

Model Order Reduction for Systems with Localized Nonlinearities

D. Dane Quinn, Ph.D.
The University of Akron

Abstract:

Structural systems can often be composed of large regions that are characterized as linear, with isolated connected regions that contain nonlinearities, representing mechanical joints or other localized nonlinearities. The development of reduced-order models for such structural systems can provide computationally efficient simulations and enable advanced engineering design. In this work, systems with isolated nonlinearities can be reduced to a linear system with an appropriately determined traction at the boundary of the isolated nonlinear region, where this added force, defined as the deviatoric force, describes the effect of the nonlinearities on the otherwise linear structure. This talk will introduce this reduction framework and utilize a neural network architecture that learns this deviatoric force from high-fidelity simulations of the original nonlinear system together with sparse measurements of the system dynamics. Thus, the neural network learns the nonlinearities directly. The neural networks are trained in an unsupervised manner without having to rely on force measurements and instead are optimized to minimize the residual of the Euler-Lagrange equations of motion. Several examples will be shown to demonstrate the approach.

D. Dane Quinn was awarded the B.M.E. degree from Georgia Tech in 1991 and, in 1995, a Ph.D. from Cornell University in the Department of Theoretical and Applied Mechanics. He is currently a Professor in the Department of Mechanical Engineering at the University of Akron. His research interests lie in the areas of applied dynamical systems and mechanics, specifically considering the effects of mode coupling and resonances in nonlinear systems, and the mechanisms by which energy is transferred through mechanical systems. This work has found numerous applications, including the development of reduced-order models for digital twins, networks of coupled micro-electro-mechanical systems, and large-scale structural systems with joints, interfaces, and other isolated nonlinearities.