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Numerical Solution of Partial Differential Equations and Initial Value problems of stiff ODEs with Physics Informed Random Projection Neural Networks

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Over the last few years, physics-informed machine learning has been used to solve both direct and inverse problems of time-depended non-linear PDEs and ODEs that model high-dimensional multiscale systems. Here, we address a physics-informed machine learning framework based on Random Projection Neural Networks to numerically solve nonlinear PDEs and stiff problems of ODEs and perform numerical bifurcation analysis. The performance of the proposed numerical method is assessed via several benchmark problems, namely four systems of stiff ODEs (Prothero-Robinson, van-der Pol, Rober, and HIRES) and, three problems of nonlinear PDEs (1D viscous Burgers, 1D and 2D Bratu, 1D Allen-Cahn). The efficiency is assessed in terms of numerical accuracy and computational cost and compared with classical numerical methods including solvers for stiff ODES, Finite Differences, and Finite Elements. We show that the proposed framework outperforms the classical methods especially in cases where steep gradients arise.