A KNOWLEDGE-BASED METHOD FOR RAPID POST-EARTHQUAKE DAMAGE ASSESSMENT USING HIGH RESOLUTION OPTICAL AND SAR SATELLITE IMAGERY

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1. INTRODUCTION

With emerge of high-resolution optical satellite imagery with less than 1 meter resolution, individual building damage from post-earthquake satellite imagery can be detected at an urban scale. At the same time, the new high-resolution synthetic aperture radar (SAR) satellites, like COSMO-Skymed, TerraSAR-X and Radarsat-2, offering spatial resolutions of up to one meter in high-resolution spotlight modes, have been used for damage assessment and rapid mapping. Building damage assessment can be performed based on monophasic or multi-temporal high-resolution optical satellite imagery with less than 1 meter resolution. SAR is widely used for post-earthquake damage assessment, typically by using change detection approach based on multi-temporal SAR data. However, there are two problems when basing on a comparison between pre-event and post-event optical or SAR imagery. One is the post-event high-resolution optical or SAR imagery are not available, especially in the mountainous towns that are far away from economic center cities. The other is it requires intense human intervention when using heterogeneity data for damage assessment. These heterogeneity geospatial data, such as geologic maps, shakemaps of ground motion, can be used as an auxiliary data. There is, consequently, a strong demand for the development of robust techniques semi-automatic information of building damage extraction and interpretation of these heterogeneity data. In order to analyze these heterogeneity data for post-earthquake damage assessment, we propose a new strategy. Our approach focuses on:

1) a change detection method based on a comparison between pre-event optical imagery and post-event SAR imagery.

2) a semivaiogram method to quantify building texture.

3) knowledge rules integrating with semantic network for analyzing post-earthquake damage.

4) a fuzzy logic method used to analyze building texture between pre-event and post-event.

In order to analysis post-earthquake building damage by comparing pre-event imagery with post-even imagery, three steps have been taken in this paper. Firstly, two texture imagery based on semivaiogram were generated from high- resolution optical and SAR imagery. Then, texture imagery was classed into three types: low, middle and high. Knowledge rules based on fuzzy logic and semantic network were used to analyze post-earthquake building damage. Lastly, an area-based building damage map was generated to analyze the degree of earthquake damage in different area.

2. SEMIVARIOGRAMS

In this study, semivariance will be used here to quantify the building texture of the two high resolution satellite images: IKONOS-2 and TerraSAR-X. Square Root Pair Difference (SRPD) is defined as:

$$\mathrm{SRPD}_{(h)} = \frac{1}{\mathrm{N_h}} \sum [ABS(DN_{\mathrm{i}} - DN_{\mathrm{i+h}})]^{\frac{1}{2}} \quad .1$$

where N is the number of pixel pairs at distance h used to calculate the SRPD , and the SRPD is based on the square root of the difference between two pixels DN_{i} and $DN_{\mathrm{i+h}}$ at distance h apart.

The range of image semivariogram is taken as the optimal window size. In this study, an omni-direction texture transform using SRPD was carried out.

3. METHODOLOGY

A. Remote sensing and study area

An IKONOS-2optical image for Sep 14, 2007, recorded the area before the earthquake [Fig. 1(a)]. A TerraSAR-X-band radar image for May 16, 2008, recorded the area after the earthquake [Fig. 1(b)]. Both images were, first, geometrically corrected using appropriate Ground Control Points. The aerial images and ground data were collected from the local and national government to vivificate the method adopted in this study.

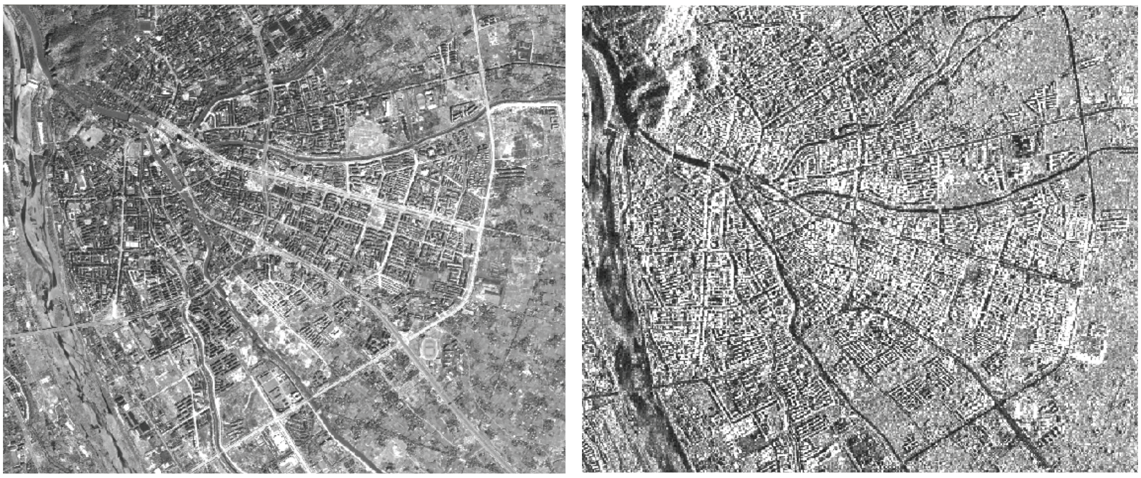

Fig. 1. Study area. (a) Pre-earthquake image. (b) Post-earthquake image.

The Magnitude 8.0 earthquake at Sichuan Wenchuan (Latitude 31.0º N, Longitude 103.4º E) on Beijing time 12th May 2008 14:28 resulted in massive buildings collapsed. The urban area of Dujiangyan is in the catastrophe district. The research team of the Institute of Space and Earth Information Science of the Chinese University of Hong Kong found that the worst case is found in northeast and centre Dujiangyan with more than 20% of houses was collapsed, while the housing damages in eastern Dujiangyan are less serious.

B. Calculating Semivariograms

In this paper the SRPD texture descriptor was used to extract building at individual building level from high-resolution optical and SAR image. When a SRPD texture layer was derived, an ISODATA clustering process was implemented. The entire SRPD image was classified into three classes: smooth, mid-range and rough texture. The building in the SRPD texture is mostly classified as rough texture.

C. Knowledge rules

The knowledge rule is like "if optical SRPD texture is high and SAR SRPD texture is middle, the possibility of building damage is also high." At the same time, knowledge rules were integrated with semantic network for analyzing post-earthquake damage. The interpretation process has two steps: a bottom-top step and a top-down step. The first step, called the top-down step, is initialized at the Scene node, through the operators associated to different nodes of the semantic network, hypotheses of the occurrence of image object on the scene. The final instance network results from the bottom-up analysis, responsible from judging those hypotheses, validating them based on our defined knowledge rules, also associated to the nodes of the semantic network.

4. Result

Our experiment is ongoing. An area-based building damage map will be generated to analyze the degree of earthquake damage in different area. The aerial images and ground data were used to vivificate the result.

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