MDS616 - Assessment 4 - Group Project - DQN algorithms for Cart Pole game

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Course: MDS616 - Reinforcement Learning
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```
[1] import gym
    import os
    import numpy as np
    import torch
    import torch.nn as nn
    import torch.optim as optim
    #import torch.nn.functional as F
    import matplotlib.pyplot as plt
    #from IPython.display import clear_output
    from IPython import display
    import random
```

Part 1: Load the gymanium environment and check the data

```
[2] # use gymnasium CartPole-v1 encironment, render mode is rgb_array
    env = gym.make("CartPole-v1")
```

```
/usr/local/lib/python3.10/dist-packages/gym/core.py:317: DeprecationWarning: WARN: Initializing wrapper in old step API which returns one bool instead of two. It is recommended to set
  deprecation(
/usr/local/lib/python3.10/dist-packages/gym/wrappers/step_api_compatibility.py:39: DeprecationWarning: WARN: Initializing environment in old step API which returns one bool instead of
  deprecation(
```

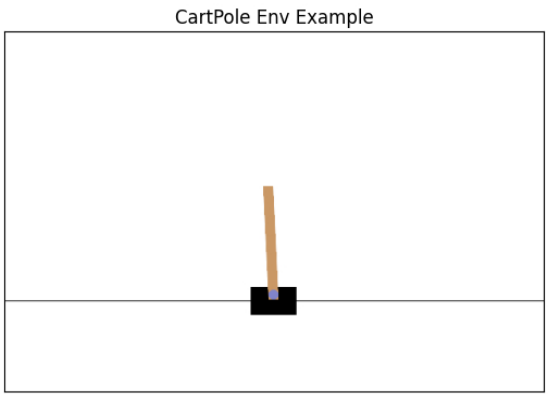
```
[3] # reset the environment
    env.reset()
```

```
array([-0.00721705, -0.00718679, -0.04909711, -0.04977763], dtype=float32)
```

```
[4] # convert env to a contiguous array and plot a picture
    # please pip install gym<=0.26.0, I recommened 0.23.0
    screen = env.render('rgb_array')
    screen = np.ascontiguousarray(screen, dtype = np.float32) / 255
```

```
/usr/local/lib/python3.10/dist-packages/gym/core.py:43: DeprecationWarning: WARN: The argument mode in render method is deprecated; use render_mode during environment initialization ins
See here for more information: https://www.gymlibrary.ml/content/api/
  deprecation(
```

```
[5] plt.figure()
    plt.imshow(screen)
    plt.title("CartPole Env Example")
    plt.xticks([])
    plt.yticks([])
    plt.show()
```



Part 2: Baseline Model and Deep Q learning

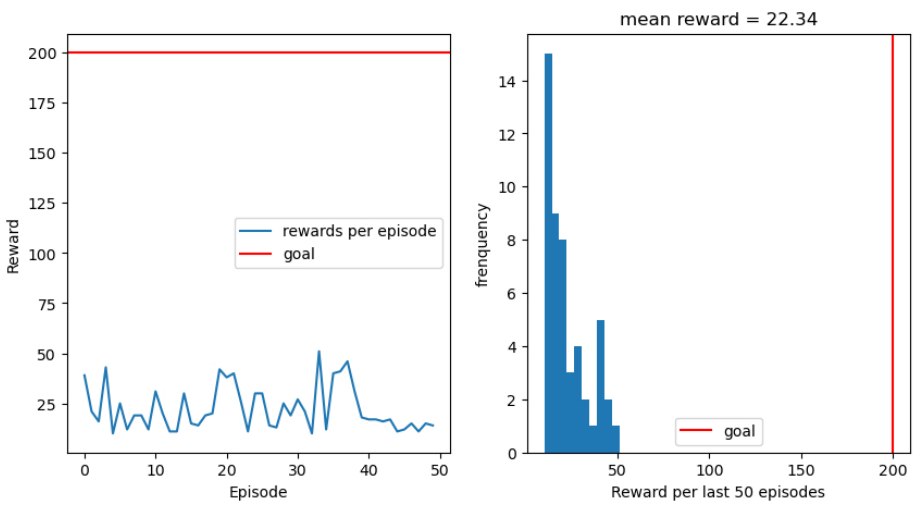
1. Baseline Model —— Random Policy

```
[6] # define a funtion to plot the results
    def plot_result(values, title=""):
        # draw a new picture when freshing
```

```
            # draw a new picture when refreshing
            plt.pause(0.02)
            display.clear_output(wait=True)

            fig, ax = plt.subplots(1,2, figsize=(10,5) ) # 2 subplots in one figure
            fig.suptitle(title)

            # plot 1 -- rewards per episode
            ax[0].plot(values, label="rewards per episode")
            ax[0].axhline(200, c='red', label='goal')
            ax[0].set_xlabel('Episode')
            ax[0].set_ylabel('Reward')
            ax[0].legend()

            # plot 2 -- mean reward of the lst 50 episodes
            ax[1].set_title("mean reward = {}".format(sum(values[-50:])/50))
            ax[1].hist(values[-50:])
            ax[1].axvline(200, c='red', label='goal')
            ax[1].set_xlabel('Reward per last 50 episodes')
            ax[1].set_ylabel('frenquency')
            ax[1].legend()

    plt.show()
```

[7]
```
# random policy
def random_policy(env, episodes):
        rewards = []
        for _ in range(episodes):
                env.reset()
                total_reward = 0
                done = False # whether the episodes ends
                while not done:
                        action = env.action_space.sample() # randomly sample
                        next_state, reward, done, info = env.step(action)
                        total_reward += reward
                rewards.append(total_reward)
                plot_result(rewards)
        env.close()
```

[ ]
```
random_policy(env, 50)
```



2. Deep Q Learning

We defined a deep Q learning class which contains the structure of a neural network, a update function and a predict function.

[8]
```
print(torch.__path__)
```

```
['/usr/local/lib/python3.10/dist-packages/torch']
```

[12]
```
class DQN:
        def __init__(self, state_dim, action_dim, hidden_dim = 64, lr=0.001):
                """
                state_dim: input dimensions
                action_dim: output dimension(s)
                hidden_dim: set 64 hidden dimensions
                lr: learning rate
                """
                # define a Neural Network
                self.model = torch.nn.Sequential(
                        torch.nn.Linear(state_dim, hidden_dim),
                        torch.nn.ReLU(),
                        torch.nn.Linear(hidden_dim,hidden_dim*2),
                        torch.nn.ReLU(),
                        torch.nn.Linear(hidden_dim*2, action_dim)
                )
                self.criterion = torch.nn.MSELoss() # use MSE as criterion
```

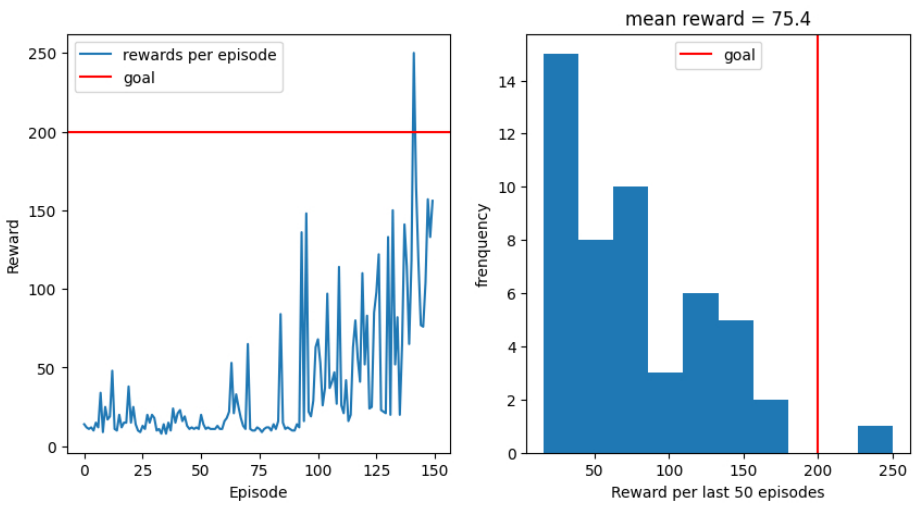
```
        self.optimizer = torch.optim.Adam(self.model.parameters(), lr=lr) # use Adam optimizer

    def update(self, state, q):
        q_pred = self.model(torch.Tensor(state)) # predict q value
        loss = self.criterion(q_pred, torch.Tensor(q)) # calculate loss function
        self.optimizer.zero_grad() # reset the gradient to 0
        loss.backward() # backward process
        self.optimizer.step() # update the optimizer

    def predict(self, state:np.ndarray) -> torch.Tensor:
        with torch.no_grad():
            return self.model(torch.Tensor(state)) # prediction value should not be regarded as the "update value"
```

```
/usr/local/lib/python3.10/dist-packages/ipykernel/ipkernel.py:283: DeprecationWarning: `should_run_async` will not call `transform_cell` automatically in the future. Please pass the res
  and should_run_async(code)
```

We defined a **DQN** function with the epsilon greedy policy.

```
[18] def DQN_process(env, model, episodes, gamma=0.9, epsilon=0.3, epsilon_decay=0.99, title="DQN_model"):
        """
        env: environment
        gamma: Markov procession gamma
        epsilon: we use epsilon greedy algorithm
        epsilon_decay: epsilon decay rate
        """
        rewards = []
        for _ in range(episodes):
            state = env.reset()
            total_reward = 0
            done = False
            while not done:
                # epsilon greedy: if the random value less than epsilon, choose the random value, otherwise use the predict value
                if random.random() < epsilon:
                    action = env.action_space.sample()
                else:
                    q_values = model.predict(state)
                    action = torch.argmax(q_values).item() # find the maximum item in q_values by their index

                next_state, reward, done, info = env.step(action) # the four parameters by doing step"action"
                total_reward += reward

                q_values = model.predict(state)
                # q value of the current step = former reward + gamma * the best prediction
                # tell the agend the episode if it is end
                q_values[action] = (reward + (0 if done else gamma * torch.max(model.predict(next_state)).item()) )
                model.update(state, q_values) # update the model base on the new q value
                state = next_state # jump to the next state

            epsilon = max(epsilon * epsilon_decay, 0.001) # epsilon decay until 0.001
            rewards.append(total_reward)
            plot_result(rewards)
```

```
[17] dqn = DQN(state_dim=4, action_dim=2, hidden_dim = 64, lr=0.001)
     DQN_process(env=env, model=dqn, episodes=150, gamma=0.9, epsilon=0.5)
```



[ ] 开始借助 AI 编写或生成代码。

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