Japan Geoscience Union Meeting 2014
(28 April - 02 May 2014 at Pacifico YOKOHAMA, Kanagawa, Japan)

HTT08-01 Room:415 Time:April 29 16:15-16:30

Estimation of ground displacements by Geomorphic Image Analysis, using multi-temporal LiDAR DEM

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In the previous study, authors developed the new method which applies the technique of image matching analysis with high resolution DEM over difference times, to estimate the minute ground displacement of less than 1m order quantitatively and easily (Mukoyama et al., 2009 and Mukoyama, 2011). The present study shows the results of subsequent case studies to measure crustal movement, earthquake fault displacements, and the movement of landslides. Additionally we will show the results of comparative verification with some field observations by GNSS stations.

There are two approaches for the calculation of ground displacements from geomorphic point cloud data which is acquirable by temporal high-resolution LiDAR survey. Iterative Closest Point (ICP) is the method for 3D-matching by iterative calculation to find the positions which minimize the difference of coordinate values between paired points in the search area. The other approach is the combined methods of 2D-image measurement for estimation of horizontal component and point cloud calculation for vertical component. These two approaches share common process for finding the best position to minimize the difference between points belong the small search window in the temporal data. For this study, we applied the latter approach which is based on the technique of digital image matching analysis using geomorphic image made from grid data of digital elevation model (DEM).

In this method, the existing Particle Image Velocimetry (PIV) algorithm was used for the 2-dimentional image matching. And orthographic slope angle image was used as measurable digital geomorphic image. Although PIV method has been developed generally for fluid analysis, grayscale gradient slope angle image is suitable for PIV analysis as it utilizes the validity of random distribution image of particles in fluid. In order to estimate vertical displacements, the vertical component is available by interpolation of the elevation values of DEM around endpoints of the calculated vector.

In recent study, above-mentioned method was applied to measure ground displacement due to the Great Japan Earthquake in 2011. In the region where liquefaction had damaged the reclaimed land, 10-50cm of lateral displacements were observed in some divided small areas, and seaward deformation of sheet-pile revetment by lateral movement was also observed at the spot on the seaside. After the earthquake, northern part of Japanese Islands moved eastward 6m or less. Verification analysis was conducted in order to compare between the results of Geomorphic Image matching Analysis and GPS observations in the region where temporal LiDAR data and GPS station data was available. Generally both of the results were corresponding with a high correlativity. In the additional study, verification analysis of landslide movement was conducted with GPS observation data; and both of the results were corresponding well with small error range.

The displacement measurement technique by high-definition digital geomorphic image made from high-resolution point cloud survey is effective and simple method, which has the accuracy of about 1/10 pixels or more. It is thought that this method is practicable for measurement of the movement of landslides, earthquake faults, etc.

References

Mukoyama, S., Nishimura, T., Asada, N. (2009) JpGU Meeting 2009 Abstract, Y167-004
Mukoyama, S. (2011) Journal of Mountain Science, Vol. 8, No. 2, pp. 239-245

Keywords: DEM, LiDAR, DEMs of Difference, image matching analysis

HTT08-02 Room:415 Time:April 29 16:30-16:45

Landslide surface deformation detection by Iwate-Miyagi Nairiku earthquake using 2.5D analysis on SAR interferometry

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We have already reported landslide surface deformation by 2008 Iwate-Miyagi Nairiku earthquake using Synthetic Aperture Radar interferometry (InSAR) images. In this study, to detect the landslide surface deformation quantitatively in the SE area of Mt.Kurikoma, report the result of 2.5D analysis on the images (i.e., combination of the images observed from ascending and descending orbits).

Keywords: SAR, interferometry, earthquake, landslide, 2.5D analysis

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HTT08-03 Room:415 Time:April 29 16:45-17:00

Evaluation of topographic measurements using UAV- and ground-based SfM and TLS: A case study at a rocky coast bench

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Recent advances in measurement methodologies of high-resolution topographic data, including terrestrial laser scanning (TLS), structure from motion photogrammetry (SfM) on unmanned aerial vehicle (UAV) and ground-based SfM, enabled detailed investigations of land surface morphology in terms of morphometry and processes. Although such advanced methodologies are becoming widely applied in geomorphological studies, the nature of such data including error estimates needs to be carefully assessed when being applied in geomorphological researches. In this study we examine similarities and differences among three methods for the topographic data acquisition at a local scale (~100 m): UAV-SfM, ground-based SfM and TLS. The study site is a coastal bench at Aburatsubo in Miura Peninsula, central Japan, which suffers from intermittent uplift by large earthquakes such as the 1923 Kanto earthquake (M 7.9). UAV-based SfM was performed from higher altitude (ca. 30 m) to lower (ca. 10 m) using a quadcopter on which a digital camera with single-focus lens is mounted. We also used a digital camera mounted on a 4-m long pole for ground-based SfM. TLS measurement was carried out using a short-range scanner from 6 scan positions. Also, coordinates of three benchmarks on ground that are commonly used in all the methods were measured using global navigation satellite system (GNSS) capable of receiving dual radiowaves and post-processing based on career-phase correction with an accuracy of centimeters. The comparisons of the point clouds and digital elevation models (DEMs) obtained by three different methods indicate that 1) SfM-based data shows good accuracies in and around, but significant discrepancies outside of the benchmarks, 2) TLS sometimes give significant lack of data in shadow areas, and 3) data quality of SfM partly depends on the altitude of its platform (either UAV and pole). These characteristics we assessed will give insights into the selection of appropriate methodology for different purposes of geomorphological surveys.

Keywords: rocky coast, structure from motion, terrestrial laser scanning, point cloud, digital elevation model, accuracy

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HTT08-04 Room:415 Time:April 29 17:00-17:15

Comparative analysis of knickpoint extraction using semi-automatic and automatic methods

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Extraction of knickpoints (or knickzones) from a DEM has gained immense significance in studies of fluvial erosion and/or slope failures because of their geomorphological significance. Previously, knickpoint extraction from a DEM included a vector-based semi-automatic, but somewhat tedious and time-consuming data processing because GIS and spreadsheet software were separately used. Raster-based Python scripting, developed in our study and deployed in the form of a toolset, can automate the processes making the extraction of knickpoints automatically, fast and user friendly. Both the methods are based on the assumption that the slope gradient along a bedrock river changes with change in measurement length and any locally steep segment of the riverbed may then be considered a knickpoint. The relative steepness index R_d or the rate of decrease of gradient along the measurement length is calculated by solving a linear regression equation, $G_d = ad + b$ where, G_d (m m^{-1}) is the stream gradient at a point and d (m) is the measure distance, while a and b are coefficients and $-a$ is regarded as R_d which means the rate of gradient decrease with increasing d. In the former method G_d is measured at the mid-point of a segment of variable length d along longitudinal stream profiles where; $G_d = (e_1 - e_2) / d$ where, e_1 and e_2 are elevations at both ends of the segment, thereby analyzing both the upstream and the downstream segments along a stream. The automated Python processing, however, follows a slightly different approach from the one previously used and thus requires a comparative analysis of the two prior to its future use. The methods differ in the calculation of the stream gradient G_d; the former employs both the upstream and downstream elevations $d/2$ apart, whereas the latter uses the elevation at the point and d downstream. In this study, the Python toolset has been applied to a 10-m DEM of a mountainous region near Mount Ontake in the Northern Japanese Alps. The results were then compared and validated with the previous method. In order to study the fluvial characteristics of the knickpoints, analysis were confined only to the stream locations, the results of which provide insights into morphological developments of the watersheds.

Keywords: automatic extraction, DEM, knickpoints, Python