

**CRUNCH Seminars at Brown, Division of Applied Mathematics**

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**Paper Review - Simulating Continuum Mechanics with Multi-Scale Graph Neural Networks**

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**Continuum mechanics simulators, numerically solving one or more partial differential equations, are essential tools in many areas of science and engineering, but their performance often limits application in practice. Here we introduce MultiScaleGNN, a novel multi-scale graph neural network model for learning to infer unsteady continuum mechanics. MultiScaleGNN represents the physical domain as an unstructured set of nodes, and it constructs one or more graphs, each of them encoding different scales of spatial resolution. Successive learnt message passing between these graphs improves the ability of GNNs to capture and forecast the system state in problems encompassing a range of length scales. Using graph representations, MultiScaleGNN can impose periodic boundary conditions as an inductive bias on the edges in the graphs, and achieve independence to the nodes' positions. We demonstrate this method on advection problems and incompressible fluid dynamics. Our results show that the proposed model can generalise from uniform advection fields to high-gradient fields on complex domains at test time and infer long-term Navier-Stokes solutions within a range of Reynolds numbers. Simulations obtained with MultiScaleGNN are between two and four orders of magnitude faster than the ones on which it was trained. (<https://arxiv.org/abs/2106.04900>)**