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An approach to post-earthquake damage detection in urban areas based on Multitemporal high resolution images

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The detection of damages caused by natural disasters (like earthquakes, floods, etc.) in urban areas represents one of the new important applications of the automatic analysis of multitemporal remote sensing images. This is made possible from the availability of very high resolution (VHR) multispectral images acquired by sensors of the last generation (e.g., Quickbird and Ikonos). In this paper, two VHR multispectral and multitemporal remote sensing images acquired in September 2003 and January 2004 by the Quickbird sensor over the city of Bam (Iran) are considered. Between the two acquisitions, an earthquake destroyed a large part of the urban area. An accurate analysis of the damages caused by the earthquake can be conducted applying change-detection techniques to the available multitemporal images. Due to the passive nature of the acquisition sensor and to its high geometrical resolution the adopted technique should be able: i) to manage differences due to the different acquisition seasons, sun light conditions and acquisition geometries for reducing the presence of false alarms; and ii) to generate change-detection maps characterized by a high geometrical precision in modeling the complex objects/areas present in the scene.

In the considered dataset the main sources of undesired false alarms are the classes of vegetation and shadows. The first class shows significant differences in the multitemporal spectral signature according to the acquisition seasons, while differences in shadows are associated to their shapes at the two considered dates, which depend on the different view angles of the acquisition sensor. In order to reduce the impact of changes non related to the earthquake event, a pre-processing procedure has been

defined, which is based on the thresholding of proper selected features. Pixels identified as vegetation or shadows are neglected from the damage-detection process. The second requirement is achieved by applying a parcel-based context-sensitive change-detection technique recently proposed in the literature [1] and effective in the analysis of VHR images. The context-sensitive technique in [1] differs from the pixel-based techniques commonly presented in the literature [2] as it explicitly models the spatial dependence among pixels. This information can not be neglected when dealing with very high geometrical resolution images. In greater detail, the spatial-context information present in different spectral channels is exploited in the framework of a multilevel approach. The scene (and hence the changes occurred in the multitemporal data) is modeled at different resolution levels, by defining multitemporal and multilevel "parcels" (i.e. a local adaptive neighborhood of a pixel that shows homogeneity in both the spatial and temporal domain). The multilevel adaptive representation of the local neighborhood of each pixel at different resolution levels is obtained by a proper segmentation algorithm that guarantees that a parcel related to a specific pixel at a given level is completely included in the parcel of the same pixel at a higher level. Once the multilevel parcel-based data set representation is completed, for each pixel the set of reliable levels is determined according to an analysis of the statistical properties of parcels. Damage identification is achieved by applying a specific comparison algorithm to each pixel of the considered multitemporal images.

Experiments carried out on the images of the urban area of the city of Bam (Iran) resulted in a change-detection map characterized by good accuracy in both homogeneous and border areas, as well as, a reasonable fidelity in modeling the shapes of changed objects/areas on the ground.

[1] F. Bovolo, L. Bruzzone, "A multilevel parcel-based approach to change detection in very high resolution multitemporal images", Proc. IEEE Int. Geosci. Rem. Sens. Symp., IGARSS05, Seoul, Korea, 25-29 Jul. 2005, vol. 3, pp. 2145-2148, 2005.

[2] L. Bruzzone, D. Fernández Prieto, "Automatic analysis of the difference image for unsupervised change detection", IEEE Trans. Geosci. Remote Sensing, vol. 38, no. 3, pp.1170-1182, 2000.