Research questions

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Idea for research project topic:

1. Investigate robustness of current RL TSC methods with respect to wrong information.
   - Wrong vehicle speed detection
   - Wrong vehicle type detected
   - Wrong number of vehicles detected
   - Vehicles turning from the wrong line
   - Vehicles driving through red lights
   - Shut-down traffic light (only in multi-intersection simulations)

   Relevant papers:
   https://par.nsf.gov/servlets/purl/10214068

2. Adapt existing strategy for an environment with both pedestrians and cyclists as well as cars.
   - Need to add features and simulation resources
   - Occasionally cyclists may use car lanes

3. Investigate whether using Recurrent NNs could be useful.
   - Can RNNs outperform other models with less input data? Other models may be able to keep up using feature engineering.
   - What Features are useful to give models time-context information?
     - Time since last phase change
     - Change of queue length in some past time interval

4. Investigate how different RL algorithms affect learning and/or final performance (DDPG, PPO, A2C, etc.)

TODOs:

1. create an overview of possible input and output features for TSC controller.
2. check how to change simulation and NN inputs to add noise, pedestrians or make other adjustments
3. check where the NNs are defined
4. check how to change the learning algorithm used
5. decide which road network to use
6. decide which input and output features to use. (use communication?)
7. run experiments

Experiment Ideas:

1.1 Compare different RL TSC methods on an environment with noisy feature vectors. Simulate defective loop detectors, cameras, etc.

=> plots:
x-axis: noise level in testing
y-axis: performance metric (throughput/ wait time/ trip time/ reward)

- Evaluate existing techniques trained in ideal conditions on different noise levels (one line per technique)
- Train new model on different noise levels (lines labelled with noise level in legend)

+ If the trained models for existing techniques can be obtained, they could be used for evaluation without modification being necessary.

1.2 Compare effects of different error causes (wrong vehicle speed, wrong queue length, wrong vehicle behaviour, etc.)

=> plots: one plot per error type, one plot for all errors combined
x-axis: noise level in testing
y-axis: performance metric (throughput/ wait time/ trip time/ reward)

- Evaluate existing techniques trained in ideal conditions on different noise levels

+ If the trained models for existing techniques can be obtained, they could be used for evaluation without modification being necessary.

2.1 Compare performance of 1-3 methods in 2-3 scenarios:

Scene 1: just cars
Scene 2: cars + pedestrians
Scene 3: cars + cyclists + pedestrians

- What adaptations are necessary to accommodate cyclists and pedestrians?
- Do existing techniques still perform well with cyclists and pedestrians on the road?

- may need to retrain all methods for comparison due to possibly increased feature vector size. Depends on which signal phases are allowed. Methods with communication may need larger communication bandwidth.

3.1

- need to retrain all methods for comparison for different feature vectors.

4.1 Compare loss during training, learned policy for various RL algorithms.

=> plots:

a. x-axis: epoch number
   y-axis: training/validation loss
b. x-axis: time in s
   y-axis: queue lengths for different traffic directions
   colour: current phase (possibly simplified)

- need to retrain all methods with each algorithm