ID- 124

Forward and Inverse Modeling of SDOF Structures Using Physics-Informed Neural Networks (PINNs)

Munesh Meghwar[1], Shanker Lal Meghwar[1], Jawaid Kamal Ansari[1], Abdul Munim Sahito[1], Sheeraz Ahmed Rahu[1]

[1] Department of Civil Engineering, Mehran University of Engineering & Technology, Jamshoro, Sindh 76020, Pakistan

**Corresponding Author Email: munesh.meghwar@faculty.muet.edu.pk*

ABSTRACT

Single-Degree-Of-Dreedom (SDOF) systems, despite their apparent simplicity, constitute fundamental building blocks for analyzing and interpreting the dynamic behavior of more complex multi-degree-of-freedom (MDOF) structures. The development of efficient and robust methodologies for both forward and inverse modeling of such systems is essential for a broad range of engineering applications, including structural design verification and structural health monitoring. This study presents the application of Physics-Informed Neural Networks (PINNs) for the forward and inverse dynamic analyses of SDOF systems. In the forward formulation, the objective is to predict the structural response in the form of displacement, velocity, and acceleration based on known physical parameters and external excitations. Conversely, the inverse formulation seeks to estimate unknown stiffness parameters from the measured dynamic responses. By incorporating the governing differential equations of motion directly into the loss function, the PINN framework ensures adherence to the physical laws while capitalizing on the approximation capabilities of the deep neural networks. The proposed PINN models demonstrated high accuracy, robustness, and interpretability in forward simulations, while also exhibiting superior performance in inverse identification tasks, particularly in the presence of uncertainties in structural stiffness. These results underscore the potential of PINNs as a unified, physics-constrained, and data-driven modeling paradigm for real-time structural system identification and response prediction.

KEYWORDS: Forward Modeling, Inverse Modeling, Physics-Informed Neural Networks (PINNs), Single Degree Of Freedom (SDOF) Systems, Structural Dynamics, Structural Identification