Enhancing shock resolution in the Sod shock tube problem via the PASSC framework

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In this work, we investigate the performance of a hybrid computational framework, referred to as PASSC (Physics-Informed Neural Network-Augmented Streamline-Upwind/Petrov–Galerkin with Shock-Capturing) [1, 2], for the simulation of shock-dominated flows. The proposed approach combines stabilized finite element methods, namely SUPG [3, 4] and YZβ shock-capturing [5, 6], with physics-informed neural networks (PINNs) to enhance solution accuracy in convection-dominated regimes. This approach leverages the stability of classical finite element methods while incorporating data-driven corrections to improve local accuracy near sharp gradients and discontinuities. As a benchmark problem, we consider the one-dimensional time-dependent Sod shock tube problem, which exhibits sharp discontinuities and nonlinear wave interactions. While classical numerical methods often suffer from spurious oscillations or excessive numerical diffusion, the hybrid PASSC framework aims to balance stability and accuracy by introducing a data-driven correction to a high-quality stabilized baseline solution. Numerical results demonstrate that the proposed method improves shock resolution, providing sharper discontinuity profiles while reducing oscillatory behavior compared to standalone approaches. The study highlights the potential of hybrid FEM–PINN strategies for challenging hyperbolic problems involving discontinuities.

This work was supported by the Scientific and Technological Research Council of Turkey (TUBITAK) under Grant No. 225M468.

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