CPS: TTP Option: Medium: Identifying, characterizing, and shaping multi-scale cyber-human interactions in mixed autonomous/conventional vehicle traffic [start date: 10/2019]

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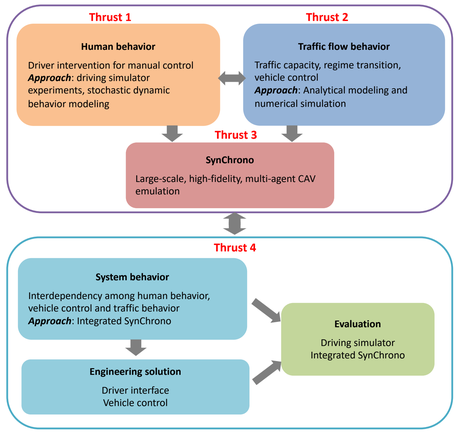
Project Objectives

Identify, characterize, and shape multi-scale cyber-human interactions in mixed autonomous and conventional vehicle traffic

Goals of This Project :

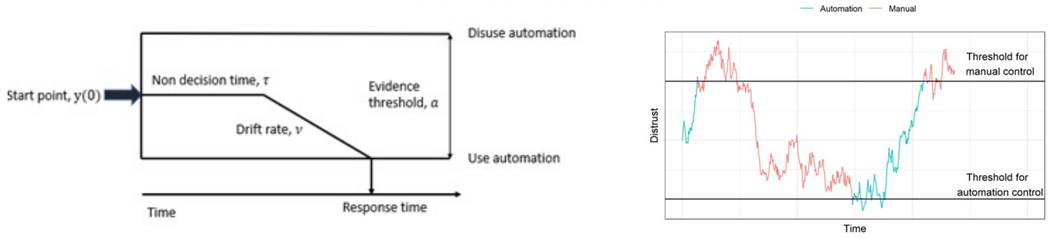
- Driver trust in vehicle automation (driver intervention)
- Analytical and computational methods to describe the effects of driver intervention on mixed traffic flow
- Prototype driver interface, and vehicle and platoon control strategies to enhance cyber-human interactions and traffic flow



Modeling automation use using microscopic traffic flow and evidence accumulation models

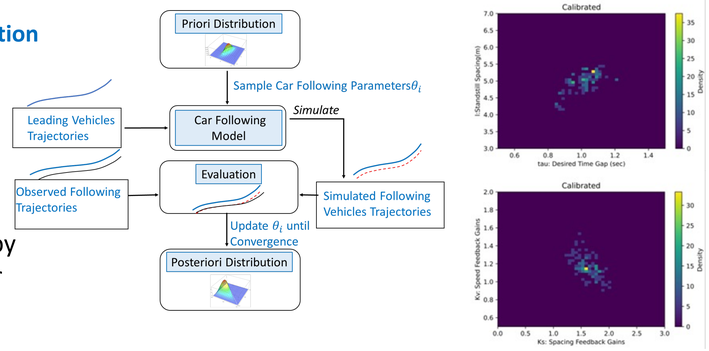
- Microscopic traffic simulations support modeling driver behavior in different traffic conditions.
- Currently, these models do not account for drivers' decisions to use or disuse vehicle automation.
- Evidence accumulation models are decision making models which can account for factors that affect disuse such as driving style similarity and driver attention.
- Integrating microscopic traffic models with evidence accumulation models can help simulate drivers' decisions to use or disuse automation.

Automation disuse model



Probabilistic Car Following Model Calibration

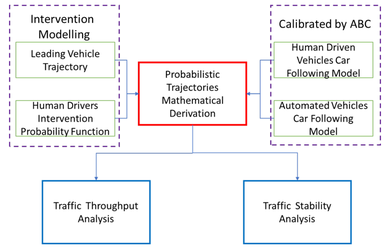
- Applied an Approximate Bayesian Computation approach to calibrate generic car following model with empirical joint distribution
- A hybrid car following model enabled by model selection to describe various car following behavior

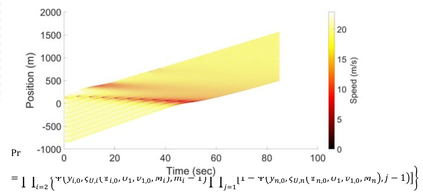


Modelling Cascading Impact on Traffic flow

Driver intervention for manual driving would trigger a disturbance.

- Theoretical traffic wave propagation approximation by Describing Function Analysis
- Probabilistic and Analytical trajectory derivation as well as stability analysis



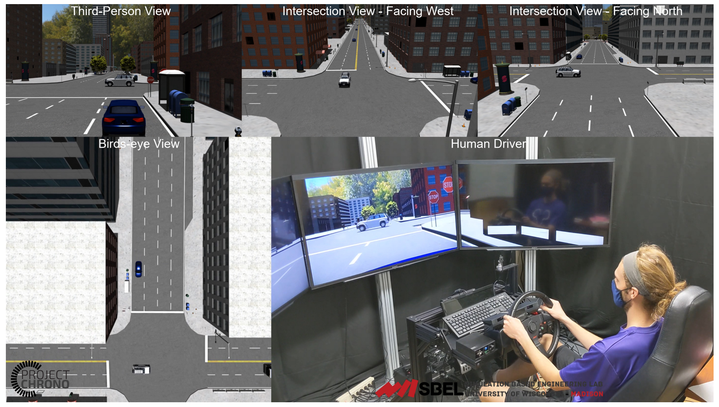


$$\Pr = \prod_{i=2}\left\{\Psi(y_{i,0},\varsigma_{i,n}(x_{i,0},v_1,v_{1,0},m_i),m_i-1)\prod_{j=1}^{1}\left[1-\Psi(y_{n,0},\varsigma_{i,n}(x_{n,0},v_1,v_{1,0},m_n),j-1)\right]\right\}$$

SynChrono: Physics-Based Autonomous Vehicle Modelling

Build out SynChrono and Chrono infrastructure for physics-based modelling of multi-agent autonomous vehicle scenarios.

- Build out virtual world infrastructure to capture more realistic environments
- Enhance sensor simulation engine to quickly simulate large virtual worlds with many details
- Integrate SynChrono with CSL simulator to embed human drivers in SynChrono simulation
- Integrate SynChrono with ROS2 and Autoware to provide access to a growing autonomous vehicle control stack
- Integrate Chrono physics with CARLA to combine realistic physics with the virtual world capabilities of Unreal Engine and CARLA



Broader Impact

Societal Impact: AVs are bound to revolutionize the transportation system. They manifestly change the ways automobiles and road infrastructure are designed. More broadly, they will reshape how we travel, work and live. Potential societal impacts are too far-reaching to fully understand, but some tangible potential benefits include improved traffic safety, reduced congestion, better utilization of travelers' time, and safer and more accessible travel options for disadvantaged travelers. A better understanding of cyber-human interactions as enabled by the outcomes of this project will transform the ways in which humans interact with autonomous systems and help fulfil their potential.

Education and Outreach: 1). Promoting the Computational Science Initiative (ProCSI) - a one week residential program for underrepresented high-school students. 2). Education and outreach using our driving simulator 3).Engineering Expo participation. 4). Development of educational modules. 5).Technology transfer to current industry partners (Volvo and Toyota)

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