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Intelligent model predictive/feedback linearization control of half-car vehicle suspension systems.

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Abstract

There exists a level of parametric uncertainty in dynamic systems which if left unaccounted, could impact negatively on performance during implementation. This thesis aims to investigate the effect of acceptably bounded uncertainty, on the performance of Vehicle Suspension Systems (VSS) in the presence of model constraints. The uncertain parameters selected in this work are vehicle sprung mass loading, vehicle forward velocity, suspension spring stiffness coefficients and suspension damper coefficients. A model of a nonlinear, 4 Degree-of-Freedom (DOF) half-car Active Vehicle Suspension Systems (AVSS) with hydraulic actuator dynamics and a similar nonlinear, 4 DOF half-car Passive Vehicle Suspension System (PVSS) model are developed in MATLAB/Simulink®. A two-loop control configuration is designed for the AVSS. This consists of an inner Proportional plus Integral plus Derivative (PID) force feedback control loop; to stabilize the hydraulic actuator and enables tracking of a desired force and an outer control loop for suspension travel control, with the aim of preventing damage by "topping" or "bottoming" (banging of the suspension components on the top or bottom of the suspension workspace). Three control methods are applied to this outer control loop: PID for performance benchmarking, Model Predictive Control (MPC) and Neural Network-based Feedback Linearization (NNFBL). MPC allows for control of systems in the presence of model constraints. NNFBL utilizes an indirect adaptive Neural Network (NN) based identification to linearize highly nonlinear systems into linear ones, allowing application of other control methods thereafter. The performance of the various AVSS controllers are compared with that of the PVSS in the frequency and time domains. In the frequency domain, a road input disturbance with frequency sweeping from $0 - 100\,Hz$ is employed to obtain output data for spectral analysis. In the time domain, a sinusoidal bump road input disturbance and a random road input disturbance are utilized to test vehicle performance. The results indicate that the AVSS is less sensitive to uncertainty in model parameters as compared to the PVSS, by performing better under varying conditions.