

Contributions to Model Predictive Active Vibration Control under Parametric Resonance

This thesis addresses the problem of active vibration control in the presence of parametric resonance. Parametric resonance arises in a broad class of systems typically characterized by time-varying structures, such as stacker cranes with variable load changes. This thesis is divided mainly into two parts. In the first part, a mathematical and a multi-body model are developed and experimentally validated on a lab-scale prototype. In addition, modal analysis is carried out analytically and experimentally. The second part highlights the challenges that parametric resonance poses for control. For this purpose, three approaches are presented. One of the common features of these approaches is the use of nonlinear model predictive control (NMPC) for the predictive countermeasure to parametric resonance, mainly for optimal trajectory planning instead of conventional methods such as input shaping. Furthermore, all three approaches share insights from the modal analysis where the time propagation of the parametric resonance is predictable. In two approaches, trajectory planning can avoid critical frequencies such as resonance frequencies by involving them as soft boundary conditions. The third approach develops a promising and completely different concept of active vibration damping based on the idea of shaping the frequency spectrum of the state and the input. Unlike the usual time domain MPC formulation, this spectral shaping is formulated as an optimization problem defined in the frequency domain. In addition to computer simulations, a real-time implementation of the nonlinear model predictive vibration control is also performed on the test bench.



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