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A SVM-Based Three-Dimensional Multi-Resolution Approach for Biomedical Inverse Scattering Problems

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In the last few years, microwave imaging techniques have been successfully used to provide the spatial distribution of tissues. In particular, because of the significant contrast of the dielectric properties between the normal tissue and the malignant tissue at microwave frequencies, microwave methods seem to be very promising diagnosis methods for the early cancer detection [1]. The cancer detection problem can be reformulated in terms of an inverse scattering one where the problem unknowns (i.e., the presence, the position, its dimensions, and the characteristics of the malignant region) are obtained starting from the measurement of the electromagnetic interactions between the biological specimen under investigation and a probing electromagnetic source. However, although inverse scattering methods are very promising, unfortunately their practical application is strongly limited by the need of 3D reconstructions, high spatial resolutions, and fast processing. An alternative to use inverse scattering techniques lies in considering learning by example techniques. In such a case, the detection problem is reformulated into a classi?cation one, where the data (i.e., the measures of the scattered field collected in an external spatial region called observation domain) and the unknowns (i.e., the geometrical and dielectric characteristics of the malignant tissue) are related by means of a transfer function estimated through an on-line procedure called training phase. The approaches based on neural networks (NN) [2] and support vector machine (SVM) have been satisfactorily applied in various and complex electromagnetic problems. In this paper, an integrated strategy based on a SVM classifier and on an iterative multi-zooming procedure is proposed. After the training procedure, which can be performed once and on-line, the geometrical and dielectric characteristics of the malignant region are estimated in real time and with a limited amount of computational resources. In particular, a succession of approximations of a probability map of the presence of malignant tissue is determined starting from the same training set. At each step, the spatial resolution is increased in a limited set of spatial regions (called "regions of interest", ROIs) defined at the previous zooming step and characterized by a greater value (with respect to the remaining part of the investigation domain) of the occurrence probability of a malignant tissue. The multi-step procedure is stopped when a detailed spatial reconstruction is reached in the ROIs. Because of the favorable trade-off among computational complexity and spatial resolution, the proposed method seems to be suitable for real time detection of cancer regions. Therefore, to preliminary assess the effectiveness and the potentialities of method, a large number of numerical experiments has been performed and a representative set of results concerning different kind of patologies both in noiseless and noisy conditions is reported and discussed.

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