Artificial Intelligent and IoT

Mini-Project

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Mini-Project Due Date: April 30, 2025., 09:00 am.
Demo Presentation Date: April 30, 2025

Mini-Project: Traffic Signal Optimization using Q-Learning and SUMO

In a smart city, traffic congestion is a major challenge. Traffic signals control vehicle movement at intersections, but traditional fixed-timing signals are inefficient in dynamic traffic conditions. In this assignment, you will:

- Use your current simulated urban intersection in **SUMO**.
- Implement a **Q-Learning agent** (AI agent) to dynamically predict and adjust traffic light durations based on real-time traffic conditions. Note: your AI agent will be considered as part of the brain of your Intelligent Transportation system. Try to identify and propose where the AI-agent should be deployed and run as well. This part of your contribution.
- Evaluate the AI agent's performance compared to a fixed-timing strategy (i.e., the traditional approach).

❑Suggested Environment Details:

- The intersection has four incoming lanes (North, South, East, and West).
- Traffic flow varies throughout the day, with peak and off-peak hours.
- Vehicles arrive at the intersection based on a probability distribution.

❑ State Representation:

- Number of vehicles in each lane.
- Average waiting time of vehicles.
- Current traffic signal phase.
- Of course you can involve further features for your state space. Depends on your simulated environment following up your presented scenario in April 2, 2025.

❑ Actions Space:

- Change traffic light phase (e.g., extend green, switch to red, etc.).

❑ Reward Function:

- Negative reward for vehicle waiting time.
- Additional penalty for long queue lengths.
- Positive reward for reducing congestion.

Mini-Project: Traffic Signal Optimization using Q-Learning and SUMO (Cont.)

❑Simulation with SUMO

- You are suggested to install **SUMO** and create a simulation scenario:
- Define road networks using **SUMO's netedit**.
- Generate traffic flow files.
- Integrate SUMO with Python using **TraCI (Traffic Control Interface)**.
- Implement a Q-Learning agent to control the traffic signal.

❑ Dataset

Instead of a static dataset, you will generate their own traffic data using SUMO simulations. The environment logs:

- Time step.
- Number of vehicles in each lane.
- Average vehicle waiting time.
- Traffic signal phase.

Note: Sample data set is saved in **traffic_signal_data.csv**. You can use it as a reference for your Q-Learning implementation. I encourage you to generate the dataset through your current simulated environment as well.

❑ Deliverables

- Python implementation of Q-Learning with SUMO.
- A report explaining the approach, results, and comparison with fixed-timing signals.
- Plots of traffic congestion reduction over time.