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Learning Solutions of Coupled Differential Equations with Physics-Informed Neural Networks

This study demonstrates the application of Physics-informed neural networks (PINNs) to solve the initial-value problem of a two-mass coupled nonlinear oscillator system. The system is governed by the coupled second-order ordinary differential equations.
A fully-connected feed-forward neural network is trained to directly approximate the displacement fields $x_1(t)$ and $x_2(t)$. The network is optimized by minimizing a composite loss function consisting of the physics residual and a weighted initial-condition loss. No labeled trajectory data are used to train the model. The PINNs solution is validated against a high-accuracy numerical method. The predicted displacements show excellent quantitative agreement with the numerical solution, achieving sub-millimeter root-mean-square errors for both masses throughout the simulated interval. These results illustrate that PINNs can accurately predict the solutions of nonlinear differential equations.

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