NRI: Addressing Safe Interaction Between Autonomous and Human-driven Vehicles

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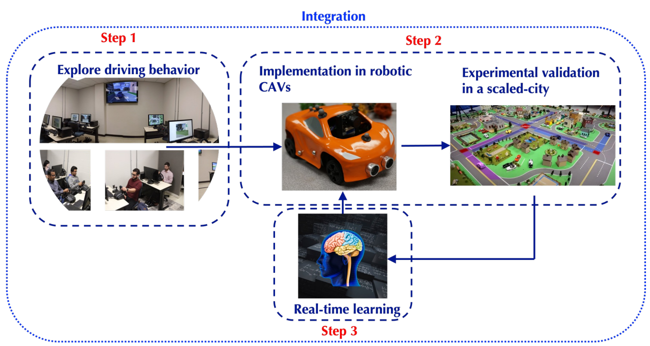
https://sites.udel.edu/ids-lab/projects/nsf-nri/

Objective

- The overarching goal of this project is to synergistically integrate human-driving behavior, control theory, and learning to develop a framework that can address a fundamental gap in current methods for the safe co-existence of connected and automated vehicles (CAVs) with human-driven vehicles (HDVs).
- The integrated framework will aim CAVs at coordinating with HDVs safely in any traffic scenario. The expected outcome of this research will enable a transformative new functionality of CAVs to interact with HDVs.



Evaluation and Experimentation Plan

The proposed framework will be implemented and validated in:

- a driver simulation testbed with driver simulators that can be used to understand the interactions between CAVs and HDVs
- a scaled smart city testbed with 50 robotic cars

Technical Approach

Step 1: Explore human drivers' reactions to several driving scenarios that will help us understand how human drivers will respond to different situations.

- CAVs may have a transformative impact on urban mobility that can lead to a significant increase in highway capacity and greater travel-time efficiency. This, in turn, may influence the drivers' behavior.
- We seek to enhance our understanding about drivers' behavior and characterize variability in human preferences.

Step 2: Derive control "prescription" functions that will yield the optimal decisions and planning of CAVs with respect to driver's behavior according to Step 1.

- The problem for each CAV is to derive its optimal control law to aim CAVs and HDVs to pass through a traffic scenario safely without stop-and-go driving. The latter is modeled as the minimization of the expected total travel delay

$$J(\mathbf{g}) = \mathbb{E}^{g}\{\sum_{t=1}^{T} c_t(X_t, U_t^{1:K})\}$$

Step 3: Develop a learning mechanism for CAVs to adapt their decisions, designated by the control prescription functions in Step 2, in situations where CAVs encounter different behavior from what they already know about human driving in Step 1.

- The problem of each CAV is reformulated to derive its optimal planning strategy ψ to aim CAVs and HDVs minimize the expected total travel delay

$$\bar{J}(\psi) = \mathbb{E}^{\psi}\{\sum_{t=1}^{T} c_t(\Pi_t, \Gamma_t^{1:K})\}$$

Scientific Impact

- Establish new approaches at the intersection of human-driving behavior, control theory, and learning in enabling CAVs to safely interact with HDVs.
- Bridge the existing gap between optimal trajectory planning and safe-critical control in CAVs .

Broader Impact

- Combining human-behavior characteristics with control theory and learning can provide significant opportunities in developing data-driven approaches aimed at improving the operation of robotic systems in real time.
- Advance the state of the art in all the interdisciplinary domains spanned by the proposed tasks combining optimal and safe control methods with new online learning methods.
- Train graduate students by exposing them to a balanced mix of theory and practice.
- Integrate the proposed research into existing courses.
- Involve undergraduate students in research and reach out to high-school students.
- Expected impact quantification: The proposed research will aim at facilitating optimal solutions with performance guarantees to allow safe and efficient co-existence of CAVs with HDVs.

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