EXPERIENCES IN OPTICAL AND SAR IMAGERY ANALYSIS FOR DAMAGE ASSESSMENT IN THE WUHAN MAY 2008 EARTHQUAKE

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1. INTRODUCTION

The Sichuan Earthquake on the 12th of May 2008, and the extensive rescue operations following this tragic event, proved the value of high-resolution optical and radar remote sensing during the emergency response. Optical data provide a fast and simple way to value "at glance" damages while radar sensors can deliver images independent of weather conditions, day and night, and thus in principle can represent a mean to obtain a damage map in the immediate aftermath of an event, providing precious information for intervention planning.

On the other hand, SAR data is far more difficult to interpret than optical data both to the expert and non-expert. Even more so with the advent of new, very-high resolution (VHR) SAR satellites like COSMO/SkyMed and TerraSAR-X; while the features of the former, mid-resolution SAR data provided by satellites like ERS and ENVISAT were quite well known, given the long experience of the scientific community [1], the characteristics of these new data still have to be completely unveiled.

It is a standard procedure to identify damaged buildings by change detection: post-event images are compared to pre-event archive images and differences taken as a clue of the presence of local damage. On the site of Ying Hsiu Wan (Sichuan) we have found a pair of pre- and post- event Quickbird images. The first image is dated 26th June 2005 while the post-event one was collected on the 3rd June 2008. Turning to SAR images, unfortunately in the case of Wuhan earthquake there were almost no former VHR SAR images of the area, because the archives are still nearly empty due to the young age of the VHR systems. Building damage assessment using only post-strike SAR images was thus to be considered. In this paper we will present some hypothesis and experiments we have performed, aimed at damage assessment relying only on post-event images..

2. HYPOTHESIS ON POST-EVENT SAR DATA

The appearance of undamaged buildings in SAR images typically consist of three identifiable areas:

- layover area, with a strong reflection due to double bounce of electromagnetic waves;
- roof area, with a reflection depending on roof roughness, shape and features;
- shadow area, weak reflection

Each of the three areas is expected to show some degree of inherent homogeneity, which is assumed to disappear or at least significantly decrease when the building is sufficiently damaged to change its apparent shape. In this latter case, indeed, the double bounce area is expected to persist only on extant portions of walls, while new corner cube structures are expected to appear within the footprint of the building where cracks in the structure –or even pieces of wall in case of collapse- cause local double reflection of the incoming electromagnetic wave. The resolution currently achievable should allow to discriminate such details. In the case of damaged buildings, thus, a lower homogeneity level is expected. Block-scale assessment seems to be more effective than pixel-level assessment [2] and evaluation will be made at the former level.

3. EXPERIMENTS

5.1. VHR Optical data

A change detection was performed by running two separate classifications, followed by a procedure to reduce the set of classes to just two final classes: "buildings" and "non-buildings". A comparison of the resulting thematic maps highlighted differences, assumed to derive from earthquake-induced damage.

5.1. VHR SAR data

Immediately after the Sichuan earthquake we activated two mechanisms we had available to collect data:

- The Italian Civil Protection Department (Dipartimento della Protezione Civile or DPC) was activated to bring help and support to the stricken population; in this framework EUCENTRE as an "expert centre" of DPC was enabled to access COSMO/Skymed data acquired over the affected area;

- Our research group is entitled to apply for TerraSAR-X data for scientific use following the acceptance of a project proposal connected to urban area mapping submitted in response to a DLR AO

SAR images from the two sources were partly overlapping including the city of Guan Xian (Dujiangyan), hardly hit by the disaster. This was chosen as the experiment site.

The hypothesised co-occurrence texture measures capable of telling homogeneous from inhomogeneous area are various but the closest to the concept expressed in the former section is probably the GLCM (Gray Level Co-occurrence Matrix) homogeneity, which was indeed computed over the images for different sizes of the sliding window. More co-occurrence textures were computed for sake of comparison.

In order to evaluate whether and how the numerical results are correlated to the damage level, we have considered two different damage maps obtained from visual interpretation of SAR [3] and optical data [4], assigning a value to each GT polygon, (e.g. 1=no damage, 2=damage, 3=severe damage). Then we computed correlation between the series of such values and the texture measure values.

4. PRELIMINARY CONCLUSIONS

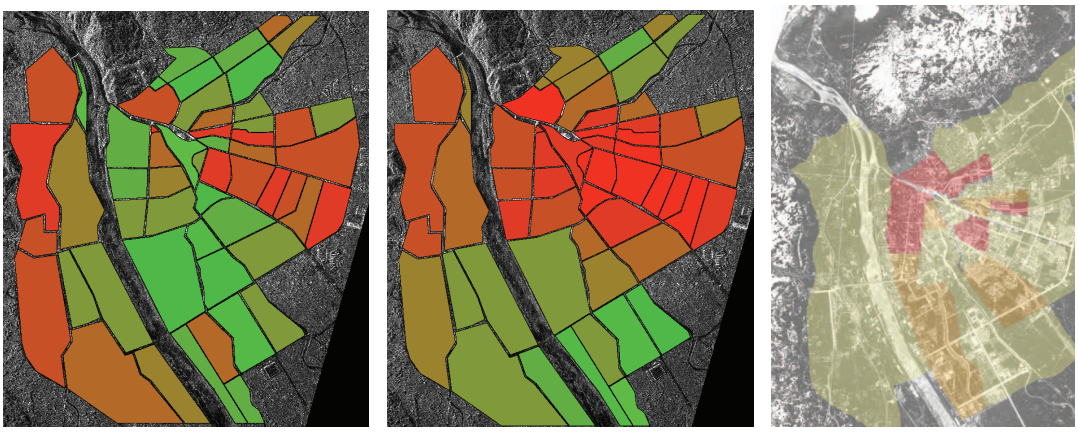

Figure 1: (left) damage map on the TerraSAR-X image, (centre) on the COSMO/SkyMed image, (right) the International Charter ground truth from visual interpretation of a SPOT image.

5.1. VHR Optical data

Preliminary results seem to suggest that the proposed procedure is actually capable of detecting earthquake induced changes to some degree, but a comprehensive assessment of result reliability is still to be performed.

5.1. SAR data

First outputs (see Figure 1) indicate that in SAR images the coefficients expressing correlation with visually interpreted images appeared to be low, but keen to definitely depart from zero if one considers sensible subsets of the polygons; for example by simply splitting the image in two parts with two definitely different average incidence angles, we obtain definitely higher values. Maps show a reasonable structure but fail to agree with the visual interpretation map except on selected subsets.

This suggests that the assumption of a connection between damage and homogeneity is reasonable but needs further assessment and specialisation. In order to really assess the validity of the algorithm, however, an on-site ground truth is necessary, as simple interpretation of medium resolution optical images is not sufficient in our opinion.

5. REFERENCES

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[2] P. Gamba, F. Dell'Acqua and G. Trianni, "Rapid damage detection in Bam area using multitemporal SAR and exploiting ancillary data", IEEE Trans. Geosc. and Rem. Sens., vol. 45, no. 6, pp. 1582-1589, 2007.

[3] http://i0.sinaimg.cn/dy/468/2008/0518/U1565P1T468D69F10665DT20080518001945.jpg

[4] http://www.disasterscharter.org/graphics/dis/CALLID_204/bp_dujiangyan20080516_03.jpg