Paper ID: 76336
oral

IAF MATERIALS AND STRUCTURES SYMPOSIUM (C2)
Smart Materials and Adaptive Structures (9)

Author: Prof. Kanjuro MAKIHARA
Tohoku University, Japan, kanjuro.makihara.e3@tohoku.ac.jp

Mr. Mizuki ABE
Tohoku University, Japan, mizuki.abe.r4@dc.tohoku.ac.jp
Mr. Yushin HARA
Tohoku University, Japan, yushin.hara.p1@dc.tohoku.ac.jp
Mr. Koyo MISHIMA
Tohoku University, Japan, koyo.mishima.s8@dc.tohoku.ac.jp

PREDICTIVE VIBRATION CONTROL USING TREE DECISION ALGORITHM WITH LOW ENERGY REQUIREMENTS

Abstract

This study proposed a novel semi-active vibration control method using tree decision algorithm. The semi-active vibration control using a piezoelectric transducer is a highly stable method that can achieve high control performance and energy efficiency. We applied MPC (model predictive control) to this semi-active vibration control and improved the control performance and robustness. The future state resulting from switching was predicted with the tree-based prediction and optimization algorithm. The trajectory was selected such that the piezoelectric transducer realized the most effective vibration control within the prediction interval. The proposed method performed predictions using a conditional prediction with a tree. The tree traversal algorithm was used to predict and optimize semi-active input, which enabled the prediction based on the discontinuous semi-active input and efficient implementation of predictive semi-active control. Further, this feature provided a flexible prediction trajectory without limitations. This feature essentially differs from that of the conventional control method based on the active control theory and enables the direct optimization of semi-active control. Moreover, the switching criterion in the method reduced the computational cost and enabled fast predictive vibration control. The simulation results proved that the proposed method could predict a discontinuous semi-active input and is computationally cost-efficient. The robustness of the proposed method was evaluated under disturbances. An intended error was introduced in the controller design, and the performance was evaluated from simulation and experiment. The robustness analysis suggested that the proposed method may achieve an acceptable performance even under a modeling error. In addition, the high control performance and robustness of the proposed method were experimentally validated. The proposed method significantly broadens the range of applications of semi-active vibration control technology. The flexible and limitation-free prediction enables us to bring the best out of semi-active vibration control with a piezoelectric transducer. The proposed method holds the following three novelties. (1) A tree-based prediction method realizes prediction and optimization based on discontinuous semi-active control input trajectory. The prediction and optimization are achieved with only two prediction models and a tree traversal algorithm that helps realize a faster and simpler implementation. (2) A tree-based prediction and optimization method does not limit the semi-active input trajectory. (3) The proposed method introduces a switching criterion to reduce the computational cost of prediction and optimization based on a discontinuous semi-active input.