An analysis on the contribution of the phase component in scene class recognition in TerraSAR-X scenes

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Traditional approaches for SAR image classification and target recognition in high resolution acquisitions discard phase information and are solely based on the detected data. Most common methods for SAR image descriptor computations are based on GMRF, Gabor filters, GLCM, first and second order statistics, or use of cumulants. Most of the descriptors are adapted versions of image features employed in optical and multimedia image processing, regardless of the data content or sensor. Therefore, the natural approach to be used when switching to SAR data is to discard the phase information and emulate an optical image by keeping only the energy in the SAR signal, in order for the employed parameters and features to preserve their physical meaning and validity. The choice of the method of computation of the descriptors depends in any case on the resolution of the data. Pixel based approaches are more suitable for low and medium resolution, while patch based approaches have become the benchmark for high resolution image processing, since the heterogeneity of the data increases and the context becomes important. While the choice of this approach is valid and gives good results (up to 90% classification accuracy or higher when the classes are highly separable in the feature space) even for high resolution SAR data, one must not ignore the fact that the SAR acquisitions are coherent. SLC SAR images are complex signals, with special spectral characteristics. This is one reason why traditional methods for image processing cannot give good results if applied directly on SLC data. Spectral based approaches which exploit the full complex signal are the alternative. SLC image phase is, with a good approximation, uniformly distributed. Moreover, the Fourier spectrum of any SLC image has a holographic property, allowing for the image to be reconstructed, at lower resolution, from any region of the spectrum, the number of samples in the region dictating the resulting resolution. These observations led to the conclusion that phase can be discarded when computing image descriptors. However, this is not the case when one makes use of several SLC image acquisitions. The phase variation from one acquisition to another is the main source of information in interferometric processing. Not only that phase becomes less random, but it describes the changes that occur on the received scene reflectivity. In the hypothesis that two successive acquisitions are taken on a stationary scene (tandem acquisitions), combined information from these data can be employed to describe the scene content. Thus, we propose the usage of spectral based descriptors that make use of the full complex signal from two or more SLC acquisitions to construct robust image descriptors. We propose a method for feature definition and extraction which combines single SAR acquisitions with interferometric information. The experiments show that the interferometric information can be very valuable for the recognition of coherent targets, increasing the recognition rate. Our approach relies on the estimation of the SAR image spectra, from which features are derived in two stages: the estimation of the model order and the extraction of the most relevant descriptors. The set of descriptors is extracted from the complex spectrum of the SAR image, using a spectral decomposition method. We consider the problem of estimating the parameters of complex-valued two-dimensional sinusoidal signals observed in noise. Our approach considers not just isolated objects but also takes into account the complexity of high resolution urban scenes, where there is a large variety of structures, which can be best understood in their context. This is why we propose to extract the feature vectors from image patches which cover a relevant area on the ground (200x200m), compared to the object size. Experiments are performed on data acquired in the context of scientific proposals LAN1613, MTH1628, and OTHER0502.