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Editorial

Advanced Modeling, Analysis and Control for Electrified Vehicles

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Electrified vehicles, especially fully driven electric ground vehicles, are expected to provide significantly increased traffic mobility and road utilization with faster response times, lower levels of fuel consumption, less environmental pollution, electrified power sources and actuators, and the benefits of greater driving safety and convenience integrated with diverse, dynamic subsystems [1–4]. As an important part of future smart transportation systems, electrified vehicles have attracted increasing attention from academia, the industry and governments around the world due to their advantages and applications. Taking advantage of the advanced architectures supported by electrified vehicles, a large number of advanced models; estimation and control techniques for electrified vehicles such as parameter estimation, electronic control steering systems and roll stability control systems; torque distribution analyses; time analyses in in-vehicle controller-area networks; multi-objective topology optimizations and controllers designed for the active suspensions of in-wheel motors have been built or conducted to improve the active safety of vehicles [1–6].

The primary goal of this Special Issue is to provide timely solutions to technological developments and challenges in the modeling, estimation, simulation, design, control and optimization of electrified vehicle systems. After a rigorous review process, 10 manuscripts were ultimately accepted which address adhesion coefficient estimation and the estimation of tire–road parameters [7,8], the optimization of an active steering system [9], braking energy regeneration [10], anti-rollover control [11], the coordinated control of vehicle dynamics [12], the integrated control of path tracking and stability [13], vehicle detection and ground segmentation [14], automatic emergency braking systems [15] and obstacle avoidance control [16]. A brief summary of these articles is provided below.

Beginning with estimations of road parameters and tire–road parameters in a vehicle dynamics system, in [7], a new method for estimating the comprehensive adhesion coefficient of three-dimensional pavement based on a dimensionless, data-driven tire model is presented to estimate the tire–road peak friction coefficient (TRPFC), in which the real-time assessment of the lateral and longitudinal adhesion coefficients of three-dimensional pavement is realized via an unscented Kalman filter (UKF). Then, a fuzzy reasoning strategy for fusing the longitudinal tire adhesion coefficient and the lateral tire adhesion coefficient is designed, and the experimental results of vehicle tests conducted with a four-wheel independently driven vehicle modified via wire (UTV) prove that the proposed estimation method can accurately estimate the peak adhesion coefficient of pavement. In [8], a combined offline and online identification-based estimation of tire–road parameters is proposed for skid-steered, wheeled, unmanned ground vehicles with flexible layout structures and strong possibilities for use in military and agricultural fields. The interaction between the

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tires and the road is first described using the Brush nonlinear tire model, the horizontal and longitudinal stiffnesses of the tire are identified offline using a particle swarm optimization (PSO) algorithm with an adaptive inertia weight, and the extended forgetting factor recursive least-squares (EFRLS) method was utilized to identify the road adhesion coefficient under the Burckhardt adhesion coefficient formula online.

Achieving advanced vehicle stability control over vehicle dynamics is a very important aspect of improving vehicle handling and safety performance. In [9], a gain-scheduled controller-based active trailer steering (ATS) system that can cope with the unstable motions of a car–trailer combination, including trailer sway, jackknifing and rollover, is optimized, the weighting matrices of the LQR controller are determined using the GDE3 evolutionary optimization algorithm, and a control objective is designed to address the tradeoff between minimizing the car–trailer's path-following performance at low vehicle speeds and the rearward amplification of high vehicle speeds. The effectiveness of the multi-objective. tuned gain-scheduling controller is demonstrated in a driver-in-the-loop single-lane-change maneuver.

In [10], a braking energy regeneration control strategy for a hybrid electric vehicle (HEV) is studied to improve performance and reduce fuel consumption. A better control strategy composed of braking regeneration and gear shifting is designed. Taking the increased electric energy of a battery as the objective function of the economic downshift law, the multi-island genetic algorithm (MIGA) is used to solve the shifting condition factors according to different deceleration speeds and motor torques and the optimal downshifting speed, and a typical city cycle in China is used to validate the proposed control strategy for braking energy regeneration in an HEV.

In [11], an anti-rollover control for the rollover risk of independently driven heavy-duty vehicles is presented. A new rollover evaluation index with an improved LTR (load transfer rate) that can describe the dynamic change in the vertical load of a tire by replacing the suspension force and the vertical inertia force of the unsprung load mass is designed. Then, a hierarchical rollover controller based on the identification of the slip rate of the road's surface and ABS control with a sliding mode variable structure and differential braking is provided. Test results achieved via hierarchical control and HIL (hardware-in-the-loop) experiments verify that the designed controller can accurately predict the risk of rollover and avoid the rollover in time under fish-hooking and angle-stepping conditions.

Furthermore, the achievement of integrated control via the coordination of aspects of a vehicle dynamics subsystem, such as active front steering (AFS), direct yaw moment control (DYC) for path following and improvements in the lateral stability the vehicle, is addressed. In [12], a hierarchical coordination control strategy comprising the coordination of active front steering and direct yaw moment is proposed to enhance the stability of a distributed-drive electric bus. An observer based on a sliding-mode observer (SMO) and an adaptive neural fuzzy inference system (ANFIS) are built to estimate the vehicle parameters; the upper-layer control focuses on a coordinated strategy, while the lower-layer control of the strategy incorporates an integral terminal sliding mode controller (ITSMC) and a non-singular fast terminal sliding mode controller (NFTSMC) to obtain the optimal additional front wheel steering angle and yaw moment, respectively. The simulation results demonstrate that the proposed strategy can effectively improve the maneuvering and yaw stability, with the ability to adapt to various extreme environments.

In [13], an integrated control strategy for path tracking and the stability of four-wheel independently driven electric vehicles is discussed to prevent rollover when driving at high speeds on high-adhesion roads and sideslip on low-adhesion roads in which the lateral stiffness of the tires and the lateral velocity, yaw rate, roll angle and roll angle velocity of the vehicle are estimated via an unscented Kalman filter. TAn integrated control strategy consisting of a path-tracking controller, roll-stability controller and lateral-stability controller is designed. The simulation results show that the proposed strategy can effectively limit the lateral load transfer rate on high-adhesion roads and the sideslip angle on low-adhesion roads at high speeds.

Recently, intelligent driving technology has attracted increasing research efforts due to its promising effect in improving efficiency, safety, traffic mobility and road utilization. In [14], aiming to address problems of over-segmentation and under-segmentation in traditional ground segmentation algorithms for vehicle detection in autonomous driving, a robust Gaussian-process-based LiDAR ground segmentation algorithm is considered for autonomous driving vehicles. The height and slope criteria and a sparse covariance function are introduced to ensure an accurate search of real ground candidate points as training data for the Gaussian process, and the proposed algorithm is tested using an autonomous driving experimental electric vehicle platform in the Intelligent Electric Vehicle Laboratory (iEVL) and the public autonomous driving dataset KITTI.

In [15], the identification of driving-condition-based automatic emergency braking systems (AEBSs) is reported for improving the active safety performance of commercial vehicles. An AEBS control strategy with adaptive driving conditions is designed in which the vehicle's mass, the position of its center of gravity, the road grade, and the tire–road friction coefficient are first estimated; then, simulated and experimental verifications of the full load and low-tire–road friction values in an extreme test scenario validated that the proposed AEBS control strategy can avoid collisions and possesses adaptability under different driving conditions.

In [16], an integrated, active obstacle-avoidance controller to ensure adaptive collision-free obstacle avoidance is presented. Taking the observed road conditions and obstacle states as inputs, a data-driven Gaussian Process Regression (GPR) model is constructed and trained to generate confidence intervals; then, scene-adaptive dynamic safety envelopes that represent the safety boundaries of obstacle avoidance are considered. Both the safety envelopes and stability are incorporated into a model predictive control (MPC) framework, and the safety of obstacle avoidance and vehicle stability can be guaranteed by solving the multi-objective optimization problem. After minimizing both the control increments and the stability feature parameters, the experiments conducted on a motion-base driving simulator show that the proposed controller can perform safe and stable obstacle avoidance in more complex scenarios.

Of course, the selected topics and papers are not a comprehensive representation of the field addressed in this Special Issue. Nonetheless, they represent the rich and multi-faceted knowledge that we have the pleasure of sharing with our readers.

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