Eco-Speed Control Using V2I Communications

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Project Overview

Stopping for red lights at intersections forms a major share of energy lost by a vehicle. Studies have indicated that an intelligent approach to vary speeds of vehicles to reduce stopping and idling at intersections can yield major savings in fuel and emissions. However, previous research showed a major shortcoming with the approach in which the goal of minimizing fuel consumption was simplified to objective functions consisting of time or change in speed. This project investigated speed adjustments at signalized intersections using signal phase and timing data (SPaT) to simulate multiple pairs of example cases of eco-speed control for different vehicle types, and compares the results. It shows that eco-speed control can reduce fuel-consumption by over 50 percent while in the vicinity of signalized intersections. It also shows that the benefits are higher for larger engine-sized vehicles when compared to smaller engine-sized vehicles.

Methodology and Framework

This research project used an eco-speed control framework for calculating the most fuel-efficient speed trajectory for a vehicle approaching a signalized intersection. It assumes availability of signal phasing and timing data to vehicles approaching the signalized intersection through a Dedicated Short Range Communication (DSRC) system enabling vehicle-to-infrastructure (V2I) communication. In order to avoid effects (such as perception-reaction delays) due to human interaction, it assumes that the vehicle is autonomous. Alternatively, the instantaneous speed advisory may be provided to drivers and the fuel-savings will depend on how accurately the driver is able to follow the system recommendations.

Case Studies

The effectiveness of the proposed eco-vehicle speed control application is evaluated considering different vehicle models, different approach speeds, and different desired delay estimates. The following assumptions are made: (a) the research team only considered the lead vehicle approaching the signalized intersection (and no inter-vehicle interaction); and (b) SPaT information is available from the intersection controller via V2I communication. The analysis includes 80 cases consisting of four different vehicle types, four different approach speeds and five different time-to-greens (TTGs). For each case, a matrix of speed profiles was built according to the procedures described in the project.

Conclusions

The conclusions of this project warrant an eco-drive system that optimizes the vehicle's speed profile so as to minimize the fuel consumption. It also shows that previous research efforts aimed at similar eco-driving techniques using simplified optimization functions of minimizing deceleration rate or duration are not necessarily correct. The research demonstrates the need to include a microscopic fuel consumption model in the estimation of the optimal vehicle trajectory. As far as future direction of this research is considered, more case studies should be analyzed incorporating alternate DSRC ranges and more vehicle types. Use of queue-clearance models and car-following models are required to enhance the model. Finally, the system should be implemented in an actual test-bed with connected vehicle technology.