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Physics-informed neural networks for non-smooth PDE-constrained optimization problems

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We study the application of well-known physics-informed neural networks (PINNs) for solving non-smooth PDE-constrained optimization problems. First, we consider a class of PDE-constrained optimization problems where additional nonsmooth regularization is employed for constraints on the control or design variables. For solving such problems, we combine the alternating direction method of multipliers (ADMM) and PINNs and propose the ADMM-PINNs algorithmic framework, which unties the PDE constraints and the nonsmooth regularization terms for iterations. Accordingly, at each iteration, one of the resulting subproblems is a smooth PDE-constrained optimization which can be efficiently solved by PINNs, and the other is a simple nonsmooth optimization problem which usually has a closed-form solution or can be efficiently solved by various standard optimization algorithms or pre-trained neural networks. Then, we consider optimal control problems of PDEs with interfaces. We employ the recently developed discontinuity-capturing neural network to tackle the non-smoothness of the PDEs with interfaces and propose hard-constraint PINNs for solving such optimal control problems. The hard-constraint PINNs ensure both the boundary and interface conditions are satisfied strictly, and meanwhile, they are decoupled from the learning of the PDEs. All these PINNs methods are mesh-free, easy to implement, and scalable to different PDE settings. Various numerical results are reported to validate the effectiveness and efficiency of the proposed PINNs methods.