Iterative algorithms for partitioned PINNs by domain decomposition preconditioners

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ABSTRACT

In this study, we propose a new iterative method suitable for parallel computation that applies to partitioned Physics-Informed Neural Networks (PINNs) [1,2] by utilizing classical domain decomposition approaches [3,4,5] based on non-overlapping subdomain partitions. The spatial domain is partitioned into a set of completely separated subdomains, where local problems are solved for the given interface condition by using partitioned PINNs in each subdomain, and then the interface condition is updated to minimize the cost function related to the continuity condition between the neighboring local neural network solutions. This approach offers the flexibility that allows various optimization techniques, such as Gradient Descent, Adagrad, and Adam methods. In addition, to speed up the convergence of the iterative method, preconditioning schemes will be proposed by using suitable Neumann problems in each subdomain and numerical results will be presented to show the performance of our preconditioning schemes. Our approach is expected to significantly improve efficiency, especially when leveraging multiple GPUs to solve large-scale application problems. Typically, the use of multiple GPUs in the classical partitioned PINNs [1,2] increases communication time greatly to result in a less satisfactory parallel scalability. Our proposed iterative method can significantly reduce the communication time and has a potential to improve the parallel scalability in the classical partitioned PINNs.

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