ESTIMATION OF RADIO REFRACTIVITY FROM RADAR CLUTTER USING BAYESIAN MONTE CARLO ANALYSIS

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In sea-borne radar applications the radio refractivity can vary considerably with both height and range, heavily affecting the propagation characteristics. One of the most extreme examples is the formation of an electromagnetic duct, where a horizontal or near-horizontal signal sent from a surface or low altitude source will end up being totally trapped within the duct. In such cases, the precise knowledge of the radio refractivity is essential in interpreting the returned radar signal.

This paper describes a Markov Chain Monte Carlo sampling approach for the estimation of not only the radio refractivity profiles from radar clutter but also the uncertainties in these estimates. Similar to the previous papers that worked on the Refractivity From Clutter (RFC) problem, it is based on the Bayesian formulation. The difference is that, instead of treating the problem as a global optimization problem, it uses unbiased Markov Chain Monte Carlo (MCMC) sampling techniques, like Metropolis and Gibbs sampling algorithms, to gather more accurate information about the uncertainties. Application of these techniques using an electromagnetic split-step fast fourier transform parabolic equation propagation model within a Bayesian framework can provide the true unbiased values of means, variances and posterior probability distributions of the estimated parameters. They are computed by taking multi-dimensional integrals of the posterior probability density (PPD), which can easily be accomplished by a MCMC sampling method. MCMC is selected because it provides unbiased sampling of the PPD, unlike global optimizers like genetic algorithm, which usually over-sample the peaks of the PPD and introduce a bias. Estimated parameters and their uncertainties are compared not only with the exhaustive search results but also with genetic algorithm results and helicopter refractivity profile measurements. Although MCMC is slower than global optimizers, the probability densities obtained by this method are closer to the true distributions.

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2. F - Wave Propagation and Remote Sensing

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