Center for Advanced Multimodal Mobility Solutions and Education

UTC Project Information – CAMMSE @ UNC Charlotte	
Project Title	Online Cooperative Lane-changing Model of Connected and Autonomous Vehicles
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Brief Description of Research Project	Relieving traffic congestion, enhancing mobility and reducing fuel emission were perceived as the main benefits of connected and autonomous vehicles (CAVs) when they were first introduced. In the last decades, increasingly significant multidisciplinary efforts have been jointly made by the automotive industry, high-tech companies, public sectors, and research institutions around the world in this domain. However, most research efforts are mainly focused on longitudinal control, such as car following model of Adaptive Cruise Control (ACC), and Cooperative ACC (CACC). In comparison, few contributions have been made towards lateral control maneuvers although lane changing behavior is extremely

	important and its relevant study becomes more and more critical particularly as a higher level of vehicle automation is enabled in the transportation system. Lateral maneuver research is a challenging undertaking that optimizes vehicle and transportation system controls by considering individual vehicle kinetics and traffic flow system harmonization comprehensively. In general, the CAV lane-changing system consists of four key modules: vehicle-to-vehicle (V2V) communication, localization, lane-changing decision and planning, and vehicle control algorithm. Researchers have fully explored the advantages of several different vision capture and positioning technologies, such as light detection and ranging (LiDAR), radar, global navigation satellite system (GNSS), differential global position system (DGPS), and high-definition (HD) map construction. These technologies lay a solid foundation for lane-changing model construction and optimal control algorithm development. Consideration of the cost and safety concerns associated with field tests, the lane-changing model is mainly developed by using a typical simulation platform, such as SUMO or VISSIM at a microscopic level. Limited by traffic flow organization patterns of these simulation software platforms, the lane-changing decision model and its optimal control in the real world may not be simulated and replicated as precisely as possible.

	More precisely, studies on lane-changing decision and planning should focus on when and where to perform lane-changing maneuvers, which should be based on real-time information and decision models to help with their real world implementation. In this regard, two main research gaps still exist: 1) decisions models may be made “jointly” in a collaborative manner rather than merely “simultaneously”; and 2) Lane changing decisions should be made in consideration of their impact on the traffic stream. In particular, the presence of the mixed traffic flow that consists of CAVs, autonomous vehicles (AVs), connected vehicles (CVs), and human vehicles (HVs), would make it more difficult to “optimally” decide the relevant lane-changing behaviors, especially under many complex driving scenarios. In addition, after making lane-changing decisions, CAVs need to plan one or more reference trajectories that are appealing for a set of objectives and update the proposed trajectories in real time to avoid potential collisions until the lane-changing process is completed. Due to the time delay in sensing, communication, computation, and execution, CAVs need to predict the possible behaviors of surrounding vehicles online to account for effective information transformation. The time-consuming control algorithms should be replaced by adaptive concurrent computation process and logic.

	This study will fill this gap by conducting several simulation-based experiments to develop a cooperative lane change decision-making model for CAVs involving more than two vehicles and different CAV penetration rates. The lane-changing decision model and optimal control algorithm would be developed and simulated on different road segments, including the mainline, merging and departure areas of freeways. This study will also aim to gain a better understanding of relevant computational efficiency in terms of time by an online computation process in order to help transfer the CAVs technologies from the laboratory to the real world market.
Describe Implementation of Research Outcomes (or why not implemented) *Place Any Photos Here*	
Impacts/Benefits of Implementation (actual, not anticipated)	
Web Links • *Reports* • *Project website*	https://cammse.uncc.edu/sites/cammse.uncc.edu/files/media/CAMMSE-UNCC-2022-UTC-Project-Information-03-Fan.pdf https://cammse.uncc.edu/sites/cammse.uncc.edu/files/media/CAMMSE-UNCC-2022-UTC-Project-Report-03-Fan-Final.pdf