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An Explicit Physics-Informed Neural Network (E-PINN) for Dynamic Response Prediction of Engineering Structures with Nonlinear Energy-Dissipating Devices

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Date: 14 September 2026 (Monday)
Time: 11:00 a.m. - 12:00 noon
Venue: Room 612B, 6/F Haking Wong Building, The University of Hong Kong

Abstract

As surrogate models for response simulations, physics-informed neural networks (PINNs) are expected to replace computationally expensive time-history analysis and achieve rapid prediction of dynamic responses of nonlinear systems. In existing PINN models, the global equation of motion of the nonlinear system is directly incorporated into the loss function, requiring the networks to learn the global dynamic behaviour of the system. As a result, network training becomes challenging, which hinders the application of PINNs to complex nonlinear systems. Guided by the decoupling strategy of linear and nonlinear mechanisms, an explicit physics-informed neural network (E-PINN) is proposed to address the challenges arising from the network learning of the coupled physical mechanisms of nonlinear systems. A lightweight TCN-LSTM module is trained to capture the nonlinear evolution mechanism of specific energy-dissipating devices, while a structured convolutional layer (SCL) module is utilized to explicitly reflect the linear evolution mechanism of the primary structure. Only the weights and biases in the TCN-LSTM module need to be optimized through the loss function focusing on the nonlinear restoring forces, whereas the weights in the SCL module are extracted from the explicit convolutional formulation of dynamic responses without requiring any training, leading to overall highly efficient network training and high-accuracy response prediction. A suspension bridge with nonlinear viscous dampers and a cable-stayed bridge with hysteretic isolators are investigated to demonstrate the performance of the proposed E-PINN in nonlinear dynamic response prediction.

About the Speaker

Prof. Cheng Su is a Professor of the School of Civil Engineering and Transportation at the South China University of Technology, and is also the President of the Guangzhou City University of Technology. Prof. Su has been actively working on seismic analysis and wind-induced vibration analysis of high-rise buildings and long-span bridges, and construction control and health monitoring of large-scale complex structures. He is also engaged in research on random vibration of structures and stochastic computational mechanics. Over 270 publications have been authored or co-authored by Prof. Su along with over 120 presentations. Prof. Su is the recipient of the Frederick Palmer Prize 2010 from the Institution of Civil Engineers, UK. He is currently the Editorial Advisory Board member of the Journal of Sound and Vibration and the Editorial Board member of the Journal of Building Structures and the Journal of Applied Mathematics and Mechanics.

- ALL ARE WELCOME -