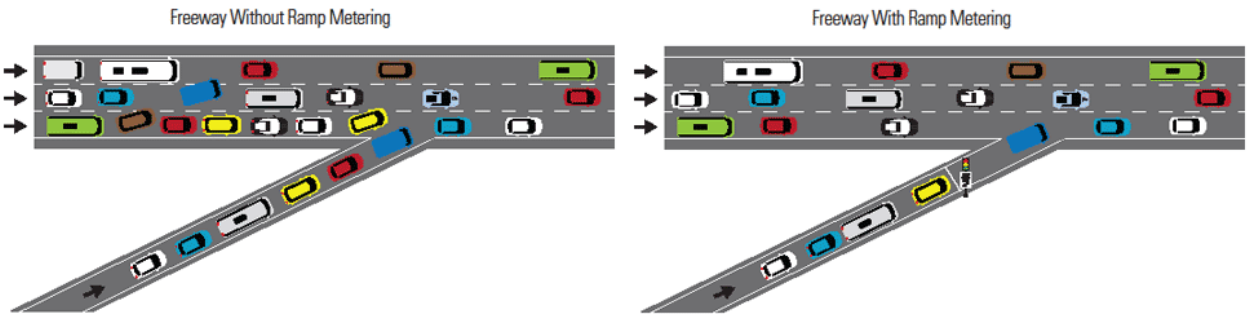
Project: Reinforcement learning for ramp metering on highways.

1. Project Description

The objective of this project is to apply algorithms of Q-learning and Deep Q-learning to learn by numerical simulation the ramp metering control on a highway. We consider a stretch of highway with a given number of lanes (which is a parameter here), with an entering ramp controlled with a traffic light. We use the traffic simulator SUMO (Simulation of Urban Mobility) to simulate the car-following and lane change of all cars. The Q-learning algorithm should control the traffic light at the ramp, in a way that it optimizes the traffic, both on the highway stretch and on the ramp.



https://ops.fhwa.dot.gov

2. Instructions

1. Use the traffic simulator SUMO (Simulation of Urban Mobility) to simulate the traffic environment in order to train an RL agent that will control ramp metering
2. Implement Q-learning and DQN algorithms from scratch. For the DQN algorithm, you can refer to the works of Romain Ducrocq:
    - Project 1: Framework DQN: https://github.com/romainducrocq/frameworQ/
    - Project 2: DQN for Intelligent Traffic Signal Control with Partial Detection:
        - https://github.com/romainducrocq/DQN-ITSCwPD/
        - **Article on ArXiv: https://arxiv.org/abs/2109.14337**
3. Check if the trained policies/models converge well during the training process based on total reward (not discounted total reward).
4. Compare the performance of the two policies/models using two different metrics of your choice (justify your selection).
5. Study the difference between the two cases:
    - Without traffic lights on the ramp
    - With traffic lights on the ramp controlled by the trained policies/models

3. Report content

The report must include the following elements:

1. Bried explanation of Q-learning and DQN algorithms

2. Description of simulations (number of lanes, car-following model, lane-changing modes, vehicle types, road length, traffic demand on the freeway and on the ramp, etc.)
3. Detailed RL problem reformulation: reward function, state definition, action space
    1. The state definition should include information related to the traffic state on both the highway and the entering ramp
    2. The reward function should consider the optimization of traffic on both the highway and the ramp (i.e., minimize ramp waiting times and maintain optimal highway flow)
4. Hyperparameters of each algorithm and ANN architecture in the case of DQN.
5. Brief description of your code:
    1. Required packages
    2. Project structure: content of each file, location of plots, location of saved models, etc.
    3. How to execute the different file(s)
6. Evaluation and results: interpretation of different plots

4. Important Insights

- The submission deadline is 31/12/2024. After this deadline, points will be deducted.
- You will also be graded on the perfection of your work.
- Submit your work (code + report) on the eLearn platform; a dedicated space has been created for this purpose.
- No new members will be accepted into the already formed groups. Students who are not yet assigned to a group must create one