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Proceeding Paper

An Integrated Internet of Things Based Slope Monitoring System †

Dr Guntha Karthik [1,*], Prof A Gopala Sharma [2] and Ms.K.Sahithi [2]

[1] Associate Professor, Electronics and Communication Department, Stanley College of Engineering and Technology for Women, Hyderabad, Telangana 500001, India
[2] Professor, Electronics and Communication Department, Stanley College of Engineering and Technology for Women, Hyderabad, Telangana 500001, India; agopalasharma@stanley.edu.in (P.A.G.S.); ssahithi90@gmail.com (M.K.S.)
[2] M.E.Student, Electronics and Communication Department, Stanley College of Engineering and Technology for Women, Hyderabad, Telangana 500001, India
* Correspondence: gkarthik@stanley.edu.com
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Abstract: Slope failure and debris flow result in several deaths and property losses. Natural disasters, such as landslides and slope failures, result in numerous fatalities and economic losses each year. This significant issue prompted the development of an early warning system to reduce accidents, failures, and financial losses. The majority of studies on real-time early warning systems have focused on forecasting landslide-prone locations; however studies on predicting landslide occurrence time points using real-time slope displacement monitoring are still lacking and require more investigation. A three-dimensional displacement sensor, a rain sensor, and a Soil Moisture sensor, as well as an Internet of Things (IoT) monitoring system, were coupled in this paper to monitor slope failure using cutting experiments on a real-scale model slope. The slope movement was monitored in real time in the lab using an integrated low-cost, efficient, and simple-to-use IoT system. The data was analyzed and the results were explained based on the collected displacement data.

Keywords: slope failure; internet of things; displacement; sensors

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1. Introduction

Landslides or slope failures occur as a result of topographical circumstances and changes in climatic variables such as severe rainfall and earthquakes. The slopes can travel in either an uphill or downhill orientation. Slope collapses are caused by a variety of factors. The fundamental source of slope instability is a steeper slope. The natural inclination of steep slopes is for items to be moved downward. The presence of too much water on the slopes is dangerous, as it causes the slopes to become unstable [6]. The loss of flora on the slopes is also a contributing factor. The strength of the slope increases as the vegetation grows. Slope collapses are caused by a variety of factors, including human-made objects. The slope failures were caused by the construction of highways, which blasted the humans' leads. As a result, an effective monitoring system is required to detect slope failures in advance, inform people, and limit human life loss. The research project's major goal is to develop a slope failure monitoring system that takes readings with the fewest possible components and high efficiency. Slope failure and dump failures have been on the rise in recent years, according to an examination of mishaps in open-pit mines.

2. Literature Survey

D.K. Yadav, "Slope Monitoring System for Open-cast Mines using LoRa Wireless Communication," both WSN and, by extension, the Internet of Things have evolved to aid real-time monitoring systems. It's preferable to have a low-power, long-range, and energy-efficient method for monitoring slope failure in open-cast mines [4]. Collaboration on WSN with IoT results in more methodical, energy-efficient, and cost-effective operations. A Study on the slope failure monitoring of a model slope using a displacement sensor, Young Seong Kim et al. (2020). The authors of this research emphasised how real-time monitoring of slope displacement is still insufficient for predicting landslide occurrence time points.

Figure 1. Slope failure at the open cast mine.

The WSN technology is applied in the open-pit mine slope detection system. Yan et al. (2010). When the slope of an open-pit mine is found to be anomalous, the WSN sends data to the monitors in a timely manner to avoid avoidable losses. Within the multi-objective optimization issue of slope detection using WSNs, the quantum genetic algorithm (QGA) is investigated. It's for creating a slope detection system's networking strategy [1]. Chang et al. (2011) employed a MEMS tilt metre with a sensitivity of 0.5 degrees in the XY direction to detect changes in slope stability properties. The ZigBee IEEE standard is used in the wireless communication network [2]. The WSN was evaluated in laboratory studies by Scaioni et al. (2012), who used fake rainfall to initiate a landslide runoff. The sensor network is built on a wireless architecture that allows data from the experiment site to be transmitted to a remote control room. It was not put at the mine site for evaluation because it is a laboratory experiment [3]. Chang et al. (2013) used WSN to monitor slope stability. It's a WSN early warning and reporting system with intelligence that can be used in slope disaster avoidance engineering [4]. Singh et al. (2014) reported the simulation and test results of a project for wireless data transmission via UART Port utilising an ARM processor and an RF transceiver operating in the license-free band of frequencies 2.4GHz to 2.4835 GHz [5].

3. Methodology

The methodology followed to execute the project is has follows during the initial stage. We have done the critical review on available literature and we have the decided the objectives based on the research gabs. Presented in there works to full fill the objectives. Suitable hardware components and software modules were selected. The integration of the proposed system was done. After designing integrated system, the laboratory investigations were carried out. In the communication and signal processing lab of Stanley College of Engineering & Technology for Women and the results were discus.

4. Block Diagram

We designed a system during which e measure the elevation values by using the displacement sensor. The recorded values are sent to the cloud using ESP8266 Wi-Fi module, and therefore the data was displayed within the things Speak software. The Hardware requirements are Power supply, Microcontroller (ARM based LPC2148), Displacement sensor, Rain sensor, Soil Moisture sensor, IoT Module and LCD (Liquid Crystal Diplay). The software requirements are Thing Speak and Keil. The above components power supply is +5V constant power. The ac voltage is 220v connected to a transformer, which steps down that ac voltage down to the level of the dc output. MEMS I2C stands for micro-electro mechanical systems. These sensor is a set of devices and 1-100-micrometer components. A rain sensor is one kind of switching device. Which is used to detect the rainfall. The soil moisture sensor is used to gauge the volumetric content of water within the soil. The LPC2148 is microcontroller and advanced RISC machine. It is 32-bit RISC processor. IoT module is a small electronic device embedded in objects, machines, and things connected to wireless networks and sends and receives data. The LCD stands for liquid crystal display and to produce an image. The LCD are embedded into the display screen. Thing speak is open source internet of things application. The keil is software developed tool and it is solve the complex problems facing embedded software developers.

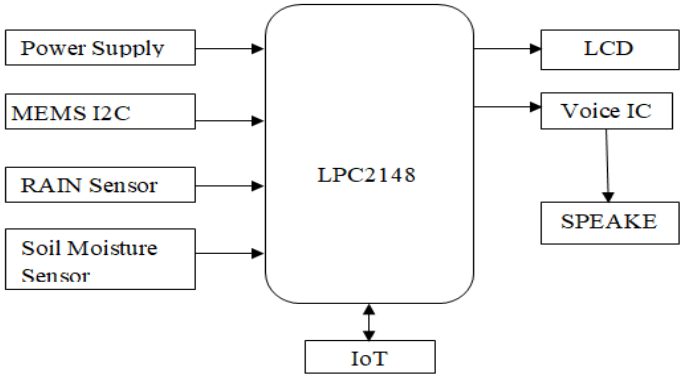

Figure 2. Block Diagram of Slope Monitoring System.

5. Algorithm

In the above figure shows that the Initializing the MEMS I2C, Rain sensor and the Soil moisture sensor. It continuously monitors the MENS I2C, Rain sensor and Soil moisture sensor the MEMS > Threshold value in case it is Yes the voice IC will be activated and the data will be transferred to IoT webpage. And the continuously the data will be checked. Incase if it is No the process will be repeated again. If the rain sensor and soil moisture sensor is equal to one in case of Yes. The voice IC will be activated and data will be transfer to the IoT webpage. And it continuously check the data. In case of No the process will be repeated again.

6. Hardware Connection

Connections are given from the power supply to the soil moisture (it measures the water level whether it is high or low). And directly it will connect to the microcontroller rain sensor, displacement sensor with module voice IC and the speaker.

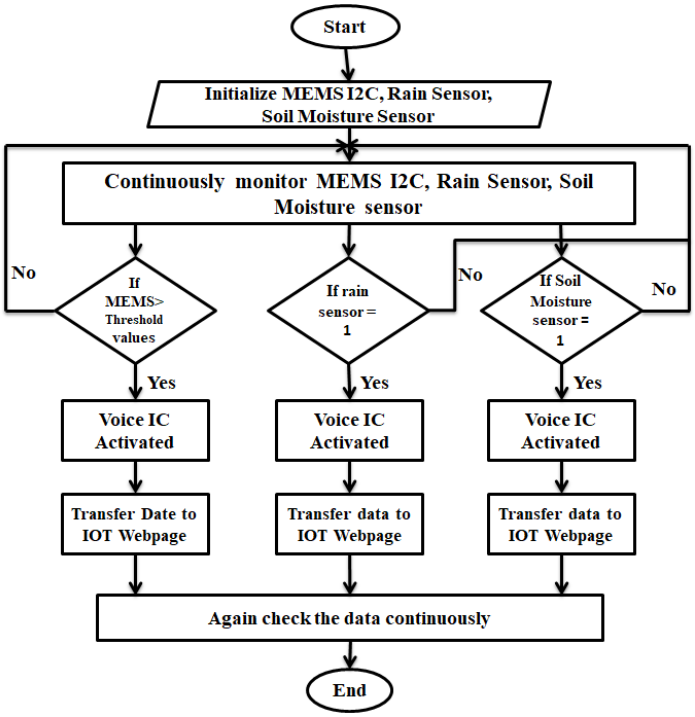

Figure 3. Flow Chart.

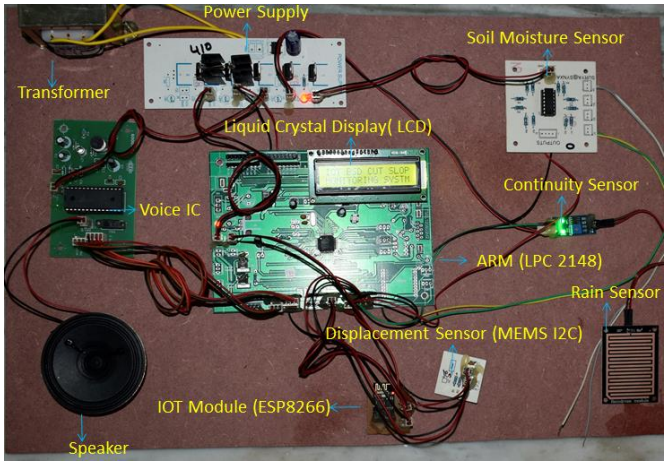

Figure 4. Hardware kit.

7. Results

Displacement sensor measures the angle of slope in four different ways such as less than 45 Degree, greater than 45 Degree and less than 25 Degree, greater than 25 Degree which is displayed on LCD screen and gives the voice of the slope of the angle. Rain sensor senses the presence of rain when it is raining it will be displayed as "It's raining" on the LCD screen. And also it gives the voice as raining. The required amount of water represents the level of water when it is high then it represents high on LCD screen otherwise it represents as low.

Table 1. Graphical Outputs.

Date	Slope Angle	Rain Sensor	Soil Moisture
20/7/2021	24.5	Dry	236
22/7/2021	20.4	Wet	258
26/7/2021	19.3	Wet	269

28/7/2021	15.8	Dry	240
30/7/2021	28.5	Wet	282
1/8/2021	33.9	Wet	296
6/8/2021	31.2	Dry	239

Figure 5. Graphical Representation of Slope Angle.

The output of the x and y axis values of the slope angle whether it is high or low is defined in the Graphical manner.

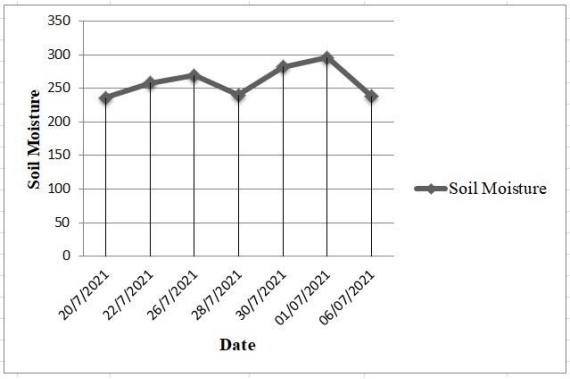

Figure 6. Graphical Representation of Soil Moisture.

The output of the x and y axis values of Soil Moisture whether it is dry or wet is defined in the Graphical manner. Things speak outputrepresents five graphs. To for displacement sensor, it stores the data and values of the slope angle by tilting the displacement sensor. And two for soil moistures representing the values of water level whether it is high or low. One for rain sensor, it stores the data that when it is rained and the values of this sensors represents as graphical manner.

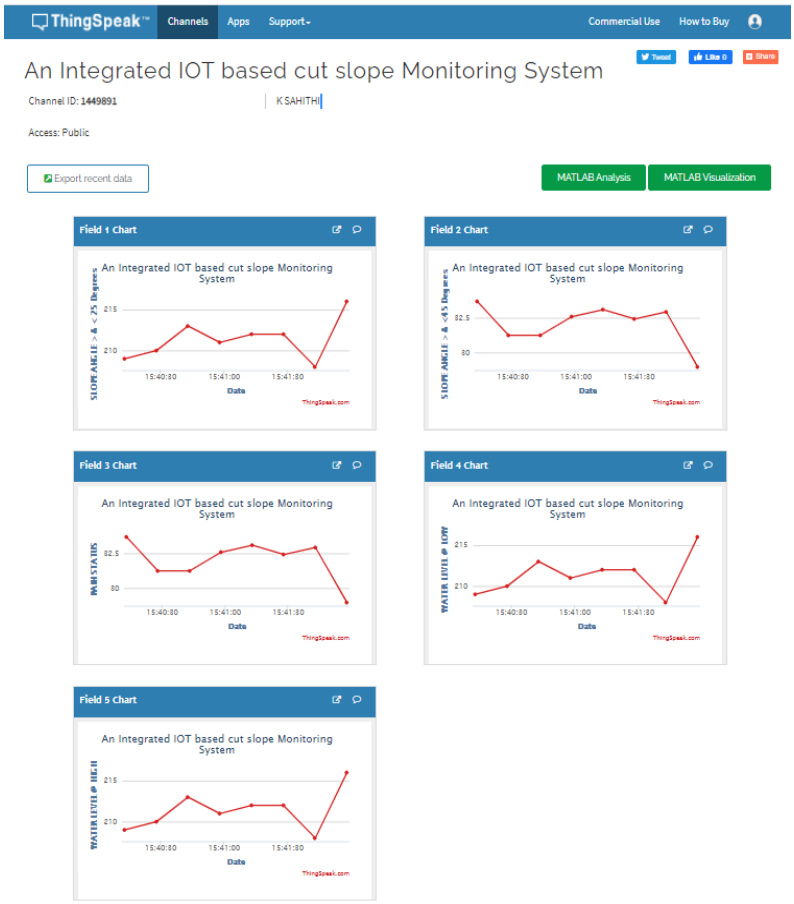

Figure 7. Things Speak output.

8. Conclusions

Slope monitoring is one of the challenging research area. In this project, we designed the hardware prototype in order to detect the movement by using the accelerometer sensor. The data that was generated by the sensor was successfully transmitted and synchronized with cloud for visualization and accessibility. The designed system was useful at the normal hilly areas and also at the mining areas. This system will also be helpful for the people living at the mountain areas in order to reduce the mortality. To apply the soft computing techniques and data processing algorithms using signal processing tools like MATLAB we can predict the future failures. Implementation in various fields and different industrial application where slope failures are the part of production process.

Institutional Review Board Statement:

Informed Consent Statement:

Data Availability Statement:

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