Separable Physics Informed Neural Networks - Applications in Structural Engineering

Anastasios Stamou[1*], Taniya Kapoor[2], Michalis Fragiadakis[1]

[1]National Technical University of Athens
Iroon Polytechniou 15780, Zografou Campus, Athens, Greece
{a stamou,mfrag}@mail.ntua.gr

[2]Technical University Delft
5 Mekelweg, 2628 CD Delft
T.Kapoor@tudelft.nl

ABSTRACT

The accurate simulation of beam dynamics under various loading conditions is always a challenge in structural engineering. Physics-informed neural networks (PINNs), a deep learning-based computational method, have demonstrated effectiveness in solving complex Partial Differential Equations (PDEs) across disciplines ranging from aerospace to civil engineering. However, applying PINNS to simulate beam response across large spatial and temporal domains is challenging in terms of computational efficiency and accuracy. To address these issues, this study utilizes Separable Physics Informed Neural Networks (SPINNs) for simulating beam deformation over large domains with varying initial and loading conditions. Several numerical experiments are conducted based on fundamental beam theories, such as Euler-Bernoulli and Timoshenko. The study highlights how SPINNs leverage their separable architecture to process spatial and temporal inputs independently, thus efficiently capturing the underlying physics of complex beam dynamics. Overall, the numerical results show that the proposed approach predicts beam deformation accurately and efficiently, highlighting their potential to produce numerical solutions with reduced computational burden, enhanced stability, and improved accuracy.