Use of Neural Networks for Automatic Classification of SAR imagery.

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ABSTRACT

In the past two decades, the rapid expansion of urban centers associated to the increase of population and mass migrations resulted in the growth of already existing urban settlements. The global view of urban areas makes satellite missions a valid instrument for updating urban maps and carrying out the analysis of settlement dynamics. Remote sensing in the optical band is a well established tool for producing maps of urban land use and monitoring changes, but it can suffer from atmospheric limitations, especially where clouds systematically occurs or when unpredictable abnormally long periods of cloud cover affect usually clear-sky regions. Hence, when a systematic, timely and reliable survey of an urban area is required, the use of SAR imagery might become suitable or even necessary. The C-band SAR data provided in the past decade by ERS-1 and ERS-2 and currently by ENVISAT, are systematically available at relatively low price. Together with LANDSAT, they provide a long term history of the urban areas, hence their value should not be overlooked. In particular, the long ERS SAR image time series provide a unique systematic means of periodically tracking, retrieving and understanding the frequently dramatic changes undergone by the land cover of large cities in many parts of the world in the past 15 years. Our study area includes the city of Rome, Italy, and its outskirts for an overall extension of about 836 square kilometers. We used a set of SLC SAR images acquired by the ERS-1 and ERS-1/2 tandem mission in three years, 1994, 1996 and 1999, with 5 acquisitions each year.

This study contributes an assessment of the potential of single-parameter SAR images in classifying land cover within and around large urban areas. Careful selection and suitable processing are required to exploit the various pieces of information embedded in both the amplitude and phase of the radar return and in its time-space behavior. The time-average amplitude of the backscattering coefficient and the degree of interferometric coherence corresponding to the late winter-early summer seasonal variations of both parameters are used together with two textural parameters of the radar amplitude image. This set of 6 parameters is exploited to discriminate among seven relevant urban/sub-urban classes, including water surfaces, agricultural land, woodland and parks, asphalted/concrete surfaces, isolated large man-made structures, and continuous high/low density residential areas. The decision-making process is performed by a classifier based on a Neural Network (NN) algorithm, which is known to show a considerable ease in using multi-domain data sources. The information extracted from the
SAR images is fused and processed by a Multi-Layer Perceptron (MPL) neural network to produce land cover maps. The network topology has been carefully designed paying special attention to the number of hidden units by using pruning algorithms. Initially we considered the case of designing a single neural network for each image to be processed. In this situation the network is trained with sets of pixels selected from the image and statistically significant to represent the classes to be distinguished. In a second step we developed a more robust architecture, trained with pixels extracted from more images, but able to provide the classification also of images not considered at all in the training phase. In this latter mode the neural network becomes a powerful fully automatic tool to perform the classification even on large collections of satellite images.