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Three-Dimensional Mapping of Tsunami Debris using Optical Sensor and LiDAR Data

Shunichi Koshimura (1) and Takumi Fukuoka (2)

(1) Tohku University, International Research Institute of Disaster Science, Sendai, Japan (koshimura@irides.tohoku.ac.jp), (2) NTT DATA Corporation, Japan (fukuokatkm@nttdata.co.jp)

Immediately following the Great East Japan Earthquake Disaster in 2011, approximately 23 million t of debris was generated and accumulated over wide areas because of the subsequent tsunami. Timely removal of the debris is an important and immediate issue for disaster recovery; therefore, accurate estimation of the quantity of debris is essential. Two estimation methods are used currently. The first is to derive the amount from experiential relationship based on the number of demolished buildings and their total floor area under the assumption that most of the debris is derived from buildings, and the second is a direct method of estimation based on the amount of debris hauled to temporary storage sites. The former has a disadvantage of estimating only the debris in accordance with demolished houses and does not consider other factors such as other structures, automobiles, driftwood, ships, and fishery facilities. The latter also has a drawback of time consumption because it requires continuous measurement at the storage depots.

Remote sensing technology is widely applied for the interpretation of wide disaster areas. In recent years, image analysis has become the main stream in interpreting damage. In particular, synthetic aperture radar is often used for discriminating the tsunami inundation areas based on backscattering intensity and for determining the damage of buildings based on aerial photographs.

In this study, a new remote sensing method has been developed for directly measuring the amount of debris distributed in the affected areas and for mapping the results. Specifically, two methods are proposed. The first extracts spatial extent of debris areas through image analysis using digital aerial photos and satellite images obtained immediately after tsunami disaster. The second determines the amount of debris on the ground and quantitatively estimates its amount (volume, weight) by integrating analysis that use the height of the debris obtained by aircraft light detection and ranging (LiDAR).

To understand the impact of the 2011 Tohoku earthquake tsunami and to observe the recovery efforts in the tsunami-affected areas, we conducted an integrated analysis identifying the spatial distribution and amount of tsunami debris, with aerial photos, satellite images, and LiDAR data. The analysis was conducted in Onagawa Town, Miyagi Prefecture including the ground truth data acquisition. The horizontal mapping of tsunami debris in Onagawa town was performed through object-based image analysis of aerial and satellite images. Integration of horizontal mapping of tsunami debris and the analysis of digital surface model (DSM) of LiDAR data yields an estimate of the volume of the debris to be used as the observation of debris removal efforts.