Learning time-dependent PDE solver using message passing graph neural networks

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One of the main challenges in solving time-dependent partial differential equations is to develop computationally efficient solvers that are accurate and stable. Here, we introduce a graph neural network approach to finding efficient PDE solvers through learning using message-passing models. We first introduce domain invariant features for PDE-data inspired by classical PDE solvers for an efficient physical representation. Next, we use graphs to represent PDE-data on an unstructured mesh and show that message passing graph neural networks (MPGNN) can parameterize governing equations, and as a result, efficiently learn accurate solver schemes for linear/nonlinear PDEs. We further show that the solvers are independent of the initial trained geometry, i.e. the trained solver can find PDE solution on different complex domains. Lastly, we show that a recurrent graph neural network approach can find a temporal sequence of solutions to a PDE.