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Neural and operator network approximations for elliptic PDEs

Friday, 13 May 2022 11:00 (1 hour)

The application of neural networks (NNs) to the numerical solution of PDEs has seen growing popularity in the last five years: NNs have been used as an ansatz space for the solutions, with different training approaches (PINNs, deep Ritz methods, etc.); they have also been used to infer discretization parameters and strategies.

In this talk, I will focus on deep ReLU NN approximation theory. I will first show how NNs accurately approximate functions with isolated singularities, for example the solutions to elliptic problems in polygons and polyhedra, or eigenfunctions of problems with singular potentials that arise in quantum chemistry. I will then introduce operator networks, which approximate the solution operator of PDEs. I will, in particular, consider operator networks that, given a fixed right-hand side, map sets of diffusion-reaction coefficients into the space of solutions (coefficient-to-solution map). When the coefficients are smooth, the size of the networks can then be bounded with respect to the H^1 norm of the error, uniformly over the parameter set. The proofs of our approximation rates combine elliptic regularity, classical and recent results in numerical analysis, and tools from NN approximation theory.

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