

CPS: Small: NSF-DST: Turning “Tragedy of the Commons (ToC)” into “Emergent Cooperative Behavior (ECB)” for Automated Vehicles at Intersections with Meta-Learning

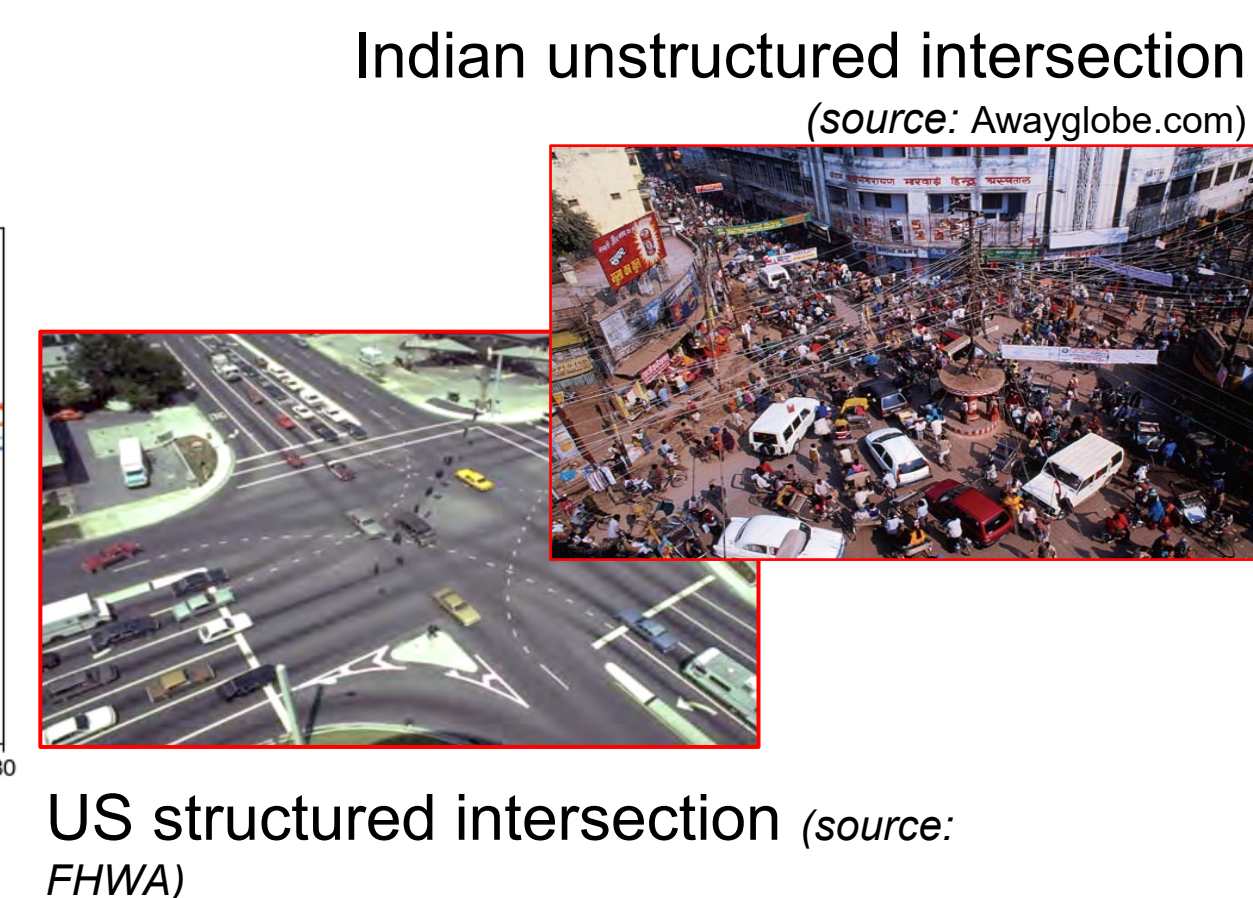
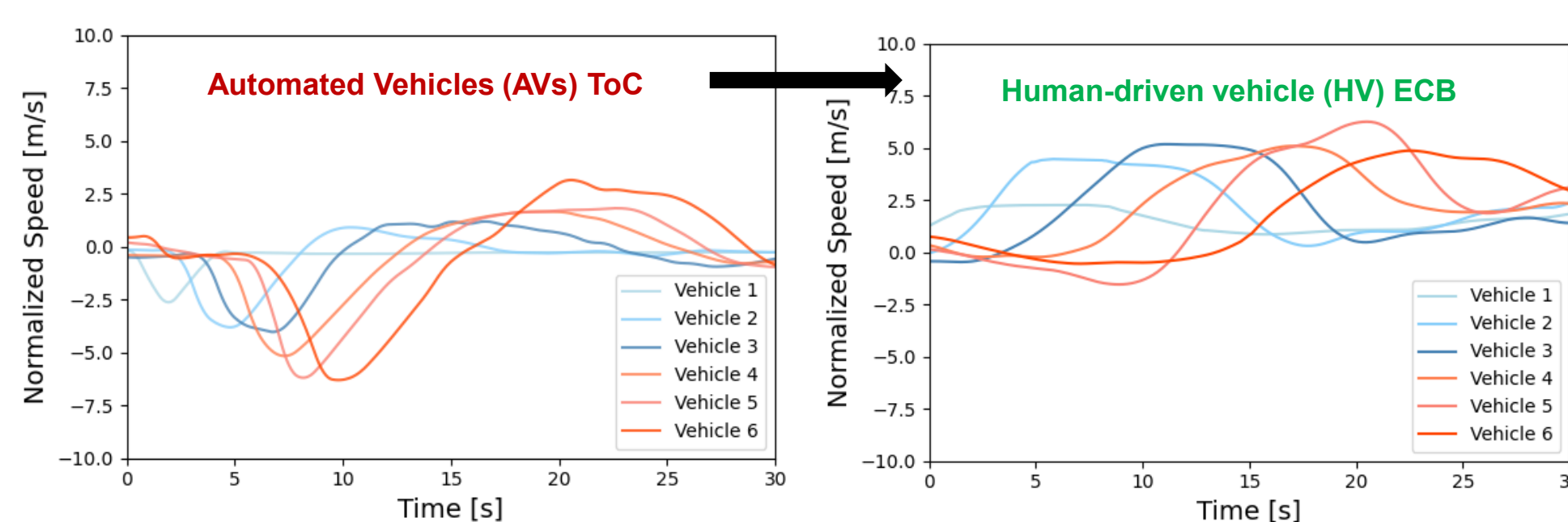
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<https://govtribe.com/award/federal-grant-award/project-grant-2343167>

CHALLENGE

How does Automated Vehicle (AV) clustering impact traffic?

- AVs optimize individual performance but collectively cause *Tragedy of the Commons (ToC)*
- Human-driven vehicles (HVs), despite individual inefficiencies, exhibit *Emergent Cooperative Behavior (ECB)* that maintains traffic flow.
- AVs lack adaptability to dynamic (structured/unstructured) traffic environments.



BROADER IMPACT

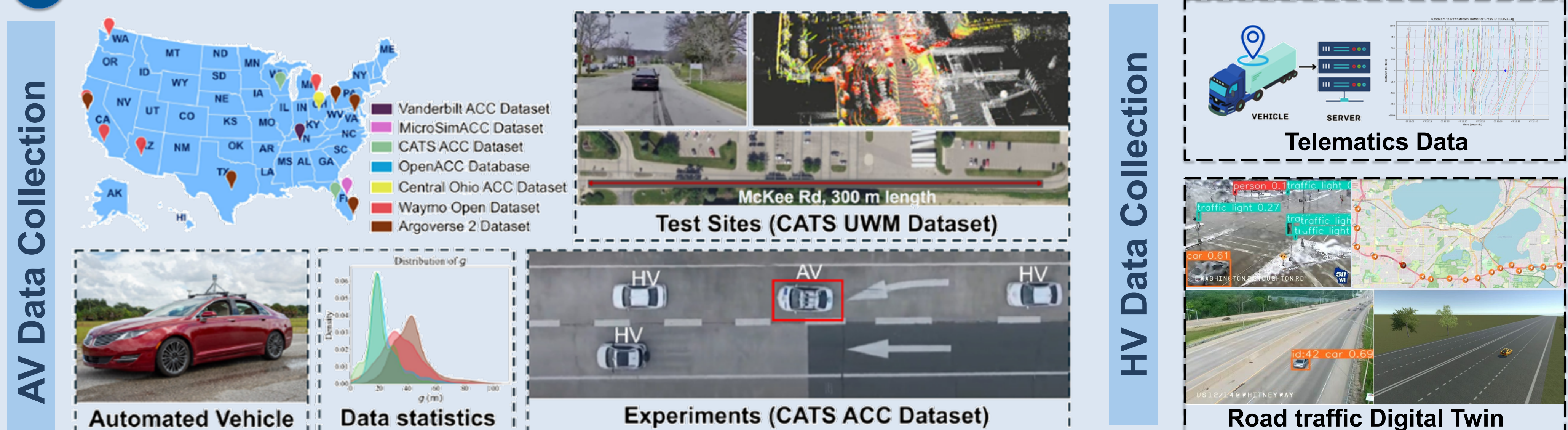
- New analytical properties and insights to multi-agent and financial systems.
- Enhances AV adaptability across structured and unstructured traffic.
- Engages policymakers and industry through real-world validation.
- Setting International Standards
- Educational and Academic Contributions

Selected Project Publications:

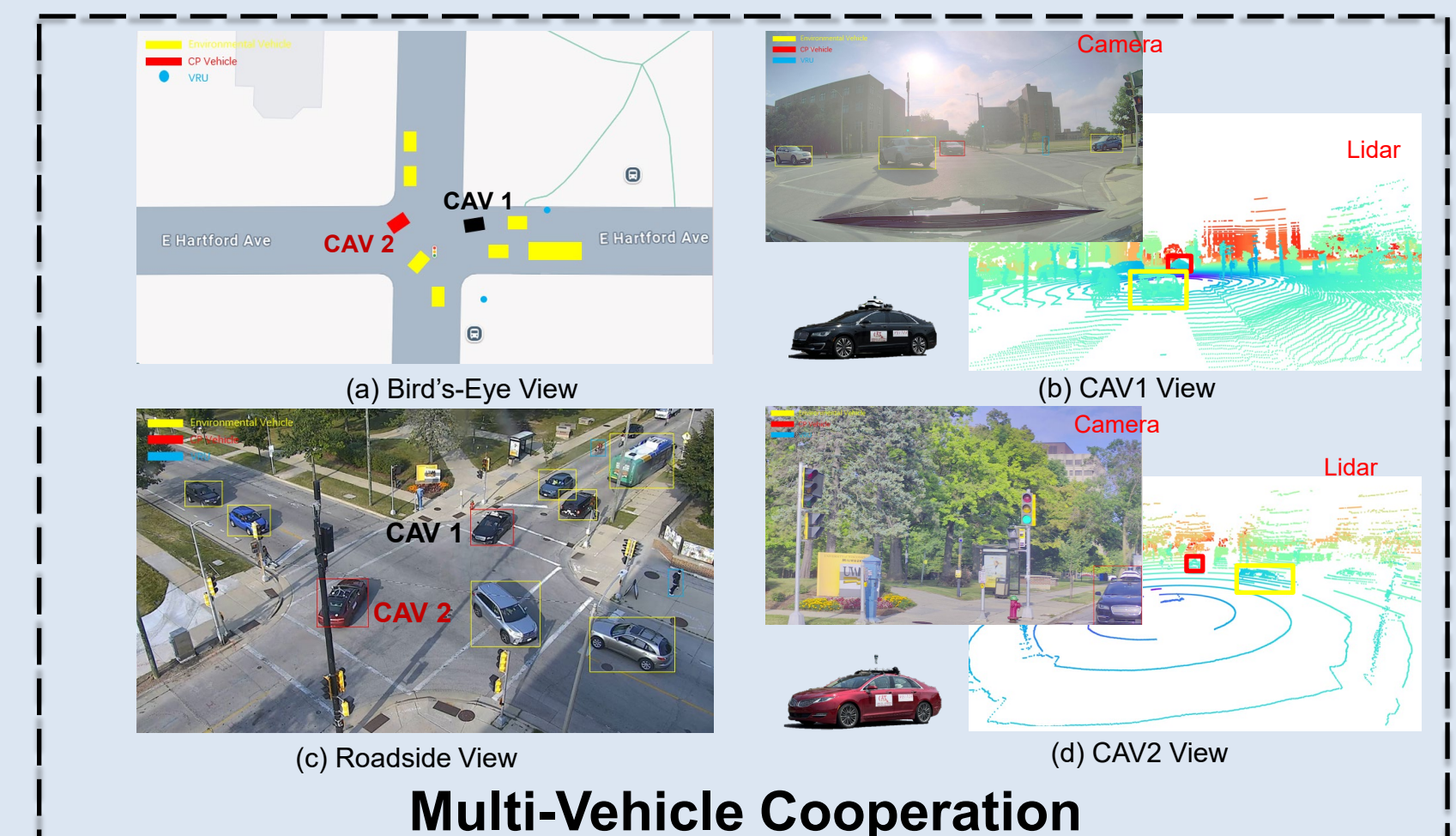
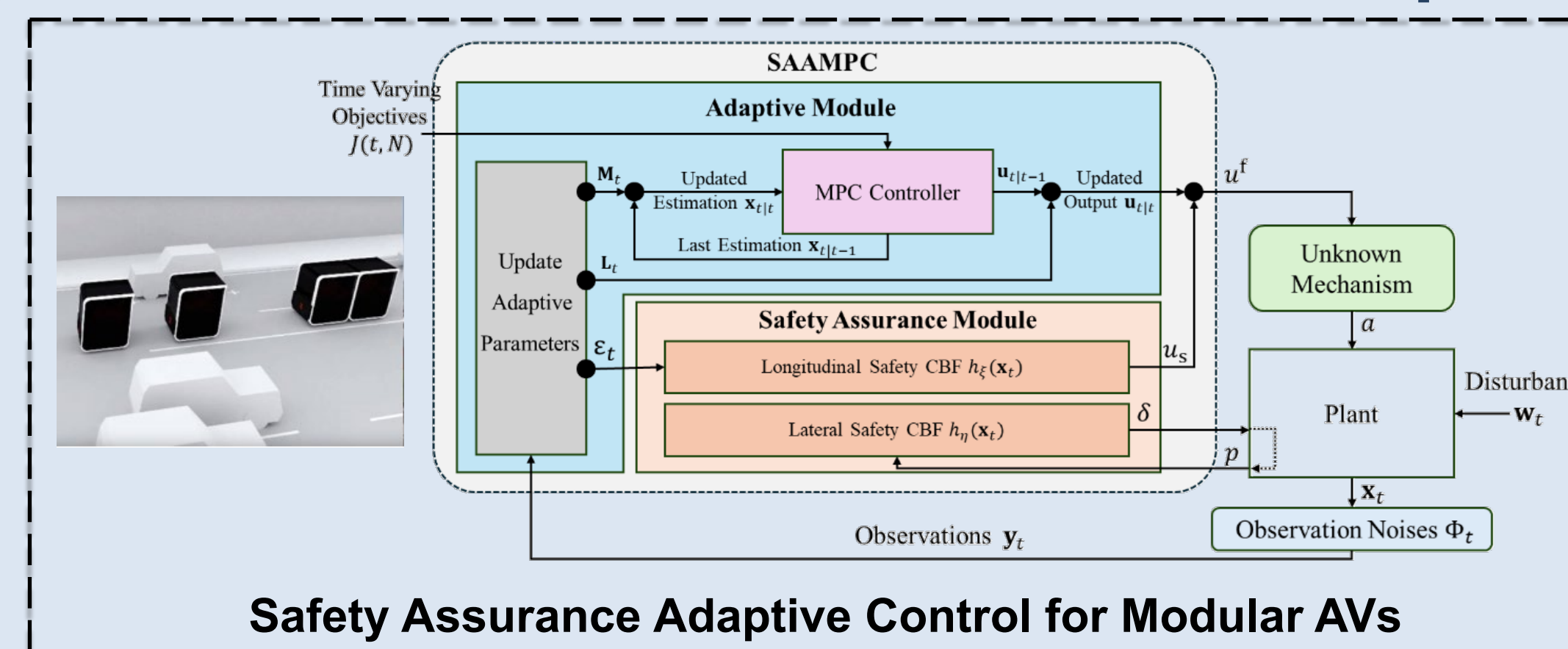
- Li, Z., Meng, H., Ma, C., Ma, K., & Li, X. (2025). Assessing Markov Property in Driving Behaviors: Insights from Statistical Tests. *arXiv preprint arXiv:2501.10625*.
- Zhou, H., Ma, K., Liang, S., Li, X., & Qu, X. (2024). A unified longitudinal trajectory dataset for automated vehicle. *Scientific Data*, 11(1), 1123.
- Ma, C., Li, H., Long, K., Zhou, H., Liang, Z., Li, P., ... & Li, X. Real-Time Identification of Cooperative Perception Necessity in Road Traffic Scenarios. *Available at SSRN* 4973353.
- Ma, C., Zhou, H., Zhang, P., Ma, K., Shi, H., ... & Li, X. Safety Assurance Adaptive Control for Modular Autonomous Vehicles. *IEEE Robotics and Automation Letters* (Under Review).

SOLUTION & RESULTS

1 Data Collection & ToC Validation



2 Advanced AV Control Method Development



3 Implementation in Physical Experiments

