Multilevel Nonuniform Grid Time Domain Algorithm for Elongated Geometries

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A numerically efficient algorithm for the fast evaluation of time-dependent potentials/fields, radiated by highly elongated three-dimensional (3D) source/observer constellations is presented. This computational scheme complements the family of Nonuniform Grid Time Domain (NGTD) based algorithms (A. Boag, V. Lomakin, and E. Michielssen, IEEE Trans. Antennas and Propagation, vol. 54, no. 7, pp. 1943-1951, July 2006) and (J. Meng, A. Boag, V. Lomakin, and E. Michielssen, J. Comp. Physics, vol. 229, no. 22, pp. 8430-8444, 1 Nov. 2010.). At the core of the generic NGTD-approach is the idea of using retarded time coordinate and amplitude compensation in order to transform the fields radiated by spatially confined and temporally bandlimited sources into slowly varying functions amenable to spatial sampling and subsequent interpolation. The proposed algorithm uses the NGTD-approach in a multilevel fashion while seeking improved performance, in particular, for elongated geometries, by analogy to the time harmonic algorithm described in (N. Costa and A. Boag, International Journal of Numerical Modelling: Electronic Networks, Devices and Fields, vol. 25, pp. 645-655, 2012). To that end, sampling rates are derived for the construction of nonuniform Cartesian grids used for representation of the left- and right-propagating fields. Elongated geometries allow for the design of exceedingly sparse nonuniform sampling grids comprising roughly a constant (i.e. source domain size independent) number of points. The proposed multilevel NGTD algorithm employs such compressed sampling representations for both outgoing and incoming fields thus symmetrizing the functionality of the sampling grids. This allows us to reduce the per-time-step computational complexity (CC) from $O(N \log N)$ of the conventional ML-NGTD (N. Costa and A. Boag, IEEE AP-S International Symposium, 2210, Memphis, TN, USA, July 2014) to $O(N)$, with N being the number of spatial source/observer points. Numerical implementation, accuracy, and linear complexity of the proposed algorithm will be demonstrated by numerical examples.