SHIBAURA INSTITUTE OF TECHNOLOGY

Abstract

Doctor of Philosophy

Hysteresis Characterization and Compensation of Smart Material-Based Actuators via a New Modified Bouc-Wen Model

by Mohd Hanif Bin Mohd RAMLI

Most smart material based actuators (smart actuators) are known for their prominent characteristics of a high resolution of positioning, high bandwidth, and the ease of integration in miniaturized systems. However, their applications are restricted by the inherent hysteresis nonlinearity. This thesis presents an alternative modification to the original Bouc-Wen (BW) model in order to improve the characterization of smart actuators those are affected by hysteresis effects. The modified BW model is formulated in the discrete-time domain. The extended particle swarm optimization technique (EPSO) is used to properly validate the proposed model. Through the simulation study, it is observed that proposed model is capable of describing rate-dependent input-output relations which is an important feature in the modeling of hysteresis phenomenon. Then, the proposed model is directly used in developing control strategies to mitigate the hysteresis effects. In this case, two control architectures are developed; a discrete nonlinear prescribed performance control (DPPC) scheme and a discrete model reference adaptive control strategy (DMRAC). In addition, theoretical analysis of the closed-loop system's stability under each control algorithm is also systematically discussed. Finally, the efficacy of formulated control strategies are verified via real case applications. The simulation and experimental results substantiate the capacity of the proposed MBW model. It is not only applicable for modeling and characterization, but also towards control development for the betterment of motion tracking problems in smart actuators that are affected by hysteresis effects.