Traffic Safety and human error
- 40,000+ annual traffic-related fatalities U.S.
- 95% crashes are related to human error
- 33% crashes related with Lane-change maneuver

Benefit of Vehicle Automation
- Eliminate Human error
- Safety ↑

Connectivity enhance automation
- Increasing sensing range
- Facilitate information dissemination

Automation + Connectivity
- Enables cooperative decision-making
- Well-informed decisions by CAV

Two types of human error
- Type-I error: when AV at fault
- Type-II error: when surrounding HDVs at fault, but AV could not avoid

Main contribution
1. Model Predictive Control (MPC) framework
2. Centralized Cooperative collision avoidance maneuvers

Scope
1. Mixed Traffic Era
2. Focus on Type-II error
3. Collision patterns (side-impact collision / rear-end collision)

Introduction

Typical Collision Patterns under Type-II error
- (a) side-impact collision and (b) rear-end collision

Evasive Maneuvers
- Deceleration maneuver: CAV decelerate to avoid the potential rear-end collision by the lane changing human-driven vehicle (LHDV).
- Lane-change maneuver: CAV lane change to the other lane (the opposite of the LHDV’s lane) to avoid the possible side-impact collision as shown above.

MPC control framework

Controller Design
- CAV & FHDV affect each others’ decisions bi-level optimization problem

Objective (cost) function

Constraints considered:
1. System equation: $t_{end}(k + 1) = dx_{acc}(k) + b_{acc}(k)$
2. Safety distance & soft constraints for speed

4. Range of the controlled variables (deceleration/acceleration range)

Simulation Results

Success rates under different initial conditions:

Conclusions & Future work

Conclusion
- Feasible to develop an MPC cooperative framework that incorporates automation and V2V connectivity
- The developed MPC framework can help CAV and HDVs effectively avoid collisions caused by Type-II error.
- The benefits of Automation + V2V Connectivity in Crash Avoidance is justified

Future work
- Consider multiple types of vehicle speed distributions
- Test MPC framework in driving simulator/ real-life test tracks
- Consider new analytical methods, including Reinforcement Learning, to address stochasticity in the experimental settings.