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Safety-Guaranteed Driving Control of Automated Vehicles

-Advanced vehicle control systems (e.g., an electronic stability control system) can greatly reduce accident rates and fatality in accidents. Vehicle control systems in automated vehicles (AVs) are able to ensure vehicle safety in many driving scenarios by cooperating with other advanced perception and path planning systems of the AVs. A typical safety-related AV control procedure contains the following steps. First, based on the sensing and perception of the surrounding environment, a decision-making algorithm determines if a collision or danger will happen. If yes, a collision-free path will be (re)planned and then well tracked. For path planning, various methods have been proposed to generate a collision-free path. However, even if a collision-free path is planned, vehicle safety cannot be guaranteed due to the unsecured vehicle path tracking performance. Although vehicle safety (i.e., a kinematic constraint) and stability (i.e., a dynamic constraint) could be controlled separately, these two aspects are always closely related to the control of AVs. Normally, good tracking performance for a planned path also relies on vehicle stability as an essential requirement. Thus, if the planned path cannot be well tracked due to the lack of vehicle stability, a tracking controller with guaranteed vehicle stability becomes necessary.

The safety-guaranteed driving control problem can be formulated as a path tracking control that satisfies both kinematic and dynamic constraints. One current method to solve the safety-guaranteed driving control problem integrates performance control (e.g., tracking control) with guaranteed safety (e.g., control barrier functions (CBFs)). Specifically, one integration includes the control Lyapunov function (CLF), where one or more CLF and CBF are integrated to achieve required control performance with guaranteed system safety (e.g., tracking a desired path with guaranteed vehicle stability). What is still needed is a method to solve the safety-guaranteed driving control problem that considers time-varying and control-dependent safety constraints.

Researchers at Arizona State University (ASU) have developed an automated vehicle (AV) control system for ensuring high-tracking control performance for time-varying and control-dependent safety constraints. This AV control system utilizes control-dependent barrier functions (CDBFs) and time-varying control barrier functions (TCBFs) integrated with control Lyapunov functions (CLFs) to achieve good tracking control with guaranteed vehicle safety.

Related publication: Safety-Guaranteed Driving Control of Automated Vehicles via Integrated CLFs and CDBFs

Potential Applications:

- Advanced driver assistance systems (ADAS)
- Automated vehicles
- Automated vehicle driving control systems

Benefits and Advantages:

- Considers both vehicle and tire stabilities in safety control of automated vehicles
- Can handle time-varying and control-dependent safety constraints
- ASU’s control system is validated by an emergent lane change maneuver through CarSim®/Simulink co-simulations