

Toward A Thousand Lights: Decentralized Deep Reinforcement Learning for Large-Scale Traffic Signal Control



PennState

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Reinforcement Learning for Traffic Signal Control

Single Intersection control

Queue length as reward for single intersection [arXiv:1905.04722]
Learning phase competition [CIKM'19a]
Learning from demonstration [CIKM'19c]
Learning from other signals [AAAI'20b]

Multi-intersection control

Learning with graph attention [CIKM'19b]
Pressure as reward for arterial [KDD'19]
Pressure as reward for city [AAAI'20a]

Simulator

Efficient traffic simulator CityFlow [WWW'19]
Learning to simulate car following model [ICDE'20]

Introduction



Figure 1. Traffic Congestion in Manhattan

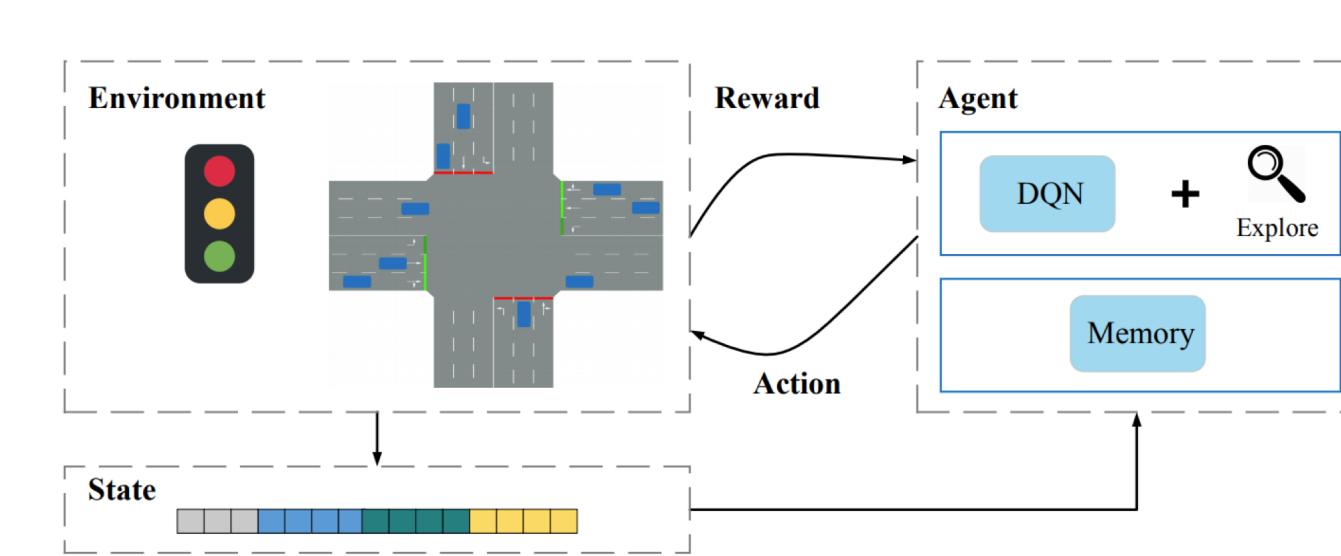


Figure 2. Reinforcement Traffic Signal Control Framework

Key challenges

1. Scalability:

How to scale up to thousands of intersections?

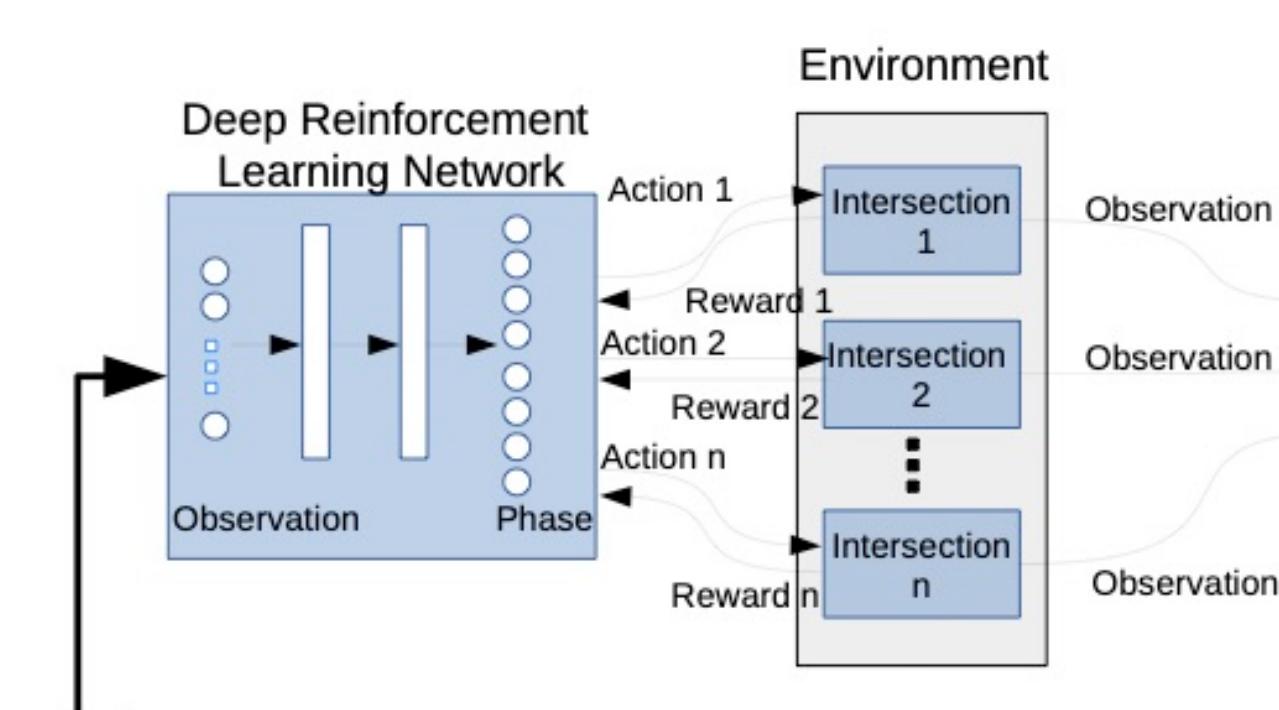
2. Signal coordination:

How to coordinate between intersections?

3. Data feasibility:

How to design the model from feasible data source

Model framework

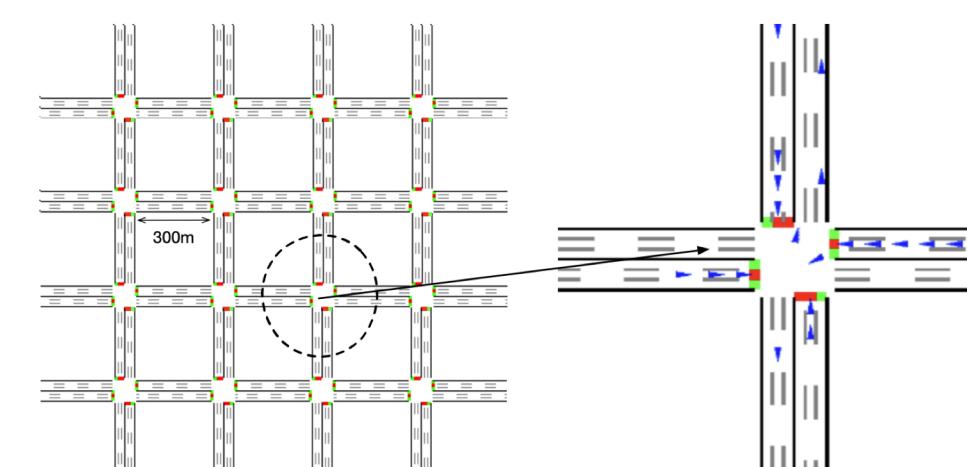


Key Features

- Scalability
- Signal coordination
- Data feasibility
- etc.

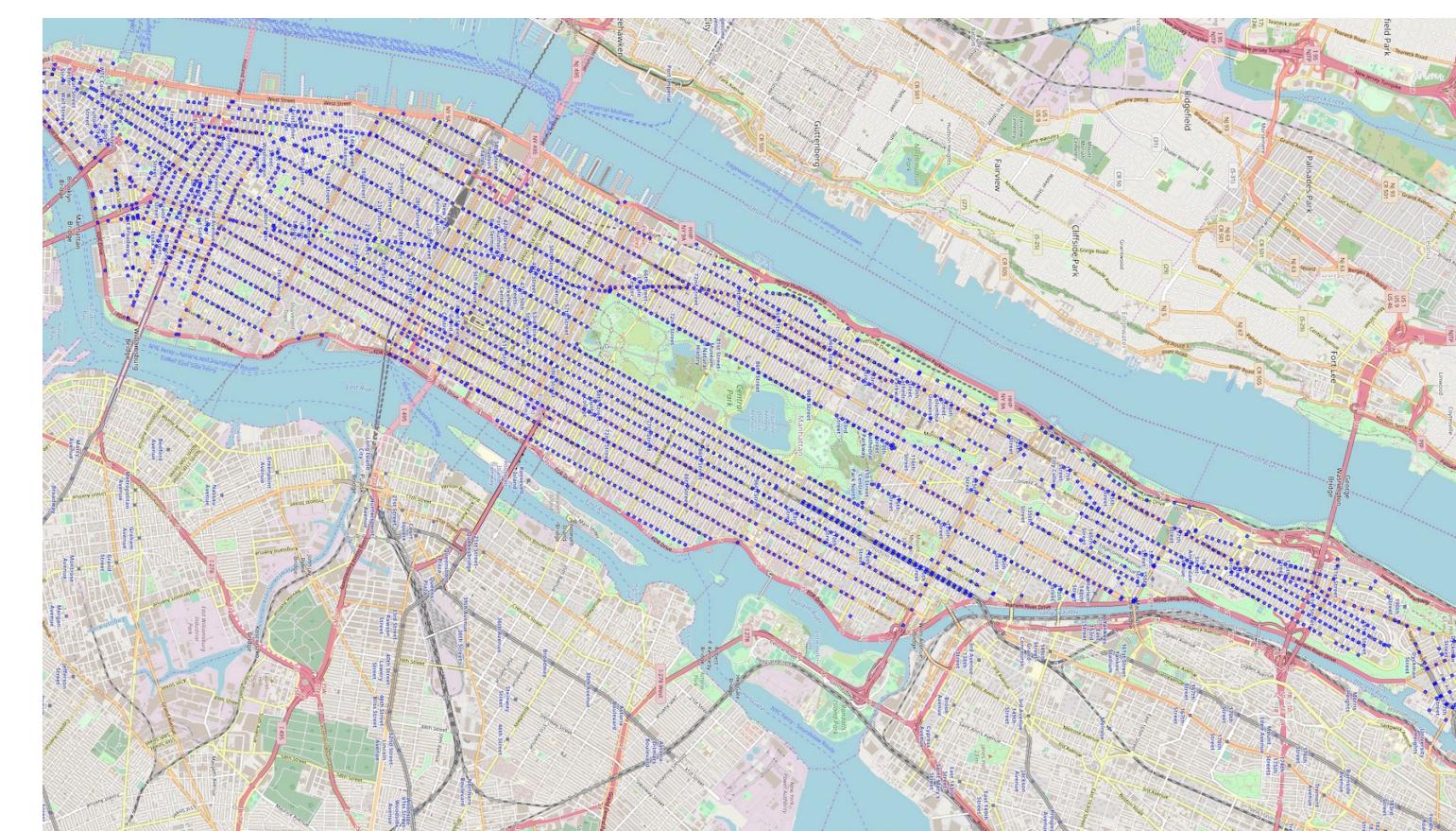
Experiments

4x4 roadnet



Model	Travel Time			
	Config 1	Config 2	Config 3	Config 4
FixedTime	573.13	564.02	536.04	563.06
MaxPressure	361.17	402.72	360.05	406.45
GRL	735.38	758.58	771.05	721.37
GCN	516.65	523.79	646.24	585.91
NeighborRL	690.87	687.27	781.24	791.44
PressLight	354.94	353.46	348.21	398.85
FRAP	340.44	298.55	361.36	598.52
MPLight	309.33	262.50	281.34	353.13

Manhattan roadnet



Model	Travel Time	
	Config 1	Config 2
FixedTime	974.23	
MaxPressure	497.76	
GRL	*	
GCN	653.45	
NeighborRL	*	
PressLight	600.42	
FRAP	512.70	
MPLight	472.51	

Methodology

Challenge #1: Trap base model & parameter sharing

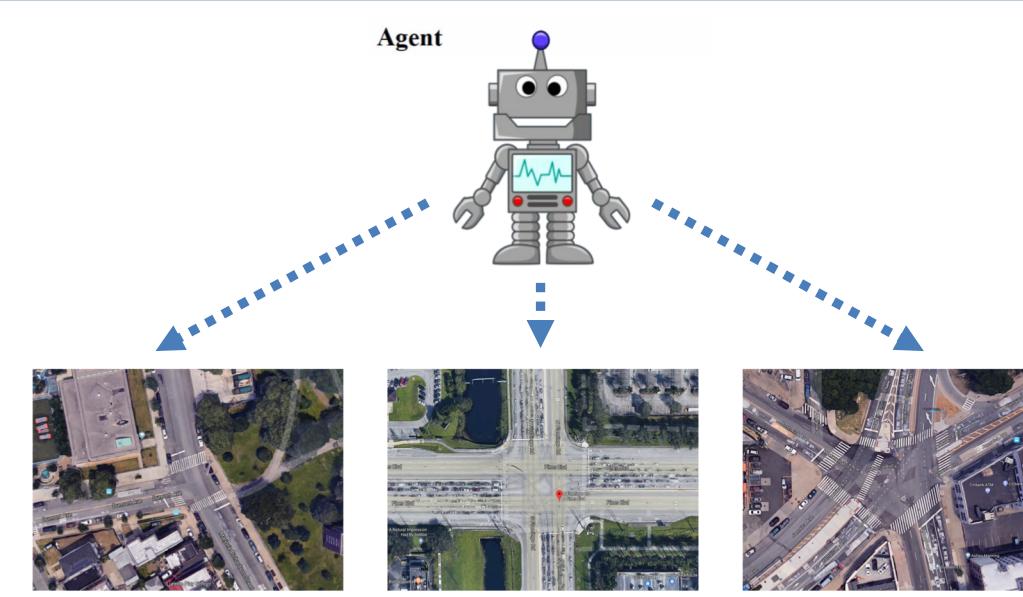
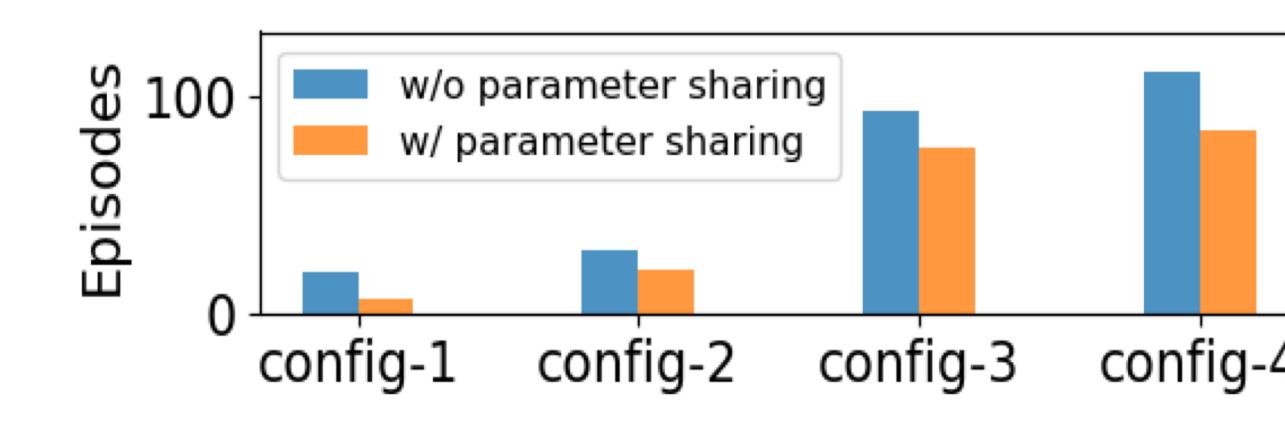
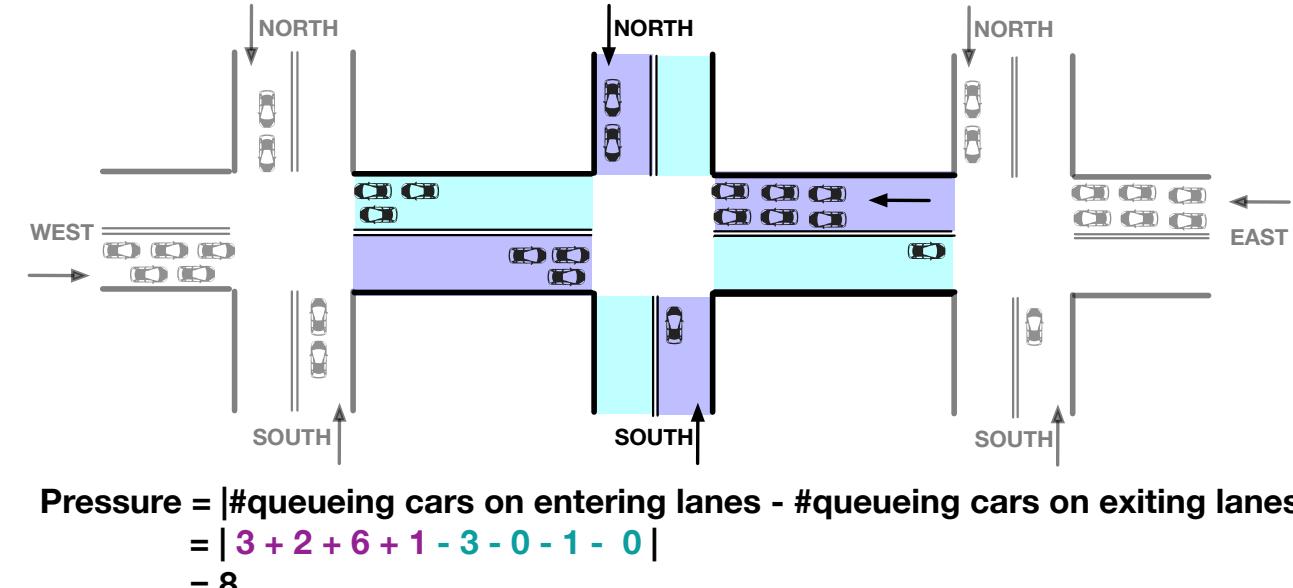


Figure 3. Trap base model for heterogeneous intersections [CIKM'19a]



Challenge #2: Pressure-based coordination



$$\text{Pressure} = |\text{#queueing cars in entering lanes} - \text{#queueing cars in exiting lanes}|$$

$$= |3 + 2 + 6 + 1 - 3 - 0 - 1 - 0|$$

$$= 8$$

Challenge #3: simple state and reward

- State:**
- Current phase
 - # Vehicles on incoming lanes
 - # Vehicles on outgoing lanes
- Reward:**
Pressure for each intersection

References

- [KDD'18] Wei et al., IntelliLight: A Reinforcement Learning Approach for Intelligent Traffic Light Control
[arXiv:1904.08117] Wei et al., A Survey on Traffic Signal Control Methods
[arXiv:1905.04716] Zheng et al., Diagnosing Reinforcement Learning for Traffic Signal Control
[KDD'19] Wei et al., PressLight: Learning Max Pressure Control to Coordinate Traffic Signals in Arterial Network
[AAAI'20a] Chen et al., Toward A Thousand Lights: Decentralized Deep Reinforcement Learning for Large-Scale Traffic Signal Control

- [CIKM'19a] Zheng et al., Learning Phase Competition for Traffic Signal Control
[CIKM'19b] Wei et al. , CoLight: Learning Network-level Cooperation for Traffic Signal Control
[CIKM'19c] Xiong et al., Learning Traffic Signal Control from Demonstrations
[AAAI'20b] Zang et al., MetaLight: Value-based Meta-reinforcement Learning for Online Universal Traffic Signal Control
[ICDE'20] Zheng et al., Learning to Simulate Vehicle Trajectories from Demonstrations
[WWW'19] Zhang et al., CityFlow: A Multi-Agent Reinforcement Learning Environment for Large Scale City Traffic Scenario



Project Website

Find datasets, code, demo and more!