AN INVERSION ALGORITHM APPLIED TO SAR DATA TO RETRIEVE SURFACE PARAMETERS

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Abstract

Rough-surface inversion has significant applications in interpretation of Synthetic Aperture Radar (SAR) data obtained over natural surfaces. By utilizing the appropriate scattering model, it may be possible to retrieve surface parameters such as roughness and dielectric constant (or moisture content). Since the pixel size in SAR data is much larger than even the longest radar wavelength, each SAR image forms too sparse a data set to be used in performing inversions based on numerical scattering models. The alternative is to use parameter estimation techniques based on approximate analytical or empirical models. The development of the inversion algorithm thus involves choosing an applicable scattering model and an appropriate estimation procedure.

Here, we will focus on inverting polarimetric, multifrequency synthetic aperture radar (SAR) data obtained over areas of bare soil and agricultural land. We use the SAR data from Fresno, California as an example, since extensive ground-truth data in the form of surface roughness and moisture content at several depths are available for this site. This will enable us to validate our final inversion results. We assume that the surfaces deviate only slightly from smooth surfaces, and thus use a small perturbation model (SPM) to express the backscattering coefficients of the rough surface in terms of its permittivity, rms surface height, and correlation length. Only the copolarized terms are retained. We utilize measurements at all three AIRSAR frequencies (P-, L-, and C-bands). The algorithm used to estimate the surface parameters is based on a nonlinear least-squares criterion. This is an iterative method, and allows for simultaneous inversion of all parameters. The least-squares optimization methods are widely used in estimation theory (Luenberger, *Optimization by Vector Space Methods*. New York: Wiley, 1968), but an additional concern for SAR applications is incorporating the stochastic nature of the unknown parameters and the data into formulation, which will be discussed in detail. Several least-squares minimization methods, including the gradient and the preconditioned conjugate gradient methods are discussed. Synthetic data are used to validate the inversion results in each case. Finally, the algorithm is applied to the Fresno polarimetric SAR data. Results will be shown and compared to the ground-truth measurements. The strength of this approach to inversion of remotely sensed data is that it can be easily modified for use with any scattering model, not only the small perturbation solution, without changing the inversion algorithm.

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