IoT-Based Earthquake and Landslide Detection System

[1]Bhagesh S. Bhosale, [2]Sankalp S. Kajave, [3] Rushikesh D. Kaotekwar,
[4]Dr. Mrs. Rupali S. Kamathe, [5]Dr. Ms. Vandana Hanchate

[1]Student, [2]Student, [3]Student, [4]Professor, [5]Asst. Prof.
[1] Dept. of Electronics and Telecommunication Engineering,
[1] P.E.S's Modern College of Engineering, Pune, India

Abstract: Earthquakes, and landslides have both devastated our lives in different ways. One of the main problems with these natural disasters is that they are unpredictable. To alleviate the problem, the early warning system plays an important role. The need for this project varies according to the landslide or earthquake. If there is any landslide or earthquake, then an alert message is sent to the concerned authorities and people in the prone areas. Earthquakes and landslides are natural disasters that can cause massive devastation to life and property in the affected area. This system monitors and provides information on landslide possibilities and earthquake detection making it available for users using the IoT platform that is ThingSpeak. This project aims to detect the earthquake and landslide at the initial stage with the help of a vibration sensor and PIR sensor and hence an alert message and location are sent through GSM and GPS modules. The proposed model can be used as an alert or warning system that will help to minimize the loss of lives and property.

Index Terms: Landslide, IoT, ThingSpeak, PIR sensor, GSM, GPS.

I. INTRODUCTION

Earthquakes and landslides are unpredictable and occur within short periods, which can cause great property loss and casualties. Therefore, landslide monitoring and warning are imperative to save lives and reduce damage [1][11]. A landslide is an event where part of the earth's surface slips down. Although there are many remote sensing techniques for landslide investigation. Earthquakes and landslides are natural disasters that can cause massive devastation to life and property. Certain regions are prone to such events in northeast India mainly, for example, Manipur is located in Zone-V (very severe intensity earthquake zone). As Manipur lies at the junction of two tectonic plates the Indian and Eurasian plates, earthquakes will be more frequent than in other lower seismic active zones. In Manipur, Landslides occur frequently during monsoon in hilly areas in the state. Studies have concluded that landslides in Manipur are mostly man-made disasters due to road widening and urbanization also increasing the potential for landslides.

The magnitude-9.0 earthquake struck at 2:46 PM. The epicenter was located some 130 km east of the city of Sendai, Miyagi prefecture, and the focus occurred at a depth of about 30 km below the floor of the western Pacific Ocean. The earthquake was caused by the rupture of a stretch of the subduction zone associated with the Japan Trench, which separates the Eurasian Plate from the subducting Pacific Plate.

In June 2013, a mid-day cloudburst centered on the North Indian state of Uttarakhand caused devastating floods and landslides, becoming the country's worst natural disaster. Landslides, due to the floods, damaged several houses and structures, killing those who were trapped. The heavy rains resulted in large flash floods and massive landslides.

There are many sensing techniques and sensors for landslide monitoring, which have capabilities for detecting soil movement and it is crucial in developing landslide monitoring systems. A monitoring and early warning system is one of the solutions that can prevent and minimize the loss caused by earthquakes and landslides.

A wireless sensor network is a type of network, which is composed of nodes that perform collectively to gather information on physical parameters in real-time [7]. Deployment of the wireless sensor network, which is integrated with IoT is proposed in many implementations, such as in agriculture [7][5] and disaster management [3].

This paper proposed the design of a wireless sensor network for earthquake and landslide warning systems. This system uses an Atmega 328 microcontroller to collect the data from sensors such as vibration sensor, Passive Infrared Sensor (PIR), and temperature sensors. The Global Positioning System (GPS) module is connected to a microcontroller to identify the coordinates of a disaster place. Also, Global System for Mobile communication (GSM) modem is connected to the microcontroller to send the alert message with coordinates. ESP8266 (Wi-Fi module) is used to send collected data to the web server.

II. LITERATURE REVIEW

In this paper, P. B. Patel et al. [4] describe, a real-time system for landslide ad earthquake detection using an accelerometer sensor and GSM. Using GSM, the alert message is sent to the concerned authority for taking further precautions.

In, A. Sofwan et al. [7] proposed a wireless sensor network design for landslide detection systems in IoT architecture. The soil moisture sensor, rain gauge, and accelerometer are used. The system consists of two columns with ten sensors and is placed with six wireless sensor nodes.

In, S. Wavhal et al. [8], proposed the Arduino-based disaster management system. This system uses the soil drift sensor and rain gauge sensor. The GSM modem is used to send the alert message. And GPRS technology is used to propagate the collected data to servers.

In, E. Intrieri et al. [12], implemented Early Warning System (EWS) to reduce the residual risk. The EWS uses 13 wire extensometers, 1 thermometer, 1 rain gauge, and 3 cameras. This system acquires data every minute and uploads it to the server.

In, Alphonsa A. et al. [9], the proposed concept for an early earthquake warning system using IoT and LABVIEW software. This system consists of 50 sensors and 20 wireless sensor nodes. The technique used for communication is the ZIGBEE protocol. ZIGBEE is preferred due to its easy interface, low cost, and also modulation is not required.

Some of the other techniques also describe the landslide and earthquake warning systems.

In, S. Voigt et al. [6], describe and discuss the assessment of multiple satellite data sources, the crisis support service cycle, the multisource image analysis, and adding of the geospatial context to satellite information to rapidly supply self-explaining geospatial information products for disaster and crisis-management support.

In, K. Martin et al. [13] describe landslide incidents using Machine learning models. Random forest and logistic regression models were selected to accomplish this research. The prediction capability of the existing models and systems is limited in terms of their accuracy.

Wherever Times is specified, Times Roman or Times New Roman may be used. If neither is available on your word processor, please use the font closest in appearance to Times. Avoid using bit-mapped fonts. True Type 1 or Open Type fonts are required. Please embed all fonts, in particular symbol fonts, as well, for math, etc.

III. SYSTEM DESIGN

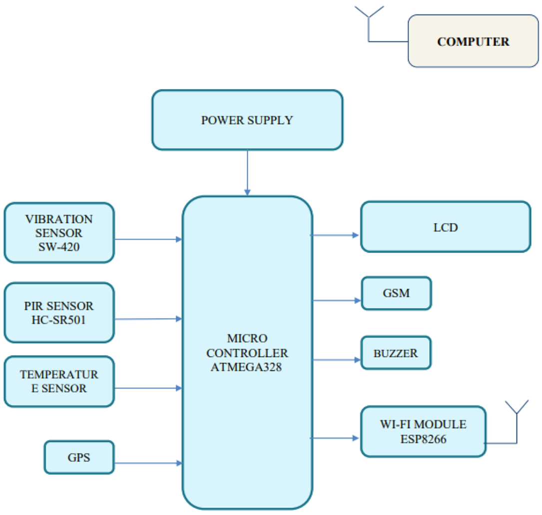

Fig. 1. The architecture of the proposed system

'Fig.1' shows the architectural diagram of the proposed earthquake and landslide detection system. Earthquakes and landslides are based on the concept of vibration and motion. The main focus is on the detection and spreading of awareness of natural disasters by interfacing various sensors to the microcontroller to build the detection system. Similarly, the GSM will give the message to the concerned authorities, and in the message, GPS will help to send the location of that exact position where the disaster is going to happen. It gives real-time data on the temperature and earthquakes and landslides which is sent to the IoT platform of things speak which further is displayed in the form of graphs and also the information is stored in the Excel sheet separately.

IV. METHODOLOGY

This system is divided into two parts: a sensing unit consisting of a vibration sensor and a PIR sensor, which detects the earthquake and motion of landslides and transmits these signals wirelessly via a Wi-Fi module. The ThingSpeak platform receives and processes the transmitted data for analyzing the data.

When the user starts the system the Wi-Fi module is to be connected to the nearest access point. At the initial stage, the vibration sensor, PIR sensor, and temperature sensor get turned on. When the vibration sensor detects the vibrations it will send the signals to the microcontroller. The same process happens with the PIR sensor. If the vibrations and landslides detect the alert message will send through the GSM module along with location coordinates to the concerned authority or registered mobile number.

Hardware Description

The following are the components used for the implementation:

1. Microcontroller (Atmega328) [14]
   - Operating voltage 4.0V to 5.5V
2. Vibration sensor (SW-420) [15]
   - Input voltage 3.3v to 5v.
   - On board LM393 chip available.
3. PIR sensor (HC-SR501)
   - Input voltage 4.5v to 20v.
   - Sensing range up to 3 to 7 meters.
   - Sensing angle 110^0 cone.
4. Temperature sensor (LM35) [16]
   - Operates voltage 4 V to 30 V
   - Operating Range −55°C to 150°C
5. Wi-Fi module (ESP8266) [17]
   - Operating frequency 2.4 GHz
   - Operating range 10 feet
6. GPS (NEO 6M)
7. GSM

Fig. 2. shows the circuit diagram of the proposed system.

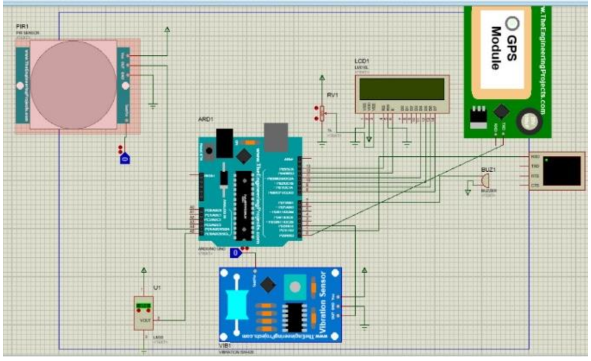

Fig. 2. Circuit Diagram of Proposed System

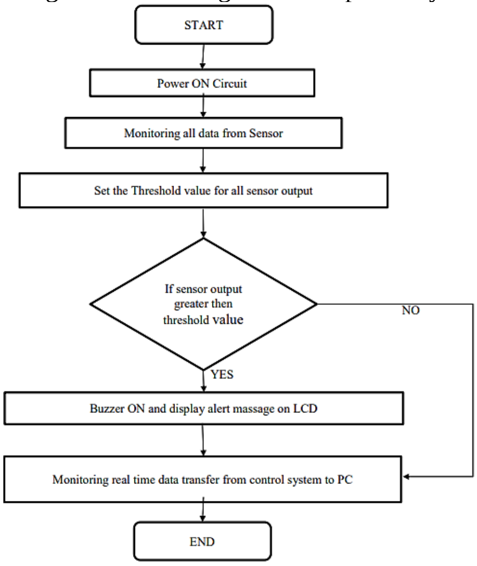

Fig. 3. Flowchart of system operations

Data Acquisition

A vibration sensor Is the first stage of data acquisition. There are a variety of sensors that can be incorporated into earthquake and landslide detection. The motion and vibration transducers are used to convert the motion and vibration into electrical signals. The PIR and vibration sensors are the typically chosen sensors for detection. A PIR and vibration sensor is ideal for this function as it detects the motion and the vibration sensor check the sensitivity. Simultaneously the GPS takes the location and as output, through GSM a message is sent to concerned authorities

Wireless data transmission using a WiFi module

Wi-Fi is a common standard for data transmitting over short and long-range around 10 meters to 300 meters. It uses 2.4GHz and 5GHz frequency bands for operations.

We follow the following steps to data transfer:

- Microcontroller board is connected to a Wi-Fi module. It is programmed to send data using the serial port protocol.
- The module connects to the nearest access point. Once connected it will send the data to the ThingSpeak server.
- To receive the data, the ThingSpeak platform is used. It displays the data in a graphical view and saved the data in a .csv file format.

Data visualization and interpretation

The system sends an alert message that an earthquake or landslide has happened at the exact location of the same. Then all the data is sent to the ThingSpeak platform which plots the graphs based on the received information and information saved in .csv format.

V. RESULTS

The system was simulated in proteus software to test its performance. The vibration and PIR sensors were interfaced with the microcontroller. The vibration and PIR sensor were tuned at a sensitivity level and the PIR sensor at detected motion.

The functionality of the system was checked to meet the following objectives:

- To monitor the landslides using appropriate sensors.
- To send the disaster alert message and the affected area coordinates.
- To send the data retrieved by the sensors through IoT technology.
- To analyze the data using the ThingSpeak platform.

The output graphs of temperature, vibration, and PIR sensor are shown in fig. 4.1, fig. 4.2, and fig. 4.3.

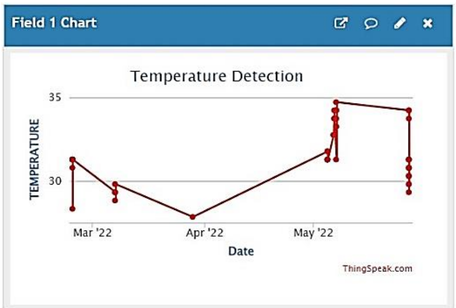

Fig. 4.1. Temperature measurement on the ThingSpeak platform

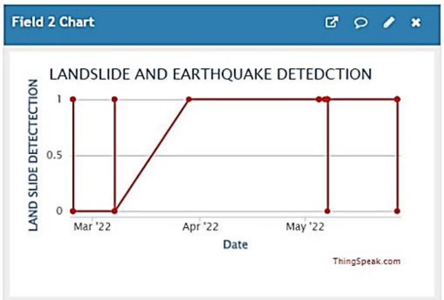

Fig. 4.2. Landslide detection on the ThingSpeak

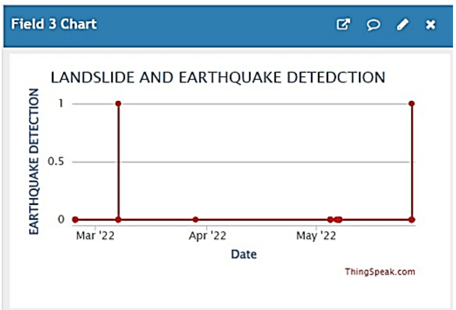

Fig. 4.3. Earthquake detection on the ThingSpeak platform

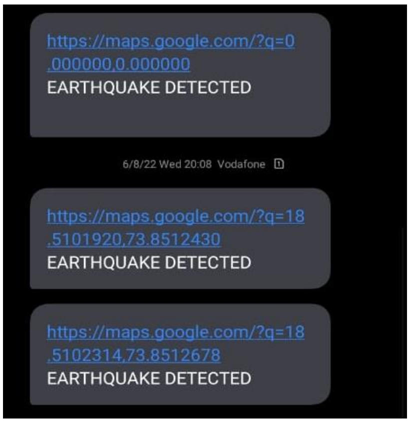

Fig. 5.1. Alert message received on registered mobile number

Fig. 5.1. shows that the alert message with location coordinates send to the registered number through the GSM module. Fig. 5.3. shows that the coordinates open in the Google Maps application.

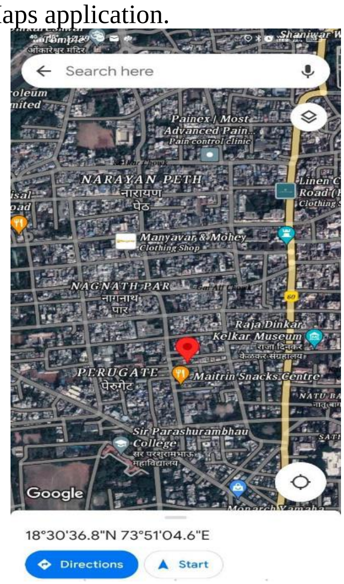

Fig. 5.2. Coordinates open in the Google Maps Application

VI. Conclusion

This paper proposes the design and implantation of an IoT-based earthquake and landslide detection system with the ThingSpeak platform to store real-time data and provide early warning or alert messages when an earthquake happens. A simulation of the proposed system was tested in Proteus Software. The prototype demonstrates the ability to transmit real-time data and alert messages to concerned authorities or registered mobile number.

VII. Future Modification

The concept can be developed further by monitoring landslide-prone areas effectively by setting up more number of wireless sensor networks. With the help of Image Processing technology in association with Machine Learning Algorithms and Artificial Intelligence.

For long-range Wi-Fi networks, TP-link Wi-Fi routers can be used as access points in wireless sensor networks.

VIII. References

1. Y. Wang, Z. Liu, D. Wang, Y. Li, and J. Yan, "Anomaly detection and visual perception for landslide monitoring based on a heterogeneous sensor network" in IEEE Sensors Journal, vol. 17, no. 13, pp. 4248-4257, July 2017.

2. K. Muthu, M. Petrou. “Landslide-hazard mapping using an expert system and GIS” IEEE transactions on geoscience and remote sensing, vol. 45, no. 2, Feb. 2007.
3. I. Benkhelifa, N. Nouali-Taboudjemat, and S. Moussaoui, "Disaster Management Projects Using Wireless Sensor Networks: An Overview,” 28th International Conference on Advanced Information Networking and Applications Workshops, 2014, pp. 605-610.
4. P. B. Patel, J. D. Jadhav, G. S. Kokare, “GSM Based Real-Time Wireless Sensor Network for Landslide Detection”, 2nd International Conference on Recent Developments in Science, Engineering, Management & Humanities, April 2018.
5. I. Mat, M. R. M. Kassim, A. N. Harun, and I. M. Yusoff, "IoT in Precision Agriculture applications using Wireless Moisture Sensor Network," in 2016 IEEE Conference on Open Systems (ICOS), 2016, pp. 24-29.
6. S. Voigt et al. “Satellite analysis for disaster and crisis management support” IEEE transaction on geoscience and remote sensing Vol. 45 No. 6 June 2007.
7. A. Sofwan, Sumardi, M. Ridho, A. Goni and Najib, "Wireless sensor network design for a landslide warning system in IoT architecture," 2017 4th International Conference on Information Technology, Computer, and Electrical Engineering (ICITACEE), 2017, pp. 280-283.
8. S. Wavhal, A. Ghodake, P. Gholap and R. Korde "Automatic detection and notification of landslide and earthquake" in IOSR Journal of Computer Engineering (IOSR-JCE) e-ISSN: 2278-0661, p-ISSN: 2278-8727PP 51-56, August 2017.
9. Alphonsa A., Ravi G., “Earthquake early warning system by IoT using a wireless sensor network” International conference on wireless communication, signal processing, and networking(WiSPNET), 2016
10. C. Lira et al., "Automatic detection of landslide features with remote sensing techniques: Application to Madeira Island," IEEE International Geoscience and Remote Sensing Symposium, 2011.
11. R. F. Romdhane, Y. Lami, D. Genon-Catalot, N. Forty, A. Lagrèze, D. Jongmans, et al., "Wireless sensors network for landslides prevention," in 2017 IEEE International Conference on Computational Intelligence and Virtual Environments for Measurement Systems and Applications (CIVEMSA), 2017, pp. 222-227.
12. E. Intrieri, G. Gigli, R. Fanti, N. Casagli "Design and implementation of a landslide early warning system " in Journal of Engineering Geology Volumes 147–148, Pages 124-136 12 October 2012.
13. K. Martin, K. Santhi, "Rainfall-induced landslide prediction using machine learning models" in African Centre of Excellence in the Internet of Things, Volume 17, Issue 11, University of Rwanda Kigali 3900, Rwanda, Feb-2020.
14. Microchip Technology Inc., “ATmega48A/PA/88A/PA/168A/PA/328/P megaAVR® Data Sheet”, DS40002061B Datasheet, 2020.
15. Texas Instruments Incorporated, “LM195/LM395 Ultra Reliable Power Transistors”, SNOSBO4C Datasheet, June 1999 [Revised April 2013].
16. National Semiconductor Corporation, “LM35 Precision Centigrade Temperature Sensors”, DS005516 Datasheet, Nov. 2000.
17. Espressif Systems, “ESP8266 Technical Reference”, June 2017.