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Post-Earthquake Building Damage Assessment Using High-Resolution Satellite Imageries, In the Case of the 2003 Bam, Iran, Earthquake

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Introduction

Earthquake is one of the inevitable natural hazards that cause lots of damages and problems to the economy, environment and the whole life of people. There fore, it is necessary to use all available knowledge and technologies for saving people and their assets through an efficient disaster management. High-resolution satellite data represent a highly effective and valuable tool for earthquake damage assessment, providing important capabilities in the response-and-recovery phases of the crisis management cycle for reconnaissance and monitoring recovery operations.

Bam Earthquake: On 26 December 2003, an earthquake of Mw 6.6 _USGS_ occurred near Bam, Iran, at 5:26 am local time. Bam is a historic town located in south-east Iran in Kerman province. Considering that the population of Bam is 100,000, the number of casualties is staggering. Before the earthquake, Bam had many traditional buildings built with mud-bricks; some of them old, but many quite recently built. This was the first earthquake of this magnitude in the last 2000 years to occur in Bam, hence there was a lack of earthquake preparedness. In terms of human cost, the Bam earthquake ranks as the worst recorded disaster in Iranian history; a tragic statistic in a nation already ranked as the World's 4th most disaster prone country (IFRC, 2004a). Damage was concentrated in a relatively small area, of roughly 16km radius, around Bam - a tourist destination on the old Silk Road, famed for its 2,500-year old citadel Arg-e-Bam. A United Nations damage assessment team estimated that 90% of buildings in Bam sustained 60-100% damage. The remaining 10% of building stock recorded 40-60% damage. According to recent reports, the death toll has reached 41,000 (IFRC, 2004c), with a final expected figure closer to 45,000.

The aim of this study to assess the building damage distribution in the urban area of Bam, Iran, using post-earthquake QuickBird panchromatic and multispectral high-resolution optical satellite images to produce a damage map. This paper introduces a robust damage detection algorithm that can be rapidly deployed in future earthquakes to aid response and recovery efforts.

The accuracy of the results could be a potential support for the deployment rescue forces within a short time after the event, when the most affected zones are still not well defined. Damage maps could be transferred in a GIS format directly to rescue teams already deployed via satellite communication tools available today. The other priority is to assess and limit human injuries and fatalities and structural damage, recovery and relief effort.

Proposed Methodology

Through recent years, considerable effort has been invested in developing automated building damage detection methods, together with techniques for visualizing damage for seeking out the hardest hit areas and monitoring the progress of recovery activities.

Proposed methodology following these steps:

- Geometric registration,
- Radiometric correction,
- Texture feature extraction
- Generate optimum feature space using Genetic Algorith(GA)
- Neural network pixel base classification in optimum feature space
- Assessment pixel base classification accuracy

- Object base classification using of pixel base classification result
- Assessment object base classification accuracy
- Generate Damage Assessment thematic GIS map.

In this application, three damage levels were detected and mapped onto the Bam urban area based on the number of collapsed buildings: slight, moderate, and heavy damage. We can distinguish two kinds of uncertainty while classifying imagery and making the decision on changes.

Dataset

High-resolution optical satellite images taken by the QuickBird satellite before and after the earthquake 30 September 2003 – approximately 3 months before the earthquake struck- and 03 January 2004 -just over one week after the earthquake- were made available. Multi-spectral images with 2.8 m spatial resolution and panchromatic images with 0.6 m spatial resolution were acquired for the two dates. Many of the differences are caused by building collapse, although seasonal variations in vegetation may also be present.

Comparison and Results

To date, comprehensive ground survey results have not been published that could be used to assess the accuracy of the damage map in this study, apart from the sampled ground damage survey on selected locations. Hence, it is difficult to tell the true accuracy of the damage maps produced in this study. However, The results was assess with aerial image that taken several days after BAM earthquake. The results shown the 81% overall accuracy for object base classification with three class and was identified 134 building damaged correctly from 137 ones.

Results from the multi-temporal change detection methodologies presented in this paper demonstrate that this damage detection algorithm using high-resolution Quickbird satellite imagery can be successfully determined the location and severity of post-earthquake building collapse. Researchers hope to use such imagery in future events to provide “real-time” assessments and refined and augmented this damage detection algorithm with new capabilities.