Automatic recognition of damaged town buildings caused by earthquake using remote sensing information: Taking the 2001 Bhuj, India, earthquake and the 1976 Tangshan, China, earthquake as examples*

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Abstract

In the high-resolution images, the undamaged buildings generally show a natural textural feature, while the damaged or semi-damaged buildings always exhibit some low-grayscale blocks because of their coarsely damaged sections. If we use a proper threshold to classify the grayscale of image, some independent holes will appear in the damaged regions. By using such statistical information as the number of holes in every region, or the ratio between the area of holes and that of the region, etc., the damaged buildings can be separated from the undamaged, thus automatic detection of damaged buildings can be realized. Based on these characteristics, a new method to automatically detect the damage buildings by using regional structure and statistical information of texture is presented in the paper. In order to test its validity, 1-m-resolution iKonos merged image of the 2001 Bhuj earthquake and grayscale aerial photos of the 1976 Tangshan earthquake are selected as two examples to automatically detect the damaged buildings. Satisfied results are obtained.

Key words: region analysis; damage recognition; image comprehension; Bhuj earthquake; Tangshan earthquake

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Introduction

As we well know, the hazard of earthquake is very wide especially in cities. The conventional methods to investigate the damage are difficult to meet the requirements in applications. In recent years, with the rapid development of remote sensing, especially the successful launch and application of high-resolution commercial remote sensing satellite, it has become possible to recognize and extract damage information by using remote sensing. The researchers at home and abroad have practiced many tentative experiments and obtained a great amount of valuable results both for study and application (LIU, 2003; ZHANG, et al, 2001; Chiroiu, Andre, 2002; Mitomi, et al, 2001; ZHU, 2003; ZHUAN, et al, 2003).
et al., 1998; Keiko, et al, 2004). Up to now, the damage recognition by using remote sensing image mainly depends on mono-temporal technique with visual interpretation or multi-temporal technique by checking the changes between the images (Chiroiu, Andre, 2002). But the two methods have many shortcomings: the multi-temporal technique leads to low-recognition precision because of different image parameters, such as different resolution or incidence of satellite, and a long time interval between images; while the mono-temporal technique has heavy workload, slow speed and low efficiency for manual visual interpretation. All these deficiencies seriously obstruct further application of remote sensing to earthquake prevention and hazard mitigation. In order to meet the practical requirements, it is necessary to find a new method to overcome these disadvantages. For this purpose, we propose a new method to automatically extract the damage information of buildings based on mono-temporal technique by using regional structure and statistical information of texture in the high-resolution image. And iKonos image of the 2001 Bhuj earthquake in India with 1-m resolution (merged by panchromatic image with 1-m spatial resolution and multi-spectral image with 4-m spatial resolution) and grayscale aerial photos of the 1976 Tangshan earthquake in China, are selected as two examples to extract damaged building information caused by earthquake and to check the validity and applicability of the method.

1 Principle and method

1.1 Current techniques to extract building damages caused by earthquake

The mono-temporal technique uses one image after the earthquake to extract damage information by manual visual interpretation. Because of the differences between undamaged buildings and damaged ones in texture, figuration, grayscale and shadow, etc, people can find damaged buildings by manual interpretation relying on the differences and their own experiences. However, this method is heavily limited by the resolution of image. In the image with an average resolution (about 10 m), only large collapsed region can be found, but in the image with 1-m spatial resolution, the damaged buildings can be distinguished one by one (Chiroiu, Andre, 2002).

The multi-temporal technique is based on the changes between the images before and after the earthquake for the same area. It mainly depends on the changes of spectrum characteristics of detected elements to detect the damaged buildings caused by earthquake by using optical remote sensing images. The histogram matching must be done first to make the pre-seismic image and post-seismic image have a similar histogram, then proper algebra operations are used to extract the changed parts of two images. The operation of change detection will be very difficult for the images with different resolutions or from different sensors. Obviously, the precision of the method is greatly influenced by the factors of spatial resolution, incidence angle of satellite or temporal interval of images. Of course, for the high-resolution images, the damage information can also be extracted by comparing two scenes and using visual interpretation for the high-resolution images.

1.2 Automatic detection method for damaged buildings based on structural and statistical information of related region

The method is based on such a fact: in the high-resolution imagery, the undamaged buildings show a homogeneous textural feature, but the damaged or semi-damaged buildings exhibit many low-grayscale blocks in their images because of their coarsely damaged sections. If we use a proper threshold to classify the brightness of image, some independent holes will appear in the damaged regions. By using such kind of statistical information of imagery as the number of holes in every region, or the ratio between the area of holes and that of their regions respectively, or the