# Traffic Flow Optimization with Reinforcement Learning

Using AI to solve the traffic problem

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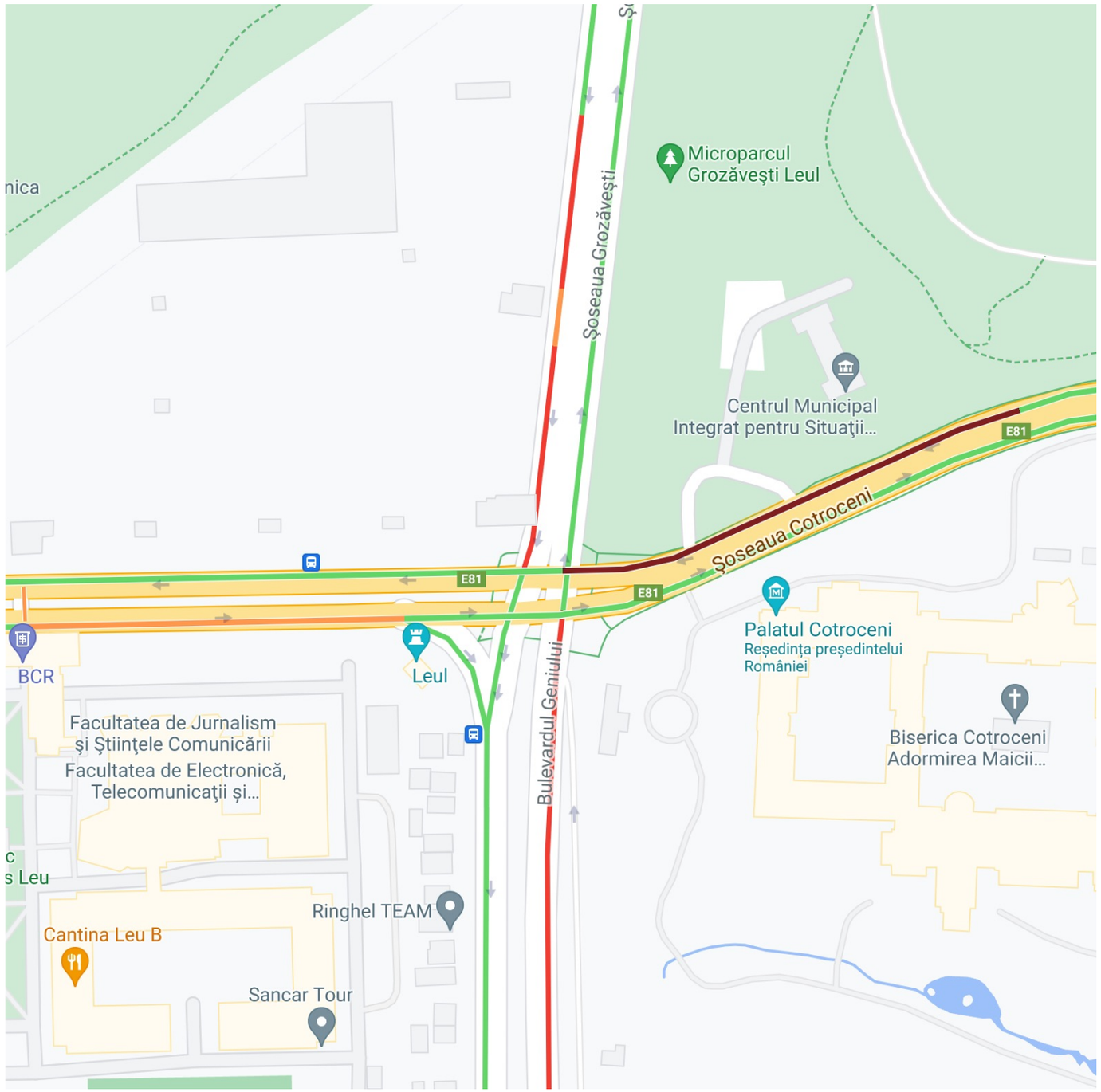
# Motivation

According to the Global Congestion Impact score, Bucharest has the worst traffic in the world in 2020.

One of the key factors of congestion is bad traffic lights systems.

# Motivation


Microparcul
Grozăveşti Leul
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Integrat pentru Situaţii...
E81
Şoseaua Cotroceni
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Palatul Cotroceni
Reşedinţa preşedintelui
României
Biserica Cotroceni
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BCR
Leul
Bulevardul Geniului
Facultatea de Jurnalism
şi Ştiinţele Comunicării
Facultatea de Electronică,
Telecomunicaţii şi...
Ringhel TEAM
Cantina Leu B
Sancar Tour

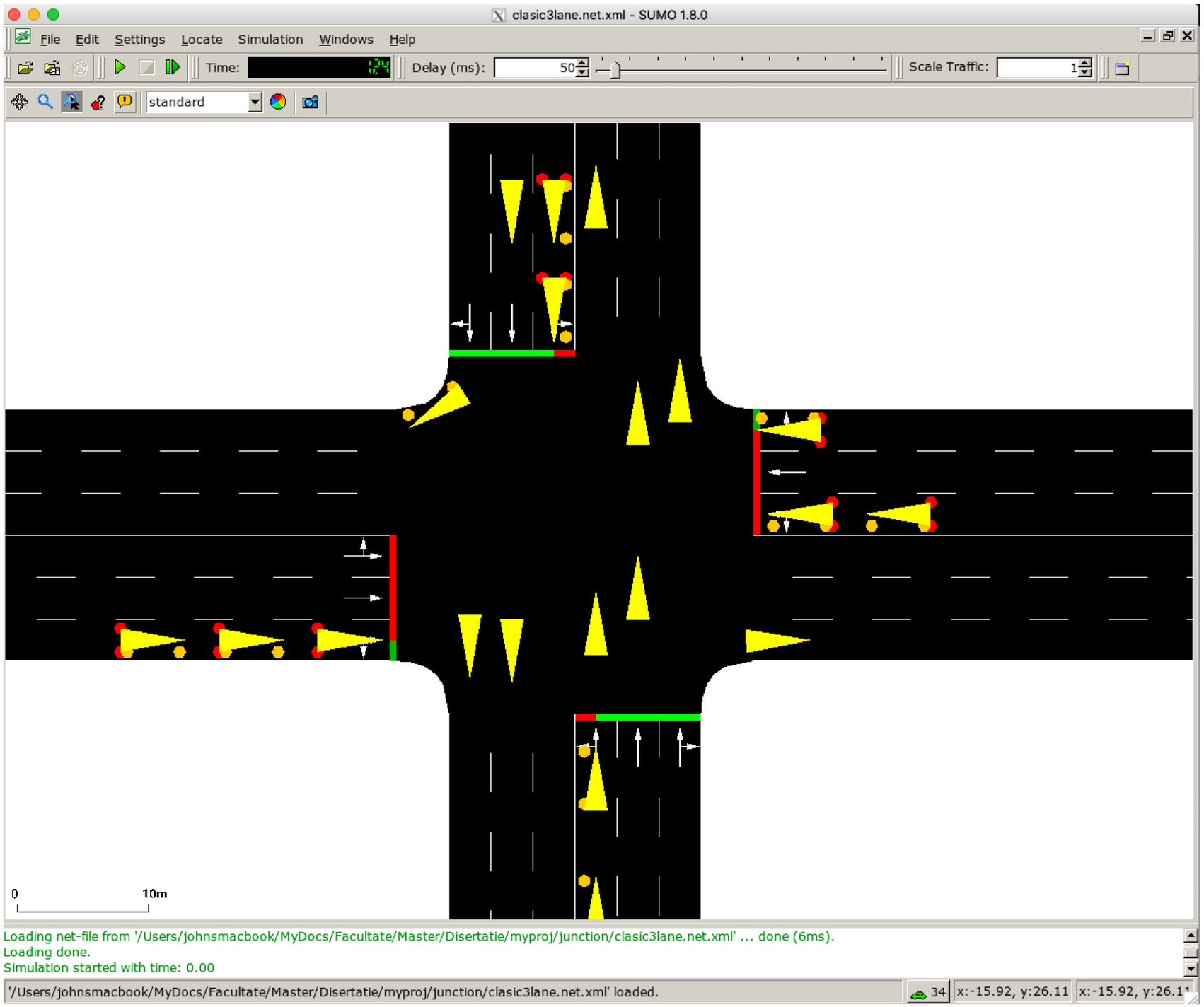
# Motivation

- Traffic flow is dynamic changing from hour to hour
- There are too many variable and cases to hardcode a good programme for red-green phases, ex. :ambulance in mission
- Multiple traffic lights need to respond to incoming cars to improve overall waiting time

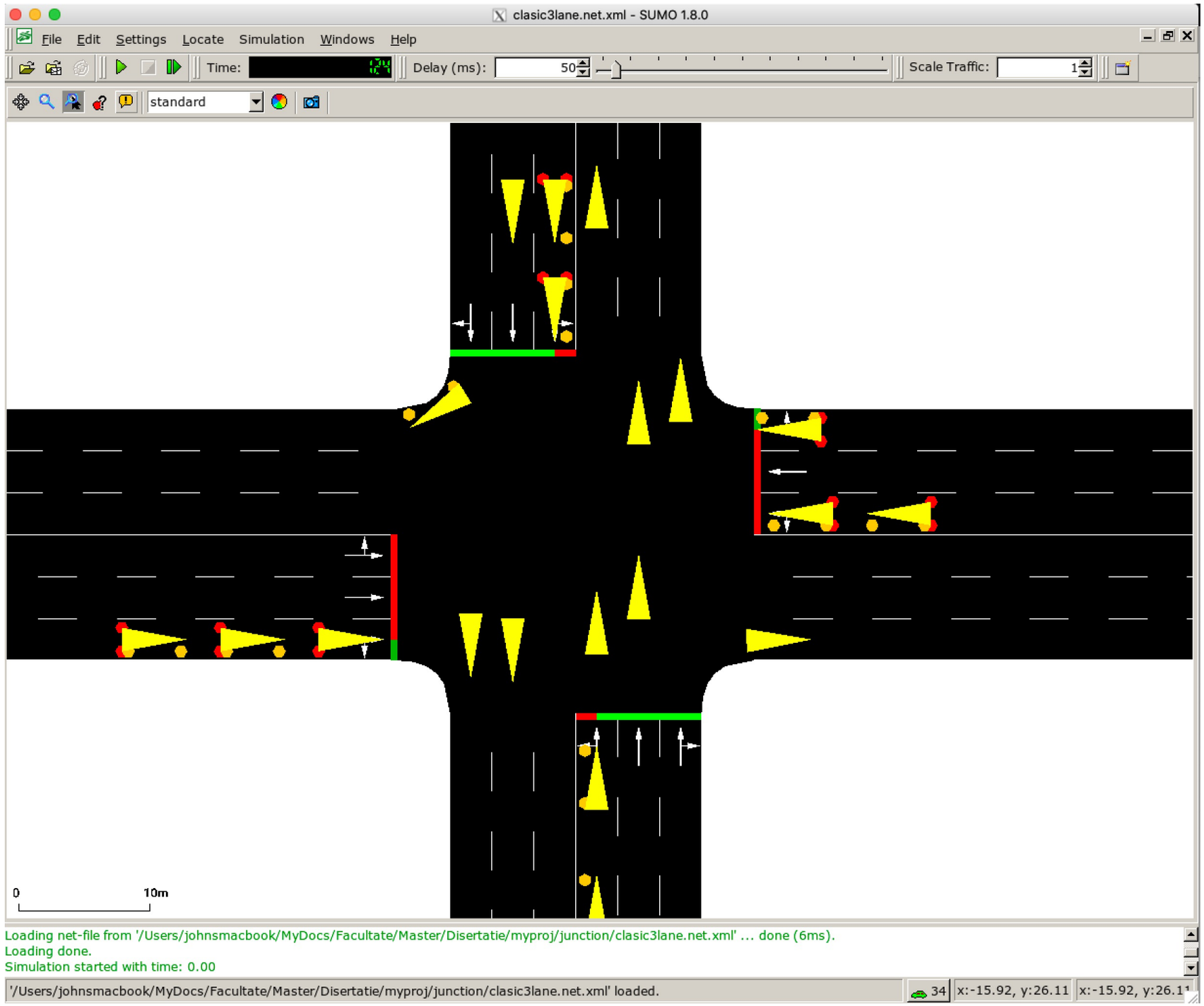
# Related Work

- SUMO, OSRM, Carla
- State-of-the-art Reinforcement Learning approaches

# SUMO


clasic3lane.net.xml - SUMO 1.8.0
File Edit Settings Locate Simulation Windows Help
Time:
Delay (ms):
50
Scale Traffic:
1
standard
0
10m
Loading net-file from '/Users/johnsmacbook/MyDocs/Facultate/Master/Disertatie/myproj/junction/clasic3lane.net.xml' ... done (6ms).
Loading done.
Simulation started with time: 0.00
'/Users/johnsmacbook/MyDocs/Facultate/Master/Disertatie/myproj/junction/clasic3lane.net.xml' loaded.
34
x:-15.92, y:26.11

# SUMO




- TraCI Python
  - Nets
- Routes for cars
- Special vehicles
  - Many stats
  - Good Docs

# Deep Reinforcement Learning

- **Machine Learning**

Type of AI that can improve its performance on a specific task by ”learning” from **given** data (Supervised Learning).

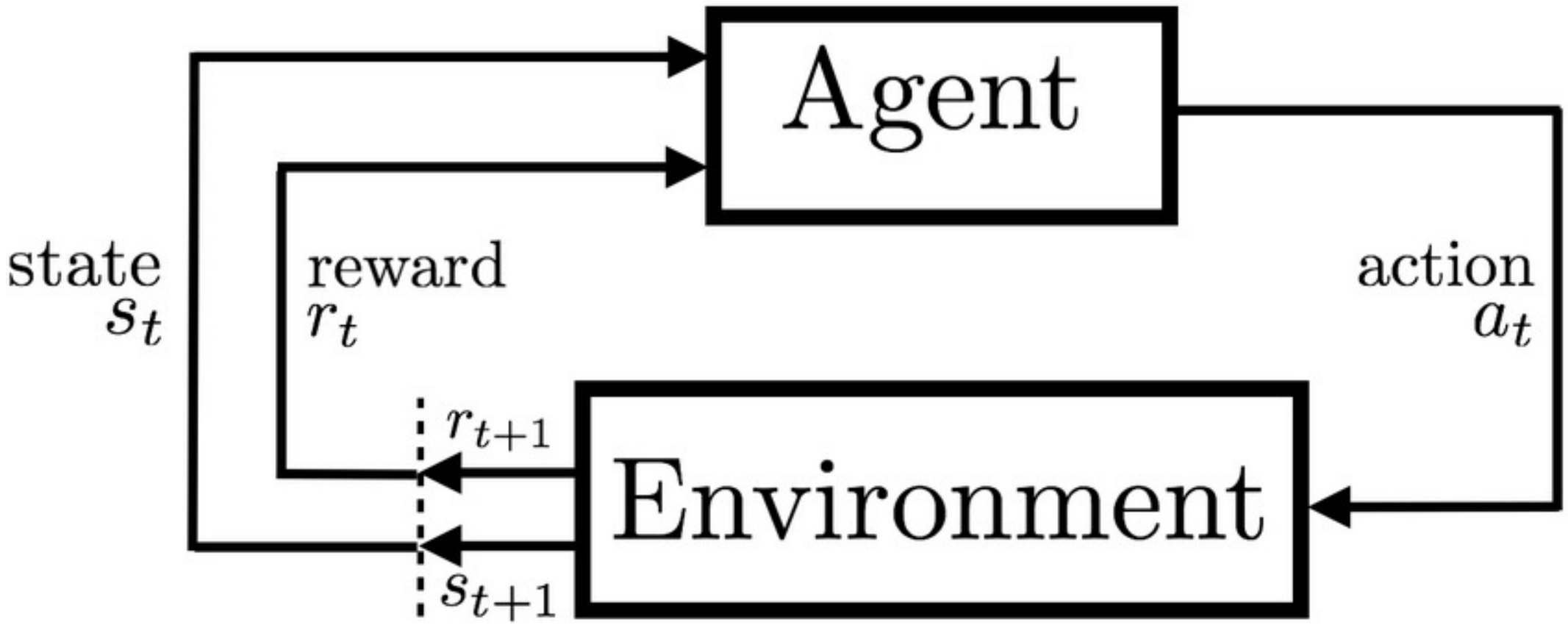
- **Reinforcement Learning**

An agent interacts with an environment and learns how to behave based on the rewards of its past actions.

- **Deep Learning**

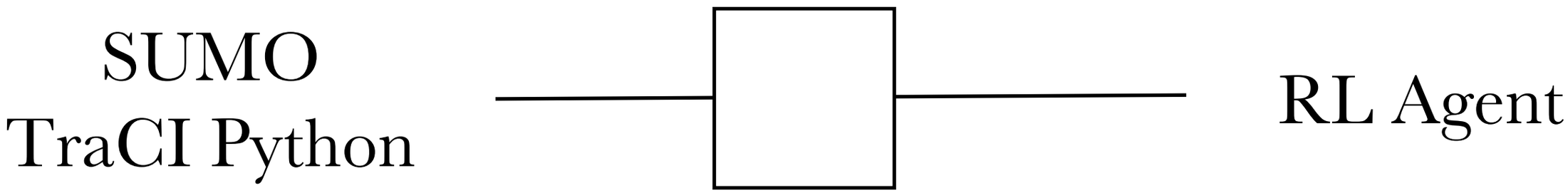
The model is based on a Deep Neural Network which can learn more complex patterns from the input data.

# Deep Reinforcement Learning



# Contribution

- How does the RL methods compare and what is the simplest configuration from which we get good results?
- How can we configure our data input to mimic real world situations, ex.: using sensors to get incoming traffic data?
- How the results compare, what exactly is enough for the RL agent to learn something?


SUMO
TraCI Python
RL Agent

**My Work**

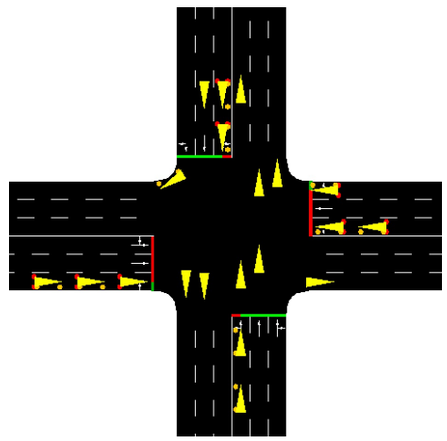
SUMO
TraCI Python

Custom Environment

RL Agent

- Reward
- Observation
- Action

# Experiments



**Setup**:
- Classic 2 roads junction with 3 lanes
- Traffic generated by custom distribution of probabilities
- Default TL Programme: 42s Green 3s Yellow 10s Left-Green Cycle

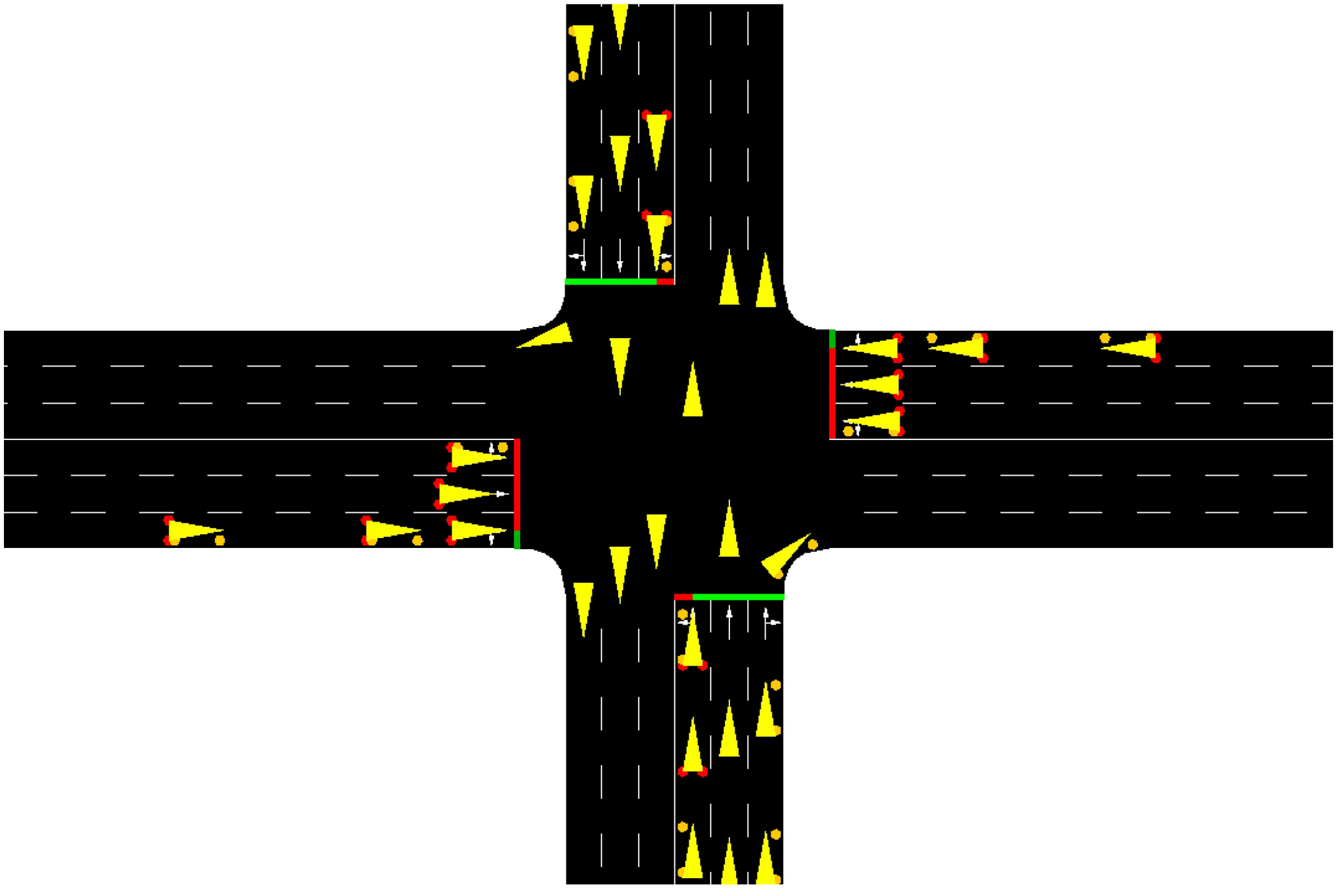
**Action**:
- [0,3] - 4 actions for each Green and Left-Green Phase

**Observation**:
- Array of size 13, first digit [0,3] for TL phase and 12 digits for each lane stopped nr of cars (1+12)
- One-hot encoding and normalized values (4+12)
- Previous normalized values + values for occupancy for each lane (4+12+12)

**Reward**:
- -1 for each stopped car for each lane
- Negative values added up for normalized observation
- Negative values for accumulated waiting time added up
- Average speed of the car

Penalty for early termination.

# Traffic junction



# Results

**Setup**:

- 150.000 steps training
- Light Traffic episodes (1000 steps with 400 cars)
- Obs. 3 and Reward 3

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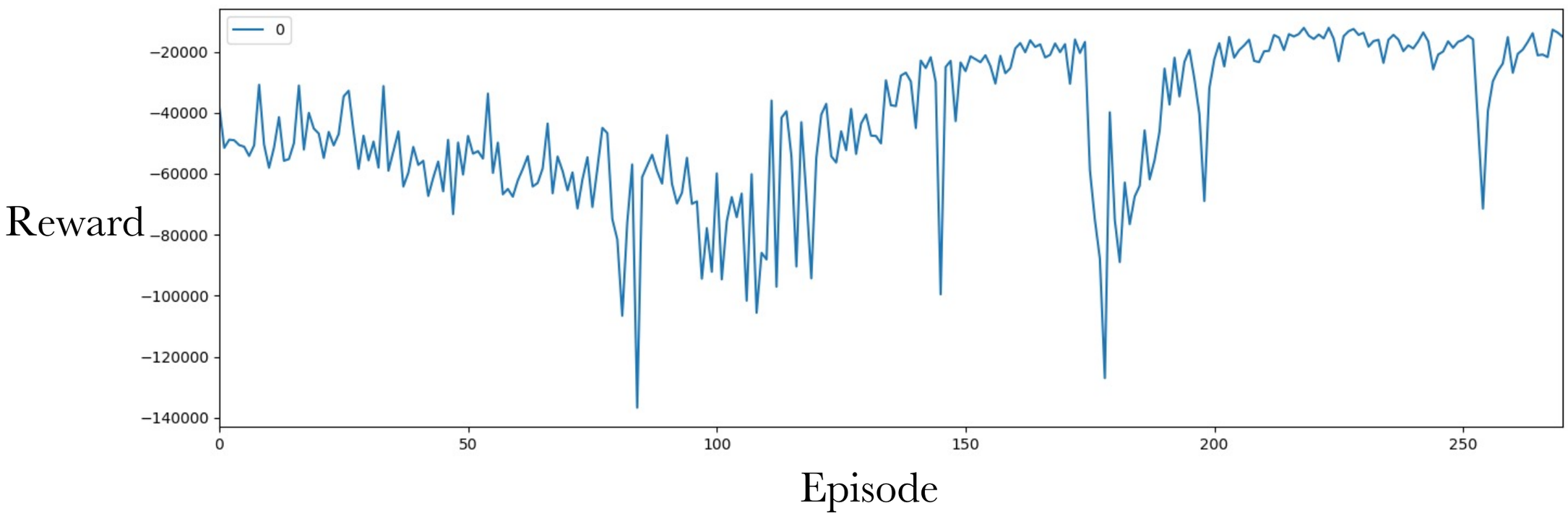
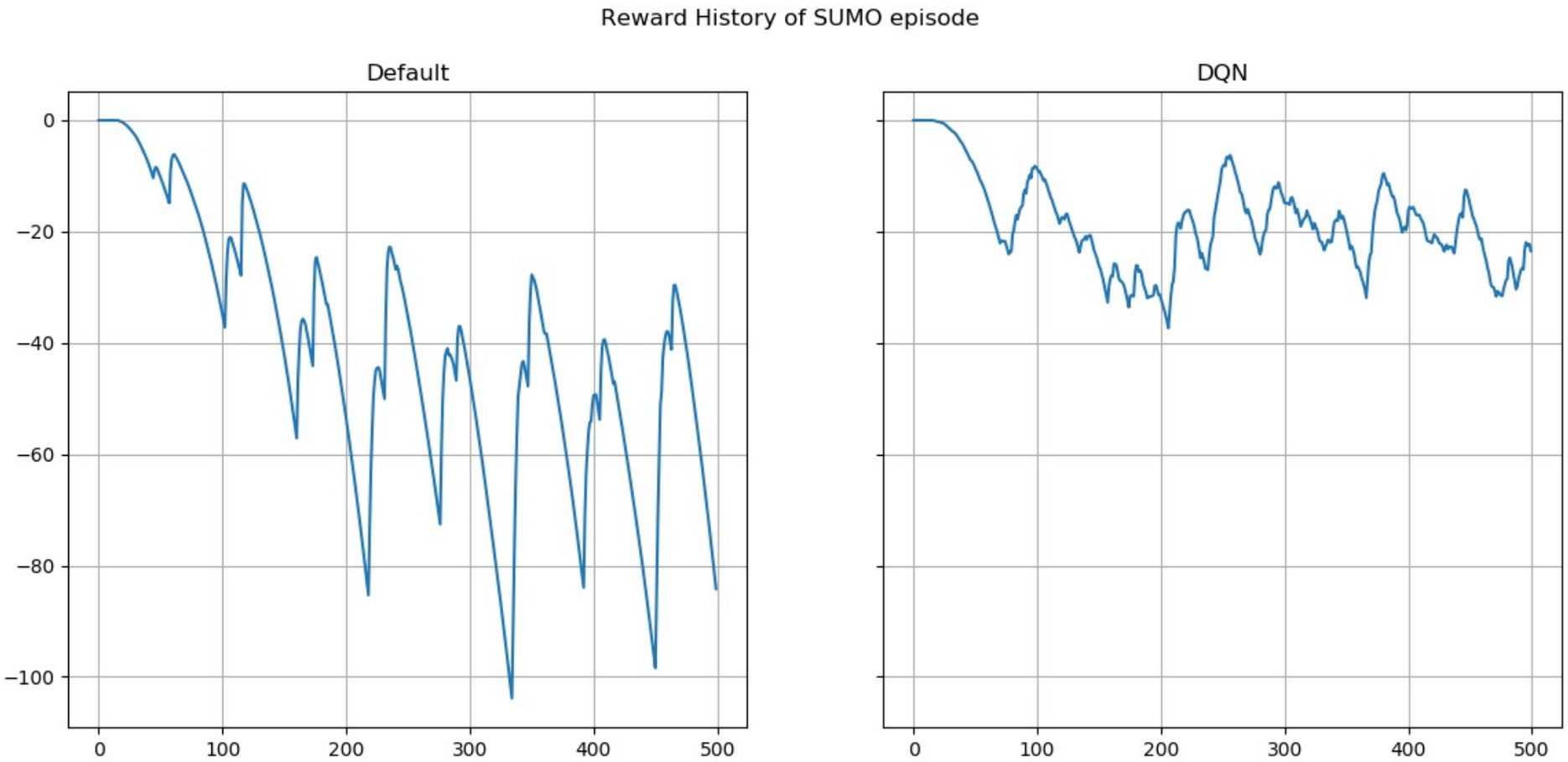
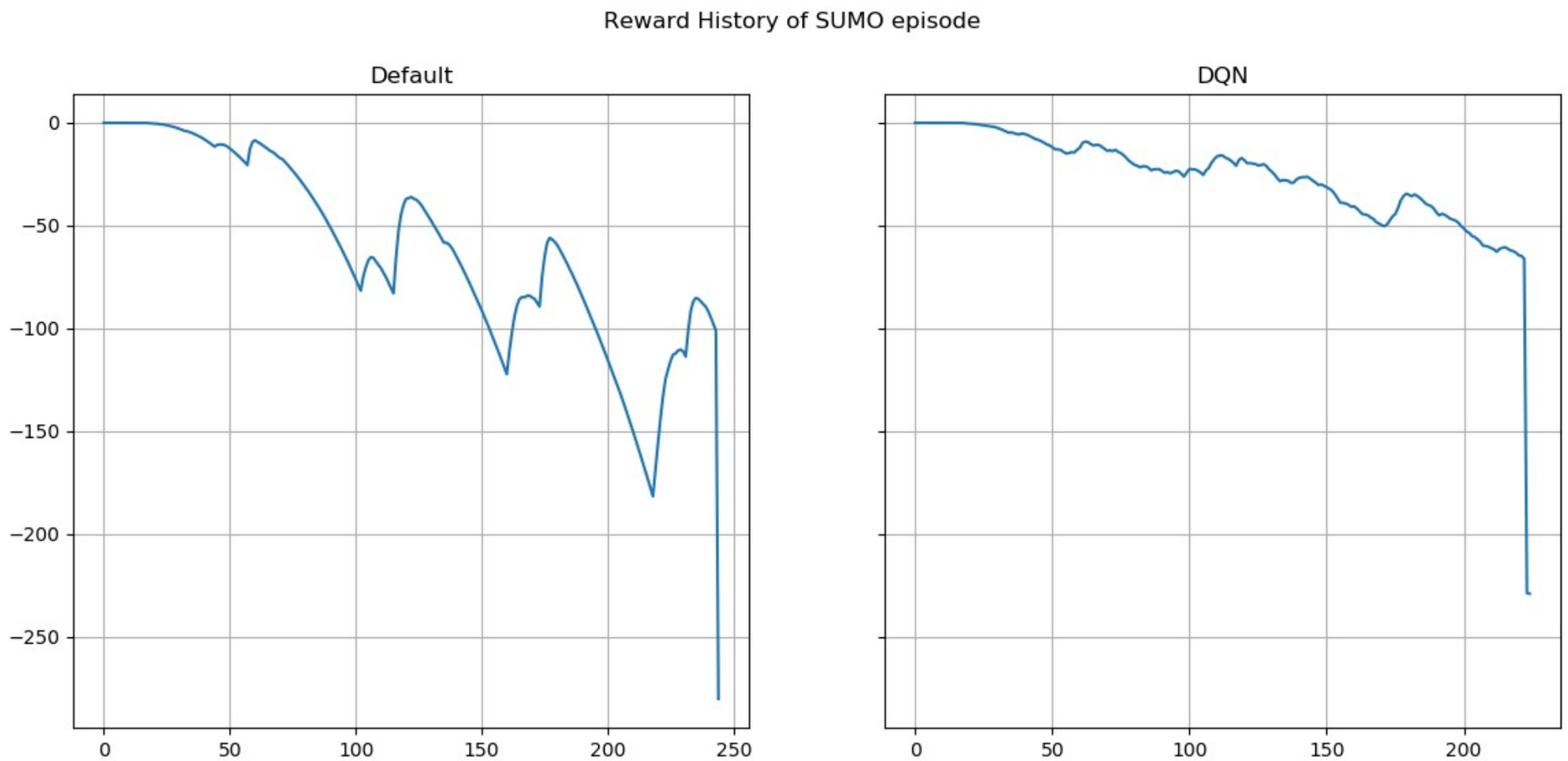


# Results



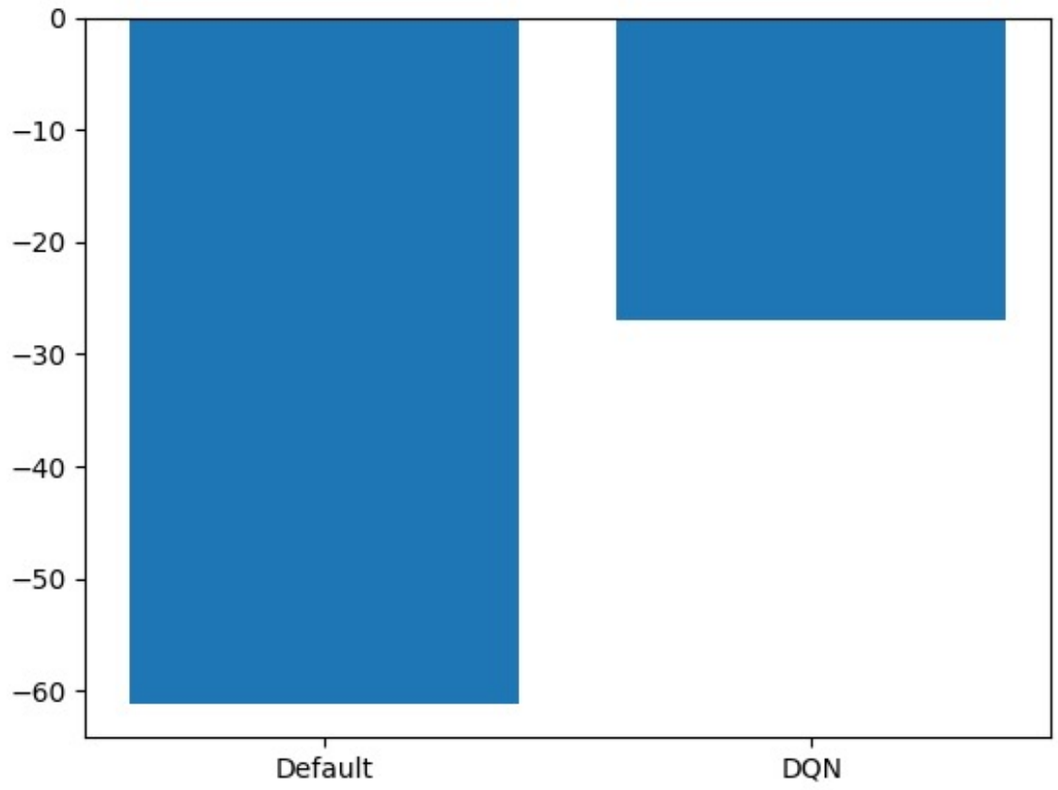

Mean Reward History on Light Traffic

# Results



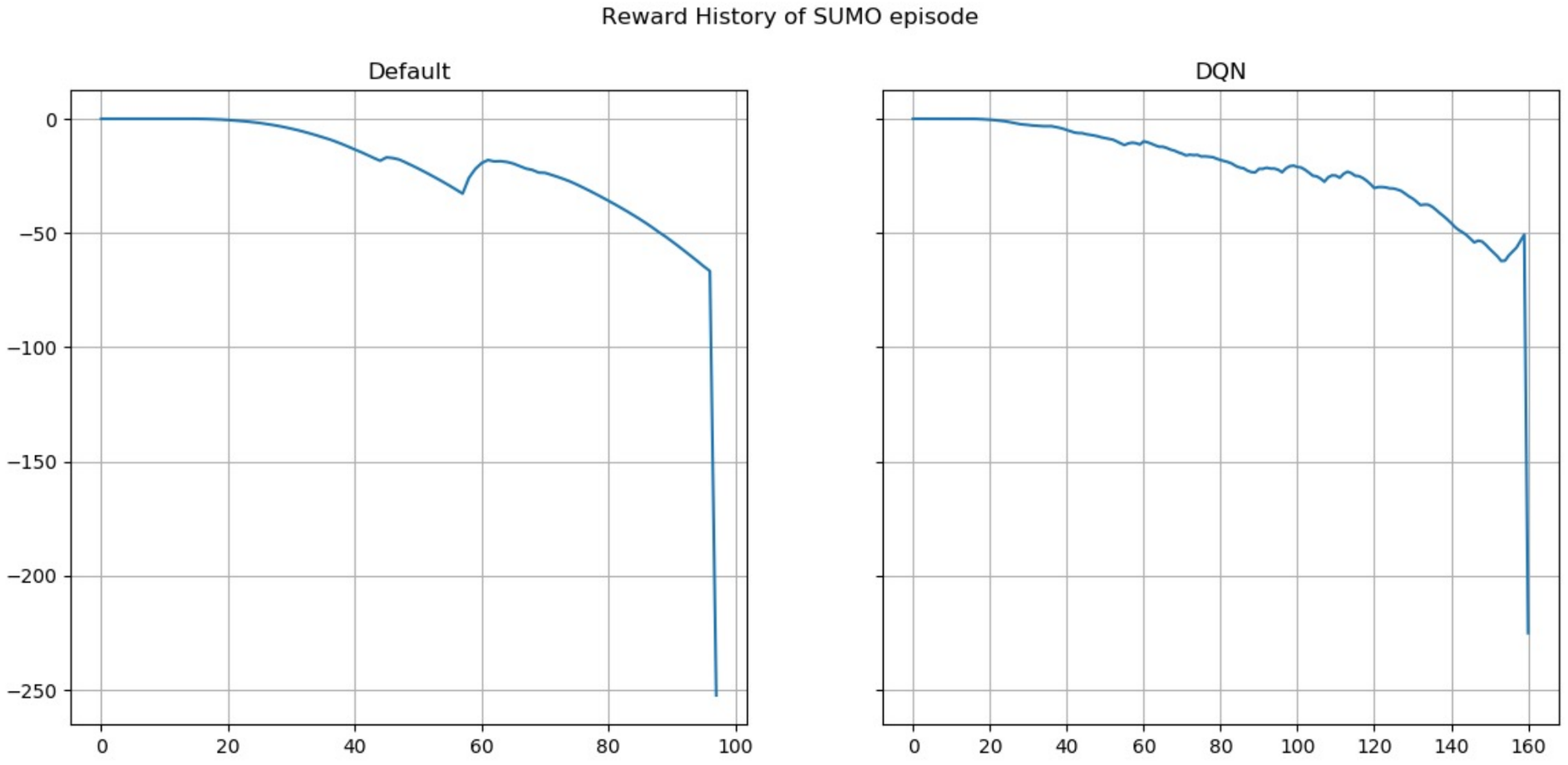

Mean Reward History on Heavy Traffic

# Results




*Average Reward per Episode on Heavy Traffic*

# Results




Mean Reward o History on One-Way Traffic

# Conclusions

- It is possible for the agent to learn to act in simple scenarios
- The agent can achieve good results with few computational resources
- The model is robust
- For complex traffic scenarios, longer training times are needed (days)

Thank you!