Accelerating Solution of Rough Surface Scattering Problems by using the UV Technique in conjunction with the Characteristic Basis Function Method and the Adaptive Cross Approximation

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In this paper the UV technique (L. Tsang, D. Chen and P. Xu, Radio Sci., Vol.36, RS5010, 2004) is introduced to accelerate the Combined Characteristic Basis Function Method (CBFM) and the Adaptive Cross Approximation (ACA) method for the problem of scattering from rough surfaces. The application of Method of Moments (MoM), based on RWG basis and Galerkin approach, to the electric field integral equation (EFIE) leads to a dense linear system. The mutual-impedance elements can be obtained by calculating the following four scalar integrals (H. T. Chen, J. X. Luo and G. Q. Zhu, Microw.Opt.Techno.Lett., Vol.48, 1615-1618, 2006)

$$I^{m\pm n\pm}=\int_0^1\int_0^{1-\eta}\frac{e^{-jkR_m^\pm}}{R_m^\pm}d\xi d\eta;I_\xi^{m\pm n\pm}=\int_0^1\int_0^{1-\eta}\xi\frac{e^{-jkR_m^\pm}}{R_m^\pm}d\xi d\eta;I_\eta^{m\pm n\pm}=\int_0^1\int_0^{1-\eta}\eta\frac{e^{-jkR_m^\pm}}{R_m^\pm}d\xi d\eta;I_\zeta^{m\pm n\pm}=I^{m\pm n\pm}-I_\xi^{m\pm n\pm}-I_\eta^{m\pm n\pm} \quad (1)$$

The advantage of the four scalar integrals in (1) is that their integrands vary smoothly with the separation distance between the source and field points, which enables us to directly implement the UV technique. It is well known that the number of blocks in CBFM should be kept low and that the number of unknowns per block should be increased to achieve a higher compression rate (L. Laviada, F. L. Heras and R. Mittra etc., IEEE Antennas Propag., vol.56, 784-791, 2008). However, choosing large blocks makes step of generating the Characteristic Basis Functions (CBFs) very time- and memory-consuming, and Multilevel CBFM (MLCBFM) has been proposed to mitigate this problem. By using UV technique, the computational time and memory complexity required by the generation step are decreased from $O(B\widetilde{N}_{RWG}^2)$to $O(B\widetilde{N}_{RWG}\log\widetilde{N}_{RWG})$, where B is the number of blocks and $\widetilde{N}_{RWG}$ is the average number of RWG in each block. The objective of the proposed CBFM/ACA/UV hybrid method is similar, and we follow the MLCBFM strategy but without generating either the CBFs or the reduced matrix in the lower level (two-level domain decomposition policy is normally adopted for MLCBFM). Fig.1 summarize all the steps involved in the proposed method. Fig.2 shows a validation result for one realization of an $8\lambda\times8\lambda$ rough surface.

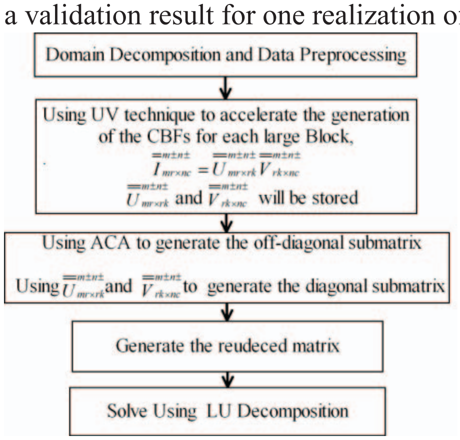

Fig.1. Flowchart of the proposed method

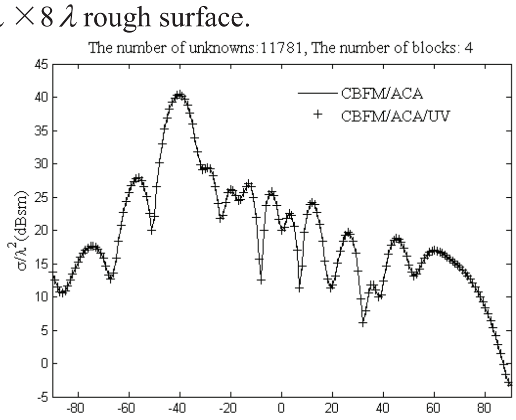

Fig.2. Validation result