New Transportation Simulation Technology for Safer Roadways

Exploratory Advanced Research . . . Next Generation Transportation Solutions

American roadways are becoming increasingly complicated and crowded as varying types of motorists and pedestrians share space. Motorists and pedestrians now must pay attention to newer vehicles such as autonomous vehicles (AVs) and e-scooters. State and local governments are seeking ways to design and operate roadways to include connected and automated vehicles. Current simulation technologies are not designed for such complex scenarios. That is why the Federal Highway Administration's (FHWA) Exploratory Advanced Research (EAR) Program is supporting two research projects which will help city planners, engineers, and other government officials to better plan the Nation's future roadways. At the University of Iowa, researchers are connecting the National Advanced Driving Simulator (NADS) with pedestrian and bicycle simulators—which allows for simulating multiple modes of transportations in real time—to conduct the research project "Developing Connected Simulation to Study Interactions Between Drivers, Pedestrians, and Bicyclists." Researchers at Iowa State University's Virtual Reality Applications Center and the Institute for Transportation are developing a system that will allow multiple simulation systems to work together with the research project "InterchangeSE: A Federated Multimodal Simulation Environment for Studying Interactions Between Different Modes of Travel."

Connected Simulation: Bringing Simulated Modes of Transportation Together

Traditional highway simulation technology looks at only a single driver at a time and models everything else, from the roadway to the other drivers or pedestrians. Connected simulation technology allows for multiple participants—driving, bicycling, walking, etc. NADS researchers have focused on driving and walking as two platforms to integrate into one simulation.

EAR Program-supported researchers are examining how people interact with each other in the same simulation; e.g., when a pedestrian chooses to cross an intersection with cars present. But in an immersive environment—with a pedestrian wearing a head-mounted virtual reality display (HMD) and a driver located in another simulator area—how can a virtual driver actually "see" a pedestrian or vice versa?

To answer this question, NADS researchers have developed avatars, or virtual representations of the driver and the pedestrian. These avatars currently can convey the direction of a person's gaze and their hand gestures. For example, to create the pedestrian avatar, the connected simulation software captures a participant's movements in the pedestrian simulator and sends them to a remote simulator that generates the avatar. Likewise, the software captures the driver's hand and head movements in the driving simulator and sends them to a remote pedestrian simulator (i.e., HMD worn by the pedestrian) that generates the driver's avatar (i.e., sitting inside the vehicle). This means, using distributed simulation technology, the person in the driving simulation can see the pedestrian and vice versa. In the future, this avatar would also show the person's expression and eye movements. A traffic service would create simulated vehicle traffic so that all simulation participants can experience the same traffic—in essence, share the same virtual world.

With the use of AVs, the ability for the AV and the motorist or pedestrian to see each other is an important interaction to explore. The goal is to create increasingly sophisticated interactions for further research as this technology is being built for cost-effective and safe scalability.

U.S. Department of Transportation
Federal Highway Administration

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InterchangeSE: A Real-Time Multiplayer Network 3D Visualization Framework to Simulate Driving Behavior and Interactions

At Iowa State University, researchers are connecting multiple platforms to allow participants using bicycling, pedestrian, and driving simulators to see each other. Source: FHWA.

One challenge transportation researchers have encountered with multimodal simulation technology is how different software packages are run on different computing platforms, limiting research capabilities. Iowa State University researchers have created InterchangeSE, which can connect multiple platforms and allow them to run together—regardless of the data and network protocols used by each individual component. This means that a driving simulation, bicycling simulation, and pedestrian simulation may be running on three different platforms, and InterchangeSE is able to show all simulation participants to each other.

The overarching goal of the project is to design, develop, and demonstrate a simulation environment where a variety of traffic and roadway situations can be created, run, and studied. Using a client-server network architecture, InterchangeSE connects physical and simulated driving agents (i.e., bicyclist and automobile driver) to a traffic simulator application. The physical participants interact with each other using a variety of displays including multiple computer monitors, HMDs such as Vive and Oculus Rift, and augmented reality displays. Driving parameters from the physical participants, such as position and heading, are network synchronized with traffic (i.e., vehicles and pedestrians) and computed by the traffic simulator. The computed traffic is relayed back to the physical driving participants, who will see them on their screens and adjust driving responses accordingly, all in real time.

Future research plans include integration of a connected AV within the Interchange framework, support for authoring traffic scenarios for use by FHWA's Turner-Fairbank Highway Research Center, and assessment of driving behaviors using bio-sensors that measure stress.

EXPLORATORY ADVANCED **RESEARCH**

What Is the Exploratory Advanced Research Program?

The EAR Program addresses the need for longer term, higher risk research with the potential for transformative improvements to transportation systems. The EAR Program seeks to leverage advances in science and engineering that could lead to breakthroughs for critical, current, and emerging issues in highway transportation by experts from different disciplines who have the talent and interest in researching solutions and might not do so without EAR Program funding.

To learn more about the EAR Program, visit https://highways.dot.gov/research/exploratory-advanced-research. The website features information on research solicitations, updates on ongoing research, links to published materials, summaries of past EAR Program events, and details on upcoming events.

Learn More

For more information about the Connected Simulation and InterchangeSE projects, contact Brian Philips, FHWA Office of Safety Research and Development, at 202-493-3468 (email: brian.philips@dot.gov).

Photo page 1: *Transportation researchers have created an innovative method for simulation participants to virtually see each other in real time.*

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