Beyond Traffic Signals: A Paradigm Shift

Intersection Control for Autonomous Vehicles

Exploratory Advanced Research . . . Next Generation Transportation Solutions

Traffic congestion costs the Nation billions of dollars each year in wasted fuel and lost productivity. Traditional traffic control systems cannot keep pace with this growing problem, but systems that work with self-driving vehicles may afford a more radical approach. "Intersection Control for Autonomous Vehicles," an Exploratory Advanced Research (EAR) Program project, is pursuing a new way to keep traffic moving. This project, awarded by the Federal Highway Administration (FHWA) in 2008, is being conducted at the University of Texas at Austin.

The Promise of Autonomous Vehicles

The precision with which autonomous vehicles can be controlled is key to the many benefits they offer: improved safety, less congestion, lower emissions, and reductions in the high costs of wasted time and fuel. Vehicles with features of autonomy are already emerging on the market, but the corresponding traffic control systems that could unleash the full potential of autonomous vehicles are yet to be developed. In addition, the transition to full automation is likely to be long and gradual, requiring traffic control systems to safely accommodate a mix of autonomous and human-driven vehicles in ever-changing proportions. An advanced intersection control mechanism will be critical to optimizing traffic flow in complex networks.

The intersection control system proposed in this EAR study promises to process traffic more efficiently than traffic lights and stop signs can without compromising safety. Its development is guided by a set of criteria that includes the use of current or near-term sensor technologies, the adoption of a standardized communication protocol, and the ability to deploy incrementally, allowing expansion to other intersections and adaptation to increasing numbers of autonomous vehicles. Absolute collision prevention, even under conditions of communications failure, and high levels of efficiency are primary goals for the system.

Making a Reservation

For intersection control, the researchers have introduced a radically different system of "reservations," in which a vehicle approaching the intersection "calls ahead" via digital short-range communications to the "intersection manager" to request a block of space–time within which to traverse the intersection. The request transmits the vehicle's time of arrival, velocity, size, acceleration capability, and arrival and departure lanes. An intersection control policy then simulates the vehicle's trajectory across the intersection, calculating the clear space required for passage and approving or denying the vehicle's request based on the space–time requirements of other processed trajectories. The intersection manager transmits a confirmation, rejection, or alternative slot to the approaching vehicle. Simulations of this system with up to three lanes in each of four directions show dramatic reductions in waiting time compared with intersections with traditional controls.

The project proposes innovations in five areas: traffic signal timing, intersection collision avoidance, autonomous traffic infrastructure, autonomous driving, and multi-agent systems. Its major tasks are the development of a detailed vehicle–infrastructure communication protocol and the development and testing of prototype agent-control algorithms.

"This project aims to take full advantage of the sensing and control capabilities of autonomous vehicles to reduce congestion," says Gene McHale of FHWA's Office of Operations Research and Development. "When traffic flow is optimized, au-

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tonomous vehicles have the potential to substantially increase roadway capacity while eliminating crashes caused by human error."

Future Efforts

The next step is to determine real-world deployment feasibility. Following evaluation of the protocols and algorithms for an individual intersection and a full-failure mode analysis, the project will simulate the feasibility of the system in networks of intersections. Actual physical implementation will first use small autonomous lab robots and later a full-size autonomous vehicle. Ultimately, the project will deliver a prototype software implementation of the intersection manager and a detailed communication protocol.

"The beauty of this system as proposed," commented David Yang, FHWA's technical representative on the project, "is its potential to facilitate the transition from today's human-driven vehicles to an era when autonomous vehicles are the norm and perhaps even to accelerate the change by demonstrating a faster and safer way to get around."

Learn More

For more information on this EAR Program project, contact David Yang, FHWA Office of Operations Research and Development, at 202-493-3284 (email: david.yang@dot.gov).

EXPLORATORY ADVANCED **RESEARCH**

What Is the Exploratory Advanced Research Program?

FHWA's Exploratory Advanced Research (EAR) Program focuses on long-term, high-risk research with a high payoff potential. The program addresses underlying gaps faced by applied highway research programs, anticipates emerging issues with national implications, and reflects broad transportation industry goals and objectives.

To learn more about the EAR Program, visit the Exploratory Advanced Research Web site at www.fhwa.dot.gov/advancedresearch. The site features information on research solicitations, updates on ongoing research, links to published materials, summaries of past EAR Program events, and details on upcoming events. For additional information, contact David Kuehn at FHWA, 202-493-3414 (email: david.kuehn@fhwa.dot.gov), or Terry Halkyard at FHWA, 202-493-3467 (email: terry.halkyard@fhwa.dot.gov).

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