DRISI
Caltrans Division of Research, Innovation and System Information

Research Notes

Transportation Safety and Mobility

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Project Title:
Vehicle Infrastructure Integration (VII)

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Connected Autonomous Vehicles: Safety During Merging and Lane Change and Impact on Traffic Flow

Discover applicable solutions to the problem of autonomous lane changing in a highway scenario with connected vehicles.

WHAT IS THE NEED?

The purpose of this project is to research how proven technologies such as Vehicle-to-Vehicle (V2V) and Vehicle-to-Infrastructure (V2I) communications can be used in negotiating safe maneuvers of autonomous vehicles, during lane change and merging in a way that safety is guaranteed and the impact on traffic flow is minimized.

Current autonomous vehicles will not be able to navigate in dense traffic unless they violate safety rules like human drivers do, by cutting in front of other vehicles putting themselves in dangerous collision spots, something no autonomous vehicle will be allowed to do by design.

WHAT ARE WE DOING?

The study focuses on the tactical and operational stages, which include evaluating the feasibility of possible lane change maneuvers, finding an appropriate gap, taking the vehicle to the appropriate longitudinal position and velocity, and performing the maneuver. All these tasks must be performed under safety and comfort constraints with minimum impact on the traffic flow.

WHAT IS OUR GOAL?

The goal is to propose applicable solutions to the problem of autonomous lane changing in a highway scenario with connected vehicles.

Caltrans

DRISI provides solutions and knowledge that improves California's transportation system

WHAT IS THE BENEFIT?

The results will motivate the involvement of the infrastructure and other stakeholders in creating a connected V2V and V2I environment which can be used to develop safer and more efficient operations on the vehicle as well as traffic level.

WHAT IS THE PROGRESS TO DATE?

The tasks involving Safety Spacing Requirements, Lane Changing Protocols, and Lane Changing and Merging of Platoons have been completed. Three different strategies are proposed for platoon lane changing:

- Synchronous maneuver: the platoon leader communicates with vehicles in the adjacent lane and requests a space for the whole platoon to move in simultaneously. In this case, the platoon acts as a single long vehicle.
- Leaders first: like the first strategy, the platoon leader requests that a space for the whole platoon is created. However, instead of waiting for the big gap to exist, the platoon leader starts maneuvering as soon as the spacing in the other lane is considered safe. This is repeated by all the vehicles in the platoon from leader to last, i.e., they monitor the gap in the adjacent lane and they move in one at a time as soon as it is safe.
- Followers first: the leader communicates the intention to change lanes to the last platoon vehicle. This vehicle executes the procedure to change lanes, including communicating to others in the adjacent lane. Once it finishes the maneuver, the last vehicle is responsible for generating the proper safe gap for the next platoon vehicle. This is repeated until the platoon leader merges.

The research team is currently working on the Validation and Verification of Safety Spacing, Minimize Impact on Traffic flow, and Simulation Testing and Evaluation tasks.

IMAGES

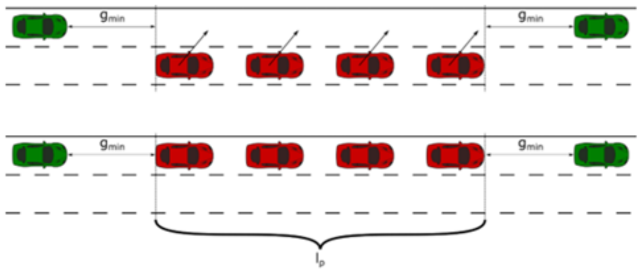


Figure 1: Illustration of a platoon (red vehicle) performing lane change under strategy 1 - Synchronous Maneuver. On top: all vehicle waited for a gap big enough to accommodate the whole platoon before initiating the maneuver. On bottom: situation after the maneuver is complete.

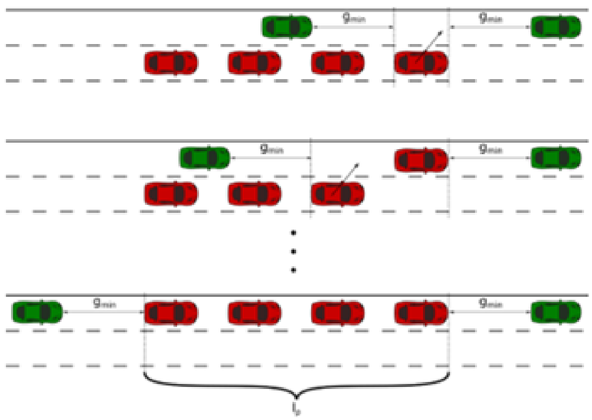


Figure 2: Illustration of a platoon (red vehicles) performing lane change under strategy 2 - Leaders First. On top: platoon leader starts lane change as soon as it senses a safe adjacent gap. Middle: the green followers keeps traveling slower than the platoon and the second vehicle starts its maneuver as soon as it is safe. Bottom: situation after the maneuver is complete.

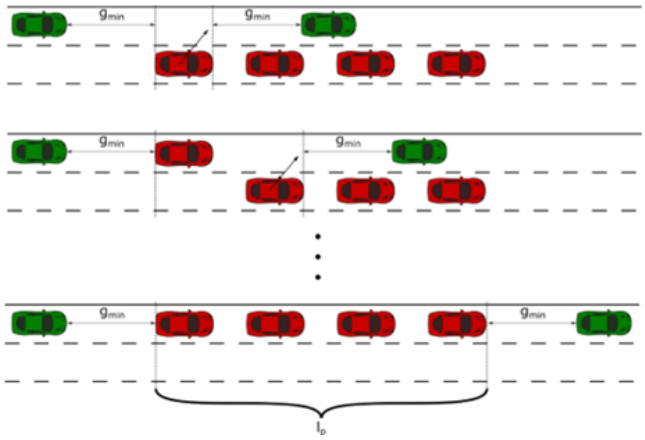
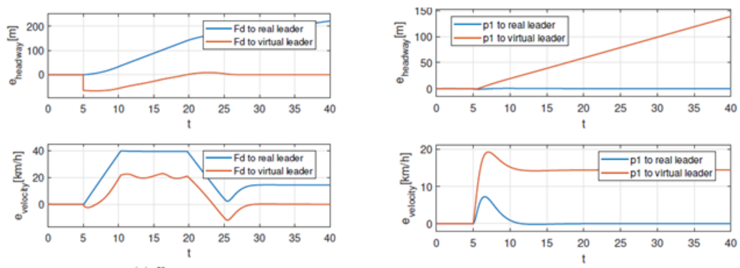
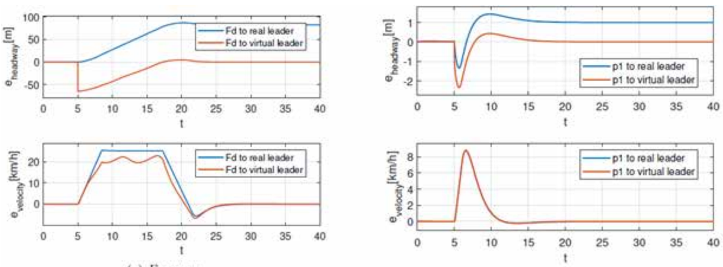


Figure 3: Illustration of a platoon (red vehicles) performing lane change under strategy 3 - Followers First. On top: last vehicle of the platoon starts lane changing as soon as it senses a safe adjacent gap. Middle: the last vehicle travels slower than the platoon to create a gap for its predecessor. Bottom: situation after the maneuver is complete.



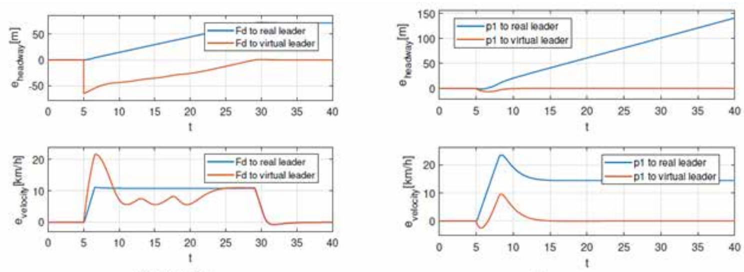
(a) F_d errors. (b) p_1 errors.

Figure 5: Scenario 2 results. On top, errors in headway and, at the bottom, errors in velocity. In blue, errors to real leader and, in red, errors to virtual leader. At the left, F_d's real leader is L_d and its virtual leader is p_3. At the right, p_1's real leader is L_o and its virtual leader is L_d.



(a) F_d errors. (b) p_1 errors.

Figure 4: Scenario 1 results. On top, errors in headway and, at the bottom, errors in velocity. In blue, errors to real leader and, in red, errors to virtual leader. At the left, F_d's real leader is L_d and its virtual leader is p_3. At the right, p_1's real leader is L_o and its virtual leader is L_d.



(a) F_d errors. (b) p_1 errors.

Figure 6: Scenario 3 results. On top, errors in headway and, at the bottom, errors in velocity. In blue, errors to real leader and, in red, errors to virtual leader. At the left, F_d's real leader is L_d and its virtual leader is p_3. At the right, p_1's real leader is L_o and its virtual leader is L_d.

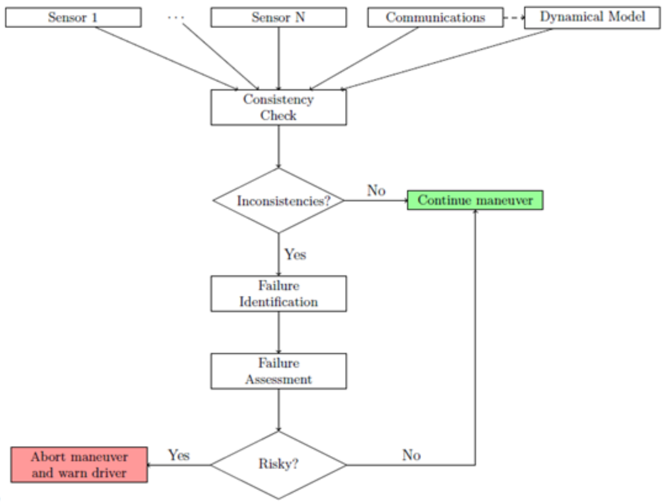


Figure 7: Flowchart of verification procedure with *N* independent sensors.