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Fast Tsunami Wave Height Prediction using Deep Neural Networks for the Shallow Water Equations

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This work presents a data-driven neural network framework for rapid tsunami wave prediction governed by the linear shallow water equations (SWEs). High-fidelity solution data are generated using a finite volume method (FVM) across a range of tsunami source parameters and initial conditions. These simulations are used to train a deep fully connected neural network that maps source parameters to maximum wave heights and arrival times at predefined gauge locations.

The proposed model is compared with FVM simulations and shows significant reduction in computational time while maintaining comparable accuracy, indicating suitability for real-time tsunami early warning systems. A theoretical analysis based on the Deep Universal Approximation Theorem is included, establishing the existence of neural network architectures that approximate the nonlinear parameter-to-observable mappings induced by the SWEs.

The trained network is also used in an inverse setting to estimate tsunami source characteristics from observed wave data. The approach is further demonstrated on the 2018 Krakatau tsunami event using real bathymetry and gauge data, showing its potential for rapid hazard assessment, sensor-based forecasting, and source identification.

Keywords: shallow water equations, tsunami modeling, neural networks, surrogate modeling, inverse problems

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