Advances in Automobile Engineering

Extended Abstract

Effects of Tilting Mechanism of Narrow Vehicle on Psychophysiological States of Driver

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Abstract

This paper proposes an integrated stability control strategy for tilting vehicles. The work extends the envelope-based lateral stability controller by introducing and enforcing the roll envelope in the optimal control design. The model predictive controller (MPC) scheme is adopted to apply the control effort only when the predicted vehicle states are leaving the safe envelopes. The non-minimum phase problem in active tilting control is handled by utilizing the predictive feature of the controller. It is shown via the simulation in CarSim that, by adopting the envelope-based control scheme, the control effort to maintain the roll stability of narrow vehicles can be greatly reduced. The integrated controller also improves the vehicle handling performance while still guarantees its lateral and roll stability. It can be applied to the emerging narrow tilting cars for urban transportation as well as conventional vehicles with semi active or active suspensions. This paper extends the integrated lateral stability controller by considering the roll degrees of freedom for motion control. An envelope approach based on rollover index is proposed for the high-level controller of the vehicle to manage the rollover stability and the control energy consumption. The desired stabilizing forces are then distributed to available actuators using a reconfigurable optimal control allocation. The reconfigurable approach provides the freedom to select different actuators for the system without redesigning the controller. The optimal control allocation also ensures the feasibility as well as system robustness. It is shown via the simulation in CarSim that, by adopting the proposed control approach, tilting control effort is reduced and the vehicle handling, as well as stability in both lateral and roll motions, can be furthered improved.

Narrow tilting vehicles have been proposed to address transportation issues such as traffic congestion, lack of parking space. The investigation of the effects of narrow tilting vehicles on user is insufficient though many methods for improving the stability of those were proposed. The purpose of the present study is to investigate the effects of tilting mechanism of narrow vehicles on psychophysiological states of driver as a fundamental study. Focused on user satisfaction among the components of usability, the hypotheses that a tilting mechanism affects the user's psychological state, and that the physiological indices such as a frontal alpha asymmetry, beta wave per alpha wave power based on brain activity are valid to Evaluate the state were tested. The subjective evaluation of emotional states based on Russell's circumflex model and the measurement of electroencephalography (EEG) were performed in the experiment using the proposed vehicle with the tilting mechanism. As a result, both the subject evaluation and the physiological indices based on EEG showed a significantly higher value of arousal and valence in the case of the tilting vehicle compared to the control vehicle. These results suggest that both arousal and valence levels of narrow vehicle users can be improved by a tilting mechanism. Narrow commuter vehicles can address many congestion, parking and pollution issues associated with urban transportation. In making narrow vehicles safe, comfortable and acceptable to the public, active tilt control systems are likely to play a crucial role. This paper concentrates on developing a dynamic model for narrow vehicles that can be used for the design and evaluation of active tilt control systems. The model has four degrees of freedom including lateral and tilt dynamics. The influence of gyroscopic forces due to rotating wheels and the influence of front wheel trail are included but secondary coupling effects are ignored so as to keep the model tractable. The model is used in this paper to understand the influence of vehicle tilt on the steering angle required for cornering, the desired tilt angle for any specified cornering maneuver and the influence of gyroscopic moments on transient tilting/cornering maneuvers. A study of the model equations also provides insight into how narrow vehicles can be designed so as to be self-stabilizing.

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