Landslide early warning system based on arduino with soil movement and humidity sensors

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Abstract. In this paper, a landslide monitoring system was built to detect the movement and humidity of the soil that generally causes landslides. The soil movement sensors utilizes a sliding potentiometer that converts distances into stresses and a humidity sensors. Data from sensors processed using a 10 bit Analog to Digital Converter (ADC) on the ATmega8535 microcontroller. The value of soil movement and humidity then sent digitally via serial USB communication protocol. The soil movement and humidity is displayed through the website interface in the form of graphic data and can be downloaded in the form of excel files. The results obtained through the simulation that the system is able to measure the movement of soil, soil moisture, and provide early warning through sirens. The system has a 1 mm resolution specification with a range of motion measurements with a linear correlation of 0.998. The system can also recognize sudden ground movements as an indication of landslides.

1. Introduction
Landslides or land movements in some cases do not occur spontaneously, but there are indications such as land movement. The above signs can actually be converted into an early warning system that is expected to assist in monitoring the indication of landslides. Various landslide monitoring systems have been developed using various sensors. Monitoring of landslide events monitored by ALOS / PALSAR imagery based on geomorphological satellite data interpretation [1]. Monitoring of landslide events using GPS sensors that spread at a distance of at least 5 km is able to monitor the behavior of avalanches [2]. Monitoring of landslide potential is also done through condition of water content in soil with resistivity method. Parameters used are water content, water potential and resistivity measurement used in predicting sensors [3]. Monitoring of landslides has also been done using fiber-optic that is distributed remotely. And has a measurement resolution level within 1 meter [4]. Landslide monitoring for disaster mitigation using corner reflector and satellite SAR interferometry in large landslide cases [5]. 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 [6]. Landslide mapping and monitoring by using radar and optical remote sensing [7]. Landslide monitoring system using extensiometer sensor and temperature sensor provide measuring range along 1023 mm with measuring accuracy of 1 mm [8]. From several studies conducted there are the main parameters that are used as an indication as landslide that is the shifting of soil, ground water content. In this research using extensiometer sensor that is potentiometer and soil moisture sensor. This identic combines the use of sensors performed by [3] and [8] for the measurement of continued ground movement.
2. Experimental Methods
This research uses multiturn Potentiometer sensor so it is very precise for small change with tolerance: ± 5%. The second sensor is the soil moisture sensor used to detect the percentage of water content in the soil. Both sensors will be controlled by Arduino module with ATMega328 Microcontroller type. Simulation testing system monitoring is done in the lab scale for continuous movement slowly and continuously spontaneously. Warning levels are given using different color LED indications to provide alert levels, careful levels and hazard levels. Hazard level will be added alarm as a sign of potential landslide occurs. Spontaneous movement for ground shifts will be directly indicated as the highest level of danger so that the alarm will immediately sound. System Monitoring of this landslide can be monitored using a computer and can be directly viewed through a web page on a computer connected via a USB port. The circuit illustration and test are shown in figure 1.

![Figure 1. Illustration testing and monitoring series of movement and soil moisture](image1)

3. Result and Discussion
The landslide detection system could show soil movement and the percentage of soil moisture. The user interface for the systems are shown in Figure 2.

![Figure 2. System’s User Interface](image2)

In addition, the system featured the history of soil movement and soil moisture values in the previous time period. The history data interface are shown in Figure 3.
In Figure 3, user can see the soil movement which is displayed real time. The soil movement inducing the change in potentiometer value. The greater the soil movement, potentiometer’s resistance become smaller. Sensor’s readout scale is determined using Formula 1.

\[ x_{cm} = \frac{y_{ADC}}{1023} \times 40 \]  

(1)

With \( x \) representing the result of soil movement, and \( y \) is the value of Analog Digital Converter (ADC). The smallest scale readings by the soil movement sensor is 0.4 mm. Compared to research conducted [8], in this study it was able to detect 60% more accurate soil shifts. The user interface for the soil moisture values are shown in Figure 4.

Soil moisture values indicate the percentage of water present in the soil. The soil moisture is determined using formula (2).

\[ x \% = 100 - \left( \frac{y_{ADC}}{1023} \times 100 \right) \]  

(2)

with \( x \) is the percentage of measured soil humidity value, and \( y \) is the value obtained by sensor readings. The device system is shown in Figure 5. Warning level is divided into three, i.e alert level, careful level and hazard level. These level is determined based on the magnitude of the soil movement in a certain
perion and percentage of soil humidity. The warning given by siren sound and rotator lamp. Besides that, the level was showed by LED indicator on device’s box, as in Figure 6. in lab scale testing, determining the range of level scales for humidity data, namely the alert level is achieved if the humidity value is above 25%, the careful level if the humidity value is above 25% - 65%, the hazard level if the humidity value is 65% -150%. Whereas for the soil movement determination of the alert level when it reaches a value of 0.8 cm, the careful level when it reaches the value of 2.3 cm and the hazard level when it reaches a value of 10 cm, and the value of the ground shift that can be read is up to a distance of 40 cm.

Figure 5. Landslide Early Warning System Device

Figure 6. LED Indicator for Warning Level

4. Conclusions
The landslide monitoring system has been tested and is able to recognize the distance shift in the smallest scale of 0.4 mm. The monitoring system developed considers the time of spontaneous soil shift as an indication of the hazard level for landslides suddenly. The results of monitoring soil shift values and soil moisture values can be used to indicate the occurrence of landslides. Warning of landslide hazard events for the surrounding population can be given via a siren alarm which can ring at any time when the hazard level occurs.
5. References

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