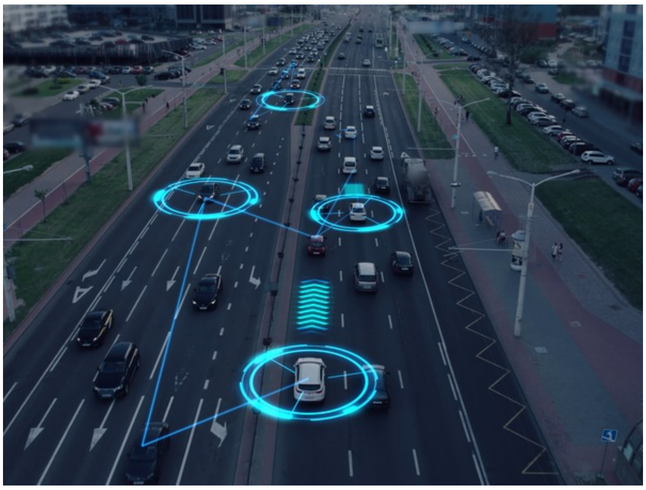
Multi-Agent Deep Reinforcement Learning Autonomous Driving Highway Lane Merge

TECHNOLOGY NUMBER: 2024-210



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Category
Software
MOSS - Michigan Open Source Support

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OVERVIEW

Enables scalable, robust autonomous ramp merging using dynamic multi-vehicle state modeling

- Outperforms previous methods by flexibly adapting to complex, multi-vehicle merging scenarios
- Full-autonomy vehicles, driver-assist systems, highway traffic management, simulation platforms

BACKGROUND

Despite significant progress in autonomous driving, Level 5 (L5) vehicles—capable of full autonomy—remain unrealized, largely due to unresolved challenges in complex traffic scenarios like highway on-ramp merging. Earlier solutions focused on two-vehicle interactions, modeling state using relative gaps and speeds. While effective in controlled situations, these approaches cannot handle the exponentially larger state and action spaces needed for realistic, multi-vehicle environments. Traditional methods struggle to generalize and often become computationally intractable as scene complexity scales. Furthermore, current evaluation frameworks lack standardization, making consistent benchmarking difficult. This landscape highlights the need for innovative models that both capture the essential dynamics of multi-vehicle merging and remain computationally feasible as real-world scenarios grow in complexity.

INNOVATION

This invention extends autonomous ramp merging solutions beyond limited two-vehicle interactions by introducing a comprehensive “full-scene” modeling approach. It generalizes the previous state variables—relative gap and speed—to all vehicles in both the traffic and merging lanes. By employing a reductionist yet complete modeling strategy, the approach focuses on dynamically identifying and adapting to the most relevant vehicles for each merging decision. This flexibility allows the model to scale to arbitrarily complex merging scenes without falling prey to exponential growth in possible states and actions. The dynamic model supports a multi-agent deep reinforcement learning environment, demonstrating strong collision avoidance and timing performance in highly interactive scenarios. Real-world applications include safer autonomous vehicles, advanced simulation for automated highway merging, traffic flow optimization, and robust, standardized evaluation frameworks for autonomous systems.

ADDITIONAL INFORMATION:

PROJECT LINKS:

DEPARTMENT/LAB:

- Luis Ortiz, Computer and Information Science, U-M Dearborn

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