Model Predictive Control of a Semi-Active Suspension System Featuring Magnetorheological (MR) Dampers

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ABSTRACT

This study presents the vibration control performance of MR damper system controlled by model predictive control (MPC). The promising features of the MPC controller is the ability to solve an online optimization problem considering the effect of constraints on control input and state variables at each time step. In order to implement MPC controller on real time, the fast control algorithm is presented for the semi-active quarter car suspension under the constraint (saturation) on damping force of MR damper. Hence, the constrained optimal control problem can be solved in a sufficiently small computational time which allows the real time implementation of MPC controller possible for the semi-active suspension as an embedded application. As the first step, the equations of motion (EOM) of a two degree-of-freedom (2-DOF) quarter car suspension with the MR damper are derived. Then, the MPC controller is designed based on the model of quarter car suspension system. In addition, the characteristics of the MR damper is also experimentally evaluated to demonstrate the physical constraints on the damping force which is considered as the control input of the semi-active suspension system. The designed MPC controller is then applied to the suspension system and its performance is compared to other standard control approaches including a proportional-integral-derivative (PID) and linear quadratic regular (LQR) optimal control in term of suspension deflection and acceleration of body, respectively. In order to demonstrate the effectiveness of the MPC controller, two different excitations of bump and random signals are adopted and corresponding vibration control performances are evaluated in both time and frequency domain. It will be demonstrated that the proposed controller can provide the improved vibration control performance (e.g. ride comfort) despite of the limitation of damping force compared with the conventional controllers.

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