AUTOMATED PROCESSING OF HIGH RESOLUTION AIRBORNE IMAGES FOR EARTHQUAKE DAMAGE ASSESSMENT

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ABSTRACT:

The mapping of natural hazards and disaster damages in urban areas is of high importance for rescue planning and the economic loss assessments. Between the possible methods for rapid mapping, the use of optical data has been largely used since long time, showing the capability to acquire detailed information in reduced time (Kerle, 2010). Compared to terrestrial mapping of damages, aerial images (airborne or UAV) can provide most complete and extended analysis of the data.

In the last three decades several papers dealt with the use of airborne and satellite images for damages detection. As exhaustively reported in (Dong and Shan, 2013), the methods vary according to the input data and the level of detail requested in the detection process. These contributions use multi-temporal (pre- and post- event) or single epochs (post-event) data provided by optical, LiDAR, SAR sensors or their combination with ancillary data such as vector maps. Often both pre- and post-event data cannot be adopted in every condition as the multi-temporal data is simply not available. Consequently, much of research effort has been focused on the use of single epoch optical data (Liu et al., 2004; Rathje et al., 2005; Rasika et al., 2005; Duan et al., 2010). Damaged buildings are tracked in single satellite images where, for example, the texture features derived from spectral information can be exploited for the purpose of detection. The methods in general can be divided between pixel and object oriented, both capable of recovering the loss information at various levels of details, depending on the image resolution.

The integration of range and image data has shown to give very promising results (Rehor, 2007; Rehor and Voegtle, 2008). Nonetheless, the drawback of such approaches is the availability of the well co-registered data over the same area.

Recently, image matching techniques have been greatly improved and they are nowadays able to provide point clouds comparable to LiDAR in terms of density and accuracy (Haala, 2013; Remondino et al., 2014). Despite this fact, the use of only photogrammetric DSM for damage assessment has been very limited until now: some multi-temporal approaches (Turker and Cetinkaya, 2005; Rezaeian and Gruen, 2007) have been presented and only in (Gerke and Kerle, 2011) a semi-automated algorithm for the detection of damages using photogrammetric point clouds from a single epoch oblique image flight is reported. In general most of the above mentioned works underlined the need of high resolution for a reliable damage assessment as this parameter is directly related to the degree of detail reached in the analysis.

In this paper, a methodology for the automated detection of damaged buildings has been developed. The algorithms use a set of high resolution overlapping aerial images as input (both nadir and oblique views). Thanks to the employed high resolution images, the proposed methodology aims at detecting both structural and non-structural damages on the buildings (i.e. Grade 3,4,5 of EMS98). Nadir views are investigated to detect damages on the building roofs, while the data from oblique views is considered for façade damage assessment. The implemented approach is sequential i.e. the damaged entities are first found on the roofs and only afterwards the building facades are investigated.

A dense point clouds is firstly extracted from the nadir images (1 point per pixel) and then true orthophotos are generated in order to couple each point of the DSM with a radiometric value. The same process is performed with the oblique views: several point clouds are generated and then the radiometric information is associated to each point (Rupnik et al., 2014). The MicMac tool (Pierrot-Deseilligny and Paparoditis, 2006) is adopted for the point cloud generation as it has shown to provide good results both in nadir and oblique image blocks.

The algorithms assume that collapsed parts of the buildings differ from the surrounding unharmed parts of the buildings in terms of spectral information and geometry – i.e. rapid texture changes and height jumps (see Figure 1). The obtained dense point cloud is filtered in order to delete the possible blunders and noise generated during the matching process. The off-ground areas are extracted using an iterative regular grid filtering (Nex and Remondino, 2012) and building regions are then defined from the off-ground areas. In this way, points corresponding to buildings can be detected in both point clouds.

On the roof areas, a region growing segmentation is performed in order to detect each roof face of the building and its boundary. As a matter of fact, collapsed building will easily appear more fragmented and irregular. The same process is performed on the oblique point clouds to detect each part of the building façades.

A set of features is then determined for each pixel: spectral information (such as texture variability, presence of lines and repetitive pattern, etc.), depth information (height variation and height variability) and context information (dimension and shape of the segmented regions) will be considered for this task. All these features are integrated in a cost function embedded in a Markov Random Field formulation with the aim of detecting collapsed parts of buildings. The advantage of this formulation is that data terms (given by the extracted features) and neighbourhood smoothness constraints are combined together.

The damages extracted from nadir and oblique data are finally merged together to provide a map of damages.

Figure 1: Generated point cloud in shaded view (a) and corresponding true ortho-photo automatically generated (b): little collapsed parts of the building are visible both from 3D and 2D data (red circles).

In the presented paper, the images acquired over some small towns in Emilia Romagna after the earthquake in 2012 will be processed. Two different typologies of images - only nadir (GSD 7cm, by Vexcel XP) and both nadir and oblique images (10cm GSD_{nadir}, by BlomOblique) - will be considered on the same area to demonstrate the higher completeness provided by multi-camera systems for this kind of applications.

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