State Vector design for Reinforcement learning in Traffic Signal control

Master‘s Thesis of Sameer Ahmed

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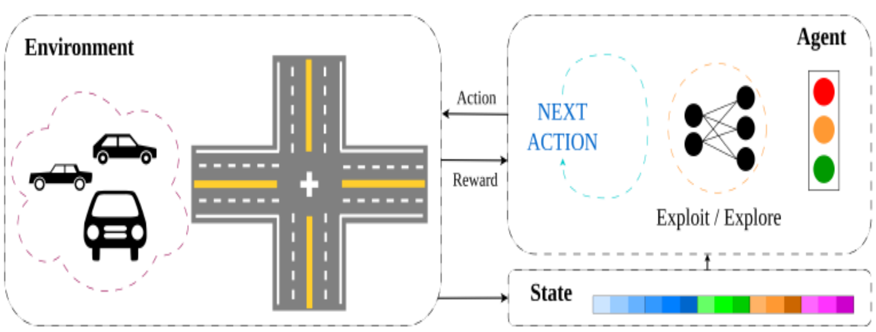
Introduction

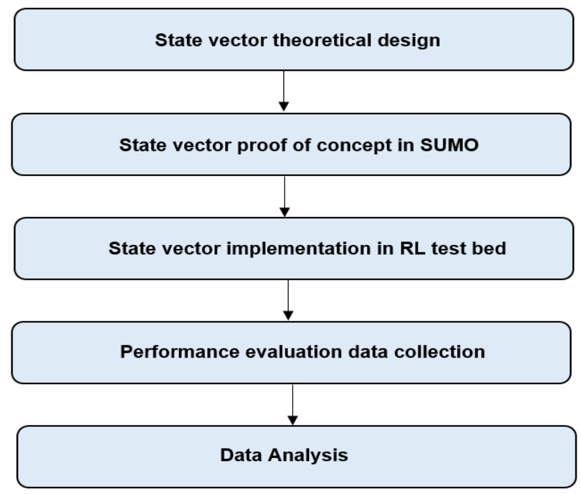
Traffic congestion is a major issue affecting urban areas globally, leading to significant economic losses, environmental pollution, and decreased quality of life. Due to the constant increase in urban population, the current infrastructure and traffic signal control system has reached its maximum capacity and the expansion of the infrastructure to accommodate the additional vehicles is not feasible. Recent advancements in artificial intelligence (AI), particularly in reinforcement learning (RL), present a viable solution for revolutionizing traffic signal control. RL models can potentially learn optimal traffic signal policies from the environment through interactions, dynamically adjusting signal timings in response to real-time traffic conditions. However, the effectiveness of an RL model in controlling traffic signals is dependent on the design of its state vector.

The primary objective of this research is to develop, analyse, and evaluate the design of state vectors for reinforcement learning (RL) models that are applied to traffic signal control. Through careful design and experimentation with several state vector configurations, this thesis seeks to improve RL models capacity to optimize urban traffic flow.



Methodology

The thesis followed a systematic process where first a comprehensive literature review was conducted to study the current RL based traffic signal control articles and what kind of state vector representations can be used effectively, secondly a theoretical and conceptual design of the state vectors was done using SUMO, thirdly, a methodology was developed to evaluate, validate and implement the designed state vectors using both SUMO simulation and a RL framework. Lastly, the results were discussed. Correlation analysis, feature importance ranking and a RL test bed was used to evaluate and validate the designed state vectors. The implementation of the state vectors in the RL framework presented the results for the objective of offset optimization for a 3 intersection network where SV-3 (delay, density and occupancy) performed the best in case of decrease in average queue length and increase in average speed, while SV-6 (intersection delay and density) performed best in case of decrease in travel time.



Results