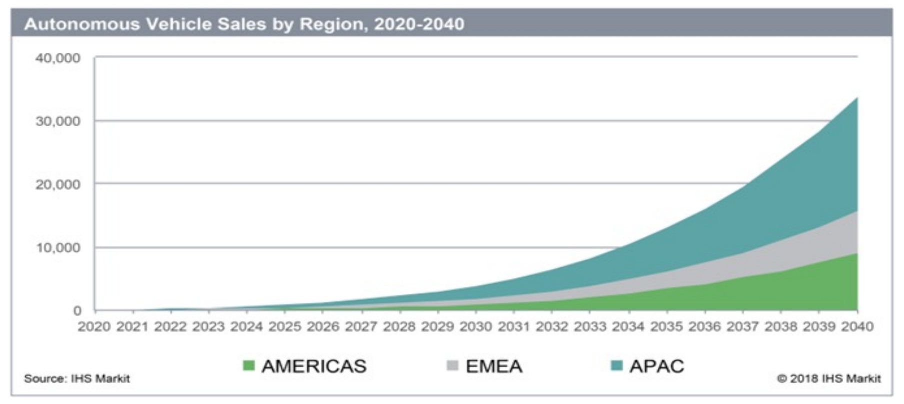
Cooperative Driving in Heterogeneous Traffic of Manned and Unmanned Vehicles

PI: Weihua Sheng, CoPI: He Bai, Oklahoma State University

https://ascclab.org

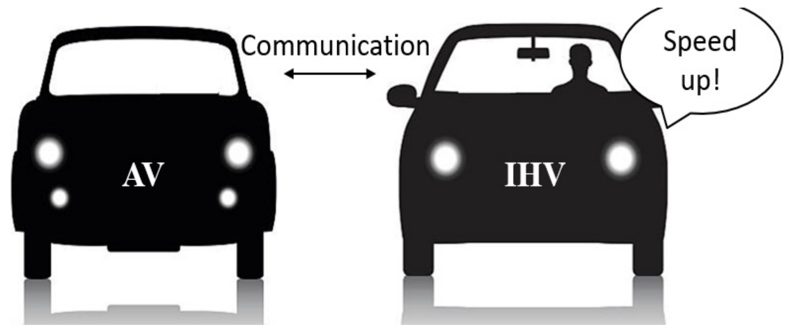
Background and Challenges

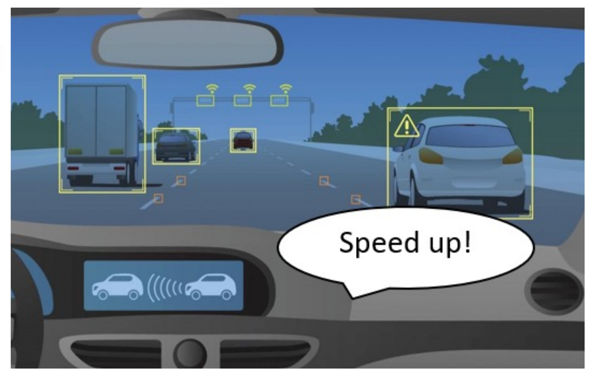
- The number of autonomous vehicles (AVs) in USA is expected to be more than 2.1 million by 2025 and 20.8 million by 2030
- Both human-driven vehicles and autonomous vehicles are expected to coexist in the next few decades
- Coordination between human driven and autonomous vehicles can ensure the safety and efficiency of future roadways

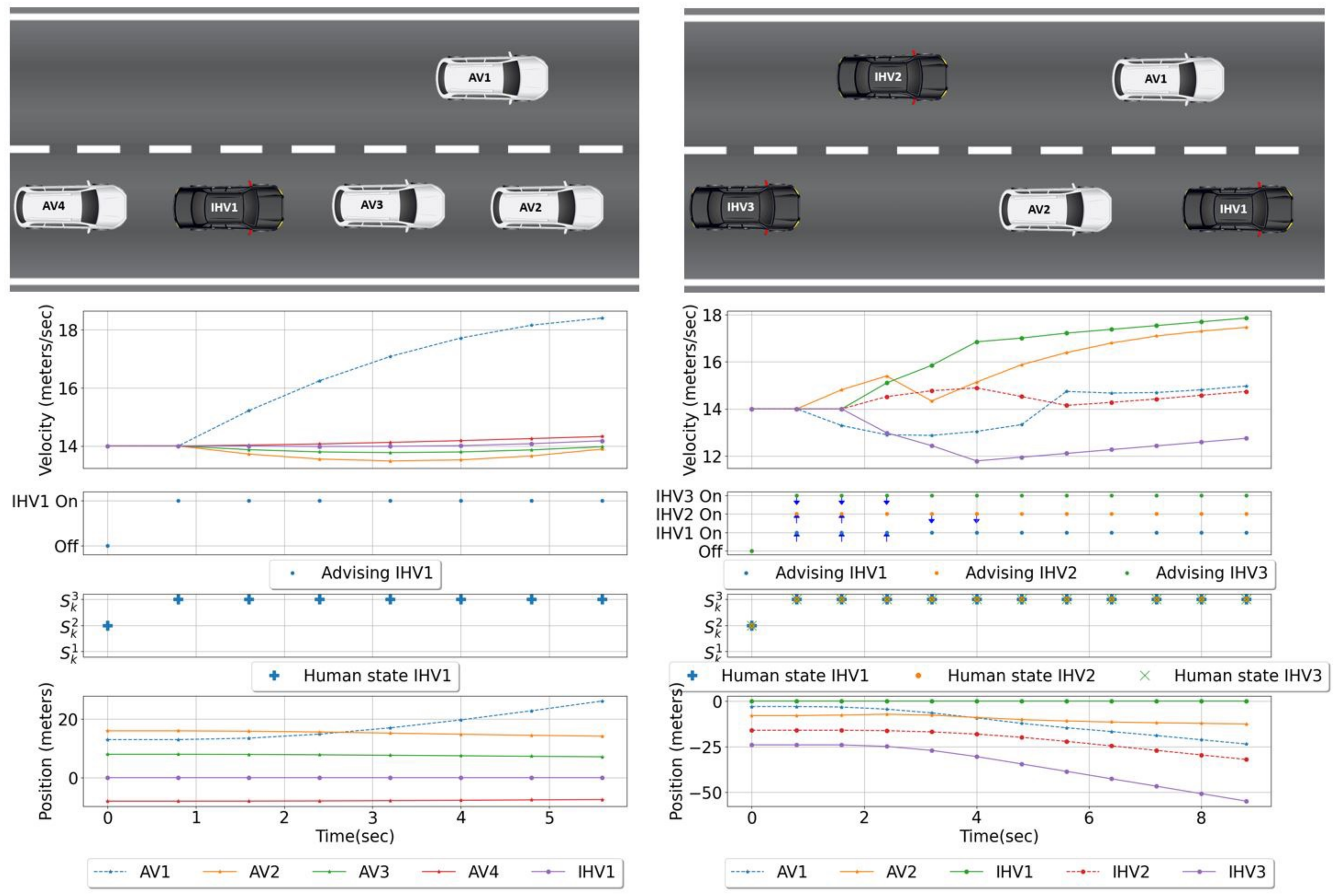


Theoretical Framework

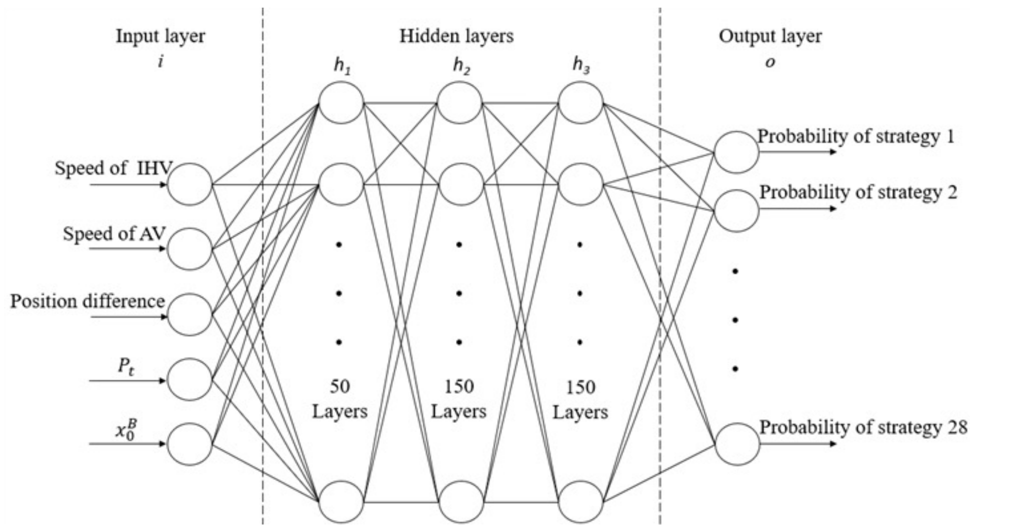
- Modeling coordination between intelligent human-driven vehicles (IHVs) and autonomous vehicles (AVs)
- System modeling with hybrid states and inputs for AVs and IHVs
- Consideration of human states: human drivers' attentive/inattentive, following advisory/not following advisory states
- Designing a stochastic model predictive controller to address the stochasticity of human states
- Formulating for multi-vehicle coordination scenarios
- Optimization speed-up with neural networks







Simulation results with multi-vehicle setup: 4AV-1IHV (left column) and 2AV-3IHV (right column) for human attentive in both cases.



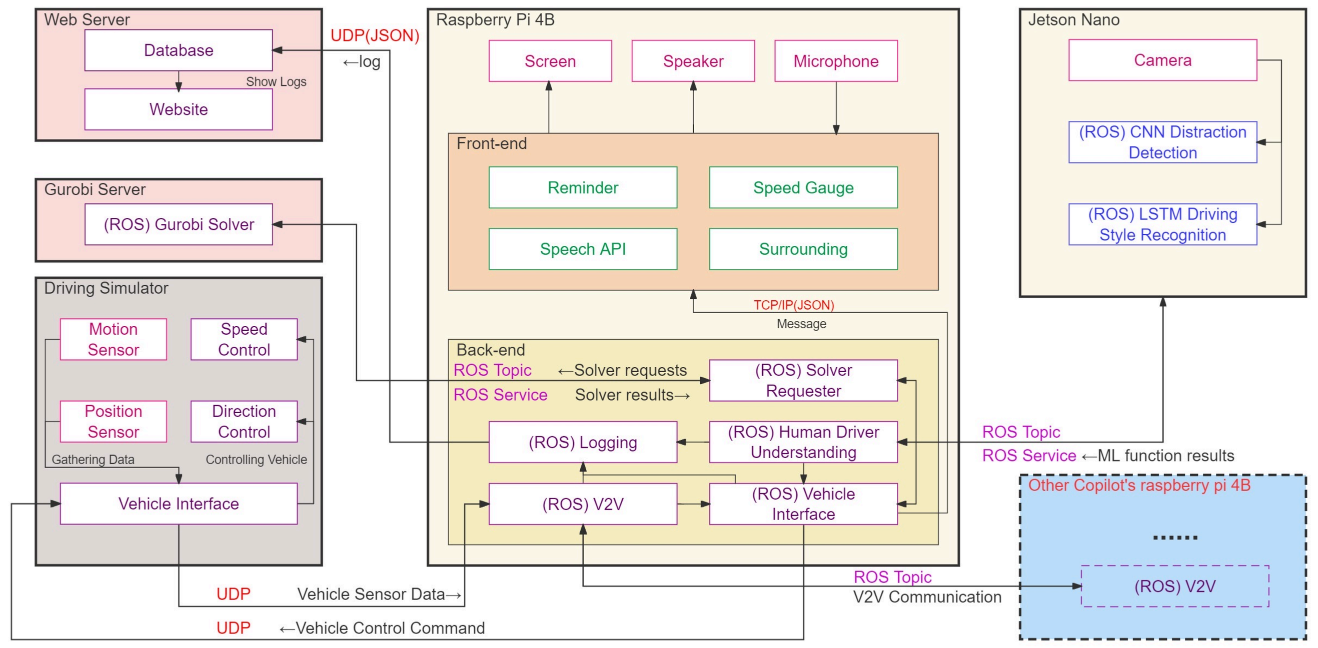
Method	Time (sec)	Accuracy (%)
Gurobi	0.325	100
NN	0.1524	99.7

Optimization with neural network speed up.

Broader Impact on Society

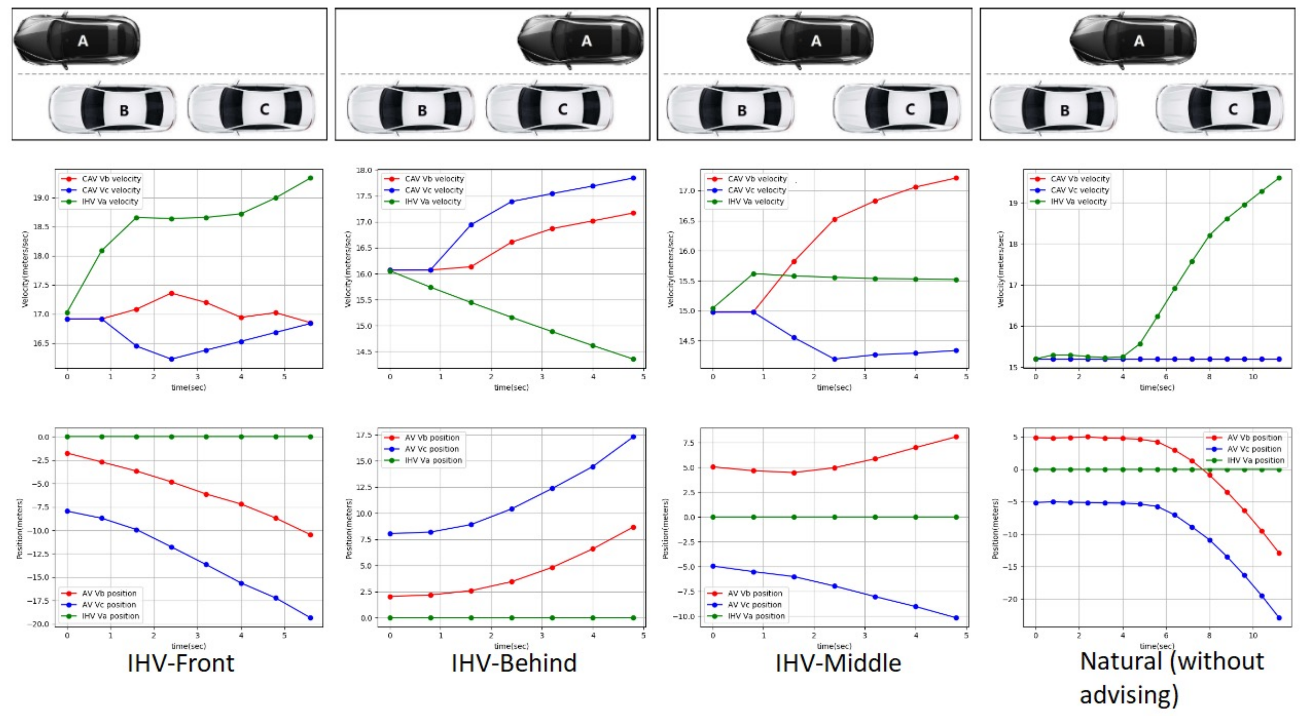
- Coordination between human-driven vehicles and autonomous vehicles can reduce road accidents
- Cooperative driving between human-driven vehicles and autonomous vehicles can lead to smoother traffic flow and reduced congestion
- Implementation of cooperative driving will result in increased confidence in AV technology

Experimental Evaluation



Experimental Setup

- A copilot for human-driven vehicles and autonomous vehicles, which evaluates the potential risk during driving and advises the drivers for optimal driving maneuver
- Integration of reliable models for understanding human drivers, such as distraction detection, driving style recognition, and driving maneuver prediction.
- Evaluate the methods through experiments in lane-merging scenarios on a cooperative driving simulation testbed.



Experimental results for lane-merging scenarios. Vehicle A is IHV. Vehicle B and C are AVs.

Scientific Impact

- This research explores the challenging problem of cooperative control of a cyber-physical-human system consisting of both manned and unmanned vehicles
- This research develops an integrated data-driven, model-based approach to modeling vehicle driving behaviors with various levels of human and machine control
- This research develops a unified decision framework for cooperative driving that leverages the differences between humans and machines in sensing, analytics, and control.

CPS Medium: Cooperative Driving in Heterogenous Traffic of Manned and Unmanned Vehicles. Award ID#:2212582