On Residual Minimization Formulation for PDEs: Failure of PINN and Implicit Bias

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Abstract: With the development of machine learning, neural network in solving PDEs, such as DeepRitz and PINN, is becoming rather popular. However (on physical problems less than 3 dimensions), its performance is worrying: in practice, there are few examples comparable to traditional numerical methods; in theory, there is a lack of stability and convergence proofs. In this report, we discuss the performance of methods such as PINN on problems with discontinuities coefficients. First, for elliptic PDEs with discontinuous coefficients, we show experimentally that PINN cannot successfully approximate the true solution of the equation. By introducing auxiliary equations, we prove that the fitting of PINN to the solutions of elliptic equations with discontinuous coefficients is invalid. Furthermore, we point out that there are still a series of patterns in this failure, which means that the PINN method has implicit regularization on such problems. Finally, we extend all results to quasilinear case.