GOALI CPS: Maneuver and Data Optimization for High Confidence Testing of Future Automotive Cyber-physical Systems

Ilya Kolmanovsky (PI, U. Mich.), Ella Atkins (U. Mich.), Barzan Mozafari (U. Mich.), Mark Oliver (AVL)
https://sites.google.com/umich.edu/testing-of-automotive-cps/

Challenge:

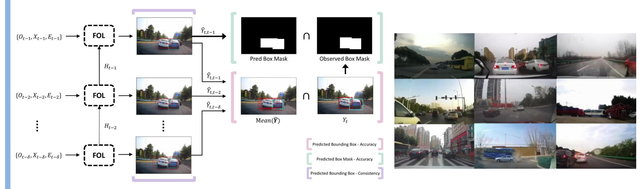
This research addresses challenges in high confidence testing of automotive systems due to on-going and anticipated introduction of advanced, connected and autonomous vehicle technologies.

Solution:

Based on the research into maneuver and data optimization to develop a tool chain for high confidence testing, verification and validation of advanced, connected and autonomous vehicles:

- Game-theoretic modeling of heterogeneous and interactive traffic for advanced vehicle decision and control system verification, validation and calibration through informing in-traffic relevant trajectories, identifying corner cases, and discovering faults.
- Model-free trajectory optimization for falsification of automotive control system time-domain specifications.
- Deep learning-based trajectory modeling from dash cameras to detect anomalous traffic scenarios.
- Smart Black Box to identify & record high-priority data for diagnostics & validation.

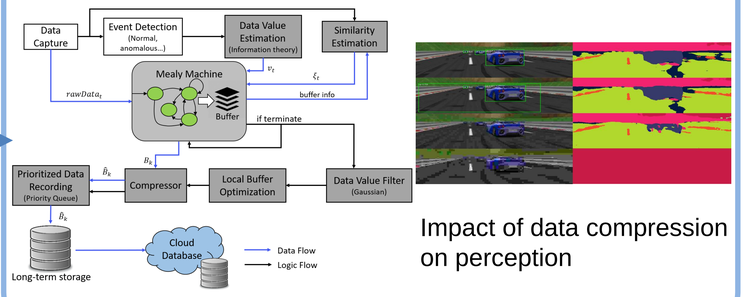
Traffic Video Anomaly Detection



Video anomaly detection by trajectory modeling. Object trajectories are predicted to detect anomalous motion.

Large-scale annotated video dataset for traffic anomaly detection.

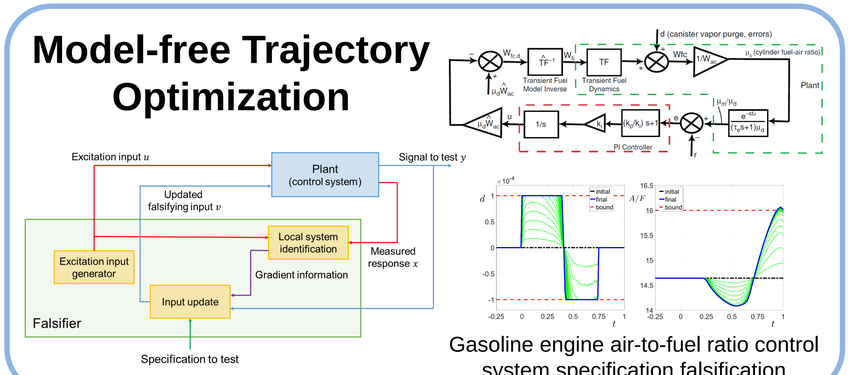
Smart Black Box



The SBB pipeline for data collection

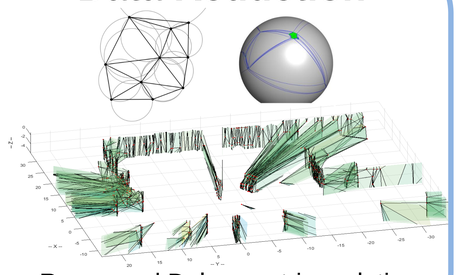
Impact of data compression on perception

Model-free Trajectory Optimization



Gasoline engine air-to-fuel ratio control system specification falsification

Data Reduction

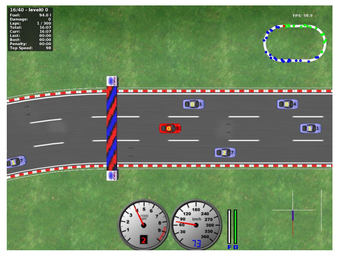


Recovered Delaunay triangulation on sampled points

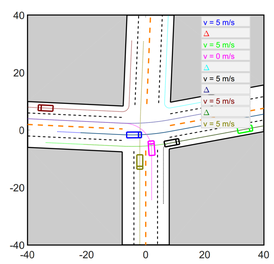
Game-theoretic Traffic Modeling

https://cps-vo.org/group/verification_tools/tool/GTTS

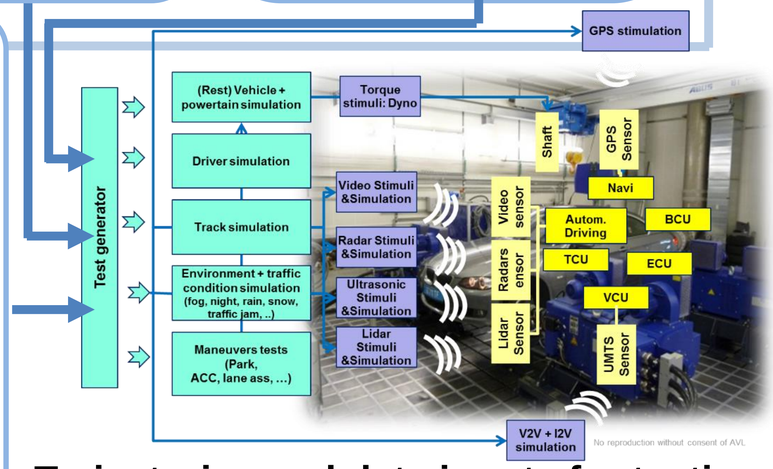
Interactions between human-driven/autonomous vehicles in multi-vehicle highway/urban traffic scenarios are modeled based on game-theoretic formulations. The developed heterogeneous and interactive traffic models serve as simulation environments for AV control system testing, evaluation and calibration.



Highway model



Urban (intersection) model



Trajectories and data inputs for testing of advanced automotive systems

Scientific impact:

- Advances CPS vehicle lifecycle management.
- Advances game, optimal control, information and data mining theories for applications in autonomous vehicle setting.
- Addresses the problem of traffic video anomaly detection and provides a large-scale annotated video dataset as a benchmark/ edge-case test set for future research into autonomous driving algorithms.
- Data acquisition and sampling strategies applicable broadly to connected vehicle & devices.

Broader impact:

- Supports the introduction of advanced vehicle technologies into mass production.
- Autonomous vehicles can have a significant societal impact, positively improving road safety, traffic efficiency, reducing energy consumption and emissions, and enabling transportation for people who are not able to drive.
- Interdisciplinary advances are integrated into courses/tutorials.

2019 NSF Cyber-Physical Systems Principal Investigators' Meeting
November 21-22, 2019 | Crystal City, Virginia

Award ID#: CNS 1544844