Editorial

Advanced Modeling and Simulation Methods for Multiphysics and Multiscale Problems

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With great success being achieved in electromagnetic (EM) modeling and simulation, EM scientists and researchers are turning their concentration towards much more challenging multiphysics and multiscale problems, which have a greater range of applications in sciences and technologies. Problems that involve large-scale and multiscale features in both space and time, that are nonlinear and multiphysics in nature, and that lack unique solutions for mathematical or engineering reasons are encountered routinely in many applications such as the design of integrated circuits and packages, the modeling of natural or artificial materials, the simulation of large-scale antenna arrays, the deterministic and stochastic investigation of EM and particle interactions, the analysis of EM compatibility in complex environments, and the optimization of geometrical and material parameters in inverse problems. In this special issue, many of these important topics have been covered and discussed.

Real-world medium exhibits complex hierarchical structures and randomness on different length scales. To capture the multiscale feature as well as the random characteristic of the real-world medium, one article in this special issue hybridized a statistical model based on the random medium theory with the deterministic method, the finite-difference time-domain (FDTD) method, to simulate the radar signal reflected by the lunar regolith layer. A unidirectionally collocated hybrid implicit-explicit FDTD method was proposed to simulate the planar structure of graphene to increase the time step by utilizing an implicit method for structures under the critical dimension.

Modern wireless systems are often operated in complex EM environments. To achieve satisfactory performance, it is critical to consider the effect of the environment when designing wireless systems. The scale difference between wireless systems and its working environment poses a very challenging multiscale problem. Two articles in this special issue discussed the fast modeling of complex EM environments and explored the environmental effect on the design of wireless systems. One work presented an algorithm to calculate total diffraction losses for multiple obstacle objects using Epstein–Peterson approach. Another article concerned the antijamming performance of receiving antennas in satellite navigation systems, where a robust method to suppress jamming for satellite navigation by reconstructing sample covariance matrix without main-lobe nulling has been proposed.

Several articles in this special issue present advanced methods in modeling and simulation of large and complex objects, which are usually encountered in multiphysics and multiscale problems. To improve the computational efficiency, high-frequency asymptotic methods, high-efficiency full-wave methods, and high-performance computing techniques can be developed. In this special issue, a high precision scattering center model was proposed based on induced currents of cone-shaped targets. To address the scattering problem from large objects, one article presented an efficient matrix compression algorithm for the nested complex source beam (CSB) method based on the truncated singular value decomposition. The computation of the augmented electric

field integral equation was accelerated by using the multilevel CSB method. A generalized single-source tangential equivalence principle algorithm was proposed to solve the EM scattering of array structures with very small distance or even connected elements. One article introduced recent work on high-performance computing based on GPU/CPU heterogeneous platform.

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