Landslide Detection Method using Laser Beam

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***Abstract*—Events of landslides in the tropics often occur, and the main causes of these events are often caused by the high intensity of rainfall. Before an avalanche occurs, it will usually be preceded by land movements that can occur slowly (creeping) or fast, depending on the condition of the type of soil that exists in that location. Some ground motion detectors include sliding stakes and inclinometers. This tool is useful as a measure of the amount of movement, especially on sloping land. The purpose of this study is to make a movement detection device that can be an alarm or early warning for residents who live in locations that are prone to movement. The benefit for science is the development of monitoring methods using laser light that have not been done so far. The results of this study will be useful for the development of methods for measuring land shifts. The signal is sent using an internet network, so that it can be monitored continuously. The significance of this research for science is the development of a method of applying sensors using laser light which has not been done so far. Recording is done by using a web-based data logger by sending visual measurement data to the data center. The accuracy of the laser beam that spreads when it is received on the target board, is done using the center cluster method.**

Keywords—landslide, laser, center cluster, detector, data acquisiton

I. Introduction

At present, disaster problems are one of the obstacles in improving the quality of human resources as well. Disasters caused by movable land are a serious threat faced by the world's population. Landslides are ranked third in the frequency of disasters in the tropics. In the case of landslides, the physical magnitude of the causes of landslides can be measured scientifically, it can be predicted correctly. Land shift is a complex event and depends on many factors. However, some parameters can be known, one of which is the movement of land on a slope. With reference to these conditions, a breakthrough must be sought with the intention that prevention of disasters can be improved by using efficient and efficient communication and information technology. The limited amount of power can be overcome by a simple but efficient telemetry model. Therefore we need a piece of equipment to read the soil conditions to be sent to data centers that are in different places, so that analysis can be carried out. An instrument inclinometer is one tool that is often used in measuring soil movements. The use of these sensors is quite famous because of their small dimensions, high sensitivity and accuracy, low power supply, and low cost [1]. The use of an inclinometer can only detect the slope of the ground. Whereas what is needed is not only the change in slope of the land, but the value of the shift to the starting point cannot be detected. Therefore it is necessary to measure or equipment that is relevant for measuring the amount of soil displacement within a certain period of time. Data on ground movement conditions that can be sent to the monitoring center are signals from translation positions that can be read from the sensor. The shift signal captured by the sensor can be stored and transmitted as needed. On the other hand, a disaster telemetry system is needed that can be made at a low cost. The purpose of this study is to produce a telemetry system for monitoring the shift of land at low speeds with high quality. The main objective of this study was to obtain a sensor design method and telemetry system for the purpose of monitoring land shifts. The benefit for science is the development of monitoring methods using laser light that have not been done so far. The results of this study will be useful for the development of methods for measuring land shifts. The effect for the community is in the form of information on moving land conditions, so that they can anticipate beforehand. The output of this research activity is to obtain a laser-based sensor system to be able to detect ground movements. The signal is sent using an internet network, so that it can be monitored continuously.

The main contribution is to get a method of measuring ground movement, so that high accuracy is obtained regarding the direction and movement of the soil. The significance of this research for science is the development of a method of applying sensors using laser light which has not been done so far. The design of a monitoring network system is more integrated on a broader scale.

II. Landslide and Measurement

A. Slope Stability

Ground movement is a general terminology of a process in which the mass of a material of the earth moves by the gravity of the earth either slowly or quickly from one place to another. In principle, ground motion occurs as a result of disruption of slope stability, ie if the magnitude of the driving force of lands that are landslides exceeds its retaining force. Slope movement can occur due to an imbalance of forces inside the soil surface and triggers of external forces acting on the slope. Inner forces can be caused by conditions of the type of soil; density of soil; the level of shear strength of each soil parameter and underground water flow. Meanwhile factors / external forces that can affect soil movement are burdens that work above the ground; rainwater that enters the ground; high slopes and so on. The types of soil in a naturally formed location can vary, including the level of soil density formed in it. In conditions of sloping soil layers, different types of soil and density levels can cause different slope failures.

There are several types of slope collapse, depending on the type of soil:

- Fall type of collapse
- Form of collapse type "avalanche"
- Form of type "Flow" collapse

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• Form of combination collapse type

In general, the shape of the slope is divided into two (2) types, namely infinite slope (infinite slope) and limited slope (finite slope). To find out whether a slope is stable or not, it can be seen from the safety figures from the analysis of the slope condition. A slope is unstable if it has a safety factor of less than 1 (FK <1), and is stable if the safety factor is> 1 (FK> 1). Usually in the analysis there will be a minimum slope requirement for stable slopes, for example with FK ⩾ 1.5.

B. Geoelectric Test

Geoelectric Test have been used for a long time, especially in the search for sources of water in the soil, but in the application in the field it turns out the geoelectric test results can also be related to the types of rocks; land or minerals - minerals that are under the surface of the earth. In principle, this test aims to measure "resistivity" or type resistance from material that is below the surface of the earth / earth. To determine the amount of resistance of this type of material is carried out by flowing electric current into the ground. The properties of electricity can be different for each material that exists. This potential electricity flow is measured; electromagnetic currents and fields to be able to know the type of resistance.

C. Inclinometer

Inclinometer is one of the tools that is often used in measuring ground motion. The instrument can identify the depth and speed of soil movement [2]. The shape of the inclinometer is like a pendulum whose outer part is a wheel to slide while to determine the ground movement this instrument is launched on a pipe that has been previously planted. The development of the nanomaterial also has a lot of impact on the more specialized instruments on the sensors used in the inclinometer. Currently land shift research tends to use Micro-Electro Mechanical Systems accelerometers on sensor inclinometers. The use of these sensors is quite famous because of their small dimensions, high sensitivity and accuracy, low power supply, and low cost [1]. The development of the accelerometer MEMS on an inclinometer is based on the slope reading obtained from measured static gravity acceleration conditions [3][4]. At present, the availability of the accelerometer MEMS is not limited to just one axis, but two, or three axes on a single chip. This development not only streamlines space but also improves its resolution. MEMS Accelerometer The use of microelectromechanical (MEMS) based sensors is growing rapidly along with the development of material technology[5-10].

Various requirements in physical phenomena used by microlectromechanical system sensors include the use of robotic control systems, pressure, acceleration, automobiles, navigation, and medical devices. Inside the MEMS itself there is a micro system consisting of: sensors, electronic circuits as signal conditioners, and actuators. Smart Sensor Current needs are an instrumentation that has better capabilities and functional values. Sensors in the system are expected to provide information on the parameters measured or can control the situation, while being able to be developed into intelligent sensors. These sensors can communicate directly with instrumentation and systems by being built through a sensor network. The advantages of this sensor network are improving instrumentation capabilities, reducing the number of hardware, working flexibly, easy to install and maintain, and improve energy efficiency.

D. Centre Cluster

Clustering is a grouping of objects so that objects in the same group are more similar to each other. Clusters include groups with small distances between cluster members, dense areas of data space, intervals or certain statistical distributions. The centroid of a finite set of k is

$$C=(x_1 + x_2 + x_3 + \ldots + x_k)/k \quad (1)$$

III. Method

The preliminary research method that has been carried out is by installing instrumentation at several points in the construction of the Soil Retaining Wall and recording the movements that are thought to occur over time. Recording is done by using a web-based data logger by sending visual measurement data to the data center.

The stages of research that have been carried out are as follows:

• Study geo-electric test equipment in relation to soil coating and landslides

• Studying the results of previous studies using geo-electric testing instruments and conducting surveys at previous research locations

• Conduct a survey at the location of the research plan

• Determine / select Geo-electric test locations

• Reviewing the Geo-electric test results which include: soil type; conditions of water flow in the soil; estimated soil coating.

Geo-electric tests have been used for a long time, especially in the search for water sources in the soil, but in the application in the field it turns out the geo-electric test results can also be related to the types of rocks; land or minerals that are under the surface of the earth. In principle, this test aims to measure "resistivity" or type resistance from material that is below the surface of the earth / earth.

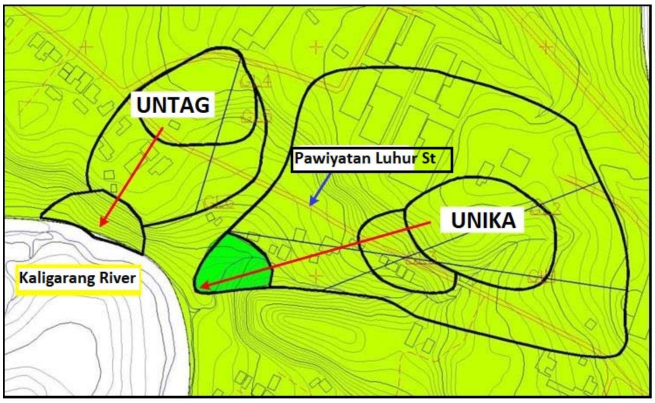

Fig. 1. Landslide in Kaligarang River Area

The system application that will be the pilot or experiment of this system is the area of land moving around the Kaligarang River, Semarang, Indonesia. Based on the results of previous studies that have been carried out since 2012 indicate "global" avalanches and the direction of landslide movements that have a relatively wide area coverage. At figure 1, UNIKA is our university nick name of Soegijapranata Catholic University. UNTAG is neighbor university that located on the south west of UNIKA. The land between UNIKA and UNTAG is tend to slide into Kaligarang River.

A. Laser Beam to Detect Landslide

The proposed method is to shoot a laser beam at the target plate. The target plate is in an area that is prone to movement, while the laser shooter is placed in a relatively stable place. The position of the point shot by the laser beam is monitored using a camera. Then the signal from the camera is connected via the internet network to the data center. The server-centered process is done to minimize and simplify the process of the microcontroller, from storage, processing, to displaying data. Information displayed through a web interface can be accessed by the user using communication networks TCP / IP wireless, UTP cable, or communication through a GSM modem. On the other hand, the monitoring conditions are sent by the server using an internet-based application to the user at a certain time lag. If the server is connected using a public internet network, the monitoring data information can be accessed wherever the user is as long as it is connected to an internet connection. The data that is sent is a shift of land to the reference. References are placed in relatively immovable parts over a distance of 30 meters. This research will develop this system consisting of the overall tool block diagram, the specifications of components and materials used, the design of constituent modules both in software and hardware, system testing, and data retrieval methods.

The system consists of:

1. Sensor system
2. Amplifier
3. Signal Transmission
4. Data Processing Center
5. Display

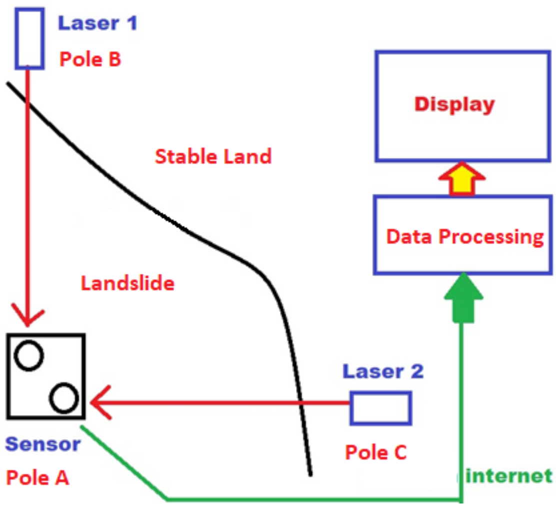

Fig. 2. Pole position for laser and sensor placement

In this study, two CCTV camera as sensors were used. This sensor is placed in the area monitored for soil movement. The stages of construction and needed equipment are presented as follows.

• Set up three Steel Poles (A, B, and C) and height each 2 meters above the ground.

• At pole A placed two pieces metal plate and two CCTV camera to capture metal plate picture. Two laser beam sources are placed which will be directed to a plate mounted on pole B and C. The use of a laser beam is needed to obtain measurement accuracy. Therefore it is necessary to place a light transmitter that is strong enough to not change easily by changes in weather and humidity.

B. Laser Beam Adjusment

For long period measurement, laser beam direction will be change into other direction because of any climate condition. So that, the point or dot that reflected into monitor metal plate become inaccurate. On this research, control plate is placed between laser source and monitor metal plate to ensure that the beam is on the right direction. If the laser beam do not pass the hole of the control plate, the laser beam direction needs to be adjusted.

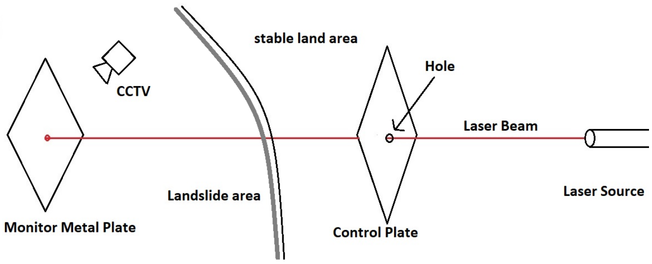

Fig. 3. Control plate for adjusting laser beam direction

C. Detection of the Laser Beam Center

Laser beam projection on the monitor metal board is too big to decide size of landslide per certain period. There is about one centimeter radius. In order to obtain more precision measurement, central cluster method is applied. Based on imaging signal processing system, by using inverted signal and center cluster method, the center of beam is calculated.

Center of laser beam will be change when there are any landslides on pole A. If projection of laser beam is reduced, there is need adjustment on laser source direction. It will be happen when the laser beam changes its direction because of climate or other condition.

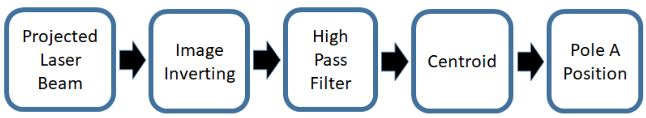

Fig. 4. Pole A position calculation

IV. RESULT

After some experiment using previous system presented, some result are obtained. The figure bellow is an example of laser beam projection on the monitor metal plate that placed on Pole A. projection of this beam is too thick to be detected of its centre, because of long distance between laser source and monitor metal plate.

Fig. 5. Laser beam at monitor metal plate on Pole A

By using signal processing calculation, the image will be inverted in order to get much contrast of image. But transition between white and black area are still appear in this image. High pass filter is applied to much contrast.

Fig. 6. Inverted laser beam at metal plate

Centre of projected laser beam is calculated using centre cluster method to obtain the right position of Pole A. this centre will be changed when there are any landslide on Pole A position.

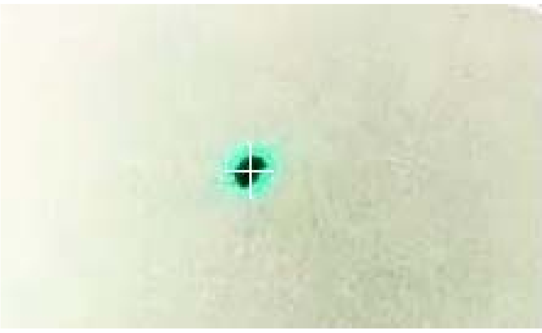

Fig. 7. Result of the center of detected laser beam

V. Conclusion

Landslide could be detected using laser beam projection to obtain the precision measurement. Laser beam have to project into target plate that placed on the potential landslides. One plate control with a hole must be installed in place between laser beam source and target plate to adjust he laser beam direction.

Laser beam that projected on the target plate will be processed by inverting image projected. After that, high pass filter is applied in order to get much contrast. The centre of beam is calculated by using centroid method.

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