

Vehicle Attitude and Disturbance Suppression Control Based on Optimal Torque Allocation to Front and Rear Wheels

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In recent years, automated driving systems for automobiles have been actively developed. In such systems, an onboard computer calculates control signals to control the braking and driving forces of the four wheels, steering torque, and other vehicle actuators. In general, ride comfort is closely related to jerk, and suppressing jerk is therefore important for ensuring occupant comfort. In fully automated driving systems, in which occupants do not perform driving operations, a smooth reference trajectory with reduced jerk can be generated and the vehicle can be controlled to follow it. However, in vehicles driven by a human driver, automatic intervention to suppress jerk may degrade vehicle maneuverability. Therefore, a driving assistance control system that achieves both occupant comfort and high maneuverability is required.

When the braking and driving forces of individual wheels can be controlled independently, anti-dive forces generated by the suspension geometry can be utilized to produce roll and pitch moments as well as vertical forces acting on the vehicle body. Therefore, appropriately controlling the anti-dive forces is expected to improve occupant comfort. Fig. 1 shows the mechanical system composed of the vehicle and the occupant considered in this study.

The objective of this study is to develop a control method that improves occupant comfort by utilizing anti-dive forces while maintaining vehicle maneuverability. Specifically, for a mechanical system consisting of a vehicle and an occupant, the front-rear force distribution is determined by formulating a model predictive control problem to suppress variations in the attitudes of both the vehicle and the occupant while achieving the target driving force requested by the driver. In addition, a control method for suppressing the vertical motion of the vehicle caused by road surface irregularities is presented. Fig. 2 shows the system composed of the vehicle and the driver. This study considers a driving assistance control problem that achieves both rapid tracking of the target vehicle speed and improved occupant comfort. It also considers a control problem that maintains the target vehicle speed while reducing the influence of road disturbances on the vehicle. The effectiveness of the proposed method is demonstrated through numerical simulations.

Two simulation conditions were evaluated: acceleration on a flat road and travel over a road disturbance. For the acceleration case, front-wheel drive, rear-wheel drive, equal front-rear allocation, and the proposed control method were compared. The vehicle-speed responses were almost identical, whereas the proposed method most effectively suppressed the occupant head inclination angle and head angular jerk. Fig. 3 shows the head angular jerk during acceleration. For the road-disturbance case, appropriate allocation of the front and rear driving forces reduced both the vertical displacement and vertical velocity of the vehicle center of gravity. Furthermore, incorporating road-disturbance information into the controller further suppressed vehicle attitude variations.

The proposed method suppressed occupant head angular jerk while maintaining vehicle speed tracking performance. It also reduced the occupant head inclination angle and the vertical displacement and vertical velocity of the vehicle center of gravity. Furthermore, incorporating road-disturbance information into the controller improved the suppression of vehicle attitude variations.

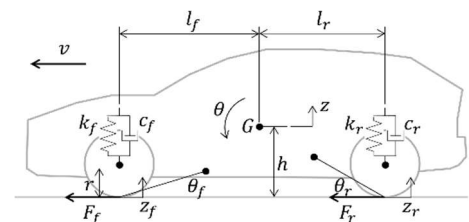


Fig.1 Vehicle model

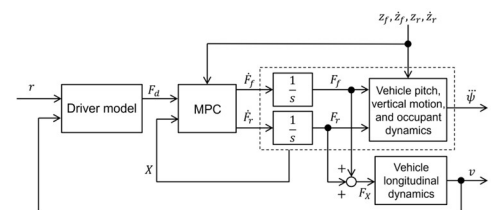


Fig.2 Vehicle control system

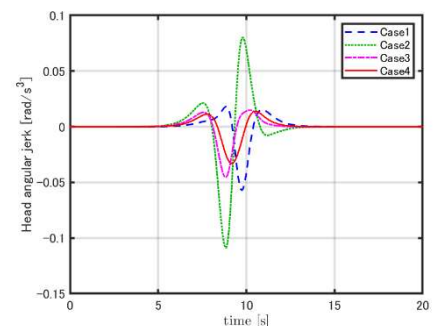


Fig.3 Head angular jerk