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PhD Dissertation Announcement

ADVANCED SLIDING MODE CONTROLLERS AND THEIR INNOVATIVE APPLICATIONS USING SMART MATERIALS

Mithun Singla

This dissertation focuses on the following two research topics involving smart materials: 1) Advanced sliding mode controllers and their applications and 2) Development of an automatic de-icing system for roads by electrical heating of embedded carbon fiber.

Sliding mode control has many advantages over other control algorithms, such as robustness to uncertainties and immunity to disturbances, but suffers chattering problems due to discontinuities in the control law. In this dissertation, an advanced sliding mode control algorithm using the smoother sign function and LQR approach to alleviate chattering is proposed. The desired sliding surface was designed using the stable eigenvectors of the controlled system. Simulation results show that the proposed approach is effective in disturbance rejection and reduction of chattering. The robustness of the proposed optimal controller was demonstrated through the implementation of active vibration control on a flexible beam with mass uncertainty. The experimental results show that the vibrations of beam with mass uncertainty can be well controlled by the proposed approach. Due to the inability to guarantee stability of a system with unmatched uncertainties, the proposed sliding mode approach is improved by replacing the LQR approach with the H_∞ approach. The stability of the proposed approach was verified with the H_∞ approach. The simulation results show that the control input generated by the proposed robust approach was very smooth compared to conventional sliding mode controllers. The experimental implementation for vibration control of a two story base-isolated structure equipped with an MR damper, where the nonlinear force generated by the MR damper acted as an uncertainty to the system, show the effectiveness of the approach.

The sliding mode control approach was used to realize the vibration suppression of vortex induced vibrations (VIV) of a jumper pipe structure via pounding tuned mass damper (PTMD) integrated with viscoelastic material. The force generated by the PTMD is analogous to the active sliding mode control approach. Comparison between simulation and experimental results demonstrated the similarity between the PTMD and the active sliding mode control approach.

Lastly, an innovative deicing system using carbon fiber as heating element was developed. A test sidewalk was prepared by embedding electrically powered carbon fiber frames into concrete pavement. A LabVIEW interface controlled the deicing process through two sidewalk surface temperature controllers (ON-OFF and Fuzzy Logic) and enabled the user to keep track of the environmental conditions, as well as save data on demand. The experimental results showed that the proposed technique effectively prevented the formation of ice on the pavement surface and that the advanced temperature controller was 80% more power efficient compared to a manual on-off switch.

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