Research Report Summary

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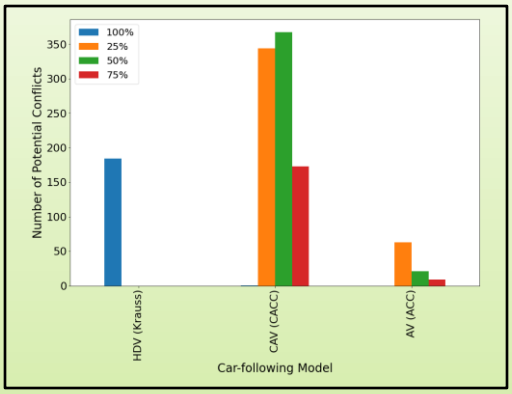
A Co-Simulation Study to Assess the Impacts of Connected and Autonomous Vehicles on Traffic Flow Stability during Hurricane Evacuation

"Ensuring safer mobility for the evacuees"

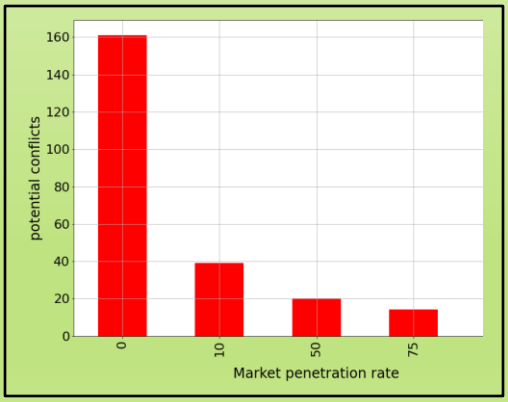
Hurricane evacuation has become a major problem for the coastal residents of the United States. Devastating hurricanes have threatened the lives and infrastructure of coastal communities and caused billions of dollars in damage. There is a need for better traffic management strategies to improve the safety and mobility of hurricane evacuation traffic. In this project, we assessed the potential safety benefits of Connected and Autonomous Vehicles (CAVs) and Autonomous Vehicles (AVs) for hurricane evacuation traffic. We simulated evacuation traffic on I-75 interstate road segment using a microscopic traffic simulation model (SUMO). We tested CAVs and AVs using two approaches. (i) microsimulation of car-following models (ii) simulation of vehicle ad-hoc network by coupling a traffic simulator with a communication simulator.

In the first approach, we used a microsimulation of CAVs and AVs represented by the Co-operative Adaptive Cruise Control (CACC) and Adaptive Cruise Control (ACC) car following models, respectively. We created mixed traffic scenarios consisting of human driven vehicle (HDV) and the vehicle technology to be tested (e.g., CAV and AV). We performed our experiments with 25, 50, 75 and 100 percentages of CAV and AV separately.

Results



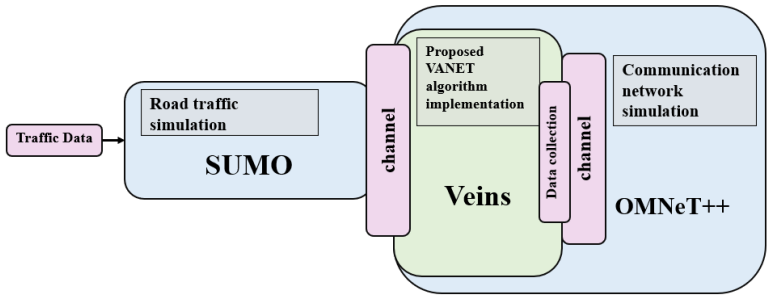
Number of potential conflicts during hurricane evacuation for different vehicle technologies



Potential conflicts during hurricane evacuation for different percentage of CAVs in co-simulation model

Simulation results show that AVs, represented by the ACC car-following model, can significantly reduce the potential number of conflicts up to 65.9% (vs. 48.7% found in our previous study) with only 25% market penetration rate. Our results suggest that ACC car following model is more stable with less standard deviation. CAVs, commonly represented by the CACC car-following model, produced highly fluctuating results with high numbers of potential

conflicts. We performed several experiments, with multiple sets of CACC model gain parameters from different literatures. Due to the high standard deviation in the simulation results and higher number of potential conflicts for all sets of CACC model gain parameters we concluded that the CACC car-following model is not appropriate to simulate the effects of CAVs, at least, in a hurricane evacuation context.



Framework to couple coupling traffic simulator with communication simulator

In our second approach, we separately assessed the connectivity of CAVs by integrating vehicle-to-vehicle (V2X) communication with car-following models. To see the connectivity aspect, we coupled a communication simulator and SUMO to incorporate car-following model with ability to communicate with other vehicles. We incorporated V2X communication on Krauss car following model, since we want to assess the effect of connectivity and Krauss is used in our base case study. We experimented for different penetration rate of CAVs (10, 50, 75, and 100). Our results show that with introducing only 10% CAV in the traffic stream, number of conflicts decreases by 75%. From our study of a vehicular ad-hoc network, we found that connectivity increases the road safety as the information dissemination help vehicle decide to take proper maneuver and stabilize the traffic.

Outcomes

Outcomes of the study

- Develop a realistic hurricane evacuation traffic using micro simulation.
- Assess the potential safety impacts of connected autonomous vehicles (CAV) during a hurricane evacuation.
- Assess the impacts of vehicle to vehicle communication during hurricane evacuation by integrating traffic and communication simulators, creating a co-simulation framework.

Impacts

Potential impacts of the study

- Researchers and practitioners should adjust vehicle model parameter and the lane changing parameters for modelling evacuation traffic.
- Agencies can recommend the use of in-vehicle ACC system as it can potentially reduce the number of crashes during evacuation.
- Agencies can deploy vehicle-to-vehicle communication technologies to stabilize traffic and reduce potential traffic conflicts.

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