed landslides monitoring and early warning generation system

Figure 2 shows the overall architecture of our system. In our architecture, we shall use special purpose sensors for collecting data. In the data collection phase, we need to consider the way of regional and site mapping, types of movements. In data collection phase, we also have to use displacement time series to define sliding mechanisms.

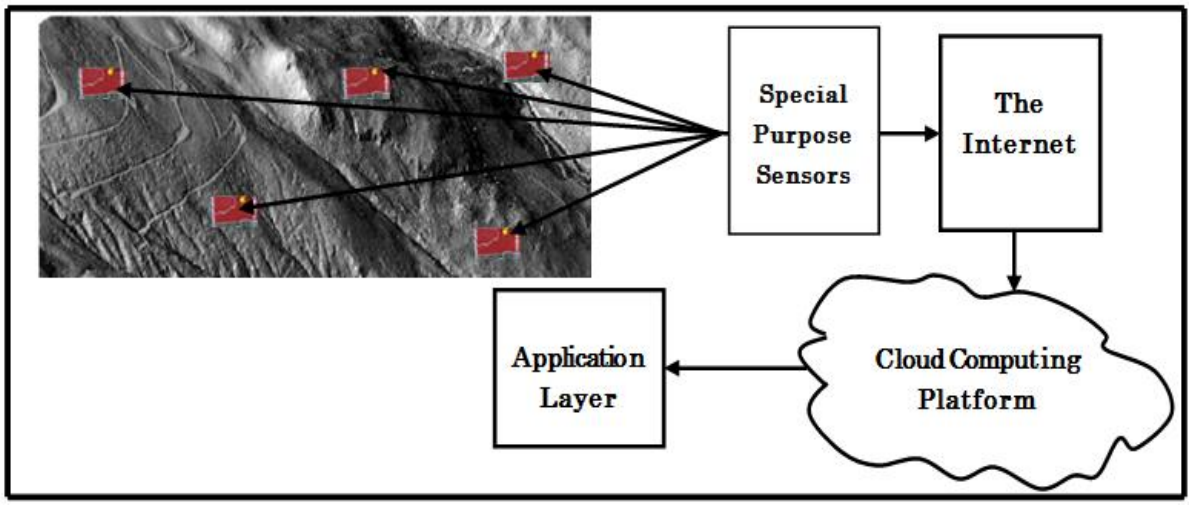

Fig. 2: Overall architecture of the system

The data collected via the sensors will be transmitted through the Internet to the cloud storage where data will be continuously analyzed under big data analysis framework to detect possibility of landslides. Finally, a platform independent application will be developed for the users so that they can obtain early warning about the landslides if they install the application.

EXPECTED RESULTS AND IMPACTS

By introducing a cloud-based framework for landslides monitoring and early warning generation, we can expect following results and impacts:

Results

- The system will be able to identify landslide distribution, process types and their state of activity for the test areas.
- It can be considered as an attempt to creation of local and regional landslide susceptibility, hazard, vulnerability, risk maps and management strategies.
- The system will be able to forecast future landslide risks in the test areas so that preventive measures can be taken in advance.

Impacts:

- The system will help in reducing the number of victims and losses caused by landslides.
- The system will provide a guideline for the authority to develop their action plan for reducing landslides related hazards.
- The system will help in selecting proper locations for the installation of gas, water and sewerage lines.

CONCLUSIONS

In this paper, we provide a theoretical framework for landslides monitoring and early warning generation. The implementation of this work will require collaboration between Civil Engineers and Computer Scientists. As interdisciplinary research is increasing nowadays around the globe such an initiative for landslides monitoring and early warning generation can help us to develop an efficient tool for serving the purpose and will help a lot to reduce the risks related to landslides.

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