5G-enabled Safe and Robust Deep Multi-agent Reinforcement Learning Framework for CAV Coordination

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Center Name: New England University Transportation Center (NEUTC)

Research Priority: Promoting Safety

Principal Investigator(s): Dr. Fei Miao, Dr. Song Han

Project Partners: University of Connecticut

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Project Start and End Date: 1/1/2024 – 6/11/2025

Project Description: This project developed and tested a safer way for connected and automated vehicles (CAVs) to move through traffic together. The team built a coordination system that used learning-based decision making for high-level driving choices and a built-in safety layer to prevent risky actions. It was designed to keep working even when sensors or vehicle-to-vehicle communications were noisy or delayed (e.g., over 5G/V2X links). The approach was validated first in simulation (city intersections and highway scenarios with human-driven cars mixed in) and then on small robotic vehicles, showing fewer collisions and smoother traffic flow than baseline methods.

US DOT Priorities: The work supported U.S. DOT priorities by improving road safety and reliability for emerging CAV technologies. It advanced practical, real-time coordination using modern communications and demonstrated how automation can reduce crashes and delays while remaining robust to imperfect data—directly aligning with the Department's focus on innovation, safety, and efficient operations.

Outputs:

- A working CAV coordination framework that combined learning-based planning with a real-time safety backstop.
- Simulation testbeds (urban intersections, highway merging) and comparison results against common baselines.
- A small-scale hardware demo using radio-connected vehicles to show real-world feasibility.
- Documentation and technical materials summarizing methods, scenarios, and results.
- Conference/manuscript submissions describing the approach and findings.

Outcomes/Impacts:

- **Safety:** Fewer collisions in mixed-traffic tests due to the safety layer that blocked unsafe maneuvers.
- **Efficiency:** Smoother vehicle movement and reduced delays compared with baseline strategies.
- **Robustness:** Stable performance despite sensing noise and communication lag, improving reliability for deployment.
- **Technology readiness:** Hardware demonstrations and clear test procedures created a pathway for pilot trials and future transfer to larger fleets.

Final Research Report: Final Report is posted here: https://www.umass.edu/neutc/projects/5g-enabled-safe-and-robust-deep-multi-agent-reinforcement-learning-framework-cav