Wheatstone Bridge Configuration Of Strain Gauge As A Soil Movement Sensor For IoT-Based Landslide Detection.

Mazran Esro[1,*], Siva Kumar Subramaniam[1], Nur Alia Batrisyia Iskandar Md Zainalabidin[2], Khairuddin Osman[1].

[1] Centre for Telecommunication Research & Innovation (CETRI), Faculty of Electronics and Computer Engineering, Universiti Teknikal Malaysia Melaka, Hang Tuah Jaya, 76100 Durian Tunggal, Melaka, Malaysia
[2]Fakulti Kejuruteraan Elektronik dan Kejuruteraan Komputer, Universiti Teknikal Malaysia Melaka, Hang Tuah Jaya, 76100 Durian Tunggal, Melaka, Malaysia

[*]Corresponding e-mail: mazran@utem.edu.my

Keywords: Strain sensor; IoT; landslide

ABSTRACT – Landslides are among several phenomenon which causes serious damage to roadside, highways and properties in Malaysia. Heavy rainfalls promote soil movement, trigger the landslide and causing damages without warning. Landslides near the critical areas such as highways and residence housing need to be closely monitored since it could cause injuries and fatal accidents. This project aims at the design and test of a sensor system to detect the soil movement and provide early warning on possible landslide to happen. The sensor is designed with strain gauge on cylindrical stainless steel road together with signal conditioning circuits. The result will indicate the accuracy of the sensing technique to detect soil movement and ultimately predict possible landslide through internet of things (IoT) platform.

1. INTRODUCTION

Landslide brings destructiveness and prominent geo-hazard that continuously affecting many tropical countries, especially in the monsoon season. For the past 25 years, rainfall has induced many landslide cases throughout Malaysia that strikes the citizens, especially near the hillside areas where lots of damaged properties, deaths and injuries have been reported. For example, landslide tragedy that occurred at Genting Highland on 30 June 1995 had killed 20 lives and more than 20 persons injured. Other landslide incidents occurred in North-South expressway near Gua Tempurung had caused extremely big loss and the cost of repair amount to ten million Ringgit Malaysia. In 2016, an incident at Taman Idaman Serendah, Rawang was caused by underground water flow, most likely from the monsoon[1] and a more recent landslide strikes in Tanjung Bungah, Penang in 2017 near a construction site where 15 people has been buried alive[2]. The main contributor of the landslides is soil movement due to rainfall. This is reflected in the reports published by D Kazmi et al. where 58% causes of landslide was due to this[3] as shown in Figure 1.

To reduce the risk of losing lives, a system must be installed to detect the soil movement which subsequently followed by landslide. This project is aimed to design a sensor to detect the possibilities of landslide occurrence via monitoring the soil movement. The soil movement may take a very small step each day and overall landslide may happen in 2-3 weeks as

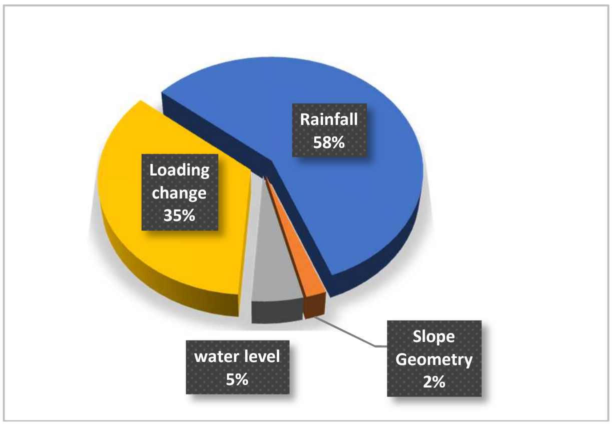

Figure 1: Causes of Landslide in Malaysia[3]

reported by Mcdonald in their geological survey[4]. Therefore a sensor will need to be connected to an online database for continuous monitoring for possible soil movement. Besides the proposed techniques, among other technologies which has been used for soil monitoring includes wireless sensor network for column based sensor using strain gauge and pressure transducer [5], [6]. Other than that, there are also remote sensing technique for large area detection[7] and silicon integrated pressure sensor using porous medium[8].

2. SYSTEM CONFIGURATION

The main components used in the system includes strain gauges, instrumentation amplifier, microcontroller, stainless steel rod transducer and some fundamental electronic devices. Strain gauge sensor whose resistance varies with applied force are arranged in Wheatstone bridge configuration. It is placed on a metal rod (stainless steel) diagonally to cover each side of the rod as shown in Figure 2. It converts force, pressure, tension, weight into a change in electrical resistance which can then be measured. Strain gauges typically measure very small and precise mechanical strain. Changes in resistance from the sensor are also very small and thus can't be measured directly with an ohmmeter. The strain gauge, therefore, must be included in a measurement system where the precise determination of a change in resistance is possible. It converts the mechanical strain into a change in electrical resistance. The wheatstone bridge is connected to an instrument amplifier which act as a signal conditioning circuit to amplify the signal.

Figure 2: Illustration of strain gauge placement on stainless steel rod

The frequency range of the soil movement is expected to be very low which is below 1kHz. There will be unwanted noise from surroundings that may be captured by the amplifier thus educing its effectiveness. Therefore, an analog low pass filter is designed to be used with the amplifier to reduce the unwanted signals. This is achieved by using a simple RC filter design with f_o turnover frequency at 1kHz. The amplification factor of the signal varies from 0-1000 times using a variable resistor attached to the input of instrumental amplifier to adjust to the required signal level.

3. RESULT & DISCUSSION

The strain gauge sensor was able to produce signal to detect the soil movement. This is achieved through a larger amplification of the signal but the unwanted signal was also amplified together with it. The output of the sensor could be viewed with Thingspeak IoT platform which shows graphical data taken directly from the sensor.

4. CONCLUSIONS

The output of the sensor can be further analyzed using Matlab analysis embedded in Thingspeak IoT cloud service. The output comes at a cost which unwanted signal within 1kHz are also amplified. The design could be further improved by using a selective band pass filter to improve the detection method.

ACKNOWLEDGEMENT

Authors are grateful to Universiti Teknikal Malaysia Melaka for allowing the undergraduate students to perform the experiments.

REFERENCES

[1] N. Cheng, M. Kumar, J. Zack, and F. Zainal, "Major landslide shakes up sleepy hollow in Serendah," *The Star Online*, 2016.

[2] A. DERMAWAN, "Landslide strikes Penang construction site," *NST Online*, 2017.

[3] D. Kazmi, S. Qasim, I. S. H. Harahap, S. Baharom, M. Imran, and S. Moin, "A Study on the Contributing Factors of Major Landslides in Malaysia," *Civ. Eng. J.*, vol. 2, no. 12, pp. 669–678, 2016.

[4] G. N. Mcdonald and R. E. Giraud, "Utah Geological Survey," no. March, p. 246, 2002.

[5] M. V. Ramesh, "Design, development, and deployment of a wireless sensor network for detection of landslides," *Ad Hoc Networks*, vol. 13, no. PART A, pp. 2–18, 2014.

[6] A. Terzis, A. Anandarajah, K. Moore, and I.-J. Wang, "Slip surface localization in wireless sensor networks for landslide prediction," *Proc. fifth Int. Conf. Inf. Process. Sens. networks - IPSN '06*, p. 109, 2006.

[7] R. Behling, S. Roessner, D. Golovko, and B. Kleinschmit, "Derivation of long-term spatiotemporal landslide activity—A multi-sensor time series approach," *Remote Sens. Environ.*, vol. 186, pp. 88–104, 2016.

[8] C. Zet, C. Fo, and D. Petri, "Pore water pressure sensor for landslide prediction," pp. 1–4, 2015.