Navigation

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1 Navigation

You are welcome to use this coding environment to train your agent for the project. Follow the instructions below to get started!

1.0.1 1. Start the Environment

Run the next code cell to install a few packages. This line will take a few minutes to run!

```
In [1]: !pip -q install ./python
```

```
tensorflow 1.7.1 has requirement numpy>=1.13.3, but you'll have numpy 1.12.1 which is incompatib
ipython 6.5.0 has requirement prompt-toolkit<2.0.0,>=1.0.15, but you'll have prompt-toolkit 3.0.
```

The environment is already saved in the Workspace and can be accessed at the file path provided below. Please run the next code cell without making any changes.

```
In [2]: from unityagents import UnityEnvironment
        import numpy as np

        # please do not modify the line below
        env = UnityEnvironment(file_name="/data/Banana_Linux_NoVis/Banana.x86_64")
```

```
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.

```
In [3]: # get the default brain
        brain_name = env.brain_names[0]
        brain = env.brains[brain_name]
```

1.0.2 2. Examine the State and Action Spaces

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

```
In [4]: # 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)
```

```
Number of agents: 1
Number of actions: 4
States look like: [ 1.          0.          0.          0.          0.84408134  0.          0.
  1.          0.          0.0748472   0.          1.          0.          0.
  0.25755     1.          0.          0.          0.          0.74177343
  0.          1.          0.          0.          0.25854847  0.          0.
  1.          0.          0.09355672  0.          1.          0.          0.
  0.31969345  0.          0.        ]
States have length: 37
```

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.

Note that **in this coding environment, you will not be able to watch the agent while it is training**, and you should set `train_mode=True` to restart the environment.

```
In [5]: env_info = env.reset(train_mode=True)[brain_name] # reset the environment
        state = env_info.vector_observations[0]            # get the current state
        score = 0                                          # initialize the score
        while True:
            action = np.random.randint(action_size)        # select an action
            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
            if done:                                       # exit loop if episode finished
                break

        print("Score: {}".format(score))
```

```
Score: 0.0
```

1.0.4 4. Training the agent

To train your own agent to solve the environment! A few **important notes**: - When training the environment, set `train_mode=True`, so that the line for resetting the environment looks like the following:

```
env_info = env.reset(train_mode=True)[brain_name]
```

- To structure your work, you're welcome to work directly in this Jupyter notebook, or you might like to start over with a new file! You can see the list of files in the workspace by clicking on ***Jupyter*** in the top left corner of the notebook.
- In this coding environment, you will not be able to watch the agent while it is training. However, ***after training the agent***, you can download the saved model weights to watch the agent on your own machine!

```
In [6]: from dqn_agent import Agent
        # init the agent
        agent = Agent(state_size=state_size, action_size=action_size, seed=0)
```

The parameters choosen for the DQR are as follows:

```
BUFFER_SIZE = int(1e5)  # replay buffer size
BATCH_SIZE = 64         # minibatch size
GAMMA = 0.99            # discount factor
TAU = 1e-3              # for soft update of target parameters
LR = 5e-4               # learning rate
UPDATE_EVERY = 4        # how often to update the network
```

And for the e-greedy algorithm:

```
eps_start = 1.0         # starting value of epsilon
eps_end = 0.01          # minimum value of epsilon
eps_decay = 0.995       # multiplicative factor (per episode) for decreasing epsilon
```

The DQN consists of two hidden layers, each with 64 units. The input layer receives the states with 37 units and the output layer has four units for the possible actions.

```
In [7]: from collections import deque
        import matplotlib.pyplot as plt
        import torch

        def dqn(n_episodes=2000, max_t=1000, eps_start=1.0, eps_end=0.01, eps_decay=0.995):
            """Deep Q-Learning.

            Params
            ======
                n_episodes (int): maximum number of training episodes
                max_t (int): maximum number of timesteps per episode
                eps_start (float): starting value of epsilon, for epsilon-greedy action selectio
                eps_end (float): minimum value of epsilon
                eps_decay (float): multiplicative factor (per episode) for decreasing epsilon
            """
            best_score = 13.0
            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
                for t in range(max_t):
                    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)
                    state = next_state
                    score += reward
                    if done:
                        break
                scores_window.append(score)       # save most recent score
                scores.append(score)              # save most recent score
                eps = max(eps_end, eps_decay*eps) # decrease epsilon
```

```
            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
            if np.mean(scores_window)>=best_score:
                print('\nEnvironment solved in {:d} episodes!\tAverage Score: {:.2f}'.format
                best_score = np.mean(scores_window)
                torch.save(agent.qnetwork_local.state_dict(), 'checkpoint.pth')
        return scores

    scores = dqn()
```

```
Episode 100        Average Score: 0.95
Episode 200        Average Score: 4.79
Episode 300        Average Score: 7.36
Episode 400        Average Score: 10.17
Episode 496        Average Score: 13.01
Environment solved in 396 episodes!        Average Score: 13.01
Episode 497        Average Score: 13.01
Environment solved in 397 episodes!        Average Score: 13.01
Episode 498        Average Score: 13.09
Environment solved in 398 episodes!        Average Score: 13.09
Episode 499        Average Score: 13.09
Environment solved in 399 episodes!        Average Score: 13.09
Episode 500        Average Score: 13.24

Environment solved in 400 episodes!        Average Score: 13.24
Episode 503        Average Score: 13.28
Environment solved in 403 episodes!        Average Score: 13.28
Episode 504        Average Score: 13.33
Environment solved in 404 episodes!        Average Score: 13.33
Episode 505        Average Score: 13.35
Environment solved in 405 episodes!        Average Score: 13.35
Episode 511        Average Score: 13.37
Environment solved in 411 episodes!        Average Score: 13.37
Episode 514        Average Score: 13.41
Environment solved in 414 episodes!        Average Score: 13.41
Episode 515        Average Score: 13.42
Environment solved in 415 episodes!        Average Score: 13.42
Episode 516        Average Score: 13.43
Environment solved in 416 episodes!        Average Score: 13.43
Episode 538        Average Score: 13.43
Environment solved in 438 episodes!        Average Score: 13.43
Episode 566        Average Score: 13.46
Environment solved in 466 episodes!        Average Score: 13.46
Episode 567        Average Score: 13.48
Environment solved in 467 episodes!        Average Score: 13.48
Episode 568        Average Score: 13.52
Environment solved in 468 episodes!        Average Score: 13.52
```

```
Episode 577        Average Score: 13.53
Environment solved in 477 episodes!        Average Score: 13.53
Episode 578        Average Score: 13.53
Environment solved in 478 episodes!        Average Score: 13.53
Episode 579        Average Score: 13.55
Environment solved in 479 episodes!        Average Score: 13.55
Episode 586        Average Score: 13.61
Environment solved in 486 episodes!        Average Score: 13.61
Episode 587        Average Score: 13.65
Environment solved in 487 episodes!        Average Score: 13.65
Episode 588        Average Score: 13.72
Environment solved in 488 episodes!        Average Score: 13.72
Episode 589        Average Score: 13.76
Environment solved in 489 episodes!        Average Score: 13.76
Episode 590        Average Score: 13.81
Environment solved in 490 episodes!        Average Score: 13.81
Episode 596        Average Score: 13.83
Environment solved in 496 episodes!        Average Score: 13.83
Episode 599        Average Score: 13.86
Environment solved in 499 episodes!        Average Score: 13.86
Episode 600        Average Score: 13.75
Episode 610        Average Score: 13.90
Environment solved in 510 episodes!        Average Score: 13.90
Episode 612        Average Score: 13.95
Environment solved in 512 episodes!        Average Score: 13.95
Episode 613        Average Score: 13.96
Environment solved in 513 episodes!        Average Score: 13.96
Episode 621        Average Score: 13.99
Environment solved in 521 episodes!        Average Score: 13.99
Episode 622        Average Score: 14.07
Environment solved in 522 episodes!        Average Score: 14.07
Episode 623        Average Score: 14.08
Environment solved in 523 episodes!        Average Score: 14.08
Episode 624        Average Score: 14.09
Environment solved in 524 episodes!        Average Score: 14.09
Episode 625        Average Score: 14.13
Environment solved in 525 episodes!        Average Score: 14.13
Episode 626        Average Score: 14.19
Environment solved in 526 episodes!        Average Score: 14.19
Episode 627        Average Score: 14.23
Environment solved in 527 episodes!        Average Score: 14.23
Episode 629        Average Score: 14.24
Environment solved in 529 episodes!        Average Score: 14.24
Episode 635        Average Score: 14.27
Environment solved in 535 episodes!        Average Score: 14.27
Episode 636        Average Score: 14.32
Environment solved in 536 episodes!        Average Score: 14.32
Episode 638        Average Score: 14.34
```

```
Environment solved in 538 episodes!        Average Score: 14.34
Episode 639        Average Score: 14.38
Environment solved in 539 episodes!        Average Score: 14.38
Episode 640        Average Score: 14.48
Environment solved in 540 episodes!        Average Score: 14.48
Episode 641        Average Score: 14.53
Environment solved in 541 episodes!        Average Score: 14.53
Episode 643        Average Score: 14.54
Environment solved in 543 episodes!        Average Score: 14.54
Episode 644        Average Score: 14.61
Environment solved in 544 episodes!        Average Score: 14.61
Episode 647        Average Score: 14.70
Environment solved in 547 episodes!        Average Score: 14.70
Episode 648        Average Score: 14.75
Environment solved in 548 episodes!        Average Score: 14.75
Episode 656        Average Score: 14.76
Environment solved in 556 episodes!        Average Score: 14.76
Episode 657        Average Score: 14.78
Environment solved in 557 episodes!        Average Score: 14.78
Episode 659        Average Score: 14.82
Environment solved in 559 episodes!        Average Score: 14.82
Episode 660        Average Score: 14.87
Environment solved in 560 episodes!        Average Score: 14.87
Episode 662        Average Score: 14.90
Environment solved in 562 episodes!        Average Score: 14.90
Episode 664        Average Score: 14.91
Environment solved in 564 episodes!        Average Score: 14.91
Episode 671        Average Score: 14.94
Environment solved in 571 episodes!        Average Score: 14.94
Episode 672        Average Score: 14.95
Environment solved in 572 episodes!        Average Score: 14.95
Episode 673        Average Score: 14.95
Environment solved in 573 episodes!        Average Score: 14.95
Episode 674        Average Score: 14.99
Environment solved in 574 episodes!        Average Score: 14.99
Episode 675        Average Score: 14.99
Environment solved in 575 episodes!        Average Score: 14.99
Episode 676        Average Score: 15.01
Environment solved in 576 episodes!        Average Score: 15.01
Episode 691        Average Score: 15.02
Environment solved in 591 episodes!        Average Score: 15.02
Episode 700        Average Score: 14.97
Episode 701        Average Score: 15.04
Environment solved in 601 episodes!        Average Score: 15.04
Episode 702        Average Score: 15.04
Environment solved in 602 episodes!        Average Score: 15.04
Episode 706        Average Score: 15.04
Environment solved in 606 episodes!        Average Score: 15.04
```

```
Episode 708        Average Score: 15.09
Environment solved in 608 episodes!        Average Score: 15.09
Episode 709        Average Score: 15.15
Environment solved in 609 episodes!        Average Score: 15.15
Episode 714        Average Score: 15.16
Environment solved in 614 episodes!        Average Score: 15.16
Episode 715        Average Score: 15.18
Environment solved in 615 episodes!        Average Score: 15.18
Episode 717        Average Score: 15.21
Environment solved in 617 episodes!        Average Score: 15.21
Episode 718        Average Score: 15.21
Environment solved in 618 episodes!        Average Score: 15.21
Episode 719        Average Score: 15.23
Environment solved in 619 episodes!        Average Score: 15.23
Episode 720        Average Score: 15.29
Environment solved in 620 episodes!        Average Score: 15.29
Episode 745        Average Score: 15.37
Environment solved in 645 episodes!        Average Score: 15.37
Episode 746        Average Score: 15.42
Environment solved in 646 episodes!        Average Score: 15.42
Episode 752        Average Score: 15.42
Environment solved in 652 episodes!        Average Score: 15.42
Episode 777        Average Score: 15.42
Environment solved in 677 episodes!        Average Score: 15.42
Episode 778        Average Score: 15.44
Environment solved in 678 episodes!        Average Score: 15.44
Episode 779        Average Score: 15.51
Environment solved in 679 episodes!        Average Score: 15.51
Episode 780        Average Score: 15.52
Environment solved in 680 episodes!        Average Score: 15.52
Episode 781        Average Score: 15.52
Environment solved in 681 episodes!        Average Score: 15.52
Episode 782        Average Score: 15.54
Environment solved in 682 episodes!        Average Score: 15.54
Episode 783        Average Score: 15.54
Environment solved in 683 episodes!        Average Score: 15.54
Episode 794        Average Score: 15.55
Environment solved in 694 episodes!        Average Score: 15.55
Episode 798        Average Score: 15.57
Environment solved in 698 episodes!        Average Score: 15.57
Episode 799        Average Score: 15.60
Environment solved in 699 episodes!        Average Score: 15.60
Episode 800        Average Score: 15.57
Episode 803        Average Score: 15.60
Environment solved in 703 episodes!        Average Score: 15.60
Episode 804        Average Score: 15.65
Environment solved in 704 episodes!        Average Score: 15.65
Episode 805        Average Score: 15.68
```

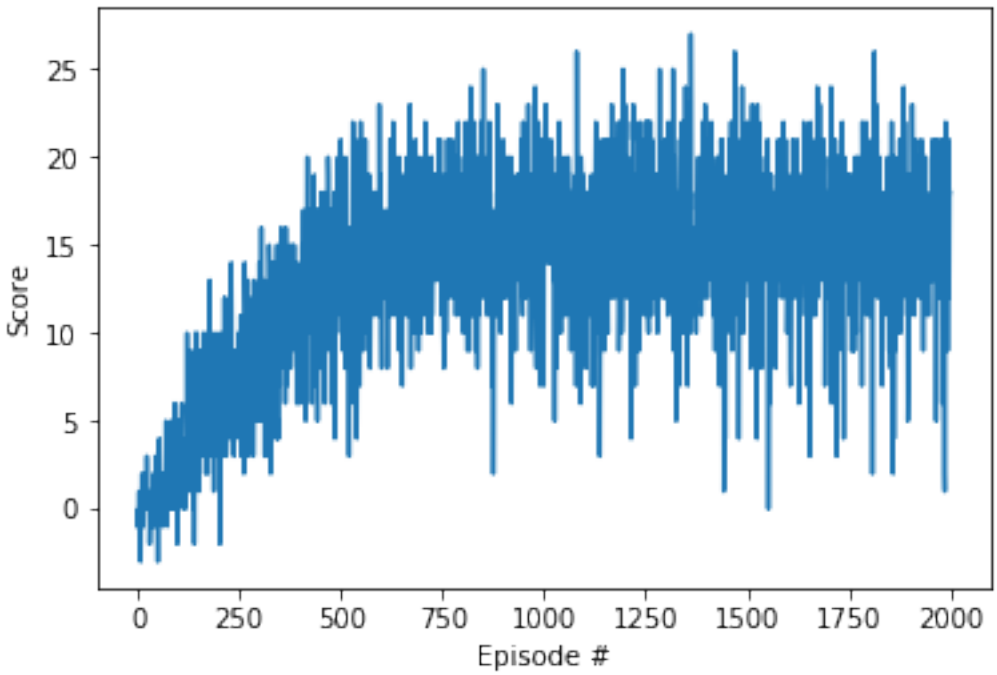
```
Environment solved in 705 episodes!        Average Score: 15.68
Episode 807        Average Score: 15.68
Environment solved in 707 episodes!        Average Score: 15.68
Episode 809        Average Score: 15.70
Environment solved in 709 episodes!        Average Score: 15.70
Episode 810        Average Score: 15.74
Environment solved in 710 episodes!        Average Score: 15.74
Episode 821        Average Score: 15.80
Environment solved in 721 episodes!        Average Score: 15.80
Episode 826        Average Score: 15.81
Environment solved in 726 episodes!        Average Score: 15.81
Episode 828        Average Score: 15.82
Environment solved in 728 episodes!        Average Score: 15.82
Episode 829        Average Score: 15.88
Environment solved in 729 episodes!        Average Score: 15.88
Episode 830        Average Score: 15.88
Environment solved in 730 episodes!        Average Score: 15.88
Episode 831        Average Score: 15.89
Environment solved in 731 episodes!        Average Score: 15.89
Episode 835        Average Score: 15.90
Environment solved in 735 episodes!        Average Score: 15.90
Episode 836        Average Score: 15.91
Environment solved in 736 episodes!        Average Score: 15.91
Episode 839        Average Score: 15.92
Environment solved in 739 episodes!        Average Score: 15.92
Episode 848        Average Score: 15.92
Environment solved in 748 episodes!        Average Score: 15.92
Episode 849        Average Score: 15.93
Environment solved in 749 episodes!        Average Score: 15.93
Episode 850        Average Score: 15.98
Environment solved in 750 episodes!        Average Score: 15.98
Episode 851        Average Score: 16.05
Environment solved in 751 episodes!        Average Score: 16.05
Episode 853        Average Score: 16.14
Environment solved in 753 episodes!        Average Score: 16.14
Episode 854        Average Score: 16.22
Environment solved in 754 episodes!        Average Score: 16.22
Episode 857        Average Score: 16.22
Environment solved in 757 episodes!        Average Score: 16.22
Episode 858        Average Score: 16.24
Environment solved in 758 episodes!        Average Score: 16.24
Episode 859        Average Score: 16.31
Environment solved in 759 episodes!        Average Score: 16.31
Episode 900        Average Score: 15.75
Episode 1000        Average Score: 15.70
Episode 1100        Average Score: 15.24
Episode 1200        Average Score: 15.56
Episode 1300        Average Score: 15.90
```

```
Episode 1400        Average Score: 15.80
Episode 1500        Average Score: 15.75
Episode 1600        Average Score: 15.63
Episode 1700        Average Score: 15.58
Episode 1800        Average Score: 15.85
Episode 1900        Average Score: 15.38
Episode 2000        Average Score: 15.51


<matplotlib.figure.Figure at 0x7f87d5223b38>
```

Clearly, the agent was able to solve the environment in episode 396. But it achieved its best score in episode 759.

```
In [8]: # 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()
```



When finished, you can close the environment.

```
In [ ]: env.close()
```

Although the model has a great score and performance, but it can be further improved by trying other algorithms like: - Double DQN - Prioritized Experience Replay - Dueling DQN - Pixel Based Learning

In [ ]: