Traffic flow Optimization using Reinforcement Learning

Summary:

Traffic congestion has been a major problem in developing and developed cities and a proper solution has not been implemented yet. This project aims to find the optimal traffic control system using reinforcement learning models. Being the data for this problem is ever changing and unpredicted, it is suitable to use reinforcement learning algorithms for solving this problem.

Objective:

Develop reinforcement learning models to optimize traffic signal timings and comparing the performance of these models with the aim of minimizing average waiting time, maximizing traffic flow and adaptable to dynamic traffic conditions.

Methodology:

- **State Representation:** The state of each intersection can be represented as a vector of features like the queue length of vehicles, the number of vehicles that entered the intersection in the last time step, the current phase of the traffic lights, and possibly time of day/weather conditions.
- **Action Definition**: The action space consists of phase settings for the traffic lights at each intersection. For example, modifying traffic lights one for straight and right-turning traffic, and one for left-turning traffic.
- **Reward Function**: Positive rewards for minimizing vehicles at each intersection and their wait times, maintaining safe distances. Negative rewards for congestion, excessive wait times, traffic rule violations, and collisions.
- **Reinforcement Learning Algorithms**: We plan to implement Double Deep Q-Network with replay buffer to learn optimal traffic light control policies and comparing its performances.

Evaluation:

Evaluate algorithm performance using metrics like average wait time, traffic flow efficiency, and safety. Optimize algorithms through fine-tuning and experimentation with hyperparameters and reward shaping before and after the implementation of the reinforcement learning.

Environment:

We can use existing traffic simulators such as Simulation of Urban Mobility (SUMO) as our environment for implementing RL algorithms.

References:

1. T. Chu, J. Wang, L. Codecà and Z. Li, "Multi-Agent Deep Reinforcement Learning for Large-Scale Traffic Signal Control," in IEEE Transactions on Intelligent Transportation Systems, vol. 21, no. 3, pp. 1086-1095, March 2020, doi: 10.1109/TITS.2019.2901791.