

# HW10: Reinforcement Learning

## 1 Getting started

Download the starter code from canvas. It consists of two files: Q-Learning.py and tests.py. You can create and activate your virtual environment with the following commands:

```
python3 -m venv /path/to/new/virtual/environment
```

```
source /path/to/new/virtual/environment/bin/activate
```

Once you have sourced your environment, you can run the following commands to install the necessary dependencies:

```
pip install --upgrade pip
```

```
pip install gym==0.23.1 pygame==2.1.2 numpy
```

You should now have a virtual environment which is fully compatible with the skeleton code. You should set up this virtual environment on an instructional machine to do your final testing.

## 2 Q-Learning

For the Q-learning portion of HW10, we will be using the environment FrozenLake-v1 from OpenAI gym. This is a discrete environment where the agent can move in the cardinal directions, but is not guaranteed to move in the direction it chooses. The agent gets a reward of 1 when it reaches the tile marked G, and a reward of 0 in all other settings. You can read more about FrozenLake-v1 here: [https://gymnasium.farama.org/environments/toy\\_text/frozen\\_lake/](https://gymnasium.farama.org/environments/toy_text/frozen_lake/). **You will not need to change any code outside of the area marked TODO, but you are free to change the hyper-parameters if you want to.** For each sampled tuple  $(s, a, r, s', \text{done})$ , the update rule for Q-learning is:

$$Q(s, a) = \begin{cases} (1 - \alpha)Q(s, a) + \alpha(r + \gamma \max_{a' \in A} Q(s', a')) & \text{if !done} \\ (1 - \alpha)Q(s, a) + \alpha r & \text{if done} \end{cases}$$

The agent should act according to an  $\epsilon$ -greedy policy as defined in the **Reinforcement Learning 1** slide. In this equation,  $\alpha$  is the learning rate hyper-parameter, and  $\gamma$  is the discount factor hyper-parameter.

- *HINT: tests.py is worth looking at to gain an understanding of how to use the OpenAI gym env.*

### 3 OpenAI gym Environment

You will need to use several OpenAI gym functions in order to operate your gym environment for reinforcement learning. As stated in a previous hint, tests.py has a lot of the function calls you need. Several important functions are as follows:

#### **env.step(action)**

Given that the environment is in state  $s$ , env.step takes an integer specifying the chosen action, and returns a tuple of the form  $(s, r, done, info)$ . 'done' specifies whether or not  $s'$  is the final state for that particular episode, and 'info' is unused in this assignment.

- Note: In the latest version of gym/gymnasium, 'done' is deprecated and replaced by more fine-grained return values that signal the end conditions of an epoch. But in this assignment with the environment you are in you should use 'done'.

#### **env.reset()**

Resets the environment to its initial state, and returns that state.

#### **env.action\_space.sample()**

Samples an integer corresponding to a random choice of action in the environment's action space.

#### **env.action\_space.n**

In the setting of the environments we will be working with for this assignment, this is an integer corresponding to the number of possible actions in the environment's action space.

You can read more about OpenAI gym here: <https://gymnasium.farama.org/api/env/>.

### 4 Submission

Please submit your file **Q\_learning.py** and **QTABLE.pkl** to Gradescope. Do not submit a Jupyter notebook .ipynb file. You can test your learned policies, by calling `python3 ./tests.py`. Make sure to test your saved Q-tables using **tests.py** on the instructional machines with a virtual environment set up as specified above. This is the same program that we will be using to test your Q-tables and Q-network, so you will have a good idea about how many points you will receive for the automated tests portion of the grade.

**The assignment is due Dec 12 at 9:30 am central time.** We are not accepting late submissions for this assignment. Regrades will only be accepted if they are due to an error in tests.py.