University of Macau

Abstract

RELIABILITY-BASED SEMI-ACTIVE CONTROL USING MR DAMPER

by Shi Yuanfeng

Thesis Supervisor: Dr. Ka-Veng Yuen

For building structures and bridges, semi-active control has received a great deal of attention in recent years. Semi-active devices are attractive because they are economical and they combine the best features of passive and active systems. Semi-active devices are characterized by their ability to dynamically vary their properties with a minimal amount of power. Because semi-active systems can only absorb or store vibratory energy, they are always stable. Preliminary studies indicate that appropriately implemented semi-active systems perform significantly better than passive systems and have the potential to achieve similar performance to fully active systems.

Within the class of semi-active control devices, one of the most promising devices is the magnetorheological (MR) damper. MR dampers have, over the last decade, been recognized as having a number of attractive characteristics for use in vibration control applications. MR dampers are relatively inexpensive to manufacture. Other attractive features include their small power requirements, reliability and stability. Requiring only 20-50 watts of power, this device can operate with a battery, eliminating the need for a large power source or generator. Because the device forces are adjusted by varying the strength of the magnetic field, no mechanical valves are required, making a highly reliable device. Additionally, the fluid itself responds in milliseconds, which allows its usage with a large bandwidth.

Because of the inherent nonlinear nature of MR damper devices, one of the challenging aspects of utilizing this technology to achieve high levels of performance is in the development of appropriate control algorithms. In this thesis, a robust reliability-based semi-active control methodology using MR damper is presented for controlling uncertain dynamical systems using feedback of incomplete noisy response measurements.

The control command signal is based on the clipped optimal controller, but the reference control forces are developed by a robust reliability-based active control method. The design criterion of the robust reliability-based active control method is based on a robust failure probability of the system represented by a linear state-space model. This criterion provides robustness for the controlled system by considering a probability distribution over a set of possible models with a stochastic model of the excitation so that robust performance is expected. The reference active control forces can be calculated using incomplete response measurements at the current and/or previous time steps without requiring state estimation. Examples of a six story shear building with sensors and MR dampers installed at different locations are presented to demonstrate the efficiency of the proposed semi-active control approach. Through simulation of the building structure excited by random excitation and the 1940 El Centro earthquake, the reduction in interstory drifts and absolute accelerations is examined and the efficiency is clearly seen.