

Machine Learning in Structural Dynamics: Estimation, Generation, Reduction, and Rare-Event Modelling

C. S. Manohar

Professor (Retired)

Department of Civil Engineering

Indian Institute of Science Bangalore

Brief Biographical Sketch

C. S. Manohar served as a faculty member in the Department of Civil Engineering at the Indian Institute of Science from 1993 to 2024, retiring from service in July 2024. His research interests include structural system identification, treatment of uncertainties, and computational reliability modelling. He currently spends part of his time in academics and R&D activities, serving as an Adjunct Faculty Member at IIT Jodhpur and as a consultant to Bosch Global Software Technologies, Bangalore.

Abstract

This talk explores how several classical problems in vibration engineering can be re-examined through the lens of modern machine learning. The discussion focuses on four representative problems:

1. Combined state and parameter estimation in instrumented structures
2. Simulation of earthquake ground motions in situations where recorded data are scarce
3. Model order reduction for high dimensional structural systems
4. Rare-event simulations arising in time-variant reliability estimation.

The talk juxtaposes established tools to tackle these problems with ML-based approaches and examines what new capabilities can be achieved by using ML-based tools. Specific ML tools considered include recurrent neural networks and their modern enhancements, reservoir computing, generative AI frameworks, autoencoders for nonlinear model reduction, and reinforcement learning approaches for adaptive rare-event sampling. Approximately 70% of the talk is devoted to developing these machine learning based perspectives, while the remaining portion briefly outlines related research carried out by the speaker and his students.