LAND SLIDE DISPLACEMENT DETECTION USING TIME SERIES DIGITAL SURFACE MODEL ACQUIRED BY A TERRESTRIAL LASER SCANNER

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ABSTRACT: Recently, the terrestrial laser scanner is considered as useful measurement equipment for acquiring a three-dimensional data. In this study, a terrestrial laser scanner which has +/- 2.5cm accuracy is examined whether the terrestrial laser scanner is reliable to present the tendency of landslide movement. The test area is covered by protection blocks, and they are being moved by landslide movement. Landslide movement was detected by measuring the movement of protection blocks. Totally three scenes of test area were acquired during 2004 and 2006. The three scenes of the protection blocks were registered in global coordinate system, then the landslide movement was investigated. The landslide movement detected in the three scenes was evaluated by comparing with landslide movement measured by a total station. Although the measurement accuracy of landslide using the terrestrial laser scanner was worse than the total station, the scanning data showed the tendency of landslide movement of the test area.

Key words: Landslide detection, Lidar

1. INTRODUCTION

There are many landslide areas in Shikoku, Japan. Therefore monitoring landslide is one of important things to prevent disaster. Ground expansion and contraction meters and GPS are commonly used for landslide measurement. The devices require much labor works to measure the whole surface of the area where landslide occurs.

Currently, laser scanner which can acquire 3D coordinates of an object in a short time has been used for surface measurement. In this study, a terrestrial laser scanner which has +/- 2.5cm accuracy was examined that it can detect the movement tendency of landslide.

The test area for this study is Chou-Ja in Kochi prefecture, Japan. There are protection blocks to prevent the landslide movement (figure 1). The blocks have been moved by landslide. The tendency of landslide movement was investigated by measuring the movement of the blocks.

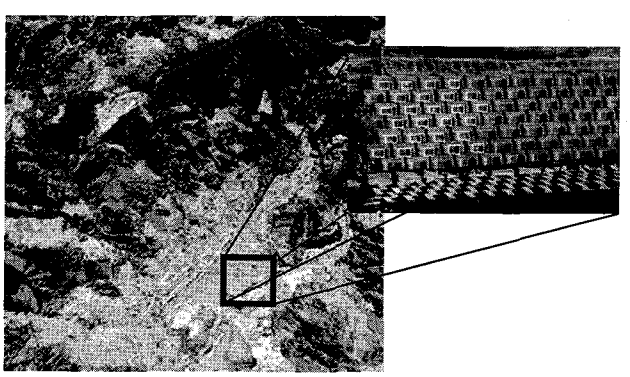

Figure 1. Protection blocks in the test area

2. DATA USED

For the landslide measurement, Riegl LMS-Z210 was used. Table 1 shows the specification of the terrestrial laser scanner.

The movement of protection blocks was measured in October 2004, December 2005 and September 2006.

Table 1. Specification of Riegl LMS-Z210

	line scan (vertical scan)	frame scan (horizontal scan)
scan angle	80 deg	0-330 deg
angle readout resolution	0.036 deg	0.018 deg

3. METHODS

1) Registration

For the landslide displacement detection, firstly registration of the three scenes was carried out. The GCPs were taken from circle type reflector: the center of 3d point cloud of reflectors was extracted. Three points of each scene were used for the registration.

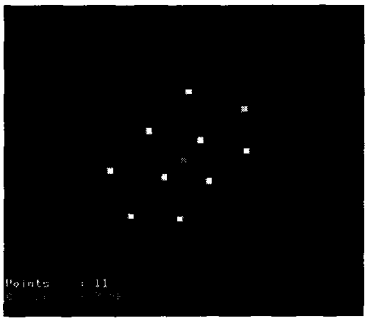

Figure 2. The center of point cloud of circle type reflector: red point indicate center, white points show the point cloud of a circle type reflector.

The three scenes were registered in global coordinate system using 3D conformal transformation (equation 1).

$$Y = \lambda MX + T$$

Equation 1. 3D conformal transformation: Y is the vector of known world coordinate system, X is the vector of model coordinate system, λ is scale factor M is a rotation matrix and T is the translation vector.

2) Landslide displace detection

Totally 14 reflectors were attached on the protection blocks. The reflectors were measured by the terrestrial laser scanner and a total station. The detected movement in Y direction measured by the total station was compared with the data obtained by the laser scanner.

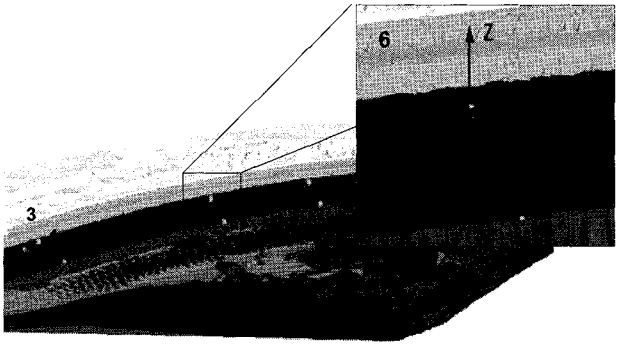

Figure 3. Reflector (observation) positions and coordinate system

4. RESULTS

1) The result of Registration

Maximum standard deviation error of the scene acquired in 2004, 2005 and 2006 were 0.052m, 0.054m and 0.016m, respectively.

2) The result of displacement detection

Mainly, the landslide has occurred in Y direction, therefore the movement in Y direction of each reflector was evaluated. Table 2 shows landslide movement between 2004 and 2005. The landslide moved minus direction in Y coordinate. The gray colored rows show that the laser scanner data failed to detect the tendency of landslide movement.

Table 2. Landslide movement between 2004 and 2005

	total station	laser scanner
observation	movement in Y direction (m)	
1	-0.0421	-0.0310
2	-0.0400	-0.0310
3	-0.0444	-0.0080
4	-0.0489	-0.0190
5	-0.0488	0.0040
6	-0.0583	0.0670
7	-0.0588	-0.0270
8	-0.0615	-0.0270
9	-0.0665	0.0080
10	-0.0675	0.0240
11	-0.0638	0.0150
12	-0.0656	-0.0230
13	-0.0655	0.0230
14	-0.0673	-0.0430

Table 3 shows landslide movement between 2004 and 2006. The landslide moved in minus direction in Y coordinate. The landslide movement detected by the laser scanner moved in minus direction.

Table 3. Landslide movement between 2004 and 2006

	total station	laser scanner
observation	movement in Y direction (m)	
1	-0.0499	-0.0580
2	-0.0522	-0.0592
3	-0.0504	-0.0350
4	-0.0533	-0.0310
5	-0.0572	0.0160
6	-0.0535	0.0670
7	-0.0586	-0.0190
8	-0.0601	-0.0390
9	-0.0630	-0.0030
10	-0.0624	-0.0620
11	-0.0615	0.0120
12	-0.0571	-0.0218
13	-0.0584	-0.0040
14	-0.0588	-0.0240

The measurement accuracy of laser scanner was poor comparing with that of total station. On the other hand, the result shows that laser scanner data may be useful to present the tendency of landslide movement if the registration and measurement accuracy is enough.

5. CONCLUSIONS

In this study, a laser scanner which has +/- 2.5cm was examined whether it can present the tendency of landslide movement, and the result shows that laser scanner data may be reliable to present the tendency of landslide movement.

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