DRISI

Caltrans Division of Research, Innovation and System Information

Research Results

UTC - Control and Management of Urban Traffic Networks with Mixed Autonomy, (UCCONNECT)

Researchers developed simulation models for controlling mixed traffic flow of vehicles with varying levels of autonomy and manually driven vehicles to improve mobility at the network scale.

Transportation Safety and Mobility

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Project Title:
UTC - Control and Management of Urban Traffic Networks with Mixed Autonomy, (UCCONNECT)

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WHAT IS THE NEED?

Automobiles are increasingly equipped with autonomous and semi-autonomous technologies such as adaptive cruise control and automated lane-keeping. It is apparent that increasing numbers of these smart vehicles will have a dramatic impact on networklevel mobility factors such as traffic congestion and travel times. It was speculated that by platooning groups of smart vehicles along the roadway with these autonomous capabilities could improve mobility. Research was needed to determine if platooning smart vehicles in a mixed traffic flow would result in improved mobility.

WHAT WAS OUR GOAL?

The goal was to have researchers develop simulation models for controlling mixed traffic flow, where some fraction of vehicles are equipped with varying levels of autonomy and the remaining are manually driven, in order to determine traffic mobility improvements at the network scale.

WHAT DID WE DO?

Caltrans contracted the University of California at Berkeley researchers to develop capacity models for roads with mixed autonomy (networks in which a fraction of the vehicles on each road are equipped with autonomous capabilities). Using these models, researchers studied routing behavior on transportation networks. The assumption was made that the additional travel time caused by congestion on a road is inversely related to capacity and proportional to the total number of vehicles on the road. Given a network of roads leading from origins to destinations, selfish vehicles will choose the route that minimizes total delay, achieving a Wardrop equilibrium (when all users behave cooperatively in choosing their routes to ensure the most efficient use of the whole system).

A mixed traffic profile was considered for this research, where a fraction of vehicles are smart and able to form platoons, and the remaining are regular and manually driven. Researchers developed two models for road capacity under mixed autonomy that are based on the fundamental behavior of autonomous technologies such as adaptive cruise control. One model is where smart vehicles are able to maintain shorter headways with any preceding vehicle. The other model is where smart vehicles are only able to maintain a shorter headway if the preceding vehicle is also smart. Researchers then analyzed transportation networks and determined that the delay on each road or link is a function of two quantities: the number of vehicles with autonomous capabilities on the link and the number of regular vehicles on the link. Researchers also studied the price of anarchy for such networks, that is, the ratio of the total delay experienced by having traffic routed through a congested network in an uncoordinated manner to traffic being routed through a congested network in a way to optimize traffic flow.

WHAT WAS THE OUTCOME?

- Capacity models for transportation networks with mixed autonomy were developed.
- Researchers presented pairwise separable and non-separable cost functions for traffic networks under mixed autonomy.
- It was demonstrated that the price of anarchy (the ratio of the total delay experienced by having traffic routed through a congested network in an uncoordinated manner to traffic being routed in a way to optimize traffic flow) has no limit unless there are constraints. What makes a difference in improving congestion is the addition of more autonomous vehicles.
- Researchers defined a notion corresponding to the maximum possible travel time improvement due to the presence of autonomous vehicles. It was shown that when all the links in a network are different by a factor less than 4, the price of anarchy is not unlimited.
- Researchers presented simulations results via the Simulation of Urban MObility (SUMO) program that showed tight agreement between the theoretical models and practice.
- Results of this research show that the price of anarchy (the ratio of the total delay experienced by selfish routing to the socially optimal routing policy) can be arbitrarily large for such mixed autonomous networks.

WHAT IS THE BENEFIT?

The results of the simulations performed under this research could be further verified in a field operational test. The benefit to the public could be reduced time on the road to get from origin to destination in a mixed traffic (autonomous vehicles and regular vehicles) environment.