CRUNCH Seminars at Brown, Division of Applied Mathematics

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Solving PDE related problems using deep-learning

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Motivated by the physical experiment of acoustic waves propagating in an underwater homogeneous domain, we discuss the inverse problem: Simulating the physical experiment, we solve the acoustic wave equation and save the data at a small number of sensors over many time steps and given these sensor measurements we aim to find and identify the shape of an obstacle inside the domain. We use a deep-learning framework to build an image segmentation of the domain where the segment is an arbitrary polygon (large sample space) that is the obstacle. We improve the model using a physically-informed loss term designed based on the wave equation. A weakness of the present model is the presence of measurement noise. To overcome this difficulty we propose an encoder-decoder architecture based on the time-reversal property of the wave equation, exploiting its noise robustness feature inside the learning algorithm. In a separate project, we discuss an explicit deep-learning based numerical scheme for the 1D wave equation that remains stable when violating the CFL condition. We continue this research for optimized numerical schemes using deep-learning that remain stable for high-frequencies and coarse grids. Results are presented for both projects demonstrating the usefulness of the deep learning approach.