Developing Novel Electromagnetic Devices with High-Accuracy and Low-Cost Numerical Simulation

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Research Topics

・High-speed, high-precision, and finite-difference time-domain (FDTD) method using graphics processing unit and error analysis

・Object identification form GPR images using deep neural networks

Research Seeds

・High-speed, high-precision, and finite-difference time-domain (FDTD) method using graphics processing unit and error analysis

The finite-difference time-domain (FDTD) method and the constrained interpolation profile (CIP) method, which are used for electromagnetic (EM) simulation in the time domain, require vast computational resources. Moreover, numerical dispersion error arises from central-difference approximation. We have developed a parallel computation algorithm on multi-node GPU clusters and error compensation method with dispersion relation equation. Using our method yields results that show good agreement with exact solutions.

・Object identification from GPR images using deep neural networks

We have developed a method of identifying underground objects using ground penetrating radar (GPR) images analyzed with a deep neural network (DNN). In this study, to detect an underground object automatically from a GPR image by the DNN, we generated several hundred thousand GPR images for training the DNN using a fast finite-difference time-domain (FDTD) simulation with graphics processing units (GPUs). Furthermore, characteristics of underground objects are extracted and learned from generated GPR images by a nine-layer convolutional neural network (CNN). Results show that the CNN can identify six materials with roughly 80% accuracy in inhomogeneous underground media.

Related Technology

・Analysis of EM fields for EM devices (indoor/outdoor wireless communication, UWB, lightning, GPR, etc.)

・Parallelized for numerical EM simulations (FDTD, CIP, MoM, etc.)

・Construction of a cluster/grid environment on Linux

・Parallel programming techniques on clusters, grids, and GPUs