Optimizing Vehicle Response in a Combined Ride and Handling Full Car Model by Optimal Control Strategies

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ABSTRACT

This paper focuses on the control of combined ride and handling full car model of a Four-Wheel Steering (4WS) Vehicle and determines how can ride and handling influence together by the road irregularities and front and rear steering inputs and disturbances like side wind. In this regard, a 9 DOF vehicle model is proposed as a combined ride and handling model which include both ride and handling state variables. The inputs are front steering angle that acts by the driver, road vertical conditions and control input that is rear wheel steering angle (In special case vertical actuators between sprung mass and unsprung mass are assumed as ride control inputs). It is shown that how these inputs can influence on vehicle ride and handling response and improve the ride response by handling control input. Control inputs are 4 actuators for each wheel that control vertical displacement of sprung mass and 2 actuators for rear wheels that control the rear steering angle. The model describes vertical and lateral displacements and rotations and it is considered to have quasi-static conditions in longitudinal displacement. Control strategies that are used in this paper are Linear Quadratic Regulator (LQR) and Dynamic Programming (DP) that regulates vertical displacements and tracks the yaw rate reference.

The results show that using the mentioned 4WS system improves ride characteristics while tracks the desired trajectory and have reliable handling response. It is also shown that ride actuator inputs remained negligible through the handling input (steering angle) but the handling control input is not negligible by road vertical inputs (ride inputs). It is also shown that model complexity could not yield effective influences on vehicle handling response in comparison with a simple 3DOF handling model.

Key Words:
Combined Ride and Handling Car Model, Optimal Control, Vehicle Dynamics, Vehicle Handling, 9DOF Car Model