Agent-based Modeling and Simulation of Driving Behavior using Naturalistic Data

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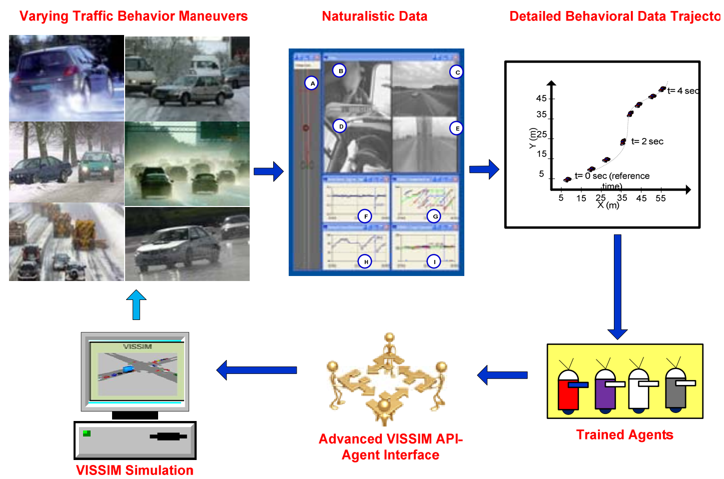
Traffic analysis and management tools do not accurately model a driver's ability to recognize and respond to varying driving situations and different environments. Car-following models are typically implemented by including multiple types of drivers and behavioral rules, based only on *a priori* statistical distributions. This project addresses these limitations by examining individual drivers' actions during critical events using agent-based simulation, and addressing three interrelated and critical threads: 1) naturalistic data processing and extraction of critical traffic flow and driving tasks' parameters; 2) development and implementation of artificial-intelligence-based driver class agents that encapsulate individual drivers' decision logic during critical events; and 3) testing and evaluation of the developed agents in an internationally acclaimed simulation platform (VISSIM).



Agent Based Modeling (ABM) is a relatively new paradigm for exploring the behavior of complex systems. Within the transportation domain, ABM is particularly appropriate for modeling systems in which human decision making and action are a critical component. ABM has the ability to capture the natural behavior of traffic in an environment and is best applied to simulations when the interactions of agents are complex, nonlinear or discontinuous. The agents are heterogeneous when each individual is different, and the agents exhibit complex behavior including learning and adaptation.

Ten drivers have been selected from the 8- Truck Naturalistic Study. As part of our study, car-following situations for these drivers have been automatically extracted from the enormous volume of driving data in the database in order to efficiently analyze drivers' behavior when approaching a preceding vehicle. The data has been used in two different approaches. First, calibration and reconstruction of psycho-physical model (Wiedemann's) regimes has been conducted using an evolutionary algorithm. Second, the data has been used to train an agent to replicate the driver's behavior in the emergency regime.

Backpropagation (BP) artificial neural network (ANN) was used to train individual agents. The algorithm learns by associating any state observation (e.g., time since trigger, speed, car-following distance, yaw angle, road geometry) with the following action of the driver (e.g., accelerate, decelerate steer, etc.) during a critical event. The degree by which the agent action matches the driver's action constitutes a reward in the learning sequence. During the learning process, each agent tries to maximize the degree by which it approximates the actual driver's actions. At the end of the training phase, the agent becomes a clone of the driver as far as the driving actions are considered. ANN is a supervised learning process that gains information from the naturalistic driving actions. Unlike the car-following model calibration methods, ANN has the ability to handle high dimensional nonlinear interpolation problems and with a set of limited input and output training data. BP neural network has the objective of minimizing the deviation of the output of neural network from naturalistic driving action. Preliminary results show that under 1Hz and 10Hz data resolution, the neural agent performed better than the GHR model. Compared to naturalistic data, the GHR model with optimized calibrated parameters resulted in a 9.7 percent error (1 HZ) while the neural agent had a 6.79 percent error (30.5 percent better performance) for a 1HZ data and 0.8 percent error for 10 Hz data. The agents are being validated within a simulation environment using VISSIM simulation software. As a final product, an artificial-intelligence Agent Class prototype will be developed. Analysis of trained agents' characteristics will provide the industry with methods for developing more accurate and sensitive traffic simulation models for safety-critical events and could lead to future research developing new generations of traffic simulation models to accurately model impacts of driver behavior on traffic. This effort is also a platform to capitalize on current major national naturalistic data collection efforts, to generate agents not only for different vehicles, trucks, cars, motorcycles, but also for different types of drivers, teenagers, older drivers, experienced, and inexperienced.

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