Land-Use Land-Cover Classification of SAR Images by Means of Segmentation Techniques exploiting Ancillary Optical Data

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Many recent works proposed in literature show an increasing interest in using SAR image for human settlements expansion monitoring especially in those countries where cloud cover, haze and smog may prevent a consistent optical images acquisition. Even though there is a quite general consensus in pointing at SAR as the possible solution for this issue, and spatial analysis is usually preferred to single pixel one, paving the way to new algorithms and theories, there is less agreement on general methodologies for human settlements extents extraction in large geographical areas. Moreover, only a few algorithms are devoted to land-use land-cover (LU/LC) classification using SAR and in most of the cases they are based on polarization signatures, a feature which rely more on the physics of surface scatterers than on the effective land use. The works we propose are aimed at studying the Chinese environment in terms of LU/LC using SAR images at high resolution and it is based on two different phases. At first, human settlements extents are extracted using an algorithm called BuiltArea, based on three Local Indicators of Spatial Association and two textural features [1]. The algorithm is, to some extent, sensor and resolution independent and provides a binary image where built-up areas are represented as white pixels on a dark background. The second phase is devoted to the classification of urban areas in terms of three different land uses according to CORINE [2] nomenclature and to those typical of Chinese environment. The classification procedure is primary based on image segmentation techniques in order to encode statistical homogeneous areas as independent regions: the aim is to classify each aforementioned region as a single land-use thanks to the similar statistical behaviour which characterize each land-cover. The followed criterion is the a-majority one, selecting as the region representative class the one which the majority of the pixels in that region belongs.
After the 2010 Symposium held in Guilin (China) the research continued in two different but complementary ways. At first, three different segmentation techniques, based on different methodologies, have been compared in order to establish which segmentation approach is more suited for SAR images. The Canny edge detector and region merging techniques used in the first analysis were than compared with other two algorithms, specific for remote sensing data segmentation: the Berkeley University "BIS"[3] and the P.R. Marpu [4] algorithms. The first one is an object-based image analyzer algorithm, where compactness, shape and scale parameters may be adjusted in order to obtain the desired level of segmentation. On the contrary, the other algorithm is based on a graph theoretic approach together with a region growing technique where the graph is used to guide the merging process. The conducted analysis, based on ENVISAT/ASAR images of Shanghai and Beijing cities, have shown that higher accuracies are obtained using the Marpu Algorithm, followed by the ImgSeg and Canny edge approaches.
The second part of this research is mainly focused on the fusion of SAR and optical information, exploiting optical multispectral data provided by sensors onboard of Chinese Beijing-1 and HJ1 satellites, launched in 2006 and 2008 respectively with EO, disaster monitoring and urban development tasks. In particular, the idea is to perform the segmentation task on the optical images, taking advantage of the characteristics of the segmentation algorithms, originally conceived for optical data. Moreover, even if optical images acquired on the same area of the SAR sensor may not always be available, and considering the fact that segmentation algorithms provide a blocks-level subdivision of the image and this is a urban feature which almost never changes, also dated optical images may be employed for this tasks, easing the entire procedure. Results show that the segmentation provided by optical data together with a minimum distance supervised classification applied to the SAR image, lead to a better discrimination between classes in terms of accuracies evaluated with the confusion matrix. It is also worth to consider the fact the all the analysis performed have been validated with ground truths extracted on optical images by means of shapefile extraction, subsequently superimposed on SAR images.

[1] P. Gamba and M. Stasolla, "Spatial indexes for the extraction of formal and informal human settlements from high resolution sar images," IEEE Journal of Special Topics on Applications of Remote Sensing, 2008.
[2] http://www.eea.europa.eu/publications/COR0-landcover
[3] http://berkenviro.com/berkeleyimgseg/
[4] P. R. Marpu, "P. R. Marpu, "Geographic object-based image analysis," Ph.D Thesis, 2009.