Electromagnetic Scattering Analysis from the Terrain Profiles Using BiConjugate Gradient Method

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Many propagation models have been introduced in the last three decades. Geometrical theory of diffraction (GTD) is a high frequency based method and concerns the wedge diffraction of the objects. Although the computed results using this method agree well with the experimental data, modeling the terrain profile is very complicated resulting a considerably long computation time. Another proposed approach is the parabolic wave equation (PWE) depending on the Helmholtz equations. This method provides fast computational analysis at the cost of accuracy such that it gives importance to the forward propagating fields and neglects the backscattered ones. An alternative propagation model is an integral equation (IE) method that is based on a method of moments (MoM) formulation. An IE is formed by applying the boundary conditions on the scattered surfaces and is solved via MoM. However, MoM type solutions suffer from both storage and CPU time requirements, since a very large number of unknowns N is required for the recognition of the terrain profile of interest. The conventional MoM requires an operation count of $O(N^3)$ for matrix inversion, whereas iterative techniques such as Bi-Conjugate Gradient (BiCG) have a computational complexity $O(N^2)$ for matrix-vector product per iteration. In order to reduce the computational cost and storage requirements, a novel scheme, named novel spectral acceleration (NSA) is proposed, (J. T Johnson and H-Chou, *Radio Science,* vol. 33, no. 5, 1277-1287, 1998) which accelerates the matrix-vector products and is based on the spectral representation of 2D Green's function. Although NSA is well suited for the forward backward method (FBM) that it proceeds the forward and backward sweeps of the propagating fields, it can also be used in any standard iterative method like BiCG algorithm.

The purpose of this study is to obtain an efficient and accurate simulation tool that can handle wave propagation over the terrain profiles in the rural areas. For the reliability, the results will be compared with ITU-R 1546 curves scanning a distance from 1 to 1000 km. The numerical algorithm is based on BiCG method in conjunction with NSA so that the operation count is reduced to $O(N)$**.** Some preliminary results for slightly rough surfaces with height deviations small compared to λ_0 (λ_0 being the free-space wave length) are given and compared with a conventional MoM approach (λ_0 = 1m & pulse width = λ / 10). Results to more general terrain profiles and their comparisons with the measurements will be presented at the conference. The aim is to reach large distances at UHF / VHF bands. This study on the terrain profiles has also been treated in the literature (J. A. Lopez, M.R. Pino, F. Obellerio, and J. L. Rodriguez, *J. Electromagn. Waves and Appl.,* vol. 15, no. 8, pp. 1049-1074, 2001) with FBM but BİCG has never been applied to such a system. Although the number of iterations to reach to the exact solution is larger than the FBM, BiCG is more robust in many situations and endures divergence problem. Especially in transverse electric (TE) case, the residual error stays fixed after a few iterations for FBM. BiCG, however, still decreases the error at each iteration**.**