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Toward the definition of a semi-automated building inventory tool and its use for earthquake damage assessment

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Detailed analyses of damages in urban and suburban areas, as well as any other kind of damage assessment applied to cultural features, is nowadays basically relying on ground surveys. While these surveys are made available in faster and faster ways by the use of modern positioning and multimedia technologies [1], the ability of remotely sensed data to cover in sort time large areas in rugged and possibly unreachable parts of any country in the world remains unchallenged so far.

The information provided by very high resolution (VHR) images in a damaged area, either optical, as in the most widely used space-borne systems, or SAR, as available in the near future, is however useless if not delivered in an user-friendly format. To this aim, semi-automatic approaches to change detection and image interpretation may play a role. In fact, they allow evaluating to a certain degree the damage assessment and reduce the effort required to extract vector or object information from raster data. One of these approaches is the recognition of buildings and the characterization of a very large amount of them, quickly recognizing and classifying any change that may have occurred. The present work is devoted to the description of such a system, based on automatic classification and geometrical refinement of objects recognizable as building in VHR optical images, and its application to quick yet sufficiently precise damage assessment in urban areas.

The proposed methodology is based on the integration of a supervised classification step and an unsupervised segmentation algorithm, mixed with some a priori information about the urban environment and the basic land use classes that usually compose it. While classification has been exploiting the approach developed in our group in

[2,3] and will not repeated here, the segmentation step is a novel addition to our urban recognition tool set. It is based on the watershed algorithm [4] and requires a substantial image pre-processing to avoid over segmentation by the selection of an appropriate segmentation function. Thus, each land use class is separately processed. First, in order to reduce noise, “salt and pepper” classification noise is reduced by morphological dilate. Then, a more precise regularization for other classes is added:

- *Trees*: noise blobs are removed after considering some geometric information about trees. Basically, they have a circular form and at least a 2m diameter. Thus, erosion by a proper disc element and then reconstruction by dilation are performed.
- *Houses*: houses are eroded and reconstructed as well. However, the element is a square. Moreover, very big blobs are discarded, assuming they are very large bright soil areas.
- *Shadows/Roads*: Small blob areas are treated as classification noise (e.g. cars on the streets). No assumption about geometric features is made.

This “regularized” image is used to impose minima on the multi-spectral gradient image of the original scene to avoid over-segmentation. Actually, noise could be still present, thus is preferable to remove isolated watershed lines shorter than 40 pixels at the end of the segmentation procedure.

The final step consists in matching the classification and the segmentation results, so that the scene interpretation is more accurate and less prone to misclassification by matching spectral and spatial extracted features. Every basin is therefore assigned by majority voting to the most represented class in the land use map. Although very simple, this algorithm allows to sensibly reduce spectral noise and to improve, for our purposes, building recognition.

Further geometrical constraints could now be applied to each recognized building, in order to improve the reconstruction of its footprint. These constraints are however strongly dependent on the area of the world the data refers to, and should be carefully defined. In most cases an assumption that usually holds is that buildings have not rounded corners, and will be considered in this work.

In the end, the refined building footprints may be obtained from a scene. The overall procedure have been tested in various urban areas and provides refined result in reasonable time, one hour of computational time on a standard PC for a 5000 x 5000 scene, and has been tested on Quickbird pan-sharpened images of the town of Bam, Iran, to detect the damages cause by the disastrous earthquake of December 2003.

Quantitative analysis has been performed by comparison of pre- and post-event images and provide an absolute accuracy for the detection of damaged buildings up to 80%. Moreover, discrimination between grade 1-3 and 4-5 for evaluation the damages has been proved with 70% accuracy. More results will be provided at the conference.

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