Parameter Estimation for the Frequency-Dependent Scattering Center Model Using the RELAX Algorithm

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The characterization of electromagnetic scattering from a complex target over a broad frequency band can be a computationally expensive task. Using a frequency domain solver, the electromagnetic boundary value problem must be solved one frequency at a time. One means of decreasing computation time is to use model-based parameter estimation (MBPE), whereby a mathematical model that matches or approximates the expected physical results can be used to take fewer samples of an observed output and interpolate unknown samples via the model.

The scattering center model, which consists of a complex exponential series of frequency with complex amplitude coefficients, is a standard model for high-frequency scattering from complex targets. Furthermore, the geometrical theory of diffraction predicts a frequency dependence in the aforementioned amplitude term, which is known only for certain canonical shapes. Models with and without this frequency dependence have been considered for various radar signature applications. For broadband interpolation, the frequency dependence is deemed very important. The extraction of the frequency dependence in the model has been reported by a number of researchers (e.g. A. Moghaddar, Y. Ogawa and E. K. Walton, *IEEE Trans. Antennas Propagat.*, 10, 1412-1418, 1994. R. Moses et al, *Proc. Image Understanding Workshop*, Pacific Grove, CA, 1998). The situation considered in those works is from the feature extraction perspective, where a densely sampled data set is available. However, our interest here is the case of an extremely undersampled data set in order to achieve computational savings.

In this paper, we apply the RELAX algorithm (J. Li and P. Stoica, *IEEE Trans. Sig. Proc.*, 2, 281-295, 1996) to extract the model parameters in the frequency-dependent scattering center model. RELAX is an enhanced CLEAN algorithm that redistributes the energy of the identified scatterers, or relaxes their parameter values, through an iteration process. It relieves the error propagation tendencies in CLEAN at the expense of more computational effort. From numerical test examples, we find that the accurate extraction of the frequency-dependent terms is the most difficult. This observation is consistent with previous findings reported by Moses et al, who computed the Cramér-Rao bounds on the model parameters. RELAX significantly outperforms CLEAN in this regard. As a result, the RELAX algorithm provides a further reduction in the number of sparse frequency samples needed to represent the scattering data than CLEAN. Results for hypothetical examples and actual computational electromagnetics data are reported.