

Report

October 21, 2019

1 Navigation

For this project, you will train an agent to navigate (and collect bananas!) in a large, square world.

If running on the Udacity Workspace, the environment is already saved in the Workspace and can be accessed at the file path provided below. When running locally change the os variable (MACOS, LINUX, WINDOWS_32, WINDOWS_64) to match your OS

```
[1]: from unityagents import UnityEnvironment
import numpy as np
import timeit

os = 'MACOS'
os_env = {
    'LINUX_X86': "./envs/VisualBanana_Linux/Banana.x86",
    'LINUX_X86_64': "./envs/VisualBanana_Linux/Banana.x86_64",
    'MACOS': "./envs/Banana.app",
    'WINDOWS_X86_32': "./envs/VisualBanana_Windows_x86/Banana.exe",
    'WINDOWS_X86_64': "./envs/VisualBanana_Windows_x86_64/Banana.exe",
}

print('Running on self built enviroment')
env = UnityEnvironment(file_name=os_env[os])
```

Running on self built enviroment

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.

```

[2]: # get the default brain
brain_name = env.brain_names[0]
brain = env.brains[brain_name]

```

1.0.1 2. Examine the State and Action Spaces

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

```

[3]: # 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

```

1.0.2 3. Create a Memory Buffer

```
[4]: import numpy as np
from collections import namedtuple, deque

import random
import torch

import matplotlib.pyplot as plt
%matplotlib inline

class ReplayBuffer:
    '''Fixed-size buffer to store experience tuples.'''

    def __init__(self, device, action_size, buffer_size, batch_size, seed):
        '''Initialize a ReplayBuffer object.

        Params
        =====
        action_size (int): dimension of each action
        buffer_size (int): maximum size of buffer
        batch_size (int): size of each training batch
        seed (int): random seed
        '''

        self.action_size = action_size
        self.memory = deque(maxlen=buffer_size)
        self.batch_size = batch_size
        self.seed = random.seed(seed)
        self.device = device
        self.experience = namedtuple('Experience', field_names=['state', '
↪'action', 'reward', 'next_state', 'done'])

    def add(self, state, action, reward, next_state, done):
        '''Add a new experience to memory.'''
        e = self.experience(state, action, reward, next_state, done)
        self.memory.append(e)

    def sample(self):
        '''Randomly sample a batch of experiences from memory.'''
        experiences = random.sample(self.memory, k=self.batch_size)

        states = torch.from_numpy(np.vstack([e.state for e in experiences if e
↪is not None])).float().to(self.device)
        actions = torch.from_numpy(np.vstack([e.action for e in experiences if
↪e is not None])).long().to(self.device)
        rewards = torch.from_numpy(np.vstack([e.reward for e in experiences if
↪e is not None])).float().to(self.device)
```

```

        next_states = torch.from_numpy(np.vstack([e.next_state for e in
→experiences if e is not None])).float().to(self.device)
        dones = torch.from_numpy(np.vstack([e.done for e in experiences if e is
→not None]).astype(np.uint8)).float().to(self.device)

        return (states, actions, rewards, next_states, dones)

    def __len__(self):
        '''Return the current size of internal memory.'''
        return len(self.memory)

```

1.0.3 4. Training

Create a method that takes an agent and trains the model to solve the task.

```

[5]: def train(checkpoint_filename, agent, n_episodes=2000, max_t=1000, eps_start=1.
→0, eps_end=0.01, eps_decay=0.995):
    """
    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
→selection
    eps_end (float): minimum value of epsilon
    eps_decay (float): multiplicative factor (per episode) for decreasing
→epsilon
    """

    scores = [] # list to store scores from each episode
    scores_window = deque(maxlen=100) # last 100 scores
    eps = eps_start # initialize epsilon

    average_score = 0.0
    best_average_score = 0.0
    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] # 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
            agent.step(state, action, reward, next_state, done)

```

```

        state = next_state                                # update the score
        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

    average_score = np.mean(scores_window)
    print(f'\rEpisode {i_episode}\tAverage Score: {average_score:.2f}',
    ↪end="")
    if i_episode % 100 == 0:
        print(f'\rEpisode {i_episode}\tAverage Score: {average_score:.2f}')

    if average_score >= 13.0 and average_score > best_average_score:
        best_average_score = average_score
        print('\nEnvironment solved in {:d} episodes!\tAverage Score: {:.
    ↪2f}'.format(i_episode, average_score))
        torch.save(agent.qnetwork_local.state_dict(), checkpoint_filename)

    return scores

```

1.0.4 5. Setup for using Q Network

Setup variables and utility functions for using Q Network. `testWrapper` is a utility method for timing the training process.

```

[6]: import torch
    from qnetwork.agent import Agent as QNetwork_Agent

    device = torch.device("cuda:0" if torch.cuda.is_available() else "cpu")

[7]: def runQNetworkTest(checkpoint_filename, buffer_size, batch_size, seed, gamma,
    ↪lr, update_every, tau, hidden_layer_lengths):
    memory = ReplayBuffer(device, action_size, buffer_size, batch_size, seed)
    agent = QNetwork_Agent(
        device, memory, action_size, state_size, seed,
        batch_size, gamma, lr, update_every, tau, hidden_layer_lengths
    )

    scores = train(checkpoint_filename, agent)

    # 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()

def testWrapper(func, *args, **kwargs):
    def wrapped():
        return func(*args, **kwargs)
    return wrapped

```

5.a Run using Buffer Size of 100,000

```

[8]: # 64 Hidden Layers
SEED = 0
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

wrapped = testWrapper(runQNetworkTest, 'checkpoint-100000.pth', BUFFER_SIZE,
    ↳BATCH_SIZE, SEED, GAMMA, LR, UPDATE_EVERY, TAU, { 'fc1': 64, 'fc2': 64 })
print(f'Time Taken: {timeit.timeit(wrapped, number=1)}')
```

```

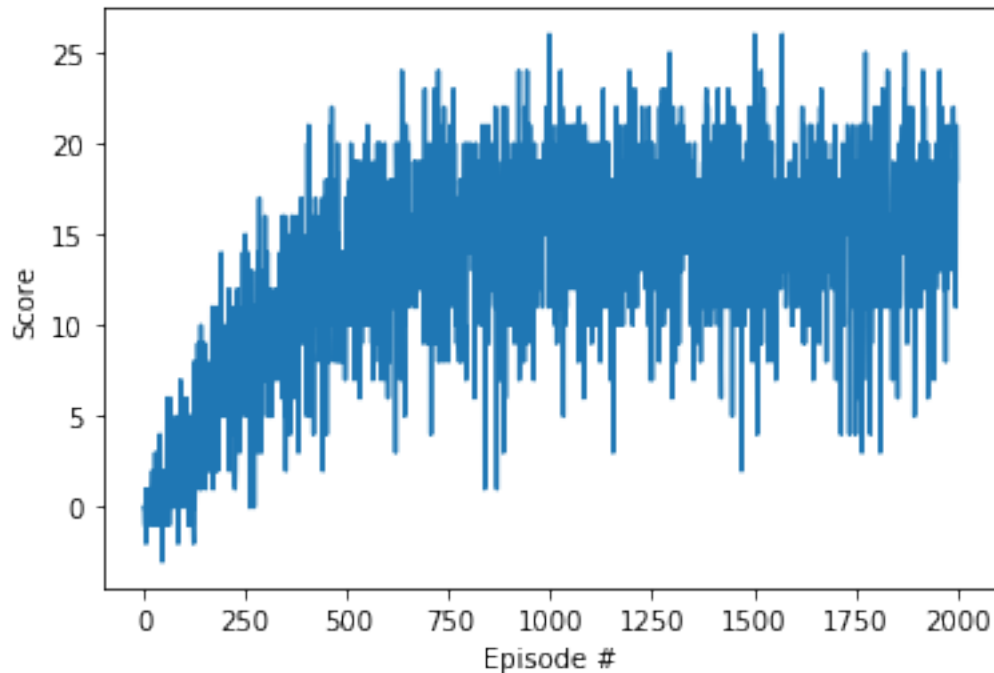
Network(
  (fc1): Linear(in_features=37, out_features=64, bias=True)
  (fc2): Linear(in_features=64, out_features=64, bias=True)
  (fc3): Linear(in_features=64, out_features=4, bias=True)
)
Network(
  (fc1): Linear(in_features=37, out_features=64, bias=True)
  (fc2): Linear(in_features=64, out_features=64, bias=True)
  (fc3): Linear(in_features=64, out_features=4, bias=True)
)
Episode 100      Average Score: 1.05
Episode 200      Average Score: 4.35
Episode 300      Average Score: 7.72
Episode 400      Average Score: 10.52
Episode 500      Average Score: 12.76
Episode 511      Average Score: 13.02
Environment solved in 511 episodes!      Average Score: 13.02
Episode 515      Average Score: 13.06
Environment solved in 515 episodes!      Average Score: 13.06
Episode 516      Average Score: 13.09
Environment solved in 516 episodes!      Average Score: 13.09
Episode 517      Average Score: 13.16
Environment solved in 517 episodes!      Average Score: 13.16
Episode 518      Average Score: 13.25
```

Environment solved in 518 episodes!	Average Score: 13.25
Episode 541 Average Score: 13.27	
Environment solved in 541 episodes!	Average Score: 13.27
Episode 543 Average Score: 13.31	
Environment solved in 543 episodes!	Average Score: 13.31
Episode 545 Average Score: 13.36	
Environment solved in 545 episodes!	Average Score: 13.36
Episode 546 Average Score: 13.39	
Environment solved in 546 episodes!	Average Score: 13.39
Episode 547 Average Score: 13.49	
Environment solved in 547 episodes!	Average Score: 13.49
Episode 550 Average Score: 13.52	
Environment solved in 550 episodes!	Average Score: 13.52
Episode 551 Average Score: 13.57	
Environment solved in 551 episodes!	Average Score: 13.57
Episode 553 Average Score: 13.61	
Environment solved in 553 episodes!	Average Score: 13.61
Episode 554 Average Score: 13.65	
Environment solved in 554 episodes!	Average Score: 13.65
Episode 557 Average Score: 13.73	
Environment solved in 557 episodes!	Average Score: 13.73
Episode 558 Average Score: 13.75	
Environment solved in 558 episodes!	Average Score: 13.75
Episode 584 Average Score: 13.81	
Environment solved in 584 episodes!	Average Score: 13.81
Episode 586 Average Score: 13.82	
Environment solved in 586 episodes!	Average Score: 13.82
Episode 587 Average Score: 13.86	
Environment solved in 587 episodes!	Average Score: 13.86
Episode 588 Average Score: 13.88	
Environment solved in 588 episodes!	Average Score: 13.88
Episode 589 Average Score: 13.89	
Environment solved in 589 episodes!	Average Score: 13.89
Episode 590 Average Score: 13.98	
Environment solved in 590 episodes!	Average Score: 13.98
Episode 592 Average Score: 14.03	
Environment solved in 592 episodes!	Average Score: 14.03
Episode 593 Average Score: 14.10	
Environment solved in 593 episodes!	Average Score: 14.10
Episode 596 Average Score: 14.12	
Environment solved in 596 episodes!	Average Score: 14.12
Episode 600 Average Score: 14.00	
Episode 627 Average Score: 14.16	
Environment solved in 627 episodes!	Average Score: 14.16
Episode 628 Average Score: 14.17	
Environment solved in 628 episodes!	Average Score: 14.17
Episode 630 Average Score: 14.18	
Environment solved in 630 episodes!	Average Score: 14.18

Episode 635	Average Score: 14.20	
Environment solved in 635 episodes!		Average Score: 14.20
Episode 636	Average Score: 14.30	
Environment solved in 636 episodes!		Average Score: 14.30
Episode 638	Average Score: 14.31	
Environment solved in 638 episodes!		Average Score: 14.31
Episode 639	Average Score: 14.35	
Environment solved in 639 episodes!		Average Score: 14.35
Episode 640	Average Score: 14.38	
Environment solved in 640 episodes!		Average Score: 14.38
Episode 649	Average Score: 14.40	
Environment solved in 649 episodes!		Average Score: 14.40
Episode 666	Average Score: 14.43	
Environment solved in 666 episodes!		Average Score: 14.43
Episode 669	Average Score: 14.49	
Environment solved in 669 episodes!		Average Score: 14.49
Episode 670	Average Score: 14.56	
Environment solved in 670 episodes!		Average Score: 14.56
Episode 679	Average Score: 14.57	
Environment solved in 679 episodes!		Average Score: 14.57
Episode 696	Average Score: 14.61	
Environment solved in 696 episodes!		Average Score: 14.61
Episode 697	Average Score: 14.62	
Environment solved in 697 episodes!		Average Score: 14.62
Episode 698	Average Score: 14.73	
Environment solved in 698 episodes!		Average Score: 14.73
Episode 700	Average Score: 14.67	
Episode 701	Average Score: 14.75	
Environment solved in 701 episodes!		Average Score: 14.75
Episode 702	Average Score: 14.76	
Environment solved in 702 episodes!		Average Score: 14.76
Episode 703	Average Score: 14.79	
Environment solved in 703 episodes!		Average Score: 14.79
Episode 704	Average Score: 14.80	
Environment solved in 704 episodes!		Average Score: 14.80
Episode 705	Average Score: 14.85	
Environment solved in 705 episodes!		Average Score: 14.85
Episode 710	Average Score: 14.90	
Environment solved in 710 episodes!		Average Score: 14.90
Episode 712	Average Score: 14.98	
Environment solved in 712 episodes!		Average Score: 14.98
Episode 714	Average Score: 15.01	
Environment solved in 714 episodes!		Average Score: 15.01
Episode 716	Average Score: 15.05	
Environment solved in 716 episodes!		Average Score: 15.05
Episode 719	Average Score: 15.09	
Environment solved in 719 episodes!		Average Score: 15.09
Episode 720	Average Score: 15.22	

Environment solved in 720 episodes!	Average Score: 15.22
Episode 725	Average Score: 15.25
Environment solved in 725 episodes!	Average Score: 15.25
Episode 742	Average Score: 15.28
Environment solved in 742 episodes!	Average Score: 15.28
Episode 765	Average Score: 15.35
Environment solved in 765 episodes!	Average Score: 15.35
Episode 800	Average Score: 15.15
Episode 807	Average Score: 15.36
Environment solved in 807 episodes!	Average Score: 15.36
Episode 900	Average Score: 14.92
Episode 976	Average Score: 15.38
Environment solved in 976 episodes!	Average Score: 15.38
Episode 978	Average Score: 15.46
Environment solved in 978 episodes!	Average Score: 15.46
Episode 980	Average Score: 15.50
Environment solved in 980 episodes!	Average Score: 15.50
Episode 985	Average Score: 15.58
Environment solved in 985 episodes!	Average Score: 15.58
Episode 990	Average Score: 15.69
Environment solved in 990 episodes!	Average Score: 15.69
Episode 993	Average Score: 15.71
Environment solved in 993 episodes!	Average Score: 15.71
Episode 995	Average Score: 15.72
Environment solved in 995 episodes!	Average Score: 15.72
Episode 996	Average Score: 15.73
Environment solved in 996 episodes!	Average Score: 15.73
Episode 998	Average Score: 15.78
Environment solved in 998 episodes!	Average Score: 15.78
Episode 999	Average Score: 15.83
Environment solved in 999 episodes!	Average Score: 15.83
Episode 1000	Average Score: 15.91
Environment solved in 1000 episodes!	Average Score: 15.91
Episode 1003	Average Score: 15.94
Environment solved in 1003 episodes!	Average Score: 15.94
Episode 1004	Average Score: 15.97
Environment solved in 1004 episodes!	Average Score: 15.97
Episode 1005	Average Score: 16.03
Environment solved in 1005 episodes!	Average Score: 16.03
Episode 1029	Average Score: 16.09
Environment solved in 1029 episodes!	Average Score: 16.09
Episode 1031	Average Score: 16.10
Environment solved in 1031 episodes!	Average Score: 16.10
Episode 1100	Average Score: 15.39
Episode 1200	Average Score: 15.46
Episode 1258	Average Score: 16.14
Environment solved in 1258 episodes!	Average Score: 16.14

Episode 1259	Average Score: 16.16	
Environment solved in 1259 episodes!		Average Score: 16.16
Episode 1260	Average Score: 16.18	
Environment solved in 1260 episodes!		Average Score: 16.18
Episode 1261	Average Score: 16.19	
Environment solved in 1261 episodes!		Average Score: 16.19
Episode 1300	Average Score: 15.88	
Episode 1400	Average Score: 15.45	
Episode 1500	Average Score: 15.83	
Episode 1526	Average Score: 16.20	
Environment solved in 1526 episodes!		Average Score: 16.20
Episode 1573	Average Score: 16.22	
Environment solved in 1573 episodes!		Average Score: 16.22
Episode 1579	Average Score: 16.25	
Environment solved in 1579 episodes!		Average Score: 16.25
Episode 1600	Average Score: 15.97	
Episode 1700	Average Score: 15.75	
Episode 1800	Average Score: 15.17	
Episode 1900	Average Score: 15.72	
Episode 1942	Average Score: 16.28	
Environment solved in 1942 episodes!		Average Score: 16.28
Episode 1955	Average Score: 16.34	
Environment solved in 1955 episodes!		Average Score: 16.34
Episode 1963	Average Score: 16.37	
Environment solved in 1963 episodes!		Average Score: 16.37
Episode 2000	Average Score: 16.25	



Time Taken: 1807.955898418004

5.b Run using Buffer Size of 200,000

```
[9]: wrapped = testWrapper(runQNetworkTest, 'checkpoint-200000.pth', int(2e5),  
    ↪ BATCH_SIZE, SEED, GAMMA, LR, UPDATE_EVERY, TAU, { 'fc1': 64, 'fc2': 64 })  
    print(f'Time Taken: {timeit.timeit(wrapped, number=1)}')
```

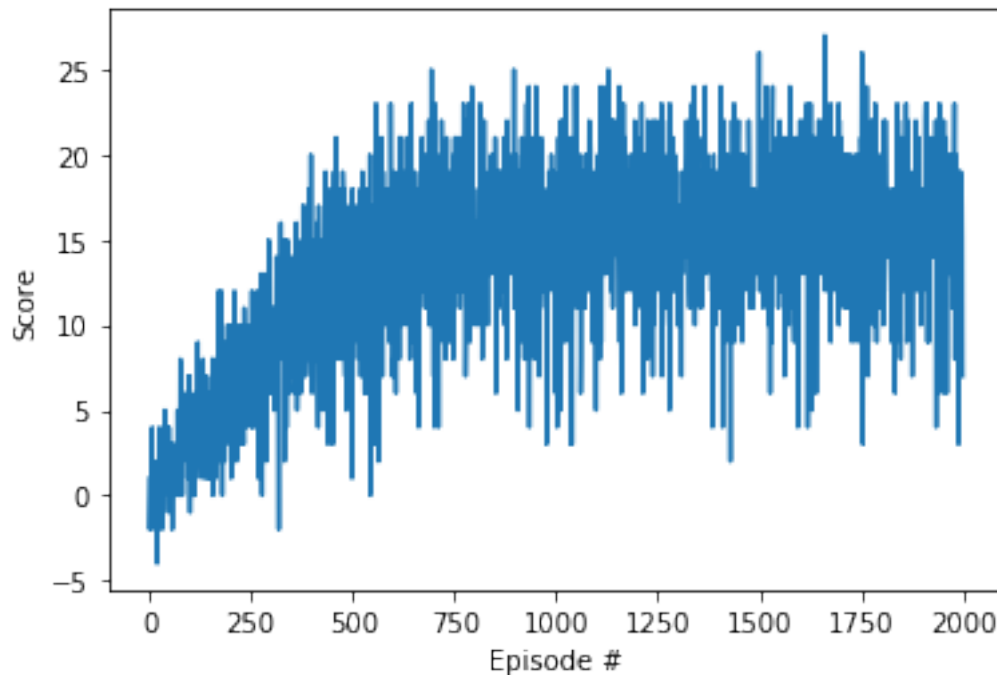
```
Network(  
    (fc1): Linear(in_features=37, out_features=64, bias=True)  
    (fc2): Linear(in_features=64, out_features=64, bias=True)  
    (fc3): Linear(in_features=64, out_features=4, bias=True)  
)  
Network(  
    (fc1): Linear(in_features=37, out_features=64, bias=True)  
    (fc2): Linear(in_features=64, out_features=64, bias=True)  
    (fc3): Linear(in_features=64, out_features=4, bias=True)  
)  
Episode 100      Average Score: 1.75  
Episode 200      Average Score: 4.69  
Episode 300      Average Score: 7.17  
Episode 400      Average Score: 10.34  
Episode 500      Average Score: 11.62  
Episode 595      Average Score: 13.02  
Environment solved in 595 episodes!      Average Score: 13.02  
Episode 600      Average Score: 12.91  
Episode 621      Average Score: 13.05  
Environment solved in 621 episodes!      Average Score: 13.05  
Episode 622      Average Score: 13.09  
Environment solved in 622 episodes!      Average Score: 13.09  
Episode 626      Average Score: 13.13  
Environment solved in 626 episodes!      Average Score: 13.13  
Episode 627      Average Score: 13.17  
Environment solved in 627 episodes!      Average Score: 13.17  
Episode 628      Average Score: 13.21  
Environment solved in 628 episodes!      Average Score: 13.21  
Episode 629      Average Score: 13.24  
Environment solved in 629 episodes!      Average Score: 13.24  
Episode 630      Average Score: 13.30  
Environment solved in 630 episodes!      Average Score: 13.30  
Episode 632      Average Score: 13.33  
Environment solved in 632 episodes!      Average Score: 13.33  
Episode 633      Average Score: 13.36  
Environment solved in 633 episodes!      Average Score: 13.36  
Episode 634      Average Score: 13.45  
Environment solved in 634 episodes!      Average Score: 13.45  
Episode 636      Average Score: 13.54
```

Environment solved in 636 episodes!	Average Score: 13.54
Episode 637 Average Score: 13.59	
Environment solved in 637 episodes!	Average Score: 13.59
Episode 638 Average Score: 13.63	
Environment solved in 638 episodes!	Average Score: 13.63
Episode 639 Average Score: 13.66	
Environment solved in 639 episodes!	Average Score: 13.66
Episode 640 Average Score: 13.72	
Environment solved in 640 episodes!	Average Score: 13.72
Episode 644 Average Score: 13.78	
Environment solved in 644 episodes!	Average Score: 13.78
Episode 645 Average Score: 13.84	
Environment solved in 645 episodes!	Average Score: 13.84
Episode 646 Average Score: 13.93	
Environment solved in 646 episodes!	Average Score: 13.93
Episode 652 Average Score: 13.95	
Environment solved in 652 episodes!	Average Score: 13.95
Episode 653 Average Score: 14.10	
Environment solved in 653 episodes!	Average Score: 14.10
Episode 654 Average Score: 14.13	
Environment solved in 654 episodes!	Average Score: 14.13
Episode 655 Average Score: 14.18	
Environment solved in 655 episodes!	Average Score: 14.18
Episode 656 Average Score: 14.27	
Environment solved in 656 episodes!	Average Score: 14.27
Episode 677 Average Score: 14.29	
Environment solved in 677 episodes!	Average Score: 14.29
Episode 678 Average Score: 14.32	
Environment solved in 678 episodes!	Average Score: 14.32
Episode 679 Average Score: 14.35	
Environment solved in 679 episodes!	Average Score: 14.35
Episode 680 Average Score: 14.44	
Environment solved in 680 episodes!	Average Score: 14.44
Episode 690 Average Score: 14.45	
Environment solved in 690 episodes!	Average Score: 14.45
Episode 691 Average Score: 14.46	
Environment solved in 691 episodes!	Average Score: 14.46
Episode 692 Average Score: 14.47	
Environment solved in 692 episodes!	Average Score: 14.47
Episode 697 Average Score: 14.51	
Environment solved in 697 episodes!	Average Score: 14.51
Episode 698 Average Score: 14.64	
Environment solved in 698 episodes!	Average Score: 14.64
Episode 699 Average Score: 14.69	
Environment solved in 699 episodes!	Average Score: 14.69
Episode 700 Average Score: 14.68	
Episode 701 Average Score: 14.78	
Environment solved in 701 episodes!	Average Score: 14.78

Episode 706	Average Score: 14.84	
Environment solved in 706 episodes!		Average Score: 14.84
Episode 707	Average Score: 14.91	
Environment solved in 707 episodes!		Average Score: 14.91
Episode 708	Average Score: 14.94	
Environment solved in 708 episodes!		Average Score: 14.94
Episode 709	Average Score: 14.98	
Environment solved in 709 episodes!		Average Score: 14.98
Episode 710	Average Score: 14.99	
Environment solved in 710 episodes!		Average Score: 14.99
Episode 711	Average Score: 15.03	
Environment solved in 711 episodes!		Average Score: 15.03
Episode 723	Average Score: 15.04	
Environment solved in 723 episodes!		Average Score: 15.04
Episode 731	Average Score: 15.05	
Environment solved in 731 episodes!		Average Score: 15.05
Episode 732	Average Score: 15.10	
Environment solved in 732 episodes!		Average Score: 15.10
Episode 761	Average Score: 15.13	
Environment solved in 761 episodes!		Average Score: 15.13
Episode 762	Average Score: 15.14	
Environment solved in 762 episodes!		Average Score: 15.14
Episode 763	Average Score: 15.30	
Environment solved in 763 episodes!		Average Score: 15.30
Episode 775	Average Score: 15.36	
Environment solved in 775 episodes!		Average Score: 15.36
Episode 788	Average Score: 15.40	
Environment solved in 788 episodes!		Average Score: 15.40
Episode 790	Average Score: 15.45	
Environment solved in 790 episodes!		Average Score: 15.45
Episode 793	Average Score: 15.52	
Environment solved in 793 episodes!		Average Score: 15.52
Episode 800	Average Score: 15.45	
Episode 842	Average Score: 15.54	
Environment solved in 842 episodes!		Average Score: 15.54
Episode 843	Average Score: 15.55	
Environment solved in 843 episodes!		Average Score: 15.55
Episode 844	Average Score: 15.56	
Environment solved in 844 episodes!		Average Score: 15.56
Episode 848	Average Score: 15.62	
Environment solved in 848 episodes!		Average Score: 15.62
Episode 849	Average Score: 15.64	
Environment solved in 849 episodes!		Average Score: 15.64
Episode 867	Average Score: 15.65	
Environment solved in 867 episodes!		Average Score: 15.65
Episode 900	Average Score: 15.50	
Episode 903	Average Score: 15.71	
Environment solved in 903 episodes!		Average Score: 15.71

Episode 910	Average Score: 15.77	
Environment solved in 910 episodes!		Average Score: 15.77
Episode 912	Average Score: 15.80	
Environment solved in 912 episodes!		Average Score: 15.80
Episode 932	Average Score: 15.82	
Environment solved in 932 episodes!		Average Score: 15.82
Episode 934	Average Score: 15.88	
Environment solved in 934 episodes!		Average Score: 15.88
Episode 1000	Average Score: 15.12	
Episode 1100	Average Score: 15.20	
Episode 1138	Average Score: 15.95	
Environment solved in 1138 episodes!		Average Score: 15.95
Episode 1139	Average Score: 16.06	
Environment solved in 1139 episodes!		Average Score: 16.06
Episode 1140	Average Score: 16.14	
Environment solved in 1140 episodes!		Average Score: 16.14
Episode 1141	Average Score: 16.15	
Environment solved in 1141 episodes!		Average Score: 16.15
Episode 1142	Average Score: 16.16	
Environment solved in 1142 episodes!		Average Score: 16.16
Episode 1143	Average Score: 16.19	
Environment solved in 1143 episodes!		Average Score: 16.19
Episode 1145	Average Score: 16.20	
Environment solved in 1145 episodes!		Average Score: 16.20
Episode 1146	Average Score: 16.23	
Environment solved in 1146 episodes!		Average Score: 16.23
Episode 1156	Average Score: 16.36	
Environment solved in 1156 episodes!		Average Score: 16.36
Episode 1166	Average Score: 16.40	
Environment solved in 1166 episodes!		Average Score: 16.40
Episode 1172	Average Score: 16.42	
Environment solved in 1172 episodes!		Average Score: 16.42
Episode 1199	Average Score: 16.52	
Environment solved in 1199 episodes!		Average Score: 16.52
Episode 1200	Average Score: 16.54	
Environment solved in 1200 episodes!		Average Score: 16.54
Episode 1201	Average Score: 16.55	
Environment solved in 1201 episodes!		Average Score: 16.55
Episode 1202	Average Score: 16.62	
Environment solved in 1202 episodes!		Average Score: 16.62
Episode 1203	Average Score: 16.63	
Environment solved in 1203 episodes!		Average Score: 16.63
Episode 1204	Average Score: 16.64	
Environment solved in 1204 episodes!		Average Score: 16.64
Episode 1207	Average Score: 16.67	
Environment solved in 1207 episodes!		Average Score: 16.67
Episode 1208	Average Score: 16.73	

Environment solved in 1208 episodes!	Average Score: 16.73
Episode 1300	Average Score: 16.01
Episode 1400	Average Score: 16.30
Episode 1500	Average Score: 15.83
Episode 1600	Average Score: 16.17
Episode 1682	Average Score: 16.76
Environment solved in 1682 episodes!	Average Score: 16.76
Episode 1683	Average Score: 16.81
Environment solved in 1683 episodes!	Average Score: 16.81
Episode 1685	Average Score: 16.88
Environment solved in 1685 episodes!	Average Score: 16.88
Episode 1686	Average Score: 16.96
Environment solved in 1686 episodes!	Average Score: 16.96
Episode 1687	Average Score: 17.00
Environment solved in 1687 episodes!	Average Score: 17.00
Episode 1695	Average Score: 17.19
Environment solved in 1695 episodes!	Average Score: 17.19
Episode 1700	Average Score: 16.95
Episode 1800	Average Score: 15.82
Episode 1900	Average Score: 15.43
Episode 2000	Average Score: 16.01



Time Taken: 1914.7703033889993

5.c Run using Buffer Size of 250,000

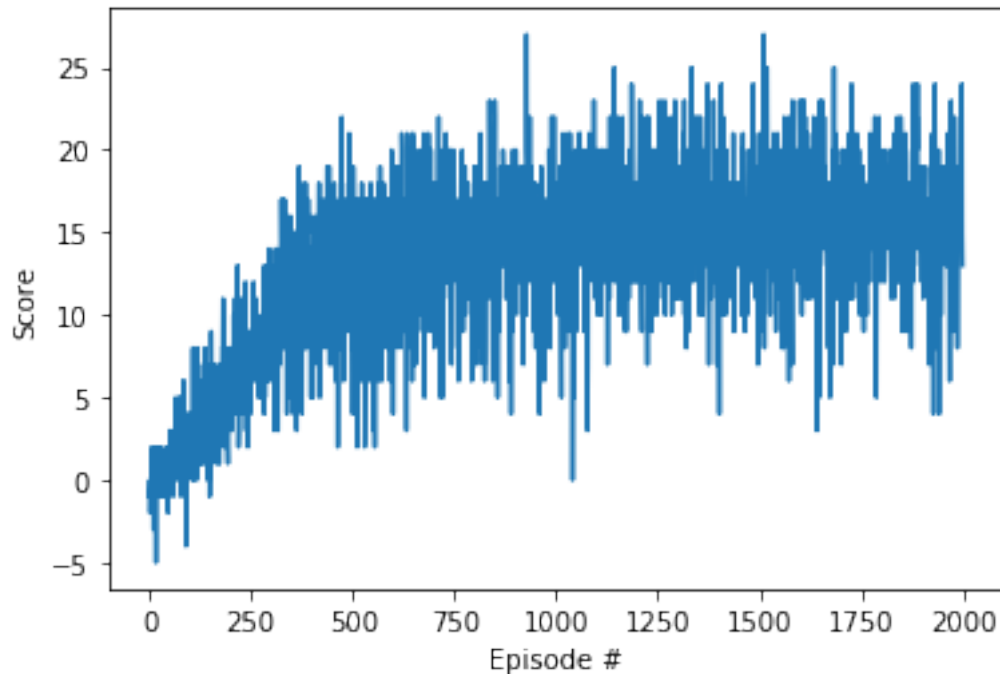
```
[10]: wrapped = testWrapper(runQNetworkTest, 'checkpoint-250000.pth', int(2.5e5),
    ↪ BATCH_SIZE, SEED, GAMMA, LR, UPDATE_EVERY, TAU, { 'fc1': 64, 'fc2': 64 })
    print(f'Time Taken: {timeit.timeit(wrapped, number=1)}')
```

```
Network(
  (fc1): Linear(in_features=37, out_features=64, bias=True)
  (fc2): Linear(in_features=64, out_features=64, bias=True)
  (fc3): Linear(in_features=64, out_features=4, bias=True)
)
Network(
  (fc1): Linear(in_features=37, out_features=64, bias=True)
  (fc2): Linear(in_features=64, out_features=64, bias=True)
  (fc3): Linear(in_features=64, out_features=4, bias=True)
)
Episode 100      Average Score: 0.98
Episode 200      Average Score: 3.89
Episode 300      Average Score: 7.58
Episode 400      Average Score: 11.02
Episode 500      Average Score: 12.75
Episode 600      Average Score: 12.24
Episode 621      Average Score: 13.12
Environment solved in 621 episodes!      Average Score: 13.12
Episode 622      Average Score: 13.23
Environment solved in 622 episodes!      Average Score: 13.23
Episode 626      Average Score: 13.25
Environment solved in 626 episodes!      Average Score: 13.25
Episode 627      Average Score: 13.31
Environment solved in 627 episodes!      Average Score: 13.31
Episode 630      Average Score: 13.34
Environment solved in 630 episodes!      Average Score: 13.34
Episode 631      Average Score: 13.36
Environment solved in 631 episodes!      Average Score: 13.36
Episode 639      Average Score: 13.43
Environment solved in 639 episodes!      Average Score: 13.43
Episode 642      Average Score: 13.49
Environment solved in 642 episodes!      Average Score: 13.49
Episode 643      Average Score: 13.57
Environment solved in 643 episodes!      Average Score: 13.57
Episode 644      Average Score: 13.66
Environment solved in 644 episodes!      Average Score: 13.66
Episode 646      Average Score: 13.68
Environment solved in 646 episodes!      Average Score: 13.68
Episode 648      Average Score: 13.74
Environment solved in 648 episodes!      Average Score: 13.74
Episode 649      Average Score: 13.83
Environment solved in 649 episodes!      Average Score: 13.83
Episode 652      Average Score: 13.86
```


Environment solved in 652 episodes!	Average Score: 13.86
Episode 655 Average Score: 13.89	
Environment solved in 655 episodes!	Average Score: 13.89
Episode 665 Average Score: 13.97	
Environment solved in 665 episodes!	Average Score: 13.97
Episode 676 Average Score: 13.99	
Environment solved in 676 episodes!	Average Score: 13.99
Episode 687 Average Score: 14.01	
Environment solved in 687 episodes!	Average Score: 14.01
Episode 693 Average Score: 14.06	
Environment solved in 693 episodes!	Average Score: 14.06
Episode 695 Average Score: 14.07	
Environment solved in 695 episodes!	Average Score: 14.07
Episode 700 Average Score: 14.12	
Environment solved in 700 episodes!	Average Score: 14.12
Episode 712 Average Score: 14.16	
Environment solved in 712 episodes!	Average Score: 14.16
Episode 733 Average Score: 14.26	
Environment solved in 733 episodes!	Average Score: 14.26
Episode 734 Average Score: 14.31	
Environment solved in 734 episodes!	Average Score: 14.31
Episode 736 Average Score: 14.36	
Environment solved in 736 episodes!	Average Score: 14.36
Episode 742 Average Score: 14.37	
Environment solved in 742 episodes!	Average Score: 14.37
Episode 751 Average Score: 14.39	
Environment solved in 751 episodes!	Average Score: 14.39
Episode 753 Average Score: 14.40	
Environment solved in 753 episodes!	Average Score: 14.40
Episode 755 Average Score: 14.48	
Environment solved in 755 episodes!	Average Score: 14.48
Episode 756 Average Score: 14.55	
Environment solved in 756 episodes!	Average Score: 14.55
Episode 757 Average Score: 14.56	
Environment solved in 757 episodes!	Average Score: 14.56
Episode 800 Average Score: 14.20	
Episode 896 Average Score: 14.59	
Environment solved in 896 episodes!	Average Score: 14.59
Episode 897 Average Score: 14.63	
Environment solved in 897 episodes!	Average Score: 14.63
Episode 900 Average Score: 14.54	
Episode 904 Average Score: 14.65	
Environment solved in 904 episodes!	Average Score: 14.65
Episode 905 Average Score: 14.71	
Environment solved in 905 episodes!	Average Score: 14.71
Episode 906 Average Score: 14.79	
Environment solved in 906 episodes!	Average Score: 14.79

Episode 913	Average Score: 14.87	
Environment solved in 913 episodes!		Average Score: 14.87
Episode 925	Average Score: 14.95	
Environment solved in 925 episodes!		Average Score: 14.95
Episode 928	Average Score: 14.99	
Environment solved in 928 episodes!		Average Score: 14.99
Episode 929	Average Score: 15.07	
Environment solved in 929 episodes!		Average Score: 15.07
Episode 930	Average Score: 15.08	
Environment solved in 930 episodes!		Average Score: 15.08
Episode 931	Average Score: 15.13	
Environment solved in 931 episodes!		Average Score: 15.13
Episode 934	Average Score: 15.18	
Environment solved in 934 episodes!		Average Score: 15.18
Episode 935	Average Score: 15.19	
Environment solved in 935 episodes!		Average Score: 15.19
Episode 936	Average Score: 15.24	
Environment solved in 936 episodes!		Average Score: 15.24
Episode 944	Average Score: 15.27	
Environment solved in 944 episodes!		Average Score: 15.27
Episode 945	Average Score: 15.35	
Environment solved in 945 episodes!		Average Score: 15.35
Episode 946	Average Score: 15.44	
Environment solved in 946 episodes!		Average Score: 15.44
Episode 1000	Average Score: 15.27	
Episode 1100	Average Score: 14.93	
Episode 1141	Average Score: 15.45	
Environment solved in 1141 episodes!		Average Score: 15.45
Episode 1142	Average Score: 15.52	
Environment solved in 1142 episodes!		Average Score: 15.52
Episode 1144	Average Score: 15.69	
Environment solved in 1144 episodes!		Average Score: 15.69
Episode 1145	Average Score: 15.70	
Environment solved in 1145 episodes!		Average Score: 15.70
Episode 1146	Average Score: 15.72	
Environment solved in 1146 episodes!		Average Score: 15.72
Episode 1147	Average Score: 15.77	
Environment solved in 1147 episodes!		Average Score: 15.77
Episode 1149	Average Score: 15.78	
Environment solved in 1149 episodes!		Average Score: 15.78
Episode 1153	Average Score: 15.79	
Environment solved in 1153 episodes!		Average Score: 15.79
Episode 1154	Average Score: 15.80	
Environment solved in 1154 episodes!		Average Score: 15.80
Episode 1179	Average Score: 15.81	
Environment solved in 1179 episodes!		Average Score: 15.81
Episode 1200	Average Score: 15.52	
Episode 1207	Average Score: 15.83	

Environment solved in 1207 episodes!	Average Score: 15.83
Episode 1208 Average Score: 15.84	
Environment solved in 1208 episodes!	Average Score: 15.84
Episode 1235 Average Score: 15.87	
Environment solved in 1235 episodes!	Average Score: 15.87
Episode 1284 Average Score: 15.90	
Environment solved in 1284 episodes!	Average Score: 15.90
Episode 1289 Average Score: 15.93	
Environment solved in 1289 episodes!	Average Score: 15.93
Episode 1290 Average Score: 16.00	
Environment solved in 1290 episodes!	Average Score: 16.00
Episode 1292 Average Score: 16.02	
Environment solved in 1292 episodes!	Average Score: 16.02
Episode 1293 Average Score: 16.08	
Environment solved in 1293 episodes!	Average Score: 16.08
Episode 1294 Average Score: 16.10	
Environment solved in 1294 episodes!	Average Score: 16.10
Episode 1300 Average Score: 16.07	
Episode 1301 Average Score: 16.12	
Environment solved in 1301 episodes!	Average Score: 16.12
Episode 1344 Average Score: 16.17	
Environment solved in 1344 episodes!	Average Score: 16.17
Episode 1349 Average Score: 16.23	
Environment solved in 1349 episodes!	Average Score: 16.23
Episode 1351 Average Score: 16.24	
Environment solved in 1351 episodes!	Average Score: 16.24
Episode 1357 Average Score: 16.25	
Environment solved in 1357 episodes!	Average Score: 16.25
Episode 1358 Average Score: 16.27	
Environment solved in 1358 episodes!	Average Score: 16.27
Episode 1375 Average Score: 16.29	
Environment solved in 1375 episodes!	Average Score: 16.29
Episode 1400 Average Score: 15.78	
Episode 1500 Average Score: 15.27	
Episode 1600 Average Score: 16.13	
Episode 1700 Average Score: 15.54	
Episode 1800 Average Score: 15.03	
Episode 1900 Average Score: 16.19	
Episode 2000 Average Score: 15.46	



Time Taken: 1995.6891482419887

5.d Run using Buffer Size of 100,000 and Batch Size 32

```
[11]: wrapped = testWrapper(runQNetworkTest, 'checkpoint-100000x32.pth', int(1e5), 32, SEED, GAMMA, LR, UPDATE_EVERY, TAU, { 'fc1': 64, 'fc2': 64 })
print(f'Time Taken: {timeit.timeit(wrapped, number=1)}')
```

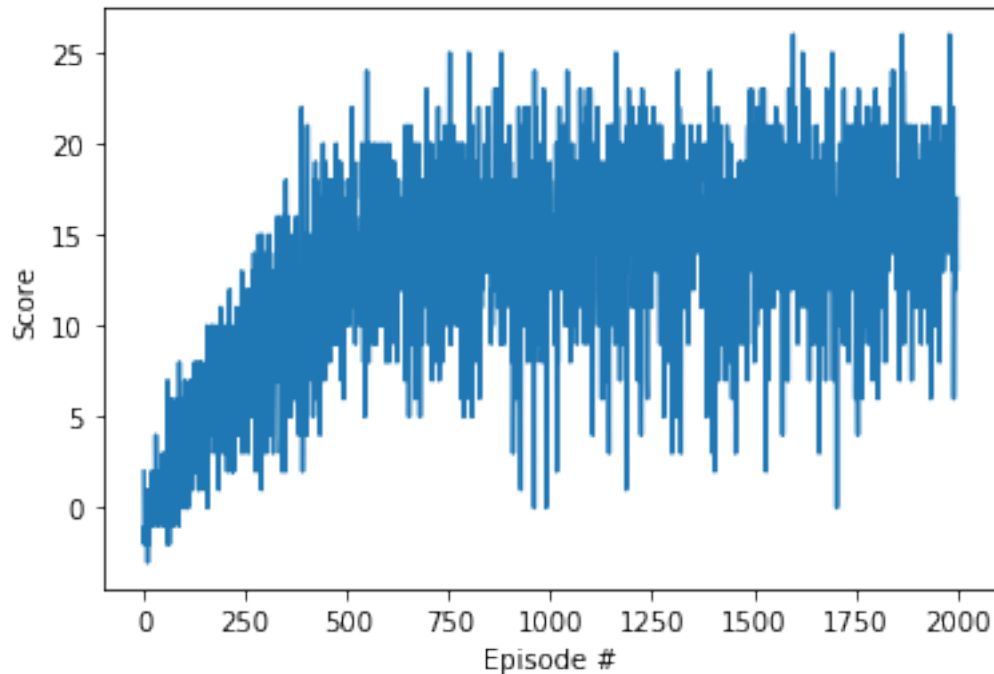
```
Network(
  (fc1): Linear(in_features=37, out_features=64, bias=True)
  (fc2): Linear(in_features=64, out_features=64, bias=True)
  (fc3): Linear(in_features=64, out_features=4, bias=True)
)
Network(
  (fc1): Linear(in_features=37, out_features=64, bias=True)
  (fc2): Linear(in_features=64, out_features=64, bias=True)
  (fc3): Linear(in_features=64, out_features=4, bias=True)
)
Episode 100      Average Score: 1.13
Episode 200      Average Score: 5.01
Episode 300      Average Score: 7.74
Episode 400      Average Score: 9.88
Episode 491      Average Score: 13.06
Environment solved in 491 episodes!      Average Score: 13.06
Episode 495      Average Score: 13.10
Environment solved in 495 episodes!      Average Score: 13.10
```

Episode 496	Average Score: 13.11	
Environment solved in 496 episodes!		Average Score: 13.11
Episode 498	Average Score: 13.15	
Environment solved in 498 episodes!		Average Score: 13.15
Episode 500	Average Score: 13.16	
Environment solved in 500 episodes!		Average Score: 13.16
Episode 501	Average Score: 13.19	
Environment solved in 501 episodes!		Average Score: 13.19
Episode 502	Average Score: 13.27	
Environment solved in 502 episodes!		Average Score: 13.27
Episode 504	Average Score: 13.31	
Environment solved in 504 episodes!		Average Score: 13.31
Episode 505	Average Score: 13.32	
Environment solved in 505 episodes!		Average Score: 13.32
Episode 506	Average Score: 13.36	
Environment solved in 506 episodes!		Average Score: 13.36
Episode 507	Average Score: 13.39	
Environment solved in 507 episodes!		Average Score: 13.39
Episode 510	Average Score: 13.41	
Environment solved in 510 episodes!		Average Score: 13.41
Episode 511	Average Score: 13.48	
Environment solved in 511 episodes!		Average Score: 13.48
Episode 512	Average Score: 13.52	
Environment solved in 512 episodes!		Average Score: 13.52
Episode 513	Average Score: 13.61	
Environment solved in 513 episodes!		Average Score: 13.61
Episode 514	Average Score: 13.63	
Environment solved in 514 episodes!		Average Score: 13.63
Episode 515	Average Score: 13.71	
Environment solved in 515 episodes!		Average Score: 13.71
Episode 516	Average Score: 13.77	
Environment solved in 516 episodes!		Average Score: 13.77
Episode 517	Average Score: 13.91	
Environment solved in 517 episodes!		Average Score: 13.91
Episode 518	Average Score: 13.96	
Environment solved in 518 episodes!		Average Score: 13.96
Episode 519	Average Score: 14.02	
Environment solved in 519 episodes!		Average Score: 14.02
Episode 520	Average Score: 14.04	
Environment solved in 520 episodes!		Average Score: 14.04
Episode 534	Average Score: 14.12	
Environment solved in 534 episodes!		Average Score: 14.12
Episode 535	Average Score: 14.24	
Environment solved in 535 episodes!		Average Score: 14.24
Episode 536	Average Score: 14.26	
Environment solved in 536 episodes!		Average Score: 14.26
Episode 537	Average Score: 14.29	

Environment solved in 537 episodes!	Average Score: 14.29
Episode 538 Average Score: 14.36	
Environment solved in 538 episodes!	Average Score: 14.36
Episode 541 Average Score: 14.39	
Environment solved in 541 episodes!	Average Score: 14.39
Episode 567 Average Score: 14.43	
Environment solved in 567 episodes!	Average Score: 14.43
Episode 600 Average Score: 14.37	
Episode 642 Average Score: 14.54	
Environment solved in 642 episodes!	Average Score: 14.54
Episode 645 Average Score: 14.64	
Environment solved in 645 episodes!	Average Score: 14.64
Episode 677 Average Score: 14.65	
Environment solved in 677 episodes!	Average Score: 14.65
Episode 696 Average Score: 14.70	
Environment solved in 696 episodes!	Average Score: 14.70
Episode 700 Average Score: 14.62	
Episode 704 Average Score: 14.73	
Environment solved in 704 episodes!	Average Score: 14.73
Episode 706 Average Score: 14.77	
Environment solved in 706 episodes!	Average Score: 14.77
Episode 708 Average Score: 14.80	
Environment solved in 708 episodes!	Average Score: 14.80
Episode 748 Average Score: 14.83	
Environment solved in 748 episodes!	Average Score: 14.83
Episode 751 Average Score: 14.84	
Environment solved in 751 episodes!	Average Score: 14.84
Episode 752 Average Score: 14.87	
Environment solved in 752 episodes!	Average Score: 14.87
Episode 753 Average Score: 15.07	
Environment solved in 753 episodes!	Average Score: 15.07
Episode 800 Average Score: 14.93	
Episode 870 Average Score: 15.11	
Environment solved in 870 episodes!	Average Score: 15.11
Episode 872 Average Score: 15.13	
Environment solved in 872 episodes!	Average Score: 15.13
Episode 874 Average Score: 15.18	
Environment solved in 874 episodes!	Average Score: 15.18
Episode 881 Average Score: 15.20	
Environment solved in 881 episodes!	Average Score: 15.20
Episode 883 Average Score: 15.22	
Environment solved in 883 episodes!	Average Score: 15.22
Episode 885 Average Score: 15.30	
Environment solved in 885 episodes!	Average Score: 15.30
Episode 889 Average Score: 15.32	
Environment solved in 889 episodes!	Average Score: 15.32
Episode 890 Average Score: 15.33	
Environment solved in 890 episodes!	Average Score: 15.33

Episode 895	Average Score: 15.36	
Environment solved in 895 episodes!		Average Score: 15.36
Episode 896	Average Score: 15.37	
Environment solved in 896 episodes!		Average Score: 15.37
Episode 897	Average Score: 15.49	
Environment solved in 897 episodes!		Average Score: 15.49
Episode 898	Average Score: 15.54	
Environment solved in 898 episodes!		Average Score: 15.54
Episode 899	Average Score: 15.58	
Environment solved in 899 episodes!		Average Score: 15.58
Episode 900	Average Score: 15.54	
Episode 903	Average Score: 15.63	
Environment solved in 903 episodes!		Average Score: 15.63
Episode 1000	Average Score: 14.76	
Episode 1090	Average Score: 15.65	
Environment solved in 1090 episodes!		Average Score: 15.65
Episode 1091	Average Score: 15.74	
Environment solved in 1091 episodes!		Average Score: 15.74
Episode 1093	Average Score: 15.75	
Environment solved in 1093 episodes!		Average Score: 15.75
Episode 1099	Average Score: 15.76	
Environment solved in 1099 episodes!		Average Score: 15.76
Episode 1100	Average Score: 15.81	
Environment solved in 1100 episodes!		Average Score: 15.81
Episode 1101	Average Score: 15.82	
Environment solved in 1101 episodes!		Average Score: 15.82
Episode 1103	Average Score: 15.83	
Environment solved in 1103 episodes!		Average Score: 15.83
Episode 1104	Average Score: 15.89	
Environment solved in 1104 episodes!		Average Score: 15.89
Episode 1110	Average Score: 15.92	
Environment solved in 1110 episodes!		Average Score: 15.92
Episode 1111	Average Score: 15.95	
Environment solved in 1111 episodes!		Average Score: 15.95
Episode 1112	Average Score: 16.00	
Environment solved in 1112 episodes!		Average Score: 16.00
Episode 1114	Average Score: 16.03	
Environment solved in 1114 episodes!		Average Score: 16.03
Episode 1116	Average Score: 16.16	
Environment solved in 1116 episodes!		Average Score: 16.16
Episode 1117	Average Score: 16.21	
Environment solved in 1117 episodes!		Average Score: 16.21
Episode 1200	Average Score: 15.41	
Episode 1300	Average Score: 15.45	
Episode 1400	Average Score: 15.22	
Episode 1500	Average Score: 14.07	
Episode 1600	Average Score: 15.95	

Episode 1603	Average Score: 16.27	
Environment solved in 1603 episodes!		Average Score: 16.27
Episode 1604	Average Score: 16.30	
Environment solved in 1604 episodes!		Average Score: 16.30
Episode 1608	Average Score: 16.33	
Environment solved in 1608 episodes!		Average Score: 16.33
Episode 1636	Average Score: 16.40	
Environment solved in 1636 episodes!		Average Score: 16.40
Episode 1637	Average Score: 16.45	
Environment solved in 1637 episodes!		Average Score: 16.45
Episode 1700	Average Score: 16.05	
Episode 1800	Average Score: 15.20	
Episode 1882	Average Score: 16.46	
Environment solved in 1882 episodes!		Average Score: 16.46
Episode 1883	Average Score: 16.49	
Environment solved in 1883 episodes!		Average Score: 16.49
Episode 1897	Average Score: 16.52	
Environment solved in 1897 episodes!		Average Score: 16.52
Episode 1898	Average Score: 16.54	
Environment solved in 1898 episodes!		Average Score: 16.54
Episode 1899	Average Score: 16.55	
Environment solved in 1899 episodes!		Average Score: 16.55
Episode 1900	Average Score: 16.51	
Episode 1917	Average Score: 16.56	
Environment solved in 1917 episodes!		Average Score: 16.56
Episode 1925	Average Score: 16.59	
Environment solved in 1925 episodes!		Average Score: 16.59
Episode 1931	Average Score: 16.60	
Environment solved in 1931 episodes!		Average Score: 16.60
Episode 2000	Average Score: 15.76	



Time Taken: 1788.9697110359994

5.e Run using Buffer Size of 200,000 and Batch Size 32

```
[12]: wrapped = testWrapper(runQNetworkTest, 'checkpoint-200000x32.pth', int(2e5),
    ↪ 32, SEED, GAMMA, LR, UPDATE_EVERY, TAU, { 'fc1': 64, 'fc2': 64 })
    print(f'Time Taken: {timeit.timeit(wrapped, number=1)}')
```

```
Network(
  (fc1): Linear(in_features=37, out_features=64, bias=True)
  (fc2): Linear(in_features=64, out_features=64, bias=True)
  (fc3): Linear(in_features=64, out_features=4, bias=True)
)
Network(
  (fc1): Linear(in_features=37, out_features=64, bias=True)
  (fc2): Linear(in_features=64, out_features=64, bias=True)
  (fc3): Linear(in_features=64, out_features=4, bias=True)
)
Episode 100      Average Score: 1.03
Episode 200      Average Score: 4.30
Episode 300      Average Score: 7.05
Episode 400      Average Score: 10.40
Episode 500      Average Score: 11.85
Episode 600      Average Score: 11.56
Episode 700      Average Score: 12.94
Episode 703      Average Score: 13.04
```

Environment solved in 703 episodes!	Average Score: 13.04
Episode 704 Average Score: 13.09	
Environment solved in 704 episodes!	Average Score: 13.09
Episode 711 Average Score: 13.21	
Environment solved in 711 episodes!	Average Score: 13.21
Episode 712 Average Score: 13.25	
Environment solved in 712 episodes!	Average Score: 13.25
Episode 713 Average Score: 13.32	
Environment solved in 713 episodes!	Average Score: 13.32
Episode 714 Average Score: 13.42	
Environment solved in 714 episodes!	Average Score: 13.42
Episode 715 Average Score: 13.51	
Environment solved in 715 episodes!	Average Score: 13.51
Episode 717 Average Score: 13.52	
Environment solved in 717 episodes!	Average Score: 13.52
Episode 719 Average Score: 13.60	
Environment solved in 719 episodes!	Average Score: 13.60
Episode 720 Average Score: 13.63	
Environment solved in 720 episodes!	Average Score: 13.63
Episode 721 Average Score: 13.74	
Environment solved in 721 episodes!	Average Score: 13.74
Episode 724 Average Score: 13.76	
Environment solved in 724 episodes!	Average Score: 13.76
Episode 725 Average Score: 13.85	
Environment solved in 725 episodes!	Average Score: 13.85
Episode 726 Average Score: 13.93	
Environment solved in 726 episodes!	Average Score: 13.93
Episode 727 Average Score: 13.97	
Environment solved in 727 episodes!	Average Score: 13.97
Episode 729 Average Score: 13.99	
Environment solved in 729 episodes!	Average Score: 13.99
Episode 730 Average Score: 14.04	
Environment solved in 730 episodes!	Average Score: 14.04
Episode 731 Average Score: 14.06	
Environment solved in 731 episodes!	Average Score: 14.06
Episode 732 Average Score: 14.08	
Environment solved in 732 episodes!	Average Score: 14.08
Episode 733 Average Score: 14.17	
Environment solved in 733 episodes!	Average Score: 14.17
Episode 734 Average Score: 14.19	
Environment solved in 734 episodes!	Average Score: 14.19
Episode 735 Average Score: 14.34	
Environment solved in 735 episodes!	Average Score: 14.34
Episode 736 Average Score: 14.37	
Environment solved in 736 episodes!	Average Score: 14.37
Episode 737 Average Score: 14.41	
Environment solved in 737 episodes!	Average Score: 14.41
Episode 738 Average Score: 14.44	

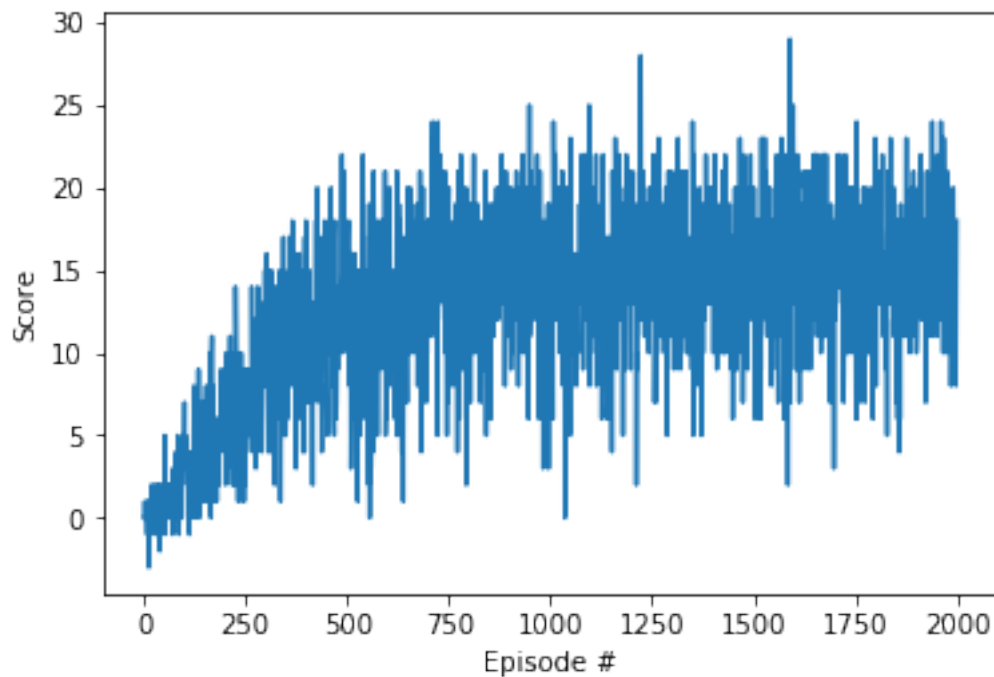
Environment solved in 738 episodes!	Average Score: 14.44
Episode 739 Average Score: 14.56	
Environment solved in 739 episodes!	Average Score: 14.56
Episode 741 Average Score: 14.58	
Environment solved in 741 episodes!	Average Score: 14.58
Episode 742 Average Score: 14.64	
Environment solved in 742 episodes!	Average Score: 14.64
Episode 744 Average Score: 14.65	
Environment solved in 744 episodes!	Average Score: 14.65
Episode 748 Average Score: 14.67	
Environment solved in 748 episodes!	Average Score: 14.67
Episode 751 Average Score: 14.69	
Environment solved in 751 episodes!	Average Score: 14.69
Episode 783 Average Score: 14.73	
Environment solved in 783 episodes!	Average Score: 14.73
Episode 784 Average Score: 14.76	
Environment solved in 784 episodes!	Average Score: 14.76
Episode 789 Average Score: 14.80	
Environment solved in 789 episodes!	Average Score: 14.80
Episode 790 Average Score: 14.88	
Environment solved in 790 episodes!	Average Score: 14.88
Episode 796 Average Score: 14.90	
Environment solved in 796 episodes!	Average Score: 14.90
Episode 797 Average Score: 14.94	
Environment solved in 797 episodes!	Average Score: 14.94
Episode 798 Average Score: 15.00	
Environment solved in 798 episodes!	Average Score: 15.00
Episode 800 Average Score: 15.05	
Environment solved in 800 episodes!	Average Score: 15.05
Episode 801 Average Score: 15.06	
Environment solved in 801 episodes!	Average Score: 15.06
Episode 802 Average Score: 15.08	
Environment solved in 802 episodes!	Average Score: 15.08
Episode 877 Average Score: 15.10	
Environment solved in 877 episodes!	Average Score: 15.10
Episode 881 Average Score: 15.14	
Environment solved in 881 episodes!	Average Score: 15.14
Episode 885 Average Score: 15.18	
Environment solved in 885 episodes!	Average Score: 15.18
Episode 886 Average Score: 15.21	
Environment solved in 886 episodes!	Average Score: 15.21
Episode 894 Average Score: 15.24	
Environment solved in 894 episodes!	Average Score: 15.24
Episode 900 Average Score: 15.10	
Episode 930 Average Score: 15.28	
Environment solved in 930 episodes!	Average Score: 15.28
Episode 931 Average Score: 15.33	

Environment solved in 931 episodes!	Average Score: 15.33
Episode 932 Average Score: 15.39	
Environment solved in 932 episodes!	Average Score: 15.39
Episode 933 Average Score: 15.46	
Environment solved in 933 episodes!	Average Score: 15.46
Episode 934 Average Score: 15.48	
Environment solved in 934 episodes!	Average Score: 15.48
Episode 938 Average Score: 15.50	
Environment solved in 938 episodes!	Average Score: 15.50
Episode 939 Average Score: 15.51	
Environment solved in 939 episodes!	Average Score: 15.51
Episode 940 Average Score: 15.56	
Environment solved in 940 episodes!	Average Score: 15.56
Episode 943 Average Score: 15.63	
Environment solved in 943 episodes!	Average Score: 15.63
Episode 946 Average Score: 15.65	
Environment solved in 946 episodes!	Average Score: 15.65
Episode 949 Average Score: 15.71	
Environment solved in 949 episodes!	Average Score: 15.71
Episode 953 Average Score: 15.81	
Environment solved in 953 episodes!	Average Score: 15.81
Episode 954 Average Score: 15.95	
Environment solved in 954 episodes!	Average Score: 15.95
Episode 955 Average Score: 15.98	
Environment solved in 955 episodes!	Average Score: 15.98
Episode 957 Average Score: 16.01	
Environment solved in 957 episodes!	Average Score: 16.01
Episode 958 Average Score: 16.02	
Environment solved in 958 episodes!	Average Score: 16.02
Episode 961 Average Score: 16.04	
Environment solved in 961 episodes!	Average Score: 16.04
Episode 1000 Average Score: 15.27	
Episode 1100 Average Score: 14.94	
Episode 1200 Average Score: 14.88	
Episode 1300 Average Score: 15.42	
Episode 1400 Average Score: 14.93	
Episode 1500 Average Score: 15.45	
Episode 1600 Average Score: 15.55	
Episode 1646 Average Score: 16.06	
Environment solved in 1646 episodes!	Average Score: 16.06
Episode 1647 Average Score: 16.14	
Environment solved in 1647 episodes!	Average Score: 16.14
Episode 1648 Average Score: 16.15	
Environment solved in 1648 episodes!	Average Score: 16.15
Episode 1649 Average Score: 16.21	
Environment solved in 1649 episodes!	Average Score: 16.21
Episode 1653 Average Score: 16.22	
Environment solved in 1653 episodes!	Average Score: 16.22

```

Episode 1655    Average Score: 16.24
Environment solved in 1655 episodes!    Average Score: 16.24
Episode 1656    Average Score: 16.35
Environment solved in 1656 episodes!    Average Score: 16.35
Episode 1661    Average Score: 16.49
Environment solved in 1661 episodes!    Average Score: 16.49
Episode 1700    Average Score: 15.57
Episode 1800    Average Score: 14.87
Episode 1900    Average Score: 15.25
Episode 2000    Average Score: 15.42

```



Time Taken: 1841.095480701988

5.f Run using Buffer Size of 250,000 and Batch Size 32

```

[13]: wrapped = testWrapper(runQNetworkTest, 'checkpoint-250000x32.pth', int(2.5e5), 32, SEED, GAMMA, LR, UPDATE_EVERY, TAU, { 'fc1': 64, 'fc2': 64 })
print(f'Time Taken: {timeit.timeit(wrapped, number=1)}')

```

```

Network(
  (fc1): Linear(in_features=37, out_features=64, bias=True)
  (fc2): Linear(in_features=64, out_features=64, bias=True)
  (fc3): Linear(in_features=64, out_features=4, bias=True)
)
Network(
  (fc1): Linear(in_features=37, out_features=64, bias=True)

```

```

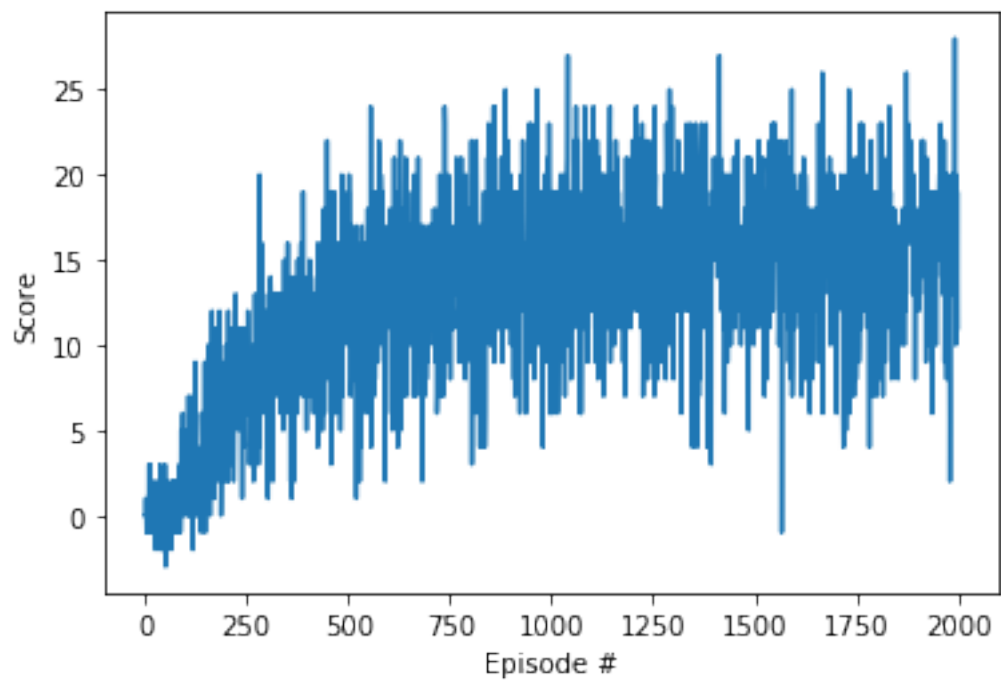
(fc2): Linear(in_features=64, out_features=64, bias=True)
(fc3): Linear(in_features=64, out_features=4, bias=True)
)
Episode 100      Average Score: 0.56
Episode 200      Average Score: 3.98
Episode 300      Average Score: 8.19
Episode 400      Average Score: 10.11
Episode 500      Average Score: 11.48
Episode 600      Average Score: 12.60
Episode 638      Average Score: 13.03
Environment solved in 638 episodes!      Average Score: 13.03
Episode 639      Average Score: 13.06
Environment solved in 639 episodes!      Average Score: 13.06
Episode 640      Average Score: 13.10
Environment solved in 640 episodes!      Average Score: 13.10
Episode 641      Average Score: 13.13
Environment solved in 641 episodes!      Average Score: 13.13
Episode 642      Average Score: 13.21
Environment solved in 642 episodes!      Average Score: 13.21
Episode 647      Average Score: 13.26
Environment solved in 647 episodes!      Average Score: 13.26
Episode 648      Average Score: 13.30
Environment solved in 648 episodes!      Average Score: 13.30
Episode 651      Average Score: 13.37
Environment solved in 651 episodes!      Average Score: 13.37
Episode 652      Average Score: 13.41
Environment solved in 652 episodes!      Average Score: 13.41
Episode 654      Average Score: 13.42
Environment solved in 654 episodes!      Average Score: 13.42
Episode 658      Average Score: 13.48
Environment solved in 658 episodes!      Average Score: 13.48
Episode 664      Average Score: 13.49
Environment solved in 664 episodes!      Average Score: 13.49
Episode 665      Average Score: 13.55
Environment solved in 665 episodes!      Average Score: 13.55
Episode 667      Average Score: 13.56
Environment solved in 667 episodes!      Average Score: 13.56
Episode 670      Average Score: 13.57
Environment solved in 670 episodes!      Average Score: 13.57
Episode 674      Average Score: 13.58
Environment solved in 674 episodes!      Average Score: 13.58
Episode 675      Average Score: 13.61
Environment solved in 675 episodes!      Average Score: 13.61
Episode 700      Average Score: 13.21
Episode 771      Average Score: 13.63
Environment solved in 771 episodes!      Average Score: 13.63
Episode 772      Average Score: 13.64
Environment solved in 772 episodes!      Average Score: 13.64

```

Episode 779	Average Score: 13.66	
Environment solved in 779 episodes!		Average Score: 13.66
Episode 780	Average Score: 13.68	
Environment solved in 780 episodes!		Average Score: 13.68
Episode 781	Average Score: 13.69	
Environment solved in 781 episodes!		Average Score: 13.69
Episode 783	Average Score: 13.81	
Environment solved in 783 episodes!		Average Score: 13.81
Episode 784	Average Score: 13.83	
Environment solved in 784 episodes!		Average Score: 13.83
Episode 786	Average Score: 13.86	
Environment solved in 786 episodes!		Average Score: 13.86
Episode 788	Average Score: 13.87	
Environment solved in 788 episodes!		Average Score: 13.87
Episode 789	Average Score: 13.88	
Environment solved in 789 episodes!		Average Score: 13.88
Episode 790	Average Score: 13.93	
Environment solved in 790 episodes!		Average Score: 13.93
Episode 794	Average Score: 14.00	
Environment solved in 794 episodes!		Average Score: 14.00
Episode 795	Average Score: 14.07	
Environment solved in 795 episodes!		Average Score: 14.07
Episode 800	Average Score: 14.07	
Episode 801	Average Score: 14.08	
Environment solved in 801 episodes!		Average Score: 14.08
Episode 804	Average Score: 14.10	
Environment solved in 804 episodes!		Average Score: 14.10
Episode 817	Average Score: 14.15	
Environment solved in 817 episodes!		Average Score: 14.15
Episode 818	Average Score: 14.17	
Environment solved in 818 episodes!		Average Score: 14.17
Episode 819	Average Score: 14.26	
Environment solved in 819 episodes!		Average Score: 14.26
Episode 820	Average Score: 14.31	
Environment solved in 820 episodes!		Average Score: 14.31
Episode 821	Average Score: 14.35	
Environment solved in 821 episodes!		Average Score: 14.35
Episode 822	Average Score: 14.38	
Environment solved in 822 episodes!		Average Score: 14.38
Episode 824	Average Score: 14.39	
Environment solved in 824 episodes!		Average Score: 14.39
Episode 861	Average Score: 14.43	
Environment solved in 861 episodes!		Average Score: 14.43
Episode 862	Average Score: 14.46	
Environment solved in 862 episodes!		Average Score: 14.46
Episode 863	Average Score: 14.49	
Environment solved in 863 episodes!		Average Score: 14.49
Episode 889	Average Score: 14.54	

Environment solved in 889 episodes!	Average Score: 14.54
Episode 898 Average Score: 14.55	
Environment solved in 898 episodes!	Average Score: 14.55
Episode 899 Average Score: 14.59	
Environment solved in 899 episodes!	Average Score: 14.59
Episode 900 Average Score: 14.59	
Episode 901 Average Score: 14.64	
Environment solved in 901 episodes!	Average Score: 14.64
Episode 905 Average Score: 14.72	
Environment solved in 905 episodes!	Average Score: 14.72
Episode 906 Average Score: 14.75	
Environment solved in 906 episodes!	Average Score: 14.75
Episode 907 Average Score: 14.79	
Environment solved in 907 episodes!	Average Score: 14.79
Episode 908 Average Score: 14.85	
Environment solved in 908 episodes!	Average Score: 14.85
Episode 931 Average Score: 14.95	
Environment solved in 931 episodes!	Average Score: 14.95
Episode 932 Average Score: 14.97	
Environment solved in 932 episodes!	Average Score: 14.97
Episode 934 Average Score: 15.06	
Environment solved in 934 episodes!	Average Score: 15.06
Episode 935 Average Score: 15.08	
Environment solved in 935 episodes!	Average Score: 15.08
Episode 937 Average Score: 15.13	
Environment solved in 937 episodes!	Average Score: 15.13
Episode 951 Average Score: 15.15	
Environment solved in 951 episodes!	Average Score: 15.15
Episode 956 Average Score: 15.17	
Environment solved in 956 episodes!	Average Score: 15.17
Episode 965 Average Score: 15.18	
Environment solved in 965 episodes!	Average Score: 15.18
Episode 971 Average Score: 15.23	
Environment solved in 971 episodes!	Average Score: 15.23
Episode 972 Average Score: 15.25	
Environment solved in 972 episodes!	Average Score: 15.25
Episode 973 Average Score: 15.27	
Environment solved in 973 episodes!	Average Score: 15.27
Episode 976 Average Score: 15.29	
Environment solved in 976 episodes!	Average Score: 15.29
Episode 1000 Average Score: 15.05	
Episode 1023 Average Score: 15.41	
Environment solved in 1023 episodes!	Average Score: 15.41
Episode 1024 Average Score: 15.45	
Environment solved in 1024 episodes!	Average Score: 15.45
Episode 1040 Average Score: 15.52	
Environment solved in 1040 episodes!	Average Score: 15.52
Episode 1041 Average Score: 15.66	

Environment solved in 1041 episodes!	Average Score: 15.66
Episode 1089 Average Score: 15.67	
Environment solved in 1089 episodes!	Average Score: 15.67
Episode 1099 Average Score: 15.77	
Environment solved in 1099 episodes!	Average Score: 15.77
Episode 1100 Average Score: 15.74	
Episode 1101 Average Score: 15.78	
Environment solved in 1101 episodes!	Average Score: 15.78
Episode 1102 Average Score: 15.80	
Environment solved in 1102 episodes!	Average Score: 15.80
Episode 1103 Average Score: 15.81	
Environment solved in 1103 episodes!	Average Score: 15.81
Episode 1104 Average Score: 15.94	
Environment solved in 1104 episodes!	Average Score: 15.94
Episode 1105 Average Score: 16.03	
Environment solved in 1105 episodes!	Average Score: 16.03
Episode 1107 Average Score: 16.11	
Environment solved in 1107 episodes!	Average Score: 16.11
Episode 1108 Average Score: 16.14	
Environment solved in 1108 episodes!	Average Score: 16.14
Episode 1109 Average Score: 16.16	
Environment solved in 1109 episodes!	Average Score: 16.16
Episode 1113 Average Score: 16.22	
Environment solved in 1113 episodes!	Average Score: 16.22
Episode 1116 Average Score: 16.26	
Environment solved in 1116 episodes!	Average Score: 16.26
Episode 1117 Average Score: 16.31	
Environment solved in 1117 episodes!	Average Score: 16.31
Episode 1118 Average Score: 16.33	
Environment solved in 1118 episodes!	Average Score: 16.33
Episode 1122 Average Score: 16.34	
Environment solved in 1122 episodes!	Average Score: 16.34
Episode 1134 Average Score: 16.41	
Environment solved in 1134 episodes!	Average Score: 16.41
Episode 1136 Average Score: 16.43	
Environment solved in 1136 episodes!	Average Score: 16.43
Episode 1200 Average Score: 15.92	
Episode 1300 Average Score: 15.92	
Episode 1383 Average Score: 16.45	
Environment solved in 1383 episodes!	Average Score: 16.45
Episode 1400 Average Score: 15.93	
Episode 1500 Average Score: 15.91	
Episode 1600 Average Score: 15.72	
Episode 1700 Average Score: 15.39	
Episode 1800 Average Score: 15.04	
Episode 1900 Average Score: 15.51	
Episode 2000 Average Score: 15.65	



Time Taken: 1790.2813828770013