Understanding Transportation Systems
An Integrated Approach to Modeling Complex Transportation Systems

Exploratory Advanced Research . . . Next Generation Transportation Solutions

The ability to model and understand the complex dynamics of intelligent agents as they interact within a transportation system could lead to revolutionary advances in transportation engineering and intermodal surface transportation in the United States. Developing such a model is the goal of "Agent-Based Approach for Integrated Driver and Traveler Behavior Modeling," a Federal Highway Administration (FHWA) Exploratory Advanced Research (EAR) Program study awarded to the University of Maryland.

Modeling Complex Patterns

There are numerous intelligent "agents" that operate within urban and regional transportation systems. Agents, such as travelers, drivers, and vehicles, interact with one another and continuously make decisions that are influenced by many different factors. These interactions, learning, and decisions produce complex system-level patterns, such as travel demand and congestion patterns. The goal of this study is to develop an agent-based approach for integrated driver and traveler behavior modeling that can better reflect these patterns that are seen every day in real urban systems.

Modeling Experience

Agent-based models have already become powerful tools for modeling complex systems in several other fields beyond transportation. Agent-based modeling and simulation (ABMS) techniques have also previously been used successfully in specific transportation applications, including multiagent traffic simulators with drivers and vehicles as agents, travel demand models with households and travelers as agents, and transportation investment models with public and private sector transportation agencies as agents. This project aims to build on existing experience to develop a coherent agent-based model capable of integrating various behaviors and simulating transportation system dynamics as an evolutionary process. Potential applications for such a tool could lead to improved understanding of driver and traveler behavior, enhanced transportation systems management concepts, and new insights for capital investment.

Model Development

This research will consider driving and travel decisions made on various time scales in a single integrated agent-based model. The main tasks of the model will be to collect measurable data about the agents and environment; estimate characteristics and rules using available data; simulate agent learning, decisionmaking, and interactions; and produce system-level outputs. Five key ABMS components will be considered within the model: (1) agent characteristics; (2) agent behavior rules; (3) observable agent behavior; (4) agent experience; (5) and attributes of the environment.

Initially, a prototype model will be developed using existing data from previous models developed by the research team. Additional driver and traveler behavior data will then be collected and developed for a full agent-based model ready for applications.

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Agent Learning

A key factor of the integrated model under development will be a learning process that allows cumulative agent experiences to lead to changes in certain agent preferences and subsequent decisions. For example, bad experiences on an alternative route could influence departure time and mode choices. Simulating agent learning will help researchers study a selection of specific agent decision types, including en-route diversions, pre-trip route choice, departure time choice, and mode choice. For agent behavior representation and estimation researchers will focus on the positive modeling approach. This approach emphasizes learning, imperfect information, and rule-based agent behavior.

Modeling Challenges

Gathering empirical information about agent behaviors and interactions under various situations is a challenging but critical part of developing agent-based models for real-world transportation applications. Four groups of proven data collection methods will be tested utilizing interactive laboratory experiments, driving simulators, and surveys to obtain the data. The most cost-effective data collection approach will then be implemented. Other challenges to address include agent behavior specification, estimation, and validation, and the need for a software platform for model implementation and applications.

Sharing Results

The goal is to demonstrate the concept in the Washington, DC—Baltimore region where additional data will be collected for agent behavior estimation and validation. The model will be used to evaluate traffic and regional demand impacts of Maryland's Inter-County Connector project and the I-270 multimodal corridor traffic management strategies will also be analyzed.

Technical reports documenting the research findings will be produced. The research team will also create a presentation to support technology transfer and information dissemination by providing training to those who are interested in developing and applying agent-based models in transportation. An open-source platform will also be built that will allow other researchers,

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@dot.gov), or Terry Halkyard at FHWA, 202-493-3467 (email: terry.halkyard@dot.gov).

practitioners, and agencies to develop modular components that can be integrated into larger agent-based models.

"The data and conceptual models will be significant research contributions. This project will advance our understanding of multimodal surface transportation," said Brian Gardner at FHWA. "The results that we expect from agent-based modeling will ultimately help anticipate and accommodate future demand travel needs, improve transportation system management and travel reliability, and provide valuable investment insight for maintaining urban transport systems and services," he added.

Learn More

For more information on this EAR Program project, contact Brian Gardner, FHWA Office of Planning, at 202-366-4061 (email: brian.gardner@dot.gov).