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Multiplicative Regularized Contrast Source Inversion Algorithm using Paralleled Computing Architecture

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Inverse scattering algorithms for electromagnetic data have been widely used in subsurface prospecting, biomedical imaging and non-destructive testings. Many of these applications require one to solve a nonlinear inverse problem to reconstruct the electrical properties in the domain of investigation. It can be formulated as an optimization problem of the electrical properties to minimize the difference between the measured and simulated data. To solve these problems, we use nonlinear inversion algorithms. One of the bottlenecks in these algorithms is the computational efficiency, especially for big dataset and large domain of investigation. Many researchers have worked on improving the efficiency of inversion algorithms by either reducing the number of unknowns or developing fast forward modeling algorithms, such as the signal-subspace-based methods [1], the iterative multi-scaling method [2], the scattering approximation [3], and etc. Most of them focus on the theoretical improvement of algorithms. In this work, we investigate the possibility of accelerating nonlinear inversion algorithms by using massively parallel computing devices. Recently, many new computing platforms have been developed. They are usually composed of many relatively simple computing cores and can achieve very high computing performances in floating-point operations. However, their computing architectures are different from the traditional CPU-based platform, and the performance of inversion algorithms can vary significantly on these platforms. Therefore it is necessary to study the performance of the algorithms on these new platforms to take advantage of their computing power. As an example, we studied the parallelization and optimization of the multiplicative regularized contrast source inversion algorithm (MR-CSI) using the compute unified device architecture (CUDA).

The CSI algorithm [4] defines contrast source as a virtual source and updates both material contrast and contrast sources iteratively in the inversion process. Compared with other methods, CSI does not require exact solutions of the forward model in each iteration. Therefore for some problems, it converges faster. The computational complexity of CSI is proportional to the numbers of frequencies, sources, receivers, and unknown parameters to invert. Therefore, it is still very challenging for applications requiring fast inversion. In this work, we focus on the acceleration of the CSI algorithm using massive paralleled computing device. Because basic linear algebra processing occupies most of the computation that can be done highly paralleled. We choose CUDA as a tool for algorithm acceleration. After careful implementation, we observe more than 15 times improvements for 2D inversion and 75 times for 3D inversion in computing speed compared with the original MR-CSI algorithm on CPU.

References

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