FUSION OF SAR AND OPTICAL DATA FOR URBAN EXTENT EXTRACTION IMPROVEMENT

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1. INTRODUCTION

Due to urban environment's complexity, a single sensor is not able to comprehensively characterize it in all its multifarious aspects. For instance, optical images have high spatial resolution and a sufficient number of spectral bands, but they are limited by light and atmospheric conditions. Radar images provide information about geometry and orientation of structures, such as terrain topography, thickness and roughness of surface cover; due to their all-weather capabilities, they allow a continuous acquisition, without any limitation, but they suffer from speckle noise. Hyperspectral imagery, instead, can resolve the finest spectral details, but spatial resolution cannot be sufficient and the management of a large amount of data could be onerous. It is straightforward that each RS sensor shows advantages and drawbacks with respect to others, and, moreover, what can be an advantage for some applications could be even a drawback for some others. Therefore, since now, many image fusion algorithms have been proposed [1-2], all aiming at obtaining superior properties by merging different data with different capabilities. They have demonstrated the effectiveness and advantages of data fusion techniques, so that the use of multiple data sets for urban area characterization will be one of the key factors from both academic and commercial perspectives for the foreseeable future [3]. To this end, technological developments and the availability of a variety of sensors have opened new perspectives for the solution of existing problems.

2. PROPOSED FUSION PROCEDURE

The proposed procedure is constituted of two phases, which is built over the procedure proposed in [4] and based on SAR data only.

SAR contribution. The first part of the chain in [4,5] addresses the extraction of bright objects (hot spots) - that potentially represent built-up features - from SAR data: starting from the autocorrelation indexes and after a 'density analysis' for the reduction of false alarms, a 1st level map providing high-probability objects is carried out. This map is not enough detailed for an accurate description of the actual urban extents, so that the employment of textures is mandatory. The GLCM matrix computed over a SAR image has provided good results, as variance and correlation are good descriptors of urban area statistics, but also the introduction of homogeneity derived from the optical sensor improves the discrimination capability.

Optical contribution. From a PAN image of the selected area GLCM is computed and the 'Homogeneity' feature is used to improve the capability of the method to determine the correct extent of the urban areas, as it takes into account the typical tonal variations (low homogeneity) that mark built-up areas. This means that the thresholding step introduced in [6] to select high values of Correlation and Variance, is now replaced by the selection of low values throughout the double-thresholding 'Homogeneity' image. Therefore, the whole processing chain needs a further point where the NDVI computation is carried out in order to mask all those vegetation areas that could be erroneously included in the final output. According to the algorithm in [6], the texture mask is used within a 2nd "Density Analysis" step - where objects containing a small number of hotspots are discarded - and finally the two intermediate built-up maps found with both L.I.S.A. and GLCM are merged together into a unique output morphologically filtered.

3. EXPERIMENTAL RESULTS

The methodologies have been tested on the two locations already presented, Pavia, Italy and Al Fashir, Sudan, in order to point out and stress any differences and/or improvements brought by the fusion technique. First the results of each procedure are shown, then compared to those achieved in the previous chapters. The couple of images used for the Al-Fashir test site is made of an ALOS PALSAR image at 6.25 m resolution and a SPOT-5 PAN image at 2.5 m resolution. Again, the SAR resolution is compatible with the output map scale, so we needed to downscale and coregister the optical image. Although the algorithm requires MS data, in this case the employment of PAN image (this means that the NDVI could not be computed) does not bring significant accuracy loss, since the particular arid environment enables a clearer separation between built-up areas and background only by means of textures. The final result is proposed in fig. 1, while in table 3.2 quantitative results reported. The overall accuracy is impressively high (more than 97%), as well as the K-coefficient (around 0.85). The inclusion error is basically absent, only 2%, and we have limited omission errors, mainly due to the absence of hotspots in the SAR image and/or the discarding policy of the algorithm that removes small objects.

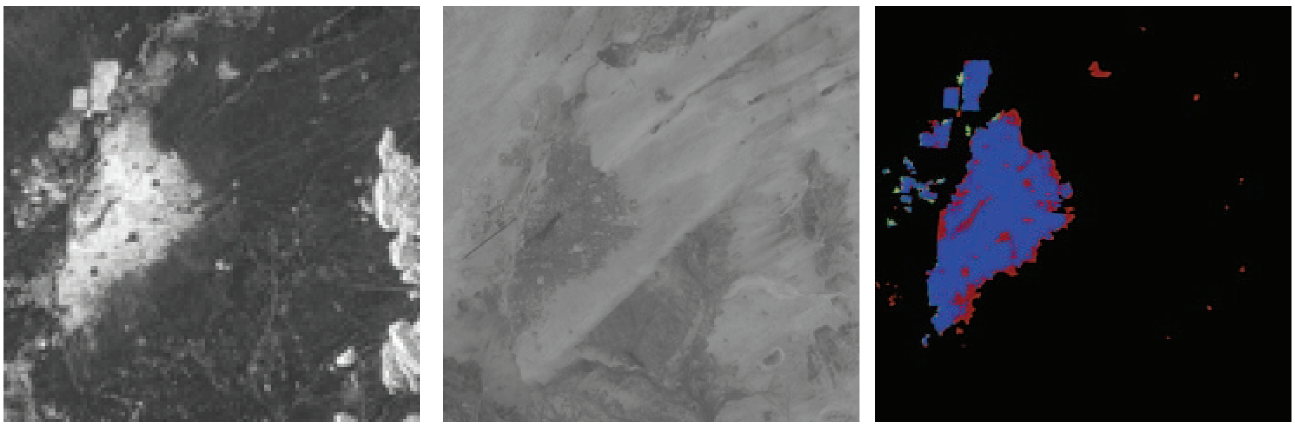

Fig.1: (a) Original ALOS and (b) SPOT image for the Al-Fashir test case, and (c)the fusion human settlement extraction results.

11. REFERENCES

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