STATISTICAL AND ANALYTICAL TECHNIQUES IN SYNTHETIC APERTURE RADAR IMAGING

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ABSTRACT

In synthetic-aperture radar (SAR) imaging, a scene of interest is illuminated by electromagnetic waves. The goal is to reconstruct an image of the scene from the measurement of the scattered waves using airborne antenna(s). This thesis is focused on incorporating statistical modeling into imaging techniques. The thesis first considers the relationship between backprojection in SAR imaging and the generalized likelihood ratio test (GLRT), a detection and estimation technique from statistics. Backprojection is an analytic image reconstruction algorithm. The generalized likelihood ratio test is used when one wants to determine if a target of interest is present in a scene. In particular it considers the case when the target depends on a parameter which is unknown prior to processing the data. Under certain assumptions, namely that the noise present in the scene can be described by a Gaussian distribution, we show that the test statistic calculated in the GLRT is equivalent to the value of a backprojected image for a given location in the scene.

Next we consider the task of developing an imaging algorithm for extended targets embedded in clutter and thermal noise. We consider the case when a fully polarimetric radar system is used. Also note that we assume scatterers in our scene are made up of dipole scattering elements in order to model the directional scattering behavior of extended targets. We formulate a statistical filtered-backprojection scheme in which we assume the clutter, noise, and the target are all represented by stochastic processes. Because of this statistical framework we choose to find the filter which minimizes the mean-square error between the reconstructed image and the actual target. Our work differs from standard polarimetric SAR imaging in that we do not perform channel-by-channel processing. We find that it is preferable to use what we call a coupled processing scheme in which we use all sets of collected data to form all elements of the scattering matrix. We show in our numerical experiments that not only is mean-square error minimized but also the final signal-to-clutter ratio is reduced when utilizing our coupled processing scheme.