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Study on a Fast Solver for Poisson's Equation Based On Deep Learning Technique

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1 Extended Abstract

Computational electromagnetic simulation has been widely used in research and engineering[1], and it usually requires solving matrix equations with millions of unknowns. The solving process needs a large amount of CPU time and memory. Therefore, it is still challenging to build real-time electromagnetic simulator in applications such as non-destructive testing, biomedical imaging, etc. With the rapid development of deep learning techniques, deep neural network demonstrates strong approximation capability and great function fitting ability[2][3]. Recently, the deep learning techniques are applied to approximate complex physical systems [4][5]. After proper data training, the trained network can mimic the solution precedure with significant speedup and fairly good accuracy.

In this study, we investigate the feasibility of solving Possion's equation based on deep learning techniques. A fast solver is proposed based on deep convolutional neural network. The training data for deep neural network is generated by a proper finite difference solver, and cost function in the optimization is designed carefully. The deep convolutional neural network was implemented in Tensorflow and was trainded on an Nvidia K80 GPU card. The fast solver proposed in this paper can make correct prediction of potential field distribution in the computaiton domain with the permittivity distribution and source location as input. Numerical results show that the preidiction error in 2D and 3D simulation can reach below 1.5% and 3% respectively. The CPU time is significantly reduced compared with traditional solvers based on finite difference method. The generalization ability has also been improved compared with traditional learning techniques. This study indicates the great potential to apply deep learning techniques to accelerate computational electromagnetic simulation.

References

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