A radar-based method for detecting tsunami devastated areas using machine learning algorithm

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(I) Introduction

After catastrophic earthquakes and subsequent tsunamis, relief activity and reconstruction activity might be delayed due to the breakdown of information network and interception of roads to the devastated zone. To rapidly estimate the impact of the tsunami, air- or spaceborne remote sensing technologies can be used. In particular, Synthetic Aperture Radar (SAR) which is available independent of atmospheric conditions is promising. In this study, a semi-automatic method using high-resolution multi-temporal SAR data (TerraSAR-X) is proposed to estimate building damage in a tsunami devastated areas related to the 2011 Tohoku earthquake tsunami.

(II) Method

As study area, Yuriage, Natori city in Miyagi prefecture is selected. In this study, we focus on multiple bounce reflection, which is a specific feature related to artificial structures and which displays high pixel value, and utilize to detect building damage. First, radiometric calibration to sigma naught, despeckling and co-registration are performed as pre-processing. Secondly, to detect multiple bounce zones on pre- and post-event TerraSAR-X data, pixels with higher sigma naught are detected based on supervised classification. Third, to generate validation data, visual interpretation of building damage is conducted by using building footprint data and aerial photographs. The study area is divided into tiles of 50 m by 50 m mesh size, and the representative value of change ratio of areas with higher sigma naught and building damage are integrated on each tile as an attribute value. Finally, the damage patterns are trained on Machine Learning algorithms, which enable automated classifications of damage patterns into predefined damage classes, and the model to detect building damage is built.

(III) Preliminary results and discussion

The evaluation of the model is conducted through cross-validation. The best accuracy is obtained as 89.2 % and kappa statistic is calculated as 0.76. To reveal the factors to cause the errors, these were divided into “False Positive Errors” and “False Negative Errors”. In particular, areas with higher sigma naught on pre- and post-TerraSAR-X data and building footprint data are combined on GIS, and these spatial distributions are compared. In the following, the factors causing classification errors are discussed and summarized;

[Features in a tile with False Positive Errors]

- Objects of high SAR backscatter except buildings could be interpreted as washed-away.
- The accumulation of debris around undestroyed buildings decreases the backscatter of image elements.
- Area of higher sigma naught related to one building is divided by the boundary of tile
- Partially damaged buildings which are inspected as “Undestroyed” decreases the backscatter of image elements.

[Features in a tile with False Negative Errors]

- After buildings/house are washed away, other buildings drifted to the same location. Therefore, the sigma naught in a tile is not decreased.

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