Efficient Method of Moments Approach for Propagation Over a Rough Surface

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Predicting electromagnetic (EM) propagation over terrain or sea surfaces is essential in many practical areas. EM rough surface scattering is of sufficient complexity that a robust analytic solution has yet to be discovered. Hence to solve such a problem it is often necessary to turn to numerical methods. Traditional numerical electromagnetic codes based on the method of moments would require a sample spacing of approximately $\lambda/8$, where λ refers to the incident field's wavelength. This requirement places a limitation on the size of the problem that can be solved, even for recent more efficient algorithms.

A method of moments algorithm seeks to solve the field integral equations by assuming the unknown current embedded in the integral can be expanded into a series of basis functions. The sampling requirement is necessary to minimize the error in the series representation from the actual current. If the actual current were a relatively smooth varying function on the surface then fewer basis functions would be needed, which means fewer points per wavelength. The parabolic wave equation method suggests that surface currents should be slowly varying on rough surfaces containing only large-scale features if the incident field phase is removed. Thus, as in (Voronovich and Zavoronty, *IEEE Trans. Geosci. Remote Sens.*, **38**, 366-373, 2000), the following form shall be assumed for the currents

$$J\left(\vec{\rho}\right) = \sum_n c_n e^{j\vec{k}\cdot\vec{\rho}} p_n\left(x\right)$$

where the $p_n(x)$ represent pulses define to be unity on the n^{th} segment of a rough surface divided into N pieces and zero elsewhere. The vector $\vec{k}$ is the incident wave vector $\vec{\rho}$ and is the cylindrical spatial coordinate, while x is the rectangular spatial coordinate. Using this choice for the basis functions it is possible to get accurate representation for the currents while sampling the surface much more sparsely. It is necessary, however, to perform integrations to obtain the matrix elements, and then proceed to invert the matrix either iteratively or directly.

Results from a numerical code will be used to observe propagation effects on electromagnetic signals over both terrain and sea surfaces. Analysis of this method's efficiency as compared to other approaches will also be discussed.