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ScienceDirect

Energy Procedia 89 (2016) 417 – 420

Energy Procedia

CoE on Sustainable Energy System (Thai-Japan), Faculty of Engineering, Rajamangala University of Technology Thanyaburi (RMUTT), Thailand

Development of Low Cost Vibration Sensor Network for Early Warning System of Landslides

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Abstract

This paper presents an early warning system of landslides using microcontroller PIC12F683 and ATmega328 based on low cost WIFI sensor networks. After landslides, the measuring system is broken. Selection of cheap and efficient system for landslide warning system is a challenging approach. We present the vibration values detected from the sensors then low cost WIFI module transmits the data to the server system. The results showed that the system can transmit data via WIFI network automatically when there are changes from the threshold value.

Peer-review under responsibility of the organizing committee of the 12th EMSES 2015

Keywords: Landslides, Wifi-Sensor, Vibration

1. Introduction

Landslide is a movement by the gravity of soil or rock slope down which may cause damage to the surrounding area [1]. A lot of damage and structural failure caused landslides have been reported over the years, so have efforts to measure and monitor landslide potential are essential to human safety and infrastructure to protect civilians. To observe the behavior of a hill with a monitoring system that has been installed or checked manually by a human expert has been carried out. The danger from landslides is one of the main natural disasters in Thailand that has caused immense loss of life and property [2]. Public awareness has risen significantly in the event of landslides and severe flooding in

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Peer-review under responsibility of the organizing committee of the 12th EMSES 2015
doi:10.1016/j.egypro.2016.05.055

Fig. 1. (a) Node sensor installation; (b) Stainless steel rod.

southern Thailand in 1988, Kathun district, Nakhon Sithammarat Province, The worst casualties were estimated at 230 casualties in Ban Kathun Nua. Subsequent damaged landslides occurred in Ban Nam Chun and Ban Nam Kor areas in Petchabun Province. In Year 2006, there have been two major landslide events in northern Thailand, Nan provinces in August and Uttaradit provinces in May. The danger of landslides across the country and mapping project has been studied to monitor landslide potential and areas affected mitigation plans across the country. Early Warning System project [3], implementation by the department of Water Resources, is a system of monitoring and early warning of landslides using measurements of rainfall data and report data using GPRS system [4]-[6].

In our node sensor, we used SHOCK-801S in the debris vibration detection, WIFI-ESP8266 in the wireless network and PIC12F683 in the controller between SHOCK-801S and WIFI-ESP8266. The sensor is installed inside a stainless steel rod as shown in Fig. 1(a). The stainless steel rod used to contain the sensor and amplifies vibration.

2. Landslide

Landslide is a movement by the gravity of soil, rock and organic materials. Weathering, or external mechanisms can be triggered to movement [7]. In Thailand, landslides mainly happen due to rainfall which leads to landslides. The saturation of the slope with water is the major cause of landslides. This effect can occur in the form of torrent, groundwater level changes, and change in water-level along coastlines, earth dams, and the banks of reservoirs, canals, lakes, and rivers. Although there are many types of mass movements are included in the term of landslide, the more limited use of the term refers only to mass movements, with different zones of weakness that separate slide material from the base material is more stable. Translational slides and rotational slides are two main types slide.

Translational slide: The landslide mass moves along a roughly planar surface with small rotation or backward tilting

Rotational slide: This is a slide in which the surface of rupture is curved concavely upward and the slide movement is roughly rotational about an axis that is parallel to the ground surface and transverse across the slide.

3. Design of landslide warning system

The system consists of field unit and base unit. Field unit include sensor and mater node as shown in Fig. 2(a).

Sensor node is divided into the following sections:

Vibration sensor: Vibration sensor 801S is the high precision vibration sensor, 801S has 2 outputs, includes digital and analog output, On-board potentiometer used to adjust the sensitivity of digital output. To get the vibration condition, this module can be read the analog output by using ADC module of microcontroller.

Wi-Fi Module: ESP8266 Wi-Fi module is a self-contained Wi-Fi network that can write directly software to module, or through another processor. ESP8266 get the lowest energy consumption. Firmware is fully compliant with 802.11 b/g/n standard 2.4 GHz. ESP8266 connect through UART interface to any microcontroller.

Microcontroller: PIC12F683 has standardized features, on-board EEPROM, voltage operating of 2.0-5.5 volts, and nanoWatt technology. 10-bit ADC with 4 channels, and Standard Compare/Capture/PWM module.

Rod: Stainless steel rod used to contain the sensor and amplifies vibration as shown in Fig. 1(b).

Master node is divided into the following sections:

High power Wi-Fi: NSW2 is outdoor high power wireless communication device with frequency 2.4 GHz (compatible with 802.11b/g/n). NSW2 used as a wireless access point and point to point.

Microcontroller with LAN: The microcontroller is used arduino UNO board with ATmega328 microcontroller. Arduino UNO board has 6 analog inputs, 14 digital output/input pins (include SPI, I2C, UART). To connect to internet in this paper used arduino Ethernet shield. Wiznet W5100 Ethernet chip was used in this arduino shield. That provides a network stack capable of both UDP and TCP.

The working of this system that show in Fig 2(b) can be explained with following steps:

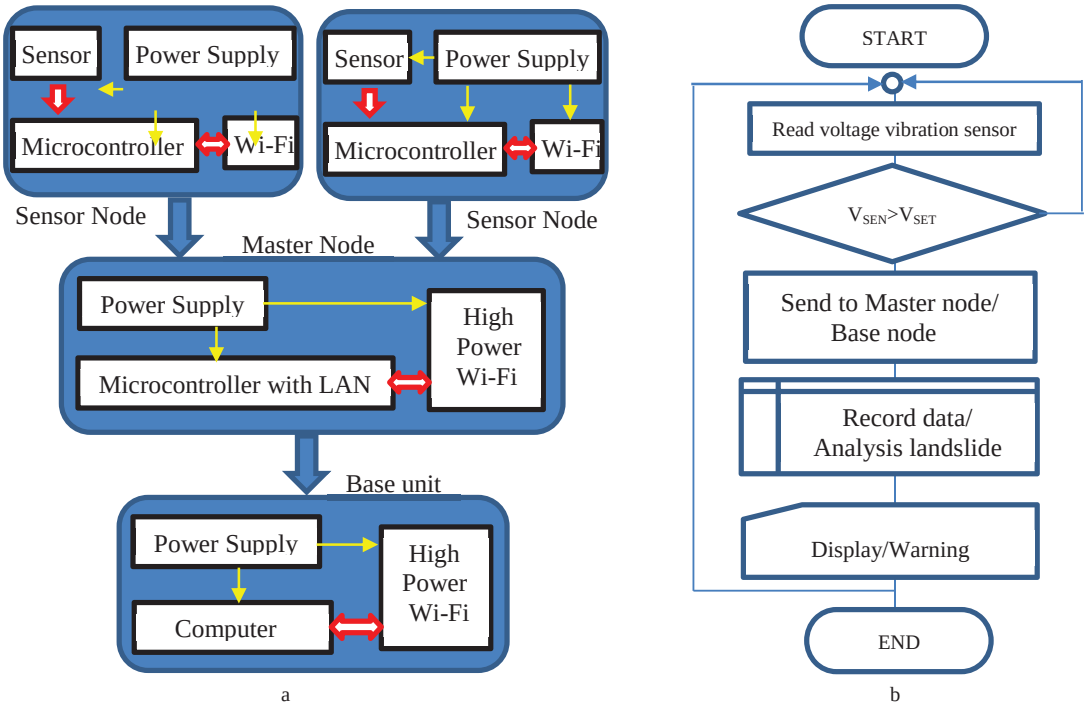


Fig. 2. (a) Block diagram of system; (b) Flowchart of system

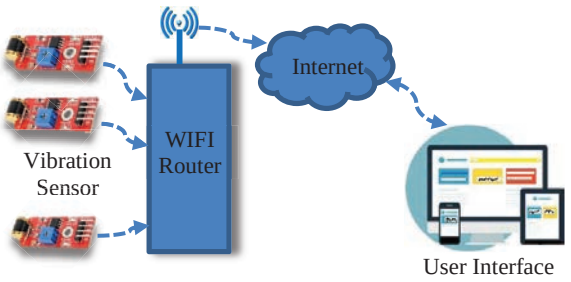
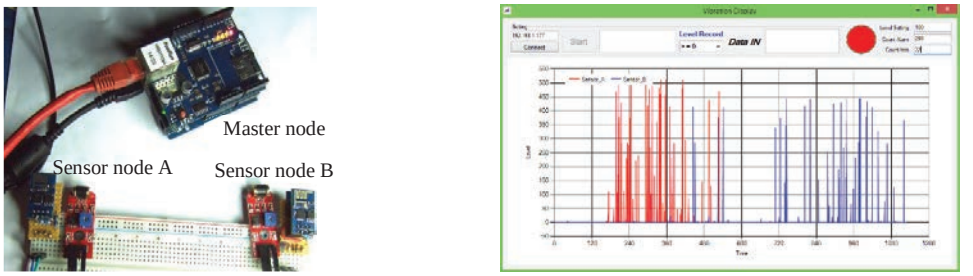


Fig. 3. Test System

1. In sensor node, PIC12F683 read voltage (0V-5V) from vibration sensor.
2. If the voltage of vibrator is greater than the settings, PIC12F683 transfer data through ESP8266 to master node.
3. Master node receive data from the sensors and then forwarded to the base node which is far away.
4. Program computer in base node display and analyze data.
5. If the results of the analysis may be caused landslides and then generate the alarm.
   -Green Signal: When all the sensor value are less than monitoring threshold
   -Orange Signal: When some sensors are greater than the monitoring threshold
   -Red Signal: When all the sensor value are reaches or exceeds the monitoring threshold.

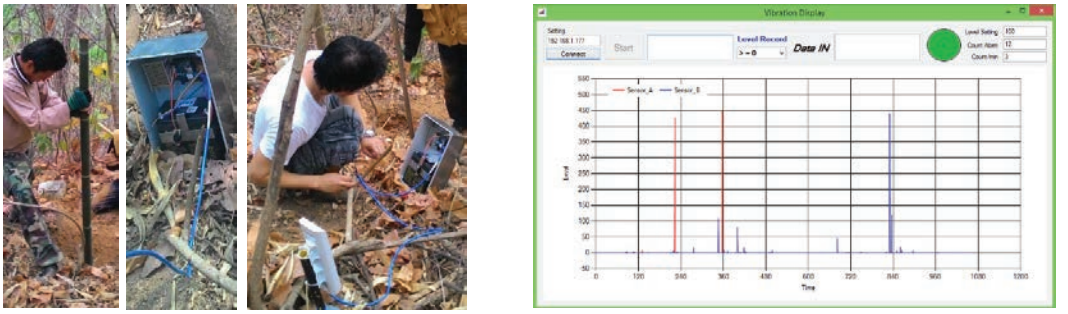
4. Test result

The test system as shown in Fig. 3. Fig. 4(a) shows the setup for laboratory test, sensors arranged on the table and measure vibration. Result of sensor is taken by ADC in to microcontroller. Fig. 4(b) shows result of vibration. Fig. 5(a) shows the installation for field test in Uttaradit provinces Thailand. Fig. 5(b) shows result of vibration when trampling into the ground.



a b

Fig. 4. (a) Setup for laboratory test; (b) Vibration display of laboratory test



a b

Fig. 5. (a) Installation for field test; (b) Vibration display of field test

5. Conclusion

In the field of geophysical research, an early warning system of landslides is one of the challenging research. This paper presents an early warning system of landslides using microcontroller in sensor node to read data from vibration sensor and then transfer data through WIFI module to master node. Master node receive data from the sensors and then forwarded to the server system which is far away. The results show that the system can transmit data via WIFI network automatically when there are changes from the threshold value.

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