Artificial Intelligence

Homework #5
Reinforcement Learning

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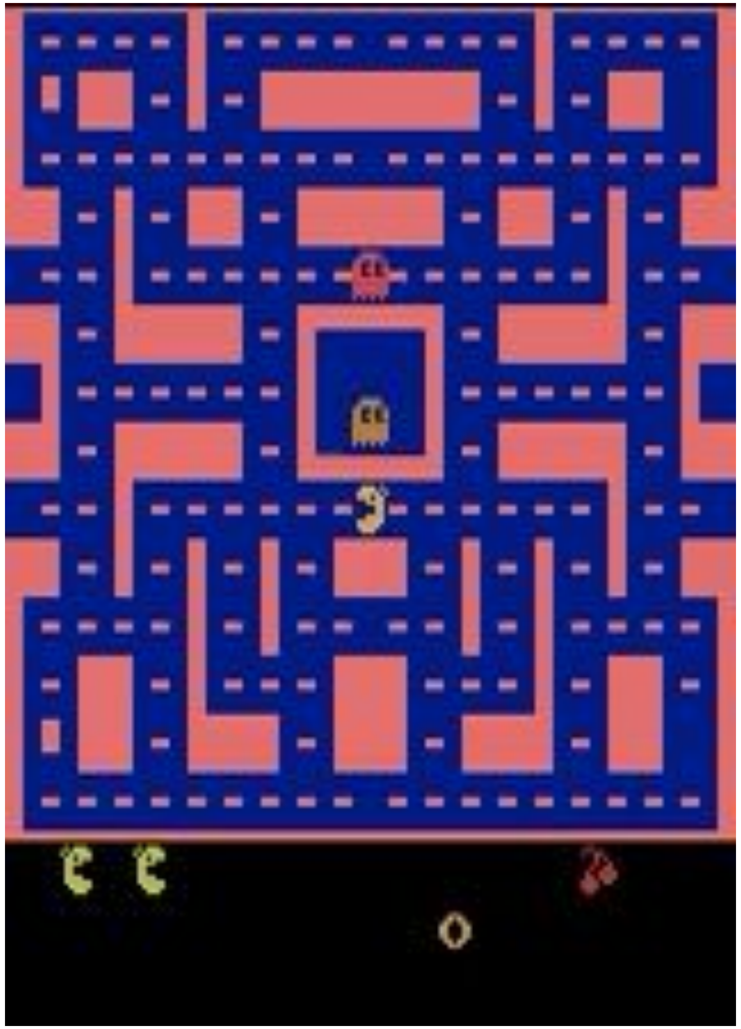
Objective

- **This assignment aims to use the OpenAI Gymnasium platform to create a Pacman game environment and apply reinforcement learning techniques to play the game.**

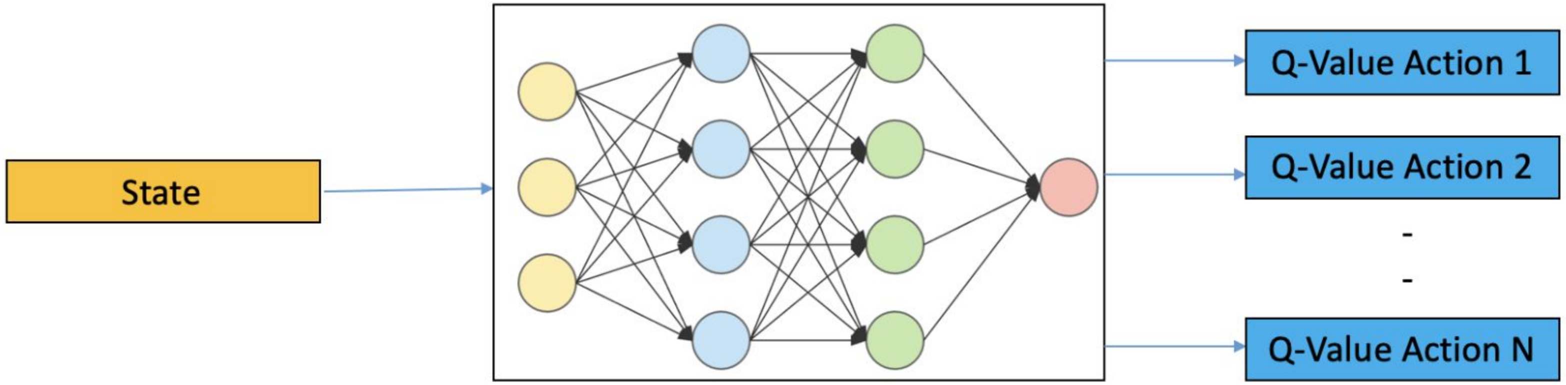
Gymnasium

[Announcing The Farama Foundation - The future of open source reinforcement learning | The Farama Foundation]



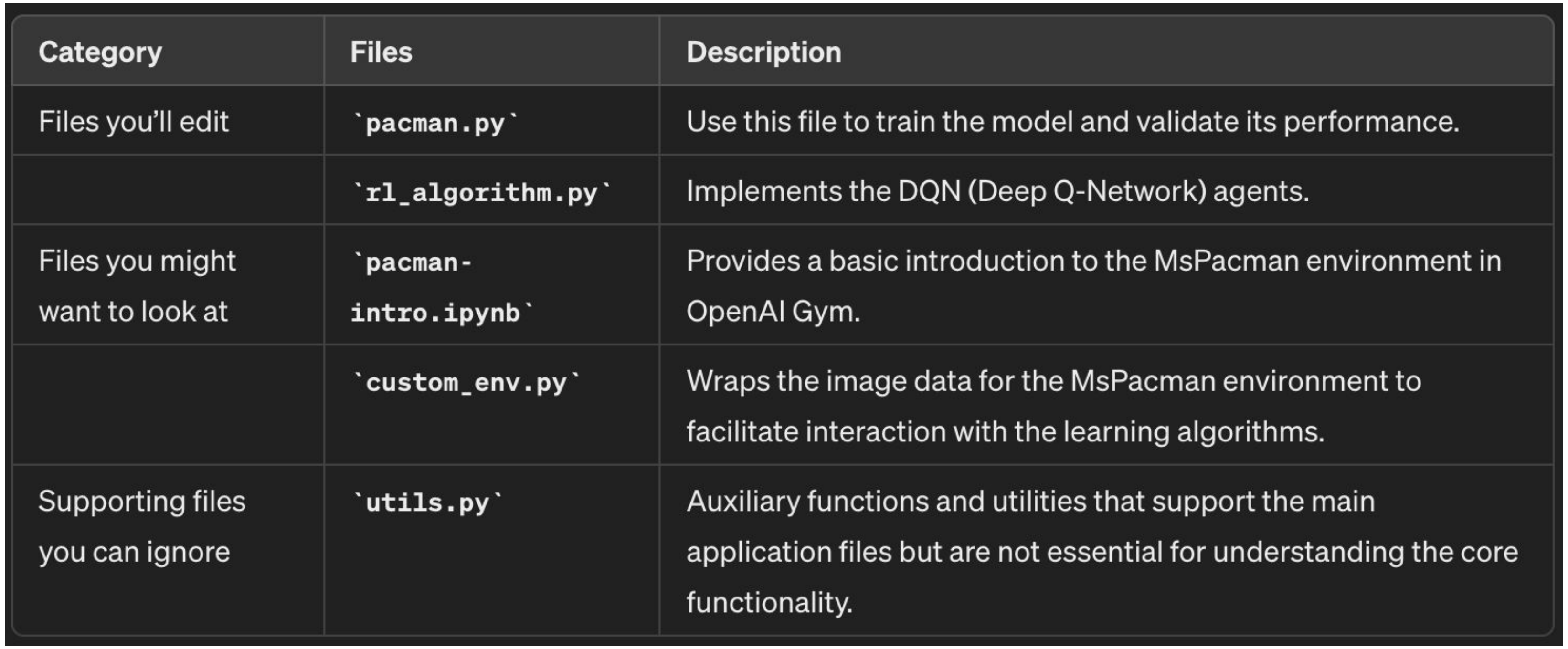
Objective (cont.)

- **Deep Q-Network (DQN)**
  - https://pytorch.org/tutorials/intermediate/reinforcement_q_learning.html
  - https://huggingface.co/tasks/reinforcement-learning
  - https://huggingface.co/learn/deep-rl-course/unit3/deep-q-network



Deep Q Learning

Project Overview

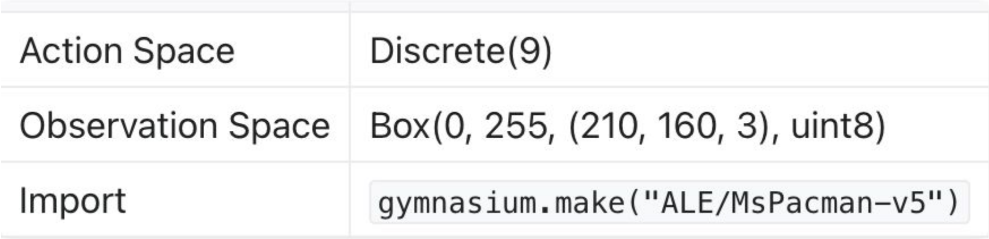


Category	Files	Description
Files you'll edit	`pacman.py`	Use this file to train the model and validate its performance.
	`rl_algorithm.py`	Implements the DQN (Deep Q-Network) agents.
Files you might want to look at	`pacman-intro.ipynb`	Provides a basic introduction to the MsPacman environment in OpenAI Gym.
	`custom_env.py`	Wraps the image data for the MsPacman environment to facilitate interaction with the learning algorithms.
Supporting files you can ignore	`utils.py`	Auxiliary functions and utilities that support the main application files but are not essential for understanding the core functionality.

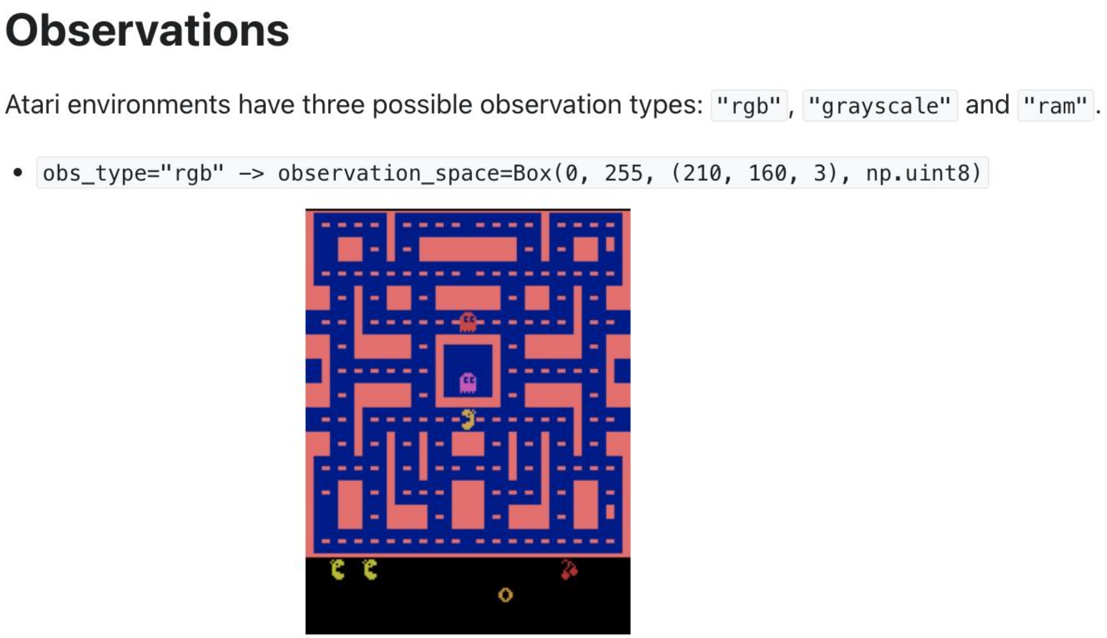
- The code for this project is organized into several Python files. You will need to read and understand some of these files to successfully complete the assignment.
- In **pacman.py**, you are required to implement the **train, validation, and evaluate functions** to train the model.
- In **rl_algorithm.py**, you will need to complete the **PacmanActionCNN** to predict actions based on image inputs. Additionally, you must implement the initialization and other functions in the **DQN** to facilitate model training.

OpenAI Gymnasium Explain

- For more detailed documentation, see the Gymnasium .
- We also provide a simple introduction in the provided code, named pacman_intro.ipynb.



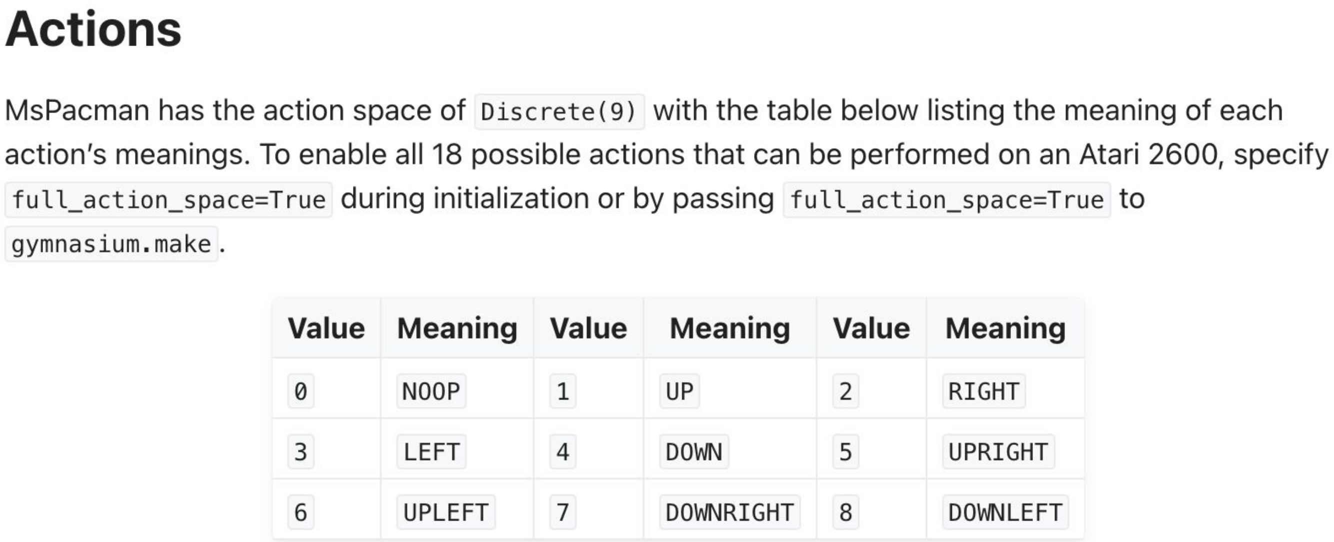
Action Space	Discrete(9)
Observation Space	Box(0, 255, (210, 160, 3), uint8)
Import	`gymnasium.make("ALE/MsPacman-v5")`



Observations

Atari environments have three possible observation types: `"rgb"`, `"grayscale"` and `"ram"`.

- `obs_type="rgb" -> observation_space=Box(0, 255, (210, 160, 3), np.uint8)`



Actions

MsPacman has the action space of `Discrete(9)` with the table below listing the meaning of each action's meanings. To enable all 18 possible actions that can be performed on an Atari 2600, specify `full_action_space=True` during initialization or by passing `full_action_space=True` to `gymnasium.make`.

Value	Meaning	Value	Meaning	Value	Meaning
`0`	`NOOP`	`1`	`UP`	`2`	`RIGHT`
`3`	`LEFT`	`4`	`DOWN`	`5`	`UPRIGHT`
`6`	`UPLEFT`	`7`	`DOWNRIGHT`	`8`	`DOWNLEFT`

Grading

- **Coding (80%)**
  - Deep Q-Network
  - README.md
  - Submission folder
  - The score for each problem is detailed in p7-8.
- **Report (20%)**
  - Must be submitted in PDF format only.
  - The score for each problem is detailed in p9.

Coding

Deep Q-Network

- Implement the Deep Q-Network, train and evaluate your agent in OpenAI Gymnasium ALE/MsPacman-v5.
- To receive full points, the evaluated reward must exceed 1500.
- No partial points will be given.
- *Grading: python pacman.py --eval --eval_model_path “MODEL_PATH”*

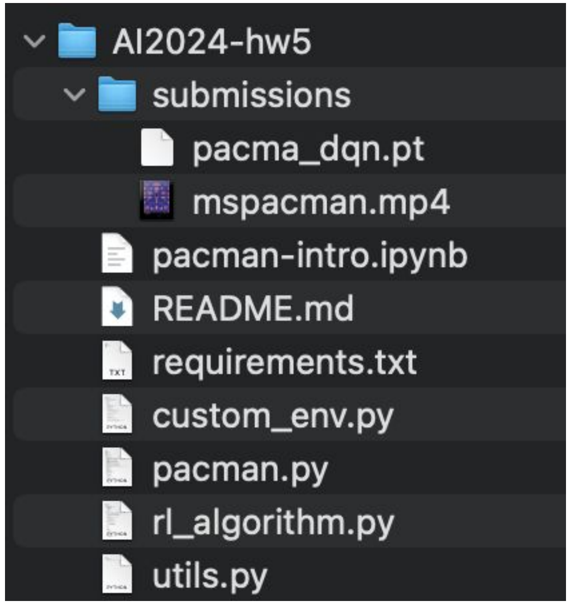
README.md

- Please provide a detailed description of how your environment is set up, as well as how to execute the training and evaluation of your code.
- The submission for reproducibility will be run according to the README. If it fails to run, it will receive a zero score. Minor modifications to the path are allowed for resubmission, but will be subject to a 10% penalty.

Coding (cont.)

Submissions (folder)

- Please ensure that your "submissions" folder includes the following items. Failure to include any of the required files will result in a 20-point penalty:
  - Model Weights: Include the saved model weights.
  - Evaluation Video: A video demonstrating the model in action.

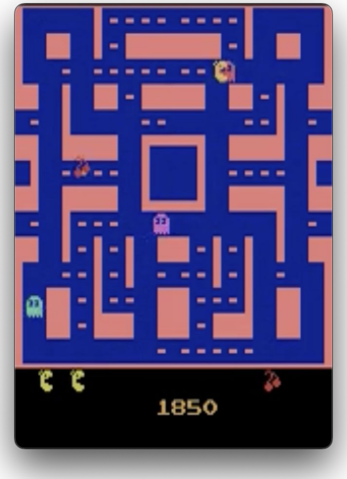


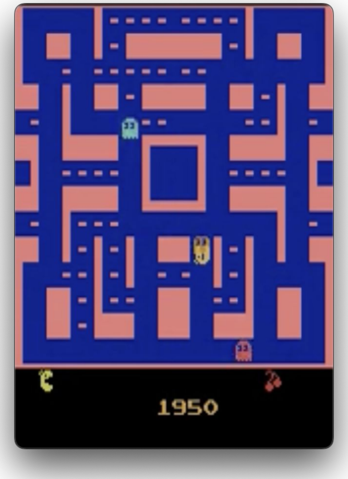
```
AI2024-hw5
  submissions
    pacma_dqn.pt
    mspacman.mp4
  pacman-intro.ipynb
  README.md
  requirements.txt
  custom_env.py
  pacman.py
  rl_algorithm.py
  utils.py
```

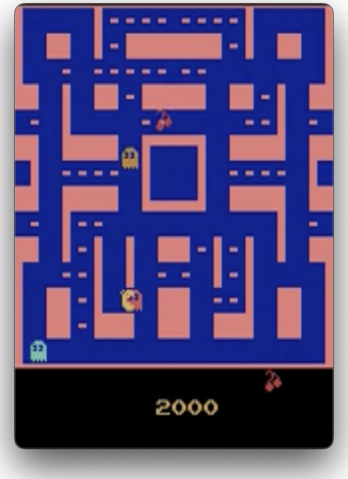
Report

- **Describe the Deep Q-Network (7%)**
- **Describe the architecture of your PacmanActionCNN (7%)**
- **Plot your training curve, including both loss and rewards. (3%)**
- **Show screenshots from your evaluation video (3%)**

("ALE/MsPacman-v5 has a total of three chances. Display the reward (score) each time you are caught.).



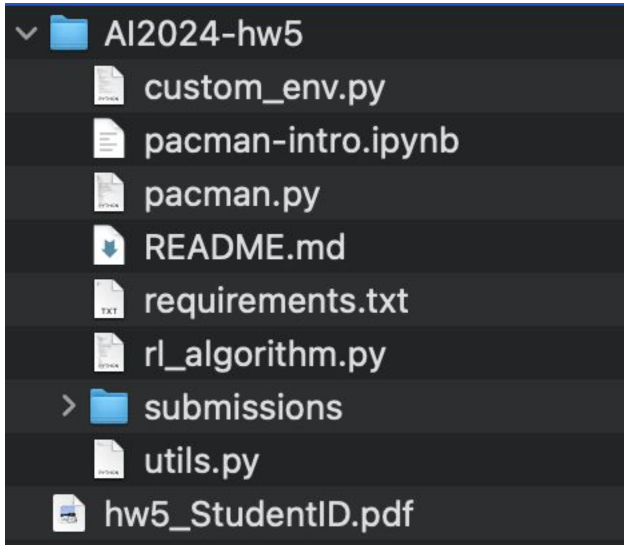




Submission

- Deadline: 2024/05/25 (Sat.) 23:59
- Submit to NTU COOL
- Your submission should include the following files:
  - hw5_<student_id>.zip
    - hw5_<student_id>.pdf
    - AI2024-hw5 (all the code we provided should be included.)
  - Do not put hw5_<student_id>.pdf into AI2024-hw5 folder

- *Note: hw5_<student_id> is an example format. For instance, if your student ID is r1234567, then the file name should be hw5_r1234567.*

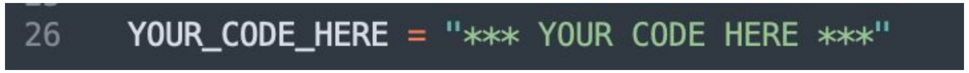


```
AI2024-hw5
    custom_env.py
    pacman-intro.ipynb
    pacman.py
    README.md
    requirements.txt
    rl_algorithm.py
    submissions
    utils.py
hw5_StudentID.pdf
```

UPDATE

AI2024-hw5-v2

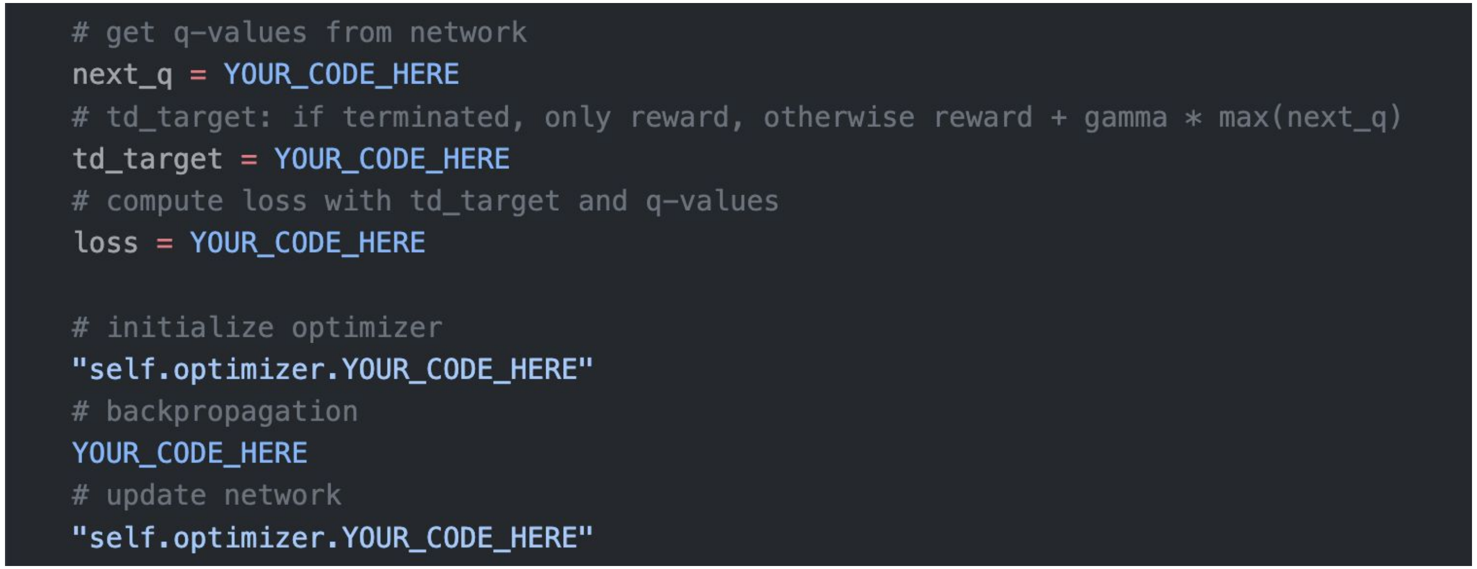
- 請各位同學注意，作業五的文件中標示為 YOUR_CODE_HERE 的部分需要你們填寫有效的程式碼以使其運行。
- 你們會發現有些地方使用了 "self.optimizer.YOUR_CODE_HERE" 的格式。使用引號是為了避免在你們尚未替換 YOUR_CODE_HERE 之前編譯出錯。完成代碼後，請記得移除這些引號，使代碼能正常執行。
- 另外，除了標有 "*** YOUR CODE HERE ***" 的部分需要同學們自行填寫外，其他部分也都可以進行修改以適應作業需求。然而，請注意，實作 DQN 的部分必須自行編寫，不應使用任何現成的套件。



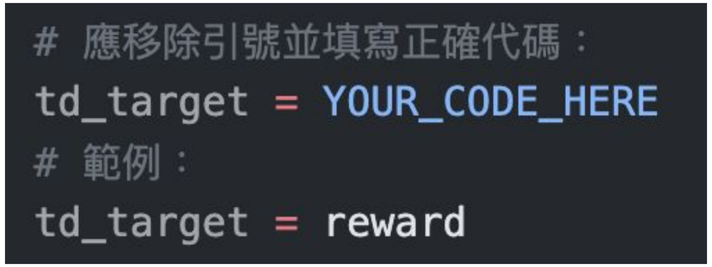
```
26    YOUR_CODE_HERE = "*** YOUR CODE HERE ***"
```

utils.py line 26 的 “*** YOUR CODE HERE ***” 不用理它。

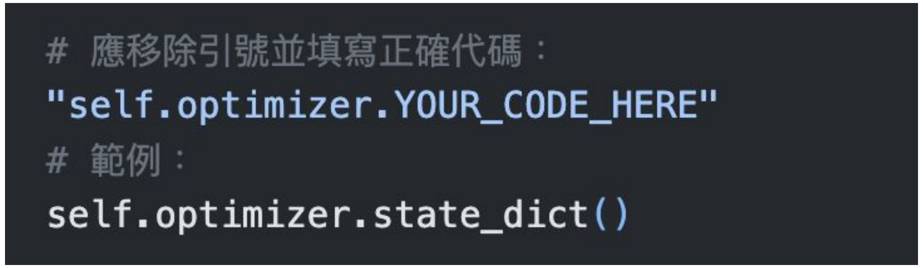
“*** YOUR CODE HERE ***” 的範例：



```
    # get q-values from network
    next_q = YOUR_CODE_HERE
    # td_target: if terminated, only reward, otherwise reward + gamma * max(next_q)
    td_target = YOUR_CODE_HERE
    # compute loss with td_target and q-values
    loss = YOUR_CODE_HERE

    # initialize optimizer
    "self.optimizer.YOUR_CODE_HERE"
    # backpropagation
    YOUR_CODE_HERE
    # update network
    "self.optimizer.YOUR_CODE_HERE"
```



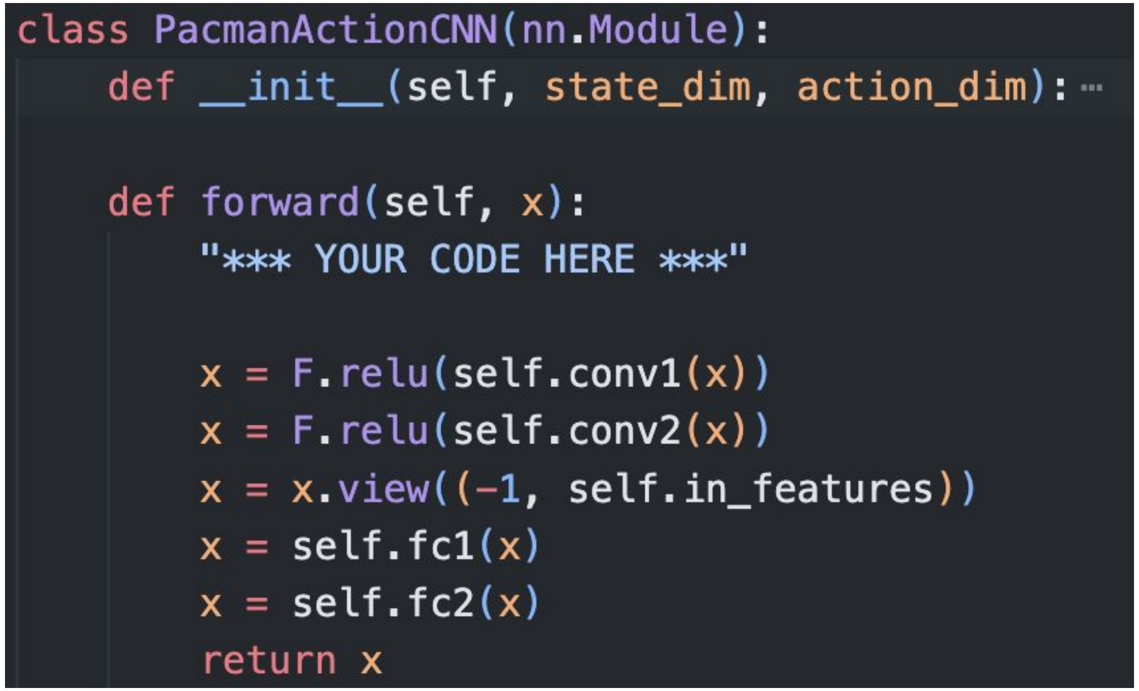
```
# 應移除引號並填寫正確代碼：
td_target = YOUR_CODE_HERE
# 範例：
td_target = reward
```



```
# 應移除引號並填寫正確代碼：
"self.optimizer.YOUR_CODE_HERE"
# 範例：
self.optimizer.state_dict()
```

PacmanActionCNN

- 為了協助不熟悉 CNN 的同學，以下是基本設定參考。
  - self.conv1 / self.conv2: https://pytorch.org/docs/stable/generated/torch.nn.Conv2d.html
  - self.fc1 / self.fc2: https://pytorch.org/docs/stable/generated/torch.nn.Linear.html#torch.nn.Linear



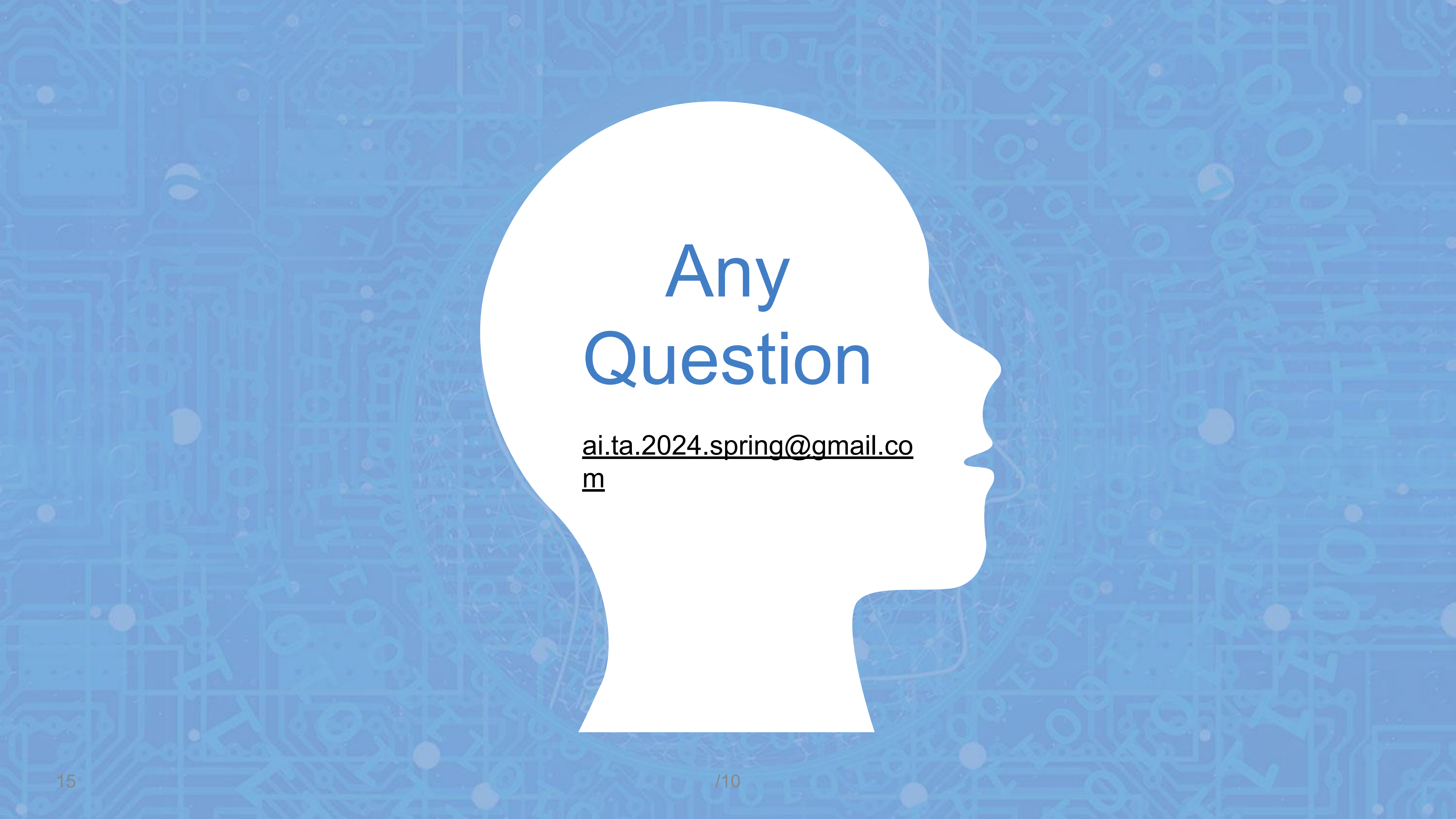
```python
class PacmanActionCNN(nn.Module):
    def __init__(self, state_dim, action_dim):⋯

    def forward(self, x):
        "*** YOUR CODE HERE ***"

        x = F.relu(self.conv1(x))
        x = F.relu(self.conv2(x))
        x = x.view((-1, self.in_features))
        x = self.fc1(x)
        x = self.fc2(x)
        return x
```

requirements.txt

```
opencv-python==4.8.1.78
swig==4.2.1
gymnasium==0.29.1
gymnasium[atari, accept-rom-license]
numpy==1.26.4
matplotlib==3.8.4
imageio-ffmpeg
imageio==2.34.1
torch
tqdm
```

UPDATED:

```
chardet
```



Any Question

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