Connecting Manual and Automated Driving Via Modeling and Simulation

Paul Green
University of Michigan
Transportation Research Institute (UMTRI)
And
Department of Industrial and Operations Engineering (IOE)
Ann Arbor, Michigan
www.umich.edu/~driving, pagreen@umich.edu, 734 763 3795

Research to develop advanced driver support systems (e.g., automatic lane keeping, intersection crash avoidance is in progress, though much of it is not very far reaching. Also in progress is research to help develop automated/autonomous/driverless/self-driving vehicles. Successes such as DARPA Grand Challenge (Thrun, et al, 2006; Urmson, et al, 2008) and the Google car have shown that such vehicles are feasible, but there is still considerable research and engineering development to do to meet production promises of 10 to 20 years from now.

In spite of their common application, there is a disconnect between those working on advanced manual and semi-automated systems (the SAE world) and those work on automated driving (the IEEE world). What can be done to bring them together – to use the knowledge of autonomous driving to make manual driving safer and to use knowledge from manual driving to develop autonomous vehicles? What common problems need to be addressed? These topics, which involve the integration of computing with a dynamic physical, engineered system, in this case, computing systems with human operators controlling motor vehicle, are central to the NSF cyber-physical system program.

Goal 1: Develop Accessible and Simple Models of Human and Automated Driving

Numerous models of human driving have been developed -- traffic network simulation models with embedded models of driver behavior, driving simulators with models of autonomous traffic, models of human manual and cognitive activities, and many others. Unfortunately, these models are quite complex and not easy to use, so they are often largely research tools. Particularly lacking are widely used models that predict the workload of the primary task of driving (e.g., Schweitzer and Green, 2007), yet all of this research concerns augmenting or replacing the human operator who now performs that task. In fact, at this point, there does not even exist a defined or common set of measures and statistics for that collaboration to occur (Green, 2013). What is needed is collaborative research that brings together the civil engineering, computing, and human factors communities, using modeling and simulation as a framework. The outcome should lead towards SAE and ISO standards, and US DOT NCAP rules, and other regulations incorporating models as an alternative to experimental evaluation in safety certification, saving time and money.

Goal 2: Develop of Low-Cost/Free Tools To Support Modeling and Evaluation

To study and develop these systems, tools that can be used for both research and development are needed. Most driving simulators (1) cost tens of thousands of dollars to purchase, (2) have

annual license fees that are several thousand dollars a year, (3) take too long to learn and provide useful output, and (4) are not suitable for teaching or introductory use. In fact, researchers generally discourage students from using research simulators for noncontract activities because of the staff cost of monitoring student use and the concern that students will introduce destructive viruses into their labs. These problems are not just confined to driving simulators, but instrumented vehicle packages, traffic simulators, and other tools used for this research. Fortunately, there are some efforts to develop low-cost systems, but these efforts need support (e.g., OpenDS – Math, et al., 2013; Car Data Toolkit - Wilfinger, et al., 2013).

The accomplishment of both of these goals should lead to the development of a research community (and graduates from those projects) who are versed in computing, civil engineering, industrial engineering, and psychology, the combined backgrounds need to do this work. Students with the desired backgrounds are rare. To support their education, educational materials to prepare them for research on manual control, image processing, and human factors is needed.

Thus, the vision described here is to bring the manual and automated driving world together through collaborative research, and as part of that activity, to support the development of low-cost research tools and models that can be used by ordinary engineers, that is, to get the research into practice.

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