Fast Solution of Scattering Problems with Tensor Train Accelerated Method of Moments on Structured and Unstructured Meshes

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It was shown that the impedance matrix resulting from the Method of Moments (MoM) discretization of the integral equations can be represented as a product (train) of the matrices (tensors) of smaller dimensions (Oseledets, Tyrtyshnikov, Lin. Alg. Appl., 2010). Such tensor train (TT) decomposition of the MoM matrix results in great reduction of the memory used for its storage when matrix sizes become large. It can also drastically reduce the CPU time required for multiplication of the matrix by vector or even evaluation of its inverse in some special cases. The fast direct solution of the TT-decomposed MoM matrix equation is limited to the case of voxelized MoM discretizaitons of the volume integral equation (VIE) formulated for homogeneous cubic scatterers. For arbitrary geometries and MoM formulations with unstructured meshes discretizing VIE or the surface integral equations, however, fast direct solution with TT decomposed MoM matrix is unavailable. In this work we demonstrate how the TT decomposition can be used for construction of the fast iterative solution of the MoM matrix equations. The proposed schemes are applicable to acceleration of MoM formulated for both the scatterers of arbitrary shape and discretized on either voxelized or unstructured meshes. The CPU time and memory complexity of the methods scale as $O(N \log N)$ with size N of the discretized problem.