COLLISION AVOIDANCE FRAMEWORK FOR AUTONOMOUS VEHICLES UNDER CRASH IMMINENT SITUATIONS

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\textbf{ABSTRACT}

Recent developments in autonomous vehicle (AV) capabilities have been discussed as a collective set of disruptive technologies that will profoundly impact the current transportation system in terms of safety. Vehicle automation removes human error from the driver within the vehicle. Recognizing the critical fact that 94\% of severe highway crashes are a result of human error, the emergence of autonomous vehicles possesses the potential to significantly enhance the safety of vehicular transportation. While the safety benefits from autonomous vehicles will be most effective when the market penetration of AVs is 100\%, the transition from a system of exclusively human-driven vehicles to that of exclusively autonomous vehicles will be an arduous and laborious process. Thus, the safety benefits of AVs will be curtailed by the human error persisting through the human-driven vehicles (HDVs) during mixed traffic flow comprised of both AVs and HDVs. A common scenario that results in traffic collision is during high-velocity lane changes. As the act of lane changing is more disruptive than simple car following, the consequences of inattention or misjudgment are severe. Thus, this paper aims to introduce a control framework for AVs to avoid collision in the presence of aggressive lane-changing human drivers. A control framework based on MPC (Model Predictive Control) is formulated to handle the human error from HDVs in the mixed traffic flow regarding two common collision patterns: rear-end collisions and side-impact collisions. This research focuses on controlling the AV’s maneuvers based on V2V connectivity in order to protect itself from human drivers recklessly performing lane change maneuvers, mitigating secondary collision on the same lane, which caused by the lane changing collision. Thereby facilitating the safety of the local traffic. Further, this research investigates how connectivity between HDVs, and AVs can further improve efficiency and safety by allowing joint decision making and sharing of real-time information. Finally, simulations are presented to test the performance of the control framework under different situations. The framework combines the two crash avoidance maneuvers can avoid the collision effectively under different situations in terms of bumper to bumper distance and relative velocity of the vehicles. The average success rate of the complete process is more than 90\%, the success rate under specific situations like low relative velocity can reach to 100\%.

\textbf{Keywords:} Autonomous vehicle, collision avoidance, imminent situations, model predictive control (MPC), optimal control, human error.