Lab 11 - Q-Learning

I. Introduction

This lab aims to learn Q-Learning algorithm via leveraging `gym` environment, to be specific, `Taxi-v3` in `gym`.

Q-Learning

The point of Q-Learning is Q-table and its updating algorithm which is like this:

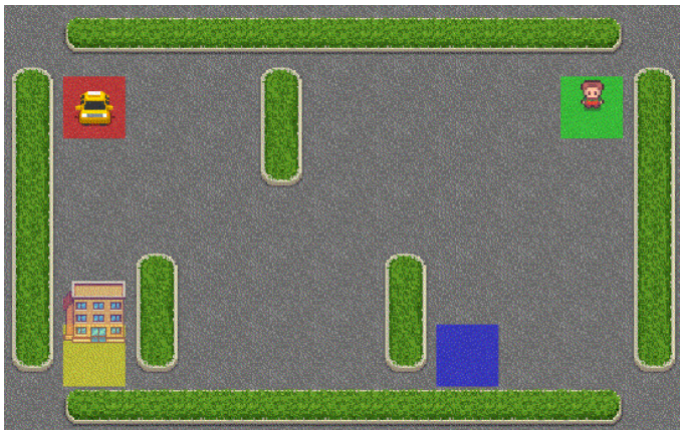
$$Q(s_t, a_t) \leftarrow \underbrace{Q(s_t, a_t)}_{\text{old value}} + \underbrace{\alpha}_{\text{learning rate}} \cdot \left(\overbrace{\underbrace{r_t}_{\text{reward}} + \underbrace{\gamma}_{\text{discount factor}} \cdot \underbrace{\max_a Q(s_{t+1}, a)}_{\text{estimate of optimal future value}}}^{\text{learned value}} - \underbrace{Q(s_t, a_t)}_{\text{old value}} \right)$$

where, as you know, s is a certain state and a is a certain action.

Taxi-v3 of gym

Briefly, gym library is a collection of problems — environments — that you can use to work out your reinforcement learning algorithms.

We use "Taxi-v3" environment to learn Q-Learning. It is a problems about taxi where the taxi needs to find a way to pick up a passenger and drop it off at the destination (hotel).



In this problem, there are 6 actions, which are 4 directions, picking up and dropping off passenger, and 500 states. Details are in gym official document.

II. Implementation

Dependencies:

```
import numpy as np
import pickle
import gym
# also you need to install pygame which is invoked by gym implictly
```

Initialize Environment

```
def init():
    ...
    env = gym.make("Taxi-v3", new_step_api=True)
    action_space_n = env.action_space.n
    state_space_n = env.observation_space.n
    ...
    Q_table = np.zeros((state_space_n, action_space_n))
```

Train & Gain Q-table

We use `train()` to train it and get Q-table. After training, we store Q-table in `.pkl` which you can use in `display()`.

What you need to implement are `select_action()` and updating algorithm.

```
def select_action(state):
    ...
    # TODO: Select an action who can lead to a maximum Q value
    action = 0
    ...

def train():
    ...
    # TODO: Update the Q table
    Q_table[state, action] = 0
    ...
```

Display

After training, you can invoke `display()` to watch the trajectory taxi takes in the map.

III. Lab Requirements

Please finish the **Exercise** and answer **Questions**.

Exercise

Read `taxi.py` and complete the Q learning algorithm by filling the *blank* places.

Evaluation result: The average reward over 100 episodes (use `eval()`)

What you should submit:

1. File: your code
2. Report: your results and brief comments

Questions

1. What are the strengths of RL; when does it perform well?
2. What are the weaknesses of RL; when does it perform poorly?
3. What makes RL a good candidate for the planning/decision problem, if you have enough knowledge about the problem?

Have fun. 🙂