Implementation of Escarpment Alarm System Using Terrestrial Reference System

Ah Ra Lee, Ashish Rauniyar, and Soo Young Shin

***Abstract*—An earthquake warning system is a system of accelerometers, communication, computers, and alarms that is devised for regional notification of an earthquake while it is in progress. earthquake mitigation system is truly important in order to prevent tremendous destruction in an area, especially in the civil residence. therefore, with the aim of building a substantial escarpment alarm system and mitigating its disastrous effect, in this paper, we propose an earthquake detection system with the integration of wireless network to transmit the data and video of the earthquake location. the Arduino module is used as a part of camera. the raspberry pi is connected to the earthquake detection sensor which is a product of Korean technology company, GMG ltd (geotechnical monitoring group). the GPS data of the earthquake location and the video is transmitted in the real time using HTTP and FTP protocol. the proposed algorithm has been implemented in the real prototype. the experiment results show that the sensor transmit the data of an earthquake prone area to the server and cellular mobile.**

***Index Terms*—Arduino, earthquake detection system, 3G communication, raspberry Pi.**

I. Introduction

An earthquake is caused by the release of stored elastic strain energy during rapid sliding along a fault. The sliding will start at some location and progress away from this hypocenter in each direction along the fault surface. The speed of the progression of this fault tear is slower than and distinct from the speed of the resultant pressure and shear waves, with the pressure wave traveling faster than the shear wave. The pressure wave will generate an abrupt shock while the shear waves can generate a periodic motion (at about one cycle per second) that is the most destructive in its effect upon structures, particularly buildings that have a similar resonant period, typically buildings around eight floors in height. These waves will be strongest at the ends of the slippage, and may project destructive waves well beyond the fault failure. The intensity of such remote effects are highly dependent upon local soils conditions within the region and these effects are considered in constructing a computer model of the region that determines appropriate responses to specific events [1]. In its most generic sense, the word earthquake is used to describe any seismic event whether a natural phenomenon or an event caused by humans-that generates seismic waves. Earthquakes are caused mostly by rupture of geological faults, but also by volcanic activity, landslides, mine blasts, and nuclear experiments. An earthquake's point of initial rupture is called its focus or hypocenter. The term epicenter refers to the point at ground level directly above the hypocenter.

Although no one can reliably predict earthquakes, today's technology is now advanced enough to be used to rapidly detect seismic waves as an earthquake begins to happen, calculate the maximum expected shaking, and send alerts to surrounding areas before damaging shaking arrives; this is called Earthquake Early Warning. Earthquake early warning can provide a few seconds to tens of seconds warning prior to ground shaking during an earthquake. Earthquake Alarms Systems is a methodology designed to provide warnings in earthquake prone regions around the world [2]. The warning messages provided by such systems can be used to reduce the damage, costs and casualties in an earthquake. Earthquake mitigation system is truly important in order to prevent tremendous destruction in an area, especially in the civil residence [3], [4]. Even a few seconds can allow time to take protective action such as taking cover in safe locations, stopping elevators and opening doors at the nearest floor, or automatically stopping critical processes to mitigate damages or to enhance public safety [5]. For the countries, which are located in the ring of earthquake prone areas, the fast information is required to be known for faster action of rescuing and medical helps. The condition of surrounding near the center of earthquake must be transmitted immediately in the real time in order to act responsively to the location [6], [7].

One of the problems is, the distance between prone earthquakes areas to the office of earthquake-observation is quite far and however, the lead-time for earthquake is much smaller. The communication through wired network is also not feasible in such scenario. By using camera in some points of locations, we propose a solution to directly transmit the condition of places near the center of earthquake wirelessly through GPRS or 3G network. The basic approach of our proposed system is that a sensor senses an area which is already being placed in an earthquake prone area; moreover, a camera records the video of the surrounding environment. The system immediately transmits the sensing information to the desired location using 3G communication.

The rest of the paper is organized as follows. In Section II, we explain our proposed algorithm along with the system design. Sections III is devoted to the experiment set up. The

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test and the prototype implementation are also explained in Section IV. Finally we draw our conclusion Section V.

II. Proposed Algorithm and System Design

The Earthquake Sensor (ESX) which is a product of Korean high tech company called GMG Ltd is located at one of the location which is highly prone to earthquake. This ESX sensor will transmit the signal zero when there is a little earthquake detected. The microprocessor uses the Raspberry Pi module [8] which is also connected to the GPRS module. Since the GPRS module is using Arduino, it requires a converter in order to connect to Raspberry Pi. There is also a camera connected to the GPRS module to record the activities around this sensor which is deployed in the earthquake prone region.

If the earthquake is felt or occurs, the ESX sensor will detect it and trigger the camera in the GPRS module to record the video of the area in fifteen seconds. Then the result of the video will be transmitted directly in real time using FTP to the server office where people (the officers) who are waiting to receive the data can oversee it. After finishing the recording and sending the video, the sensor will immediately read the specific data of the earthquake location and send it to the same server using HTTP. The officers who are in charge of handling these entire events will receive the alarm message in their phone that contains the hyperlink of the website where the data is being displayed for viewing purpose [9].

In our proposed algorithm, there are three conditions which can exist:

1) The sensor perfectly detects the earthquake.
2) The server transmits the Request 1 to the sensor (Video and data request).
3) The server transmits the Request 2 to the sensor (Data only request)

The complete algorithm structure begins from this System Flow Chart Diagram which is given in Fig.1. As explained earlier, when the ESX sensor detects the earthquake, it will directly trigger the camera to record the surrounding images in 15 seconds, and then it will directly send it to the server using FTP. It will also record the data and moreover sensor sends it to the server using HTTP.

Now, if there is no detection, the server can request two kinds of command; Request 1 and Request 2. For the Request 1, it will be the same with sensor detection action that is observing the earthquake prone areas using the camera and transmit the data back to the server. Obviously, it will be useful for routinely checkup area. The Request 2 is for giving instruction to the sensor in order to transmit only the data in those specific spotted areas.

III. Experiment

A. Raspberry to Arduino with 3G+GPS Shield

In this paper, an Arduino module is applied to work in Raspberry Pi which has complete features to implement this project. The Raspberry Pi module is shown in Fig. 2. The idea behind the Raspberry Pi and Arduino 3G shields is to connect bridge to allow to use any of the shields, boards and modules designed for Arduino in Raspberry Pi. The 3G shield and Raspberry Pi to 3G module bridge is shown is Fig. 3. It also includes the possibility of connecting digital and analog sensors, using the same pin out of Arduino, if it is within the power and capabilities of Raspberry.

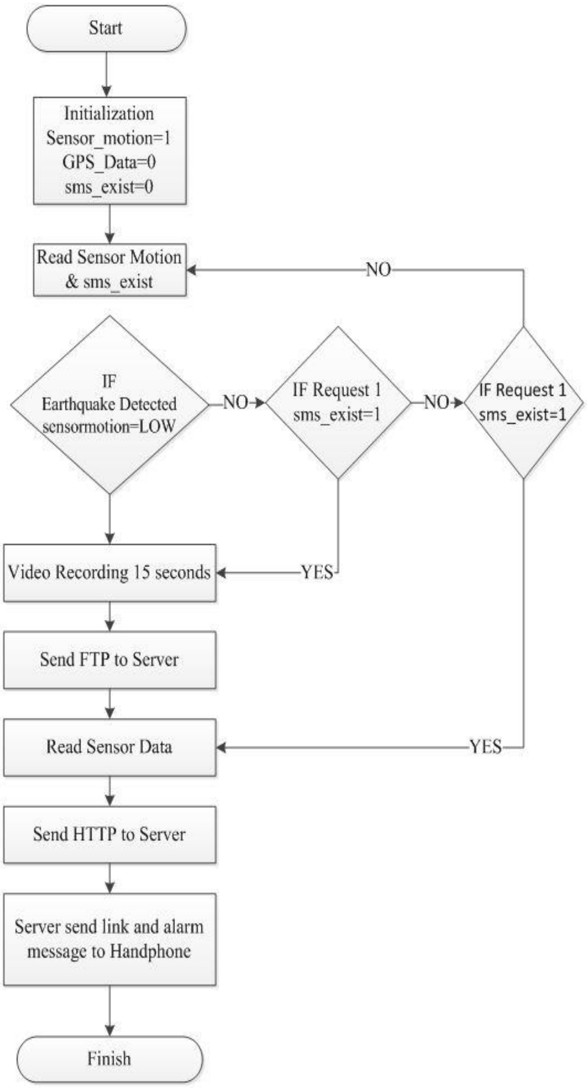

Fig. 1. Flowchart of the system.

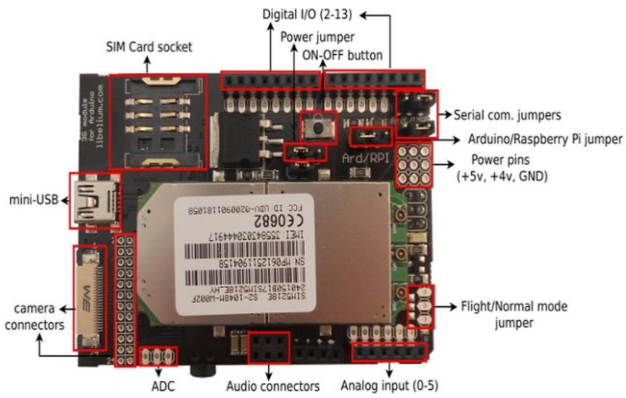

Fig. 2. Raspberry Pi module.

One of the experiments is to try using ADC or Analog to Digital Converter for the conversion. The shield includes an ADC of 12b of resolution which allows connection between any ESX sensor and Raspberry with higher precision. The communication between Raspberry and the ADC of the shield is made via i2C convertor.

Here is an example of a program that reads every channel continuously waiting 5 seconds between iterations. With a wire connecting the 5V pin with some of the pins of the ADC a value near to 5.000000 should be read.

The new 3G shield for Raspberry Pi enables the connectivity to high speed WCDMA and HSPA cellular networks in order to make possible the creation of the next level of worldwide interactivity projects inside the new "Internet of Things" era [10].

Therefore, in this project, we have used the features of the 3G and GPS to transmit the data from the earthquake sensor to the server as well as capture the video with the camera from that Raspberry Pi itself.

B. *The Earthquake Sensor*

The Earthquake detection sensor ESX is manufactured by GMG (Geotechnical Monitoring Group) Ltd in Korea. The ESX sensor detects if there is tilt or vibration of the earthquake and sensor transmit the signal accordingly for the output.

When the ESX sensor is in standby mode, the LED color is green which means there is no earthquake occurrence. However, if there is a tilt detected the LED color changes to Red, which means there is an earthquake. Consequently, sensor will transmit the signal to the processor.

It also has features to request the data by transmitting the character and request time. The ESX sensor module from GMG Company is shown in Fig. 4.

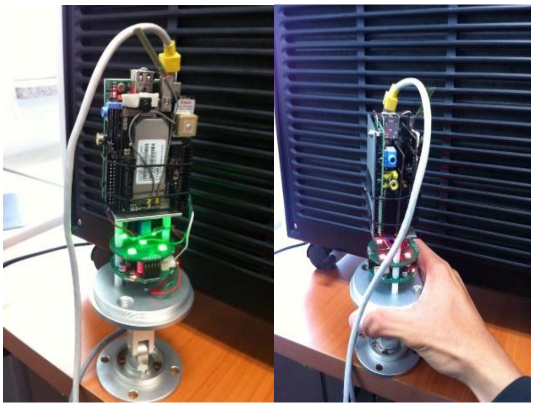

Fig. 4. GMG ESX sensor module.

IV. Prototype Implementation and Test

In order to check the validity of the prototype, our wireless earthquake detection system is implemented based on 3 basics of the algorithm. Those are the Request 1, Request 2 and the earthquake simulation.

First, Request 1, which shows the environment of the place near to the device which record the video of the surrounding. This simulation test is useful for routine checkup of the area. The result of Request 1 and Request 2 is shown in Fig. 5, Fig. 6 respectively.

The Simulation parameter for the prototype implementation and test is given in Table I. The result of earthquake detected mode is shown in Fig. 7 and the data receiving module for earthquake detected mode is shown in Fig. 8.

TABLE I: Simulation Parameter

Command	Character	Request Time
Location + video	2070	20140303164435
Location only	2040	20140303164435

Fig. 5. The result of request 1.

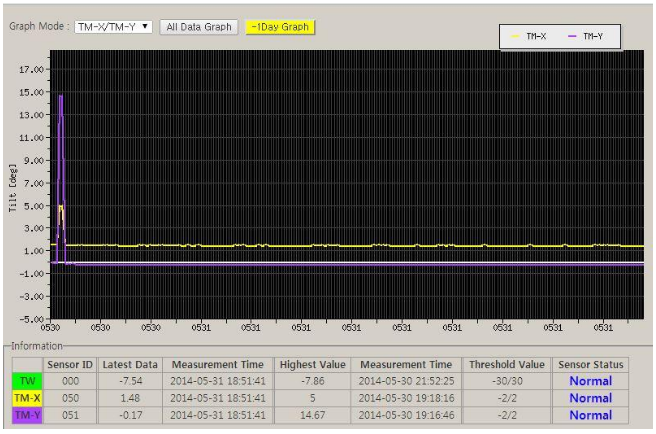

Fig. 6. The result of Request 2.

Furthermore, for the final test of the earthquake simulation, the ESX sensor is shaken a bit in order to make the sensor works, the sensor triggers the camera in order to record in 15 seconds and transmit the result using FTP to server. It will be continued to get the data of the earthquake location and transmit them to server using HTTP protocol.

Fig. 7. The result of earthquake detected mode.

The FTP data receiving module for earthquake detected mode is shown in Fig. 8 and our ESX sensor detection data is shown in Fig. 9. We can clearly see from the experiment result that, if some tilt is detected, the website server displays that it is able to detect the tilt when the earthquake happens in the real time. The reports are also transmitted to the mobile phone as shown in Fig. 10 which consists of the link to see the data and videos. So that the officer can directly see it in order to transmit the fast responds to the earthquake location.

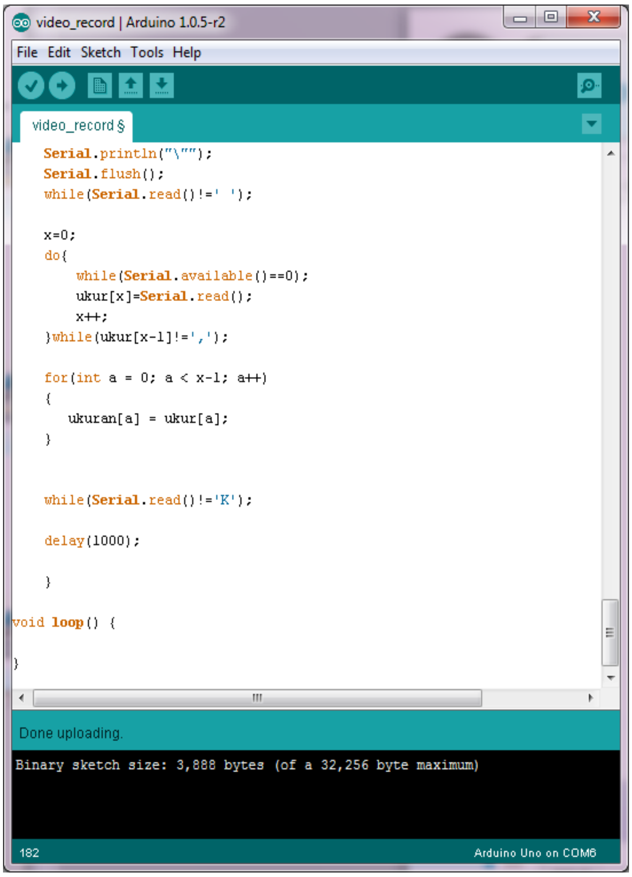

Fig. 8. The FTP data receiving module for earthquake detected mode.

	location + Video					Request Time													
Character(i)	2	0	7	0	0	2	0	1	4	0	3	0	3	1	6	4	4	3	5
ASCII Hex	32	30	37	30	30	32	30	31	34	30	33	30	33	31	36	34	34	33	35
+0x20	52	50	57	50	50	52	50	51	54	50	53	50	53	51	56	54	54	53	55
Character(o)	R	P	W	P	P	R	P	Q	T	P	S	P	S	Q	V	T	T	S	U

	Location only					Request Time													
Character(i)	2	0	4	0	0	2	0	1	4	0	3	0	3	1	6	4	4	3	5
ASCII Hex	32	30	34	30	30	32	30	31	34	30	33	30	33	31	36	34	34	33	35
+0x20	52	50	54	50	50	52	50	51	54	50	53	50	53	51	56	54	54	53	55
Character(o)	R	P	T	P	P	R	P	Q	T	P	S	P	S	Q	V	T	T	S	U

Fig. 9. Sensor detection.

Fig. 10. The mobile device receive the message with the link.

V. Conclusion

The earthquake detection system with immediate response and wireless integration is very important to prevent damage in an area. By using, 3G and GPS, the detail location of an earthquake-prone area can be monitored from the far distance. Our proposed system device is using Raspberry Pi with Arduino module as the processor and is connected to the Earthquake ESX sensor which is produced by Korean Tech Company GMG Ltd. The proposed method implementation consist of two requests i.e. Request 1 and Request 2. Request 1 is to command the sensor to transmit data and video (using FTP) or data only (using HTTP) of the location. Then another Request 2 is to transmit the video and the data immediately, if there is an earthquake. The prototype is successfully implemented and the ESX sensor can detect the tilt and transmit the video and data of the location. In order to implement in the real location, more detail improvement and specific development of the sensor and the processor are required for this algorithm. As a future works, 4G / 5G Communications will be applied for a better sensing and development.

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