Traffic Flow Optimization

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1 Introduction

Urban traffic congestion significantly impacts daily life, causing time loss, increased fuel consumption, and elevated emissions. Traditional traffic light control systems, often static, contribute to urban traffic management inefficiencies. Reinforcement Learning provides a dynamic, adaptive signal timing optimization method, potentially alleviating congestion and improving mobility.

2 Objectives

- Develop a dynamic traffic light control system using Reinforcement Learning that adapts to real-time traffic conditions to optimize flow and reduce congestion.
- Simulate and evaluate the performance of the Reinforcement Learning based system in varied traffic scenarios to demonstrate improvements in traffic throughput and reduction in waiting times at intersections.
- Compare Reinforcement Learning and traditional control methods to quantify traffic management enhancements.

3 Reinforcement Learning Techniques

This project will explore Deep Q-Networks (DQN) for their ability to handle complex, high-dimensional state spaces associated with urban traffic networks[1]. DQNs, a class of model-free, off-policy Reinforcement Learning algorithms, are well-suited for environments with continuous state spaces and discrete action spaces, making them ideal for optimizing traffic light phases in real-time based on continuous traffic flow data.

4 Proposed Methodology

- Simulation Environment Setup: Utilize the SUMO (Simulation of Urban MObility) tool to create a realistic urban traffic simulation environment. This includes defining road networks, traffic flows, and control points (traffic lights).
- Reinforcement Learning Integration: Implement a DQN model to interact with the SUMO environment via the TraCI API, processing traffic metrics such as vehicle count, queue length, and waiting times.[2].
- Training and Evaluation: The DQN model will be trained iteratively; at each step, it will decide on the optimal traffic light phase. The model's performance will be evaluated based on metrics such as average waiting time and total throughput. Training will continue until the model achieves a significant improvement over traditional control methods.
- Optimization and Scalability: After initial training, further optimize the model for efficiency and scalability, with the goal of extending the system to manage multiple intersections and diverse traffic conditions.

5 References

References

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