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(Doctoral thesis abstract)

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論文題目 (Title)	Motion Planning and Control for Collision Avoidance of Autonomous Vehicles Considering Uncertain Dynamic Urban Environments
論文要旨（2000 字程度） <p>The advent of advanced driver assistance systems (ADAS) and autonomous driving technology has significantly contributed to the global reduction of road traffic accidents. Nonetheless, achieving the ultimate goal of zero traffic accidents remains a challenging endeavor. Despite extensive research efforts by academic institutions and automotive companies, certain areas demand further enhancement. This paper focuses on the persistent issue of traffic accidents in regions with ambiguous traffic regulations, particularly in non-signalized roads and shared spaces. These areas pose unique challenges due to the close proximity of traffic participants and the unpredictable nature of their movements, necessitating a reevaluation and improvement of collision avoidance (CA) strategies.</p> <p>Firstly, when an automated vehicle needs to avoid multiple obstacles at the same time, consuming travel time and safety assurance of CA need to be carefully considered especially in the case related to unpredictable motion of obstacles. This thesis proposes a feasible solution to this situation by controlling speed and the steering wheel angle. A three-layer control algorithm which contains: (1) behavior re-planning layer, that bases on post-encroachment time (PET) provides a judgment of a function which calculates the possibility of unavoidable road accidents, (2) the path re-planning layer of a novel two-layer model predictive control (TL-MPC) that will re-plan a local trajectory and give a reference acceleration, and (3) the path tracking layer of the TL-MPC, that outputs steering wheel angle to follow the trajectory under the premise of ensuring safety constraints, is proposed to solve the CA problem in such scenario.</p> <p>Secondly, in typical traffic scenarios characterized by the absence of distinct separations among traffic participants, such as mixed traffic or shared spaces, vehicles and pedestrians often coexist, leading to situations where the ego vehicle encounters multiple pedestrians within a relatively short interaction distance. Given the stochastic nature of pedestrian movements and the need to balance time efficiency with safety during the passing process, this thesis introduces two Collision Avoidance (CA) strategies for the ego vehicle. These strategies are based on Model</p>	

Predictive Control (MPC) and the Social Force Model (SFM), aimed at addressing the CA challenge in such scenarios. The interaction dynamics between the ego vehicle and pedestrians are simplified into a Markov process, enabling the adoption of the SFM-based dynamic model. The validity of this simplification is supported by the analysis of real-world driving data. Furthermore, parameters associated with the SFM-based vehicle model are recalibrated using Particle Swarm Optimization (PSO), and this calibration process is comprehensively examined from a physical standpoint.

Thirdly, to enhance the generalizability of the SFM-based Collision Avoidance (CA) strategy in handling increasingly intricate scenarios, an adaptive parameter approach is employed for the SFM-based vehicle model. Utilizing the real-time status of the interaction system comprising both the vehicle and pedestrian, the ego vehicle will derive optimal SFM-based parameters generated through offline Particle Swarm Optimization (PSO) to effectively avert collisions.

Fourthly, in view of problems existing in artificial neural network (ANN) and MPC when designing CA methods, such as ANN normally use human driver data set, which contains instability and huge amount of noise as training data, that will result in large trial and iteration epochs to obtain results, and MPC are not yet possible to control in real-time in the dynamic motion of the vehicle due to its huge computation when facing to complex scenario. This research also proposed an ANN based neural approximation-based feedback controller (NAFC) that its training data is collected from MPC in order to ensure stability of training data and can guaranteed real-time performance.

Finally, an SFM-based driver assistance system is conducted and examined in T3R Hardware-in-the-Loop (HIL) test bench. This driver assistance system generates a local reference path for the driver based on the real-time states of vehicle-pedestrian system. This path is then seamlessly projected onto the front windshield, providing the driver with a virtual representation of the environment. The empirical results stemming from the HIL tests affirm the feasibility of the proposed SFM-based driver assistance system in guiding drivers to safe path.