Navigation

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1 Navigation

In this notebook, you will learn how to use the Unity ML-Agents environment for the first project of the Deep Reinforcement Learning Nanodegree.

1.0.1 1. Start the Environment

We begin by importing some necessary packages. If the code cell below returns an error, please revisit the project instructions to double-check that you have installed Unity ML-Agents and NumPy.

```
In [1]: from unityagents import UnityEnvironment
    import gym
    import random
    import torch
    import numpy as np
    from collections import deque
    import matplotlib.pyplot as plt
    %matplotlib inline
```

Next, we will start the environment! *Before running the code cell below*, change the file_name parameter to match the location of the Unity environment that you downloaded.

- Mac: "path/to/Banana.app"
- Windows (x86): "path/to/Banana_Windows_x86/Banana.exe"
- Windows (x86_64): "path/to/Banana_Windows_x86_64/Banana.exe"
- Linux (x86): "path/to/Banana_Linux/Banana.x86"
- Linux (x86_64): "path/to/Banana_Linux/Banana.x86_64"
- Linux (x86, headless): "path/to/Banana_Linux_NoVis/Banana.x86"
- Linux (x86_64, headless): "path/to/Banana_Linux_NoVis/Banana.x86_64"

For instance, if you are using a Mac, then you downloaded Banana.app. If this file is in the same folder as the notebook, then the line below should appear as follows:

```
env = UnityEnvironment(file_name="Banana.app")
```

```
In [2]: env = UnityEnvironment(file_name="/home/pedro/deep-reinforcement-learning/p1_navigation/
INFO:unityagents:
'Academy' started successfully!
Unity Academy name: Academy
        Number of Brains: 1
        Number of External Brains : 1
        Lesson number: 0
        Reset Parameters :
Unity brain name: BananaBrain
        Number of Visual Observations (per agent): 0
        Vector Observation space type: continuous
        Vector Observation space size (per agent): 37
        Number of stacked Vector Observation: 1
        Vector Action space type: discrete
        Vector Action space size (per agent): 4
        Vector Action descriptions: , , ,
```

Environments contain *brains* which are responsible for deciding the actions of their associated agents. Here we check for the first brain available, and set it as the default brain we will be controlling from Python.

1.0.2 2. Examine the State and Action Spaces

The simulation contains a single agent that navigates a large environment. At each time step, it has four actions at its disposal: - 0 - walk forward - 1 - walk backward - 2 - turn left - 3 - turn right

The state space has 37 dimensions and contains the agent's velocity, along with ray-based perception of objects around agent's forward direction. A reward of +1 is provided for collecting a yellow banana, and a reward of -1 is provided for collecting a blue banana.

Run the code cell below to print some information about the environment.

```
In []: # reset the environment
    env_info = env.reset(train_mode=True)[brain_name]

# number of agents in the environment
    print('Number of agents:', len(env_info.agents))

# number of actions
    action_size = brain.vector_action_space_size
    print('Number of actions:', action_size)

# examine the state space
    state = env_info.vector_observations[0]
```

```
print('States look like:', state)
state_size = len(state)
print('States have length:', state_size)
```

1.0.3 3. Take Random Actions in the Environment

In the next code cell, you will learn how to use the Python API to control the agent and receive feedback from the environment.

Once this cell is executed, you will watch the agent's performance, if it selects an action (uniformly) at random with each time step. A window should pop up that allows you to observe the agent, as it moves through the environment.

Of course, as part of the project, you'll have to change the code so that the agent is able to use its experience to gradually choose better actions when interacting with the environment!

```
In [ ]: from dqn_agent import Agent
        agent = Agent(state_size=37, action_size=4, seed=0)
        agent.qnetwork_local.load_state_dict(torch.load('checkpoint.pth'))
        env_info = env.reset(train_mode=False)[brain_name] # reset the environment
        state = env_info.vector_observations[0]
                                                            # get the current state
        score = 0
                                                           # initialize the score
        while True:
            action = agent.act(state, eps=0.0)
                                                            # get action (eps=1 means random acti
            env_info = env.step(action)[brain_name]
                                                            # send the action to the environment
            next_state = env_info.vector_observations[0]
                                                            # get the next state
            reward = env info.rewards[0]
                                                            # get the reward
            done = env_info.local_done[0]
                                                            # see if episode has finished
                                                            # update the score
            score += reward
                                                            # roll over the state to next time st
            state = next_state
                                                            # exit loop if episode finished
            if done:
                break
        print("Score: {}".format(score))
```

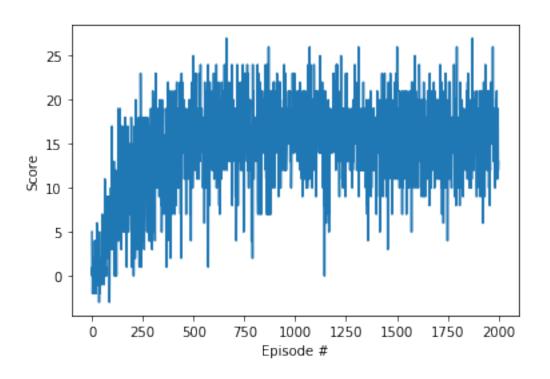
1.0.4 4. It's Your Turn!

Now it's your turn to train your own agent to solve the environment!

```
eps_start (float): starting value of epsilon, for epsilon-greedy action selection
                eps_end (float): minimum value of epsilon
                eps_decay (float): multiplicative factor (per episode) for decreasing epsilon
            .....
            scores = []
                                                # list containing scores from each episode
            scores_window = deque(maxlen=100) # last 100 scores
            eps = eps_start
                                                # initialize epsilon
            for i_episode in range(1, n_episodes+1):
                env_info = env.reset(train_mode=True)[brain_name]
                state = env_info.vector_observations[0]
                score = 0
                while True:
                    action = agent.act(state, eps)
                    env_info = env.step(action)[brain_name]
                    next_state = env_info.vector_observations[0]
                    reward = env_info.rewards[0]
                    done = env_info.local_done[0]
                    agent.step(state, action, reward, next_state, done)
                    score += reward
                    state = next_state
                    if done:
                        break
                scores_window.append(score)
                scores.append(score)
                eps = max(eps_end, eps_decay*eps)
                print('\rEpisode {}\tAverage Score: {:.2f}'.format(i_episode, np.mean(scores_win
                if i_episode % 100 == 0:
                    print('\rEpisode {}\tAverage Score: {:.2f}'.format(i_episode, np.mean(scores
                    torch.save(agent.qnetwork_local.state_dict(), 'checkpoint.pth')
                if np.mean(scores_window)>=100.0:
                    print('\nEnvironment solved in {:d} episodes!\tAverage Score: {:.2f}'.format
                    torch.save(agent.qnetwork_local.state_dict(), 'checkpoint.pth')
                    break
            return scores
        scores = dqn()
        # plot the scores
        fig = plt.figure()
        ax = fig.add_subplot(111)
        plt.plot(np.arange(len(scores)), scores)
        plt.ylabel('Score')
        plt.xlabel('Episode #')
        plt.show()
Episode 100
                   Average Score: 2.56
```

n_episodes (int): maximum number of training episodes

```
Episode 200
                   Average Score: 9.18
Episode 300
                   Average Score: 10.81
Episode 400
                   Average Score: 13.66
Episode 500
                   Average Score: 15.74
Episode 600
                   Average Score: 16.35
Episode 700
                   Average Score: 16.16
                   Average Score: 15.85
Episode 800
Episode 900
                   Average Score: 16.19
Episode 1000
                    Average Score: 16.96
Episode 1100
                    Average Score: 16.40
Episode 1200
                    Average Score: 16.17
Episode 1300
                    Average Score: 16.35
Episode 1400
                    Average Score: 15.63
                    Average Score: 15.89
Episode 1500
Episode 1600
                    Average Score: 16.06
Episode 1700
                    Average Score: 16.38
Episode 1800
                    Average Score: 15.82
Episode 1900
                    Average Score: 16.06
Episode 2000
                    Average Score: 15.99
```



Now watch the result of training

```
state = env_info.vector_observations[0]
                                                   # get the current state
score = 0
                                                   # initialize the score
while True:
   action = agent.act(state, eps=0.0)
                                                   # get action (eps=0 means trained)
    env_info = env.step(action)[brain_name]
                                                   # send the action to the environment
   next_state = env_info.vector_observations[0] # get the next state
   reward = env_info.rewards[0]
                                                   # get the reward
   done = env_info.local_done[0]
                                                   # see if episode has finished
   score += reward
                                                   # update the score
   state = next_state
                                                   # roll over the state to next time st
                                                   # exit loop if episode finished
   if done:
       break
print("Score: {}".format(score))
```

env.close()