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CHASSIS, CONNECTED AUTOMATED VEHICLES AND ITS, ELECTRICAL AND ELECTRONICS, VEHICLE DYNAMICS AND CONTROL

Research on Control Mode Switching of Vehicle Intelligent Suspension Based on DBN and T–S Fuzzy Method

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Abstract

To cover the problem of dangerous state prediction ahead of vehicle rollover and rescue the vehicle under abrupt cornering condition, a dynamic Bayesian network (DBN) merged robust control is developed to balance the vehicle ride comfort and handling performance. To discretize the automobile state attributes and prepare for the prediction, class attribute contingency coefficient (CACC) is adopted to pre-process the data conveniently and establish the category labels. The key contributions of this paper are efficient rollover prediction with probabilistic and numerical representation, a mapping rule from rollover probabilities to T–S fuzzy membership values, and an intelligent objective switchable control between ride comfort and roll stability. The co-simulation method is adopted to verify the effectiveness of this method with passive suspension, semi-active suspension, and optimal control active suspension. It is shown that the DBN-based robust control is able to reduce the roll angle by more than 27% compared to the passive suspension under double-lane change condition and has the best balancing performance. From the perspective of ride comfort testing on bounce sinusoidal roads, the vehicle DBN incorporating robust controllers can effectively reject vibrations and switch control objectives based on its running conditions.

Keywords Intelligent suspension · Dynamic Bayesian network (DBN) · T–S fuzzy modeling · Robust control · Rollover avoidance

1 Introduction

Rollover is a common form of vehicle accident and one with serious consequences. Under the cornering circumstance, poor rollover limits of high deck coach and heavy freight increase the possibility of rollover, especially at a relatively high speed (Konieczny et al., 2020). Dumping of fully loaded vehicle bodies is recognized as a serious threat to traffic participants such as pedestrians and compact sedans. There are two kinds of rollover mechanisms, one is manoeuver-induced rollover and the other one is tripped rollover (Ataei et al., 2019; Yim et al., 2010). The manoeuver-induced rollover is mainly produced by the dynamic roll behaviors, such as high-speed obstacle avoidance maneuver, while the tripped rollover always appears accompanying with a relatively high pavement bump which blocks the lateral movement of the running vehicle (Treetipsounthorn et al., 2020). The latter rollover type is considered to be related to the embankment and it is hard to escape from this instability state for the unpredictability road factors (Rodríguez-Licea, 2021).

Anti-rollover studies based on vehicle dynamics have attracted a lot of interest from researchers in recent years. Installing a mechanical structure is the most straightforward way to control the vehicle's roll attitude and improve the rollover limit. The passive anti-roll bar equipped in the automobile considerably reduces the body tilt angle which has effect on the cornering running condition (Zulkarnain et al., 2018). By increasing the torsional stiffness, the body was found to be stable and to have less rolling motion compared to a normal MacPherson suspension. In addition to purely mechanical anti-roll structures, a number of previous studies have

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