Earthquake-Induced Collapsed Building Detection with VHR Synthetic Aperture Radar Images

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INTRODUCTION

Building damage detection after earthquake is particularly crucial for identifying areas that require urgent rescue efforts.

- Remote sensing has shown excellent capability for use in rapid impact assessments.
- Synthetic Aperture Radar (SAR) can provide important damage information due to its ability to map affected areas independently from the weather conditions and solar illumination, representing an import data source for damage assessment.

Advantage

- Very high resolution (VHR) data source made it possible to extract detailed information from individual buildings.

Problem

- Difficult to detect specific buildings in complicated surroundings in VHR images.
- Collapsed building debris is visually similar to other objects such as high vegetation. This could lead to false alarms when detecting debris heaps.

A method is proposed to assess the damage to individual buildings affected by earthquakes using single post-event VHR SAR imagery and a building footprint map.

METHODOLOGY

Concept of damage detection with SAR image

An ideal example of SAR imaging of a flat roof building

- The shadow caused by the standing building covers the majority of the building’s footprint (denoted by the red line).
- No return from the building or the ground in the shadow area.
- The backscattering intensity in the area is lower than that in the surrounding area.

Further investigation-difference incidence and aspect angles

- When the flat roof and gable roof buildings are illuminated by the radar in different aspect angles, the backscattering range profiles of the buildings can be explained by Figures 3 and 4.
- Still standing building, the region of the building’s footprint in an SAR image usually has low backscattering intensity and is dark compared to surrounding areas under the condition of various incidence angles and aspect angles.
- Totally collapsed building, debris piles form. The debris exhibits brighter scattering spots caused by smaller corner reflectors resulting from the composition of different planes.
- Figure 5-examples of standing and collapsed building. Standing buildings and collapsed buildings can be separated based on features derived from the original footprint of the building.

FEATURES FOR CLASSIFICATION

- Backscattering statistics (mean, variance, skewness, kurtosis)
- Texture measures (GLCM mean, variance, homogeneity, contrast, dissimilarity, entropy, second moment, correlation)

Classifiers

Random forest (RF), support vector machine (SVM) and K-nearest neighbor (K-NN) are adopted as the classifiers for damage type classification.

Data processing flowchart

DATA AND RESEARCH AREA

The study area is old Beichuan County, where most of the damage buildings are preserved after the earthquake on May 12th, 2008. Moreover, buildings with different types of damages can be found in the study area.

Table 1. SAR data used for the experiments

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RESULTS

We obtained original footprints of 12 totally collapsed buildings and 52 standing buildings in each image. For each test, 6 collapsed buildings and 17 standing buildings are used to train samples, and the corresponding numbers of test samples are 6 and 35, respectively. Table 2, 3, 4 are the classification result of image 1, 2, 3, respectively.

CONCLUSIONS

The method is based on the concept that the original footprints of collapsed and standing buildings show different features in sub-meter VHR SAR images.

- The method is able to distinguish between collapsed and standing buildings, with high overall accuracies above 80% with the classifiers.
- Avoids the difficulties of finding exact edges for building damage detection.
- The approach shows good ability for isolated buildings.
- If the buildings are too close, the footprint of a low building may be affected by a nearby tall building’s layover in the image.