NON-LINEAR MODELING OF HYSTERESIS IN PIEZOELECTRIC
ACTUATED CANTILEVER BEAM USING THE BOUC-WEN MODEL

Presented by: Andrew Maas

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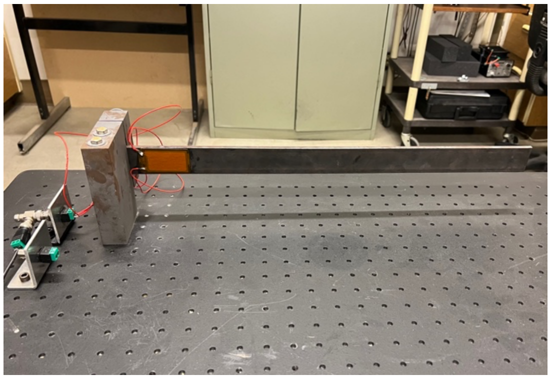
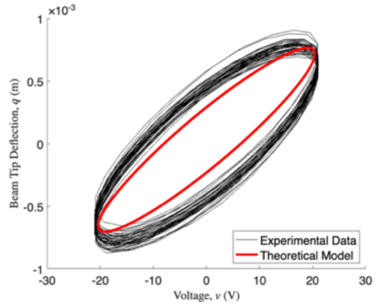
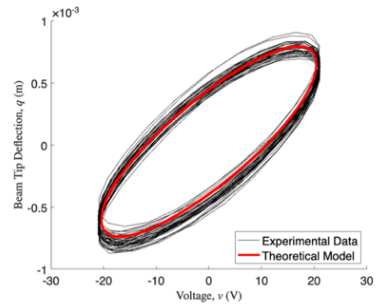





Linear Model




Non-linear Model

Piezoelectric actuators frequently exhibit a time-dependent behavioral phenomenon known as hysteresis, resulting in a lag in the deformation of the actuator compared to linear models. This hysteresis complicates control systems involving piezoelectric actuators. However, traditional modeling methods for piezo-actuated smart structures often treat the piezoelectric patches as linear actuators without considering hysteresis, leading to suboptimal controller performance.

This thesis aims to establish a comprehensive model by integrating the Euler-Bernoulli beam model with the hysteresis dynamics induced by two collocated piezo patches attached to the beam. A model expansion method will be employed to transform the partial differential equations describing beam vibration into a set of ordinary differential equations in the modal coordinate frame. These equations will then be coupled with the Bouc-Wen model describing the hysteresis of piezoelectric materials.

To identify model parameters, a genetic algorithm will be utilized and tested against experimental data collected over a wide range of excitation frequencies. The experimental dataset will be divided into two sets: a training set for the genetic algorithm and a validation set to verify the identified model. It is demonstrated that the nonlinear model with hysteresis provides better agreement with experimental results than the linear model, thereby enhancing the understanding and predictive capability of piezoelectric actuator behavior. This thesis has laid the foundation for future work on developing advanced control methods to mitigate beam vibration under external excitations, thus contributing to the optimization of smart structures' performance in various applications.

A Thesis Defense in Mechanical Engineering

California Polytechnic State University, San Luis Obispo

**Tuesday, April 30, 2024, at 9:00 AM**

Building 13-109, or Zoom: https://calpoly.zoom.us/j/89441555175

Meeting ID: 894 4155 5175