TOWARDS FULLY AUTOMATIC GENERATION OF LAND COVER MAPS FROM POLARIMETRIC SAR DATA

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1. INTRODUCTION

Ongoing SAR missions are already providing a large amount of multi-polarization or polarimetric data and more are expected in the next future from new planned missions. Such a scenario suggests fully automatic procedures for mining and effectively exploiting the information embedded in the polarimetric images, especially when multi-temporality is involved. Processing multi-polarization data for classification purposes has been carried out by a variety of supervised algorithms which span from Bayesian Maximum Likelihood to Fuzzy Logic to Support Vector Machines to Multi-Layer Perceptrons (MPL). A training phase carried out under human supervision is usually required by these procedures, thus preventing them from running in a fully automatic mode. To tackle such a crucial issue, the chaining of unsupervised and supervised modules may be considered. In particular, the unsupervised processing stage may rely on the so called Self Organized Maps (SOM) algorithm [1], which produces a self-organizing feature map where specific information is associated with each node position.

2. METHODOLOGY

This study proposes a novel fully automatic approach for producing pixel-based land cover maps from polarimetric SAR images. The method is based on the unsupervised implementation of a pre-processing phase followed by four steps. After calibration, taking into account the variability of the local incidence angle, a new multi-dimensional image is synthesized from the SLC polarimetric data by attributing a 9-component vector to each pixel. Indeed, Hoekman and Vissers demonstrated that the polarimetric properties of a target can also be expressed by nine independent single–polarization observables [2]. The 9-component image is subsequently processed in an unsupervised way according to the following scheme: first, a clustering algorithm is applied, then the clusters are singled out and labelled according to their electromagnetic scattering properties; the third step automatically selects representative pixels, which are finally used to generate the map by an unsupervised classification technique. In the first step a self-organizing network transforms the 9-dimensional image into an organized two-dimensional map, step 2 makes automatic use of results from canonical scattering models to interpret the two-dimensional map [3], step 3 computes and uses the statistical distributions of backscattering within the pixels belonging to each cluster, while step 4 exploits either an MLP Neural Network [4] or a Maximum Likelihood [5] algorithm.

3. EXPERIMENT AND RESULTS

Two different data sets relative to two sites and two radar frequencies have been used. A first case study refers to the polarimetric images acquired by the C-band RADARSAT-2 instrument over the test area of the Frascati-Tor Vergata University Campus, South-East of Rome, Italy, on 25 August 2008. The second case study considers the polarimetric L-band images taken by ALOS PALSAR over the coastal town of Nettuno, Italy, on 11 May 2007. Each specific implementation of the fully automated processing chain aimed at discriminating among the three canonical scattering mechanisms present in each area: surface scattering, volume scattering and double bounce. The separation among targets characterized by a prevailing electromagnetic behavior of these basic types are intended for a fast discrimination among coarse land cover types, e.g., bare soil or short vegetation, forests or tall vegetation, urban areas, respectively.

Fig. 1 shows the classified map (bottom) of the Tor Vergata test site yielded by the described automatic scheme, together with the RADARSAT-2 backscattering amplitude at hh polarization (top). Pixels attributed to the double bounce scattering type are represented in yellow, those classified as surface scattering are in red, while volume scattering pixels are green. The map hints at the potential of the technique in classifying polarimetric SAR data automatically. Indeed, as an example, a check against both intensive and extensive ground truth indicates that most of the buildings in the region of interest correspond to pixels with a double-bounce mechanism. The corresponding confusion matrices yielded by two chained approaches, i.e., SOM+NN and SOM+ML are reported in Table 1. The matrices have been computed on a set of 2610 ground-truth pixels, by associating buildings to double bounce, bare soil/short vegetation to surface scattering and tall vegetation to volume scattering. The table indicates that the SOM+NN method, with 96.5% overall accuracy, outperforms SOM+ML (88.9%). It is interesting to note that an exercise carried out using a straightforward supervised classification MPL algorithm on the same data set yielded an accuracy of 84.7%, hence lower than those of both unsupervised approaches. The results obtained in classifying the ALOS imagery on the Nettuno area show a similar behavior .

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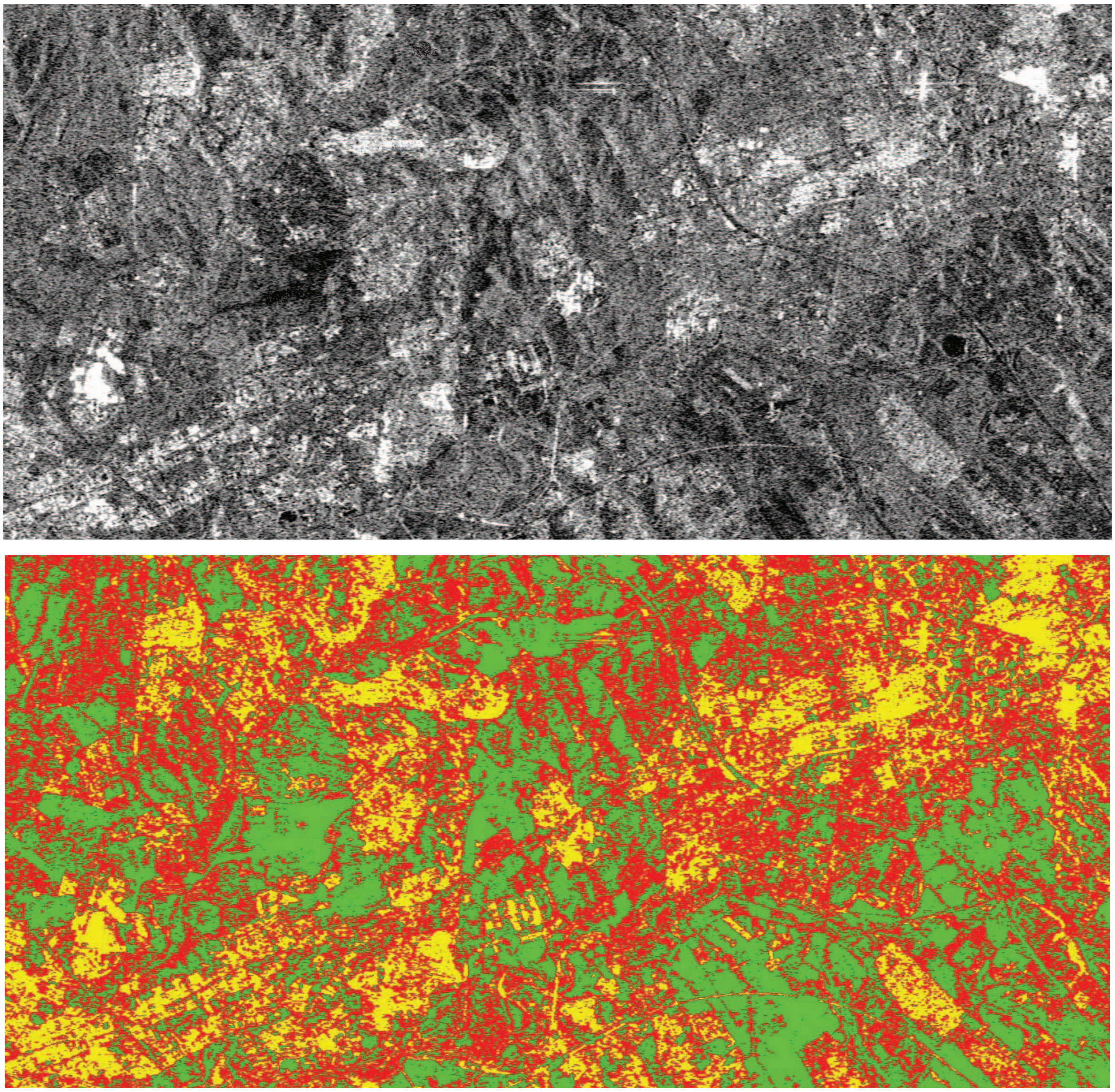

Fig. 1: Backscattering intensity at hh polarization imaged by RADARSAT-2 (top), and SOM+NN classified map (bottom). Yellow, double bounce; red, surface scattering; green, volume scattering.

Classified as	True		
	Volume	Surface	Double
Volume	91,5	0	8.8
Surface	1.8	100	0
Double	6.7	0	91.2

Classified as	True		
	Volume	Surface	Double
Volume	86.1	0	14.6
Surface	5.9	100	0.5
Double	8	0	84.9

Table 1. Confusion matrices (percent values) of classification reported in Fig. 1 for two unsupervised classification schemes, including: SOM and NN (left); SOM and ML (right).

4. References

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