Detection of Landslide Using Wireless Sensor Networks

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Abstract

Wireless sensor networking is one of the emerging areas which are extensively being used for development of real-time monitoring systems. This paper discusses the development of a wireless sensor network (WSN) to detect landslides, which includes design and development of WSN for real time monitoring system. A laboratory trial has been performed using wireless sensor networking with the integration of different sensors to detect the landslide.

1. Introduction

Landslides are the major cause of loss of life, human settlements, agriculture, forestland, and lead to damage of communication routes. The term landslide describes many types of downhill earth movements ranging from rapidly moving catastrophic rock avalanches and debris flows in mountainous regions to more slowly moving earth slides. It occurs as gravitational forces exceed the strength of material in a slope. Rocks, debris and slumps slide on a weak, fractured, slick, clayey or water-saturated planar or curved slip surface. Some landslides move slowly and cause damage gradually, whereas others move so rapidly that those can demolish property and lives suddenly and unexpectedly. As landslide moves down slope, the ground surface cracks, tilts, and drops. The causes of landslides in India are mainly due to extreme rainfall and earthquake. Landslides affect approximately 15% of land area of Indian subcontinent and reaching around 0.49 million km^2. India has a sensational record of catastrophes due to landslides [1].

2. Monitoring techniques

Monitoring, forecasting and warning of landslides are the essential features for saving the lives and assets from devastation. There are three fundamental ways for monitoring the landslide viz, visual, surveying and instrumentation. Each monitoring technique has its own advantages, disadvantages and application range. Ground based visual inspection and sampling of these on regular basis may be one of the effective ways of monitoring the landslides. Surveying includes all type of physical measurements. Surveying equipments such as levels, theodolites, electronic distance measurement (EDM), and total station provide some of the prominent landslide features [2]. However, aerial or terrestrial photogrammetry provides contour maps and cross section of landslides. The compilation of photogrammetric data enables a quantitative analysis of change in slope morphology and determination of the movement vectors. Instrumentation may include installing equipment for periodic reading of the different monitoring sensors such as inclinometer, strain guage, rain guage, clinometer, extensometer, pore pressure sensors etc. The monitoring techniques also can be divided into two groups: i) geodetic technique, and ii) non-geodetic technique. Geodetic techniques give global information on the behavior of the deformable landslide while the non-geodetic techniques give localized and locally disturbed information without any check unless compared with some other independent measurements. The present paper focuses on instrumentation monitoring and non-geodetic techniques for detecting the landslide. A laboratory trial has been performed using wireless sensor networking with the integration of different sensors. Wireless sensor networks (WSN) is one of the emerging technology that can be used for real-time locally distributed information monitoring of the landslides.WSN has the capability of large scale deployment, low maintenance, scalability, adaptability for different scenarios and low maintenance requirement which made it one of the best suited technologies for real-time monitoring [3]. A sensor network normally constitutes a wireless adhoc network, meaning that each sensor supports a multi-hop routing algorithm i.e. several nodes may forward data packets to the base station/coordinator [4]. A landslide detection system with the use of a wireless sensor network can detect the slight movements of soil or slope instability due to the several reasons such as dielectric moisture, pore pressure etc. that may occur during a landslide.

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3. Lab trial with wireless sensor network

The wireless sensor network in the laboratory trial follows a two-layer hierarchy: i) lower layer wireless sensor nodes which sample and collect the heterogeneous data from the sensor and the data packets are transmitted to the upper layer, ii) the upper layer collects the data and forwards it to the sink node (gateway) or base radio. Wireless senor nodes used are Zigbee compliant 2.4 GHz IRIS motes [5] from Crossbow. The present paper discusses the experiments performed in laboratory with the Eko nodes [6] and independent IRIS mote integrated with different digital sensors (Figs. 1 and 2). The output of digital sensor is connected with the es9200 interface board in case of Eko nodes. The IRIS motes can be programmed as nodes as well as base radio. Experiments with micro-electro mechanical system (MEMS) based Inclinometer with signal output 4-20 mA and linear range $\pm 5^0$ has been carried out and described below in detail. MEMS inclinometer can measure incline and decline i.e. positive and negative slopes, respectively.

The input to the inclinometer is given by Twin Transistor Power supply (18-24 VDC). The inclinometer is inclined at some angle and its position is fixed. The angle is measured by changing the inclination of the inclinometer. The angle is determined by observing the corresponding output of the inclinometer in nano-volt meter and comparing it with the calibration sheet as supplied by the test firm (Table 1). The output of the MEMS inclinometer as depicted in Fig. 1 is connected to the holes of the IRIS mote integrated with MDA100 sensor board to specified holes [7] for different channel output (Adc2, Adc3, Adc4, Adc5, Adc6). Data are transferred through Motes (nodes) forming mesh topology. The nearest mote to base radio transfers data to base radio. Finally data can be viewed through mote view software installed in the system. Thus by using the complete system, one can determine angular change of the slope of landslide site.\

In case of Eko-system, the output of the MEMS inclinometer as depicted in Fig. 2 is connected to the Eko interface board which is integrated with the Eko node. Data are transferred through eko nodes wirelessly forming in ad-hoc network. The base station collects data from the nearest node and consequently transmits to the gateway (sink). Gateway sends data to the computer in packet form which is viewed by eko-software already installed in the system. The pin configurations of the interface board and the eko port have been discussed in detail in [6].

4. Conclusions

Landslide causes significant changes in the Earth's natural environment. It is relatively local event; therefore, non-geodetic monitoring technique might help more significantly. WSN is also an emerging, reliable and inexpensive technology and is capable of presenting the real time monitoring over a long distance and inhospitable terrains. A multi functional IRIS mote interfaced to wireless module has been used to sample the heterogonous data with digital sensors in the present paper. Analyzing the data produced by the system, one can monitor the landslide movement, acceleration and subsequently remedial measure can be taken.

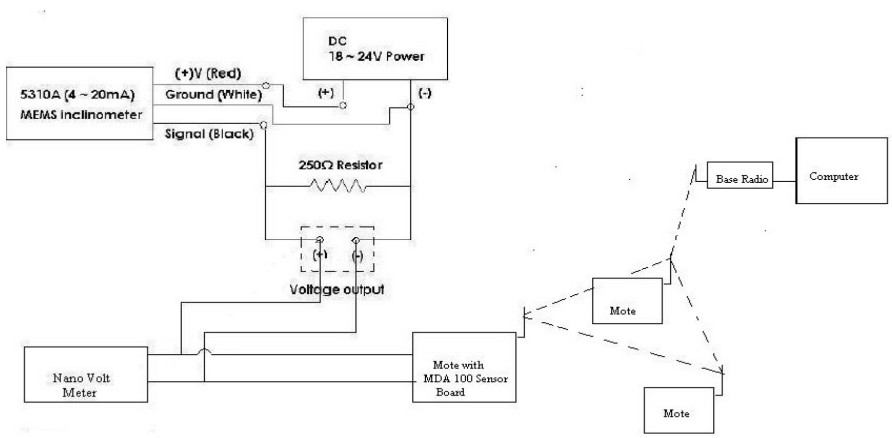

Fig.1 Digital Sensor Connection with IRIS Mote

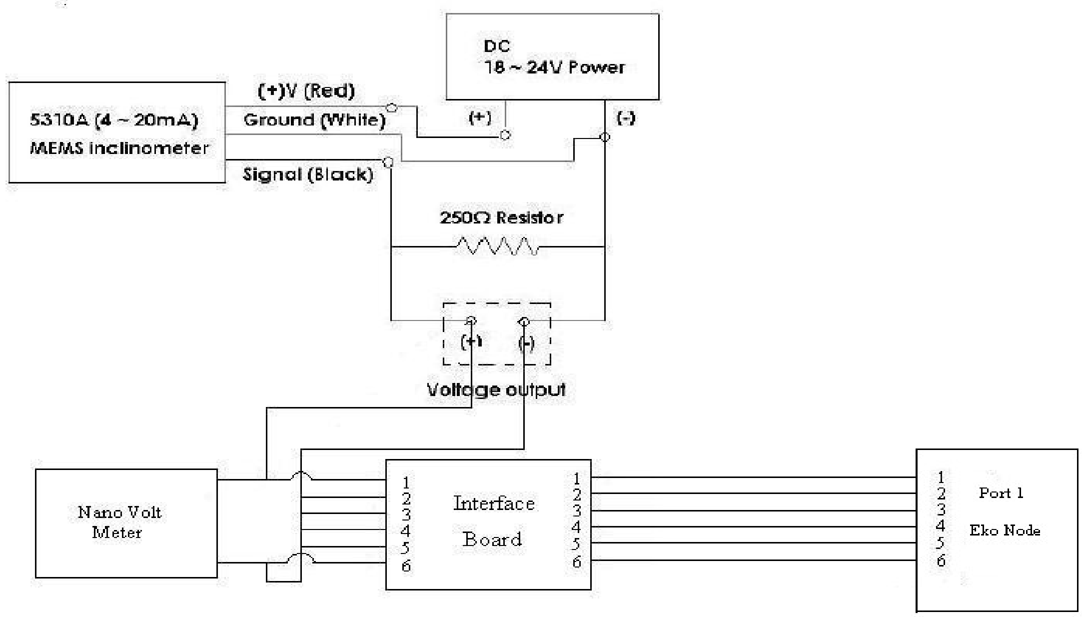

Fig. 2 Digital Sensor Connection with Eko system

Table1: Different output of sensor board with various angles

ANGLE	**ADC2**		**ADC3**		**ADC5**		**ADC6**	
	Mili-volt	**raw units**	**Mili-volt**	**raw units**	**Mili-volt**	**raw units**	**Mili-volt**	**raw units**
5°	2.42	940	2.08	815		885		954
4°	2.33	930	1.86	785	2.03	846	2.28	953
3°	2.13	925	1.93	772	2.09	816	2.37	952
2°	2.27	908	1.87	748	2.01	781	2.38	951
1°	2.07	865	1.73	715	1.89	753	2.18	950
0°	2.14	833	1.75	690	1.84	718	2.37	942
-1	2.32	780	1.96	638	1.94	669	2.66	939
-2	1.82	763	1.52	635	1.54	649	2.19	930
-3	1.75	723	1.44	610	1.49	619	2.18	869
-4	1.65	694	1.39	589	1.4	586	2.02	794
-5	1.65	665	1.39	559	1.39	561	1.87	701

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