U.S. Department of Transportation
Research and Innovative Technology Administration
RITA Office of Research, Development, and Technology

UTC Spotlight
University Transportation Centers Program

This month: Virginia Tech | December 2012

The Future of Intersection Management Using Advanced Cruise Control Systems

The concept of an automated driving environment has been studied as a way to enhance highway mobility and safety. Automobile manufacturers have begun equipping vehicles with in-vehicle technologies that have proven beneficial, including navigation, blind-spot assist, and advanced cruise control systems. Additionally, a number of vehicle technologies are being developed using wireless communication in conjunction with the Connected Vehicle research program. With in-vehicle automation and vehicle connectivity gaining momentum, Cooperative Adaptive Cruise Control (CACC) systems are expected to enter the market as an application for in-vehicle speed adaptation. The CACC is considered the latest generation of cruise control systems, which allow vehicles to communicate with other vehicles (vehicle-to-vehicle or V2V) and infrastructure (vehicle-to-infrastructure or V2I) using wireless communication. The CACC system was mainly introduced for use on highways to reduce gaps between vehicles; however, limited research efforts have studied the impact of advanced cruise control and automated vehicle systems on intersection control.

Assuming the technologies mature and connected vehicles hit the market, a valid question is whether or not we still need traditional intersection control mechanisms. For example, how will the existence of advanced cruise control systems affect intersection performance? To address these types of questions, the Connected Vehicle/Infrastructure University Transportation Center (CVI UTC) is funding a project at Virginia Tech's Center for Sustainable Mobility to develop a futuristic intersection management system that prevents crashes and reduces the total intersection delay.

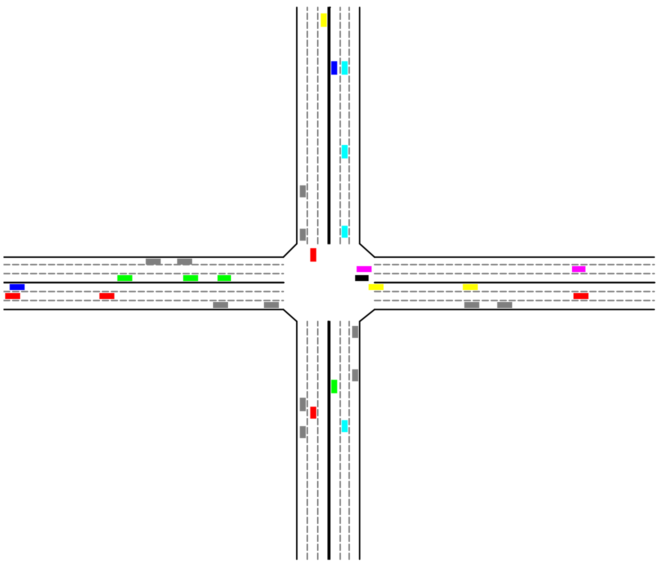
It is anticipated that, in the future, many vehicles will be automated to a certain extent; therefore, their movements in the transportation network will need to be managed. Accordingly, this research attempts to develop a framework for intersection control that communicates with equipped vehicles and adjusts their speeds within the intersection area. The main purpose of the proposed system is to prevent collisions at intersections and minimize the total intersection delay using advanced cruise control technology. In order to fulfill this goal, two research efforts are planned:

1. Develop a simulation/optimization tool, and
2. Conduct field testing to validate the system.

The first stage of the research has already been accomplished by the research group. In this stage, a new tool was developed entitled "iCACC" (intersection management for CACC vehicles). The second stage is still in progress and is part of the CVI UTC.

The iCACC tool has the ability to model any type of intersection control and takes as inputs the approach volumes, intersection characteristics, weather conditions, vehicle specifications, and the percentage of equipped vehicles at the intersection. Subsequently, the iCACC

Figure 1. A Screen Shot From the iCACC Used for Simulating Advanced Vehicles.



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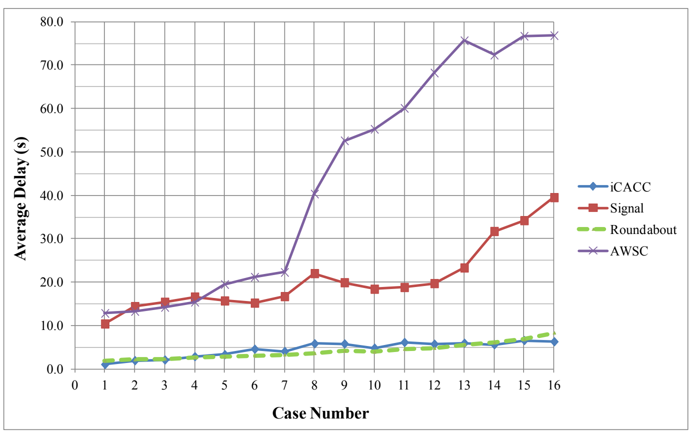
optimizes all levels of automation, from legacy vehicles (i.e., standard vehicles with no automation) to fully autonomous vehicles. Figure 1 shows a screen shot of the visualization interface for the iCACC simulation/optimization tool. (Video may be found at: [http://bit.ly/iCACC)](http://bit.ly/iCACC).

In general, this research relies on advanced computing and V2I communication so that vehicles receive and send messages to CACC-equipped vehicles. Specifically, the research presents a new simulation/optimization tool for controlling the equipped vehicles at intersections using V2V/V2I communications. The proposed idea of adjusting the arrival time of each vehicle at the intersection entrance is quite similar to the concept of metered ramps at freeways. For example, the iCACC controls the flow of vehicles to the intersection to ensure that they can smoothly proceed through the intersection with minimum delays.

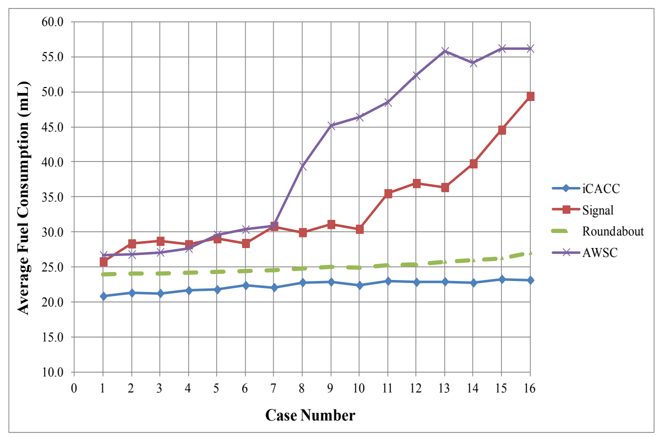
The iCACC system logic was compared to conventional intersection control, as shown in Figure 2 (a) and (b), in terms of delay and fuel consumed on a per-vehicle basis for different traffic demand cases (16 cases). The simulation results showed significant savings by using the iCACC tool compared to other conventional controls (signal, stop-sign, and/or roundabout) for the same demand level.

In general, public acceptability of the new advanced in-vehicle technologies is critical to their success, and this kind of research will provide valuable feedback for researchers, automobile manufacturers, and decision makers. It is anticipated that the research findings will contribute to the future of automation systems and connected vehicles technology.

Figure 2. Comparison Between Different Scenarios (a) Average Delay Comparison per Vehicle (seconds) (b) Average Fuel Consumption per Vehicle (milliliters)



a



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About This Project

This research is led by Hesham Rakha (hrakha@vt.edu), Professor at the Charles E. Via, Jr. Department of Civil and Environmental Engineering and the Director of the Center for Sustainable Mobility (CSM) at the Virginia Tech Transportation Institute (VTTI). This research effort is also part of the dissertation work for Ismail Zohdy (izohdy@vt.edu), Ph.D. Candidate with the Charles E. Via, Jr. Department of Civil and Environmental Engineering and a Graduate Research Assistant with the CSM center at VTTI. The methodology and results of this research have been presented at the International IEEE Conference on Intelligent Transportation Systems (ITSC 2012); the findings of this research have been presented at the ITS world congress (2012) and honored with “the Best Paper Award.” The Director of the CVI UTC is Dr. Tom Dingus (tdingus@vtti.vt.edu).