# BananaNavigationSolution

April 9, 2020

```
In [1]: import torch
        import torch.nn as nn
        import torch.nn.functional as F
        import torch.optim as optim

        import numpy as np
        import random
        from collections import namedtuple, deque, OrderedDict
        import pandas as pd
```

```
In [2]: !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.
```

```
In [3]: from unityagents import UnityEnvironment
        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: , , ,
```

```
In [4]: import matplotlib.pyplot as plt
        %matplotlib inline
```

```
In [5]: # get the default brain
        brain_name = env.brain_names[0]
        brain = env.brains[brain_name]

        env_info = env.reset(train_mode=True)[brain_name]
        state_size = len(env_info.vector_observations[0])
        action_size = brain.vector_action_space_size

        print(brain_name)
```

```
BananaBrain
```

```
In [6]: def QNet(state_size=state_size, action_size=action_size, seed=10, fc1=256, fc2=512):
            torch.manual_seed(seed)
            return nn.Sequential(OrderedDict([
                ('fc1', nn.Linear(state_size, fc1)),
                ('relu1', nn.ReLU()),
                ('dropout1', nn.Dropout(p=0.25)),
                ('fc2', nn.Linear(fc1, fc2)),
                ('relu2', nn.ReLU()),
                ('dropout2', nn.Dropout(p=0.25)),

                ('output', nn.Linear(fc2, action_size))
            ]))
```

```
In [7]: BUFFER_SIZE = 100000
        BATCH_SIZE = 64
        GAMMA = 0.995
        TAU = 1e-3
        LR = 0.001
        UPDATE_EVERY = 4 # how often to update the network
```

```
In [8]: episodes = 1000
        horizon_t = 1000
```

```
In [9]: device = torch.device("cuda:0" if torch.cuda.is_available() else "cpu")
        print(device)
```

```
cpu
```

```
In [10]: class ReplayBuffer():
             """Create the replay buffer to store the experience from the env as (s,a,r,s',done)

             def __init__(self, buffer_size, batch_size, seed=231):
                 """Initialize ReplayBuffer.

                 Params
```

```
        ======
            buffer_size (int): (maximal) capacity of the buffer and size of sampled exp
            batch_size (int): size of the random samples
            seed (int): randomize
        """
        self.batch_size = batch_size
        self.memory = deque(maxlen=buffer_size)
        self.experience = namedtuple("Experience", field_names=["state", "action", "rew
        random.seed(seed)

    def add(self, state, action, reward, next_state, done):
        """Add the tuple s,a,r,s',done) in the experience replay buffer
        """
        e = self.experience(state, action, reward, next_state, done)
        self.memory.append(e)

    def sample(self):
        """Sample random experiences with the size of batch_size.
        Returns a tuple (s,a,r,s',dones), each item as a torch vector
        """

        samples = random.sample(self.memory, self.batch_size)

        #return torch tensors
        states = torch.from_numpy(np.vstack([e.state for e in samples if e is not None]
        actions = torch.from_numpy(np.vstack([e.action for e in samples if e is not Non
        rewards = torch.from_numpy(np.vstack([e.reward for e in samples if e is not Non
        next_states = torch.from_numpy(np.vstack([e.next_state for e in samples if e is
        dones = torch.from_numpy(np.vstack([e.done for e in samples if e is not None]).
        return (states, actions, rewards, next_states, dones)

    def __len__(self):
        return len(self.memory)
```

In [11]:
```
class Agent():

    def __init__(self, state_size, action_size, seed=231):
        self.state_size = state_size
        self.action_size = action_size
        self.qnet_local = QNet(state_size, action_size).to(device)
        self.qnet_target = QNet(state_size, action_size).to(device)
        self.replay = ReplayBuffer(buffer_size=BUFFER_SIZE, batch_size=BATCH_SIZE)
        self.t_steps = 0
        self.optimizer = optim.Adam(params=self.qnet_local.parameters(), lr=LR)
        random.seed(seed)


    def act(self, state, eps):
```

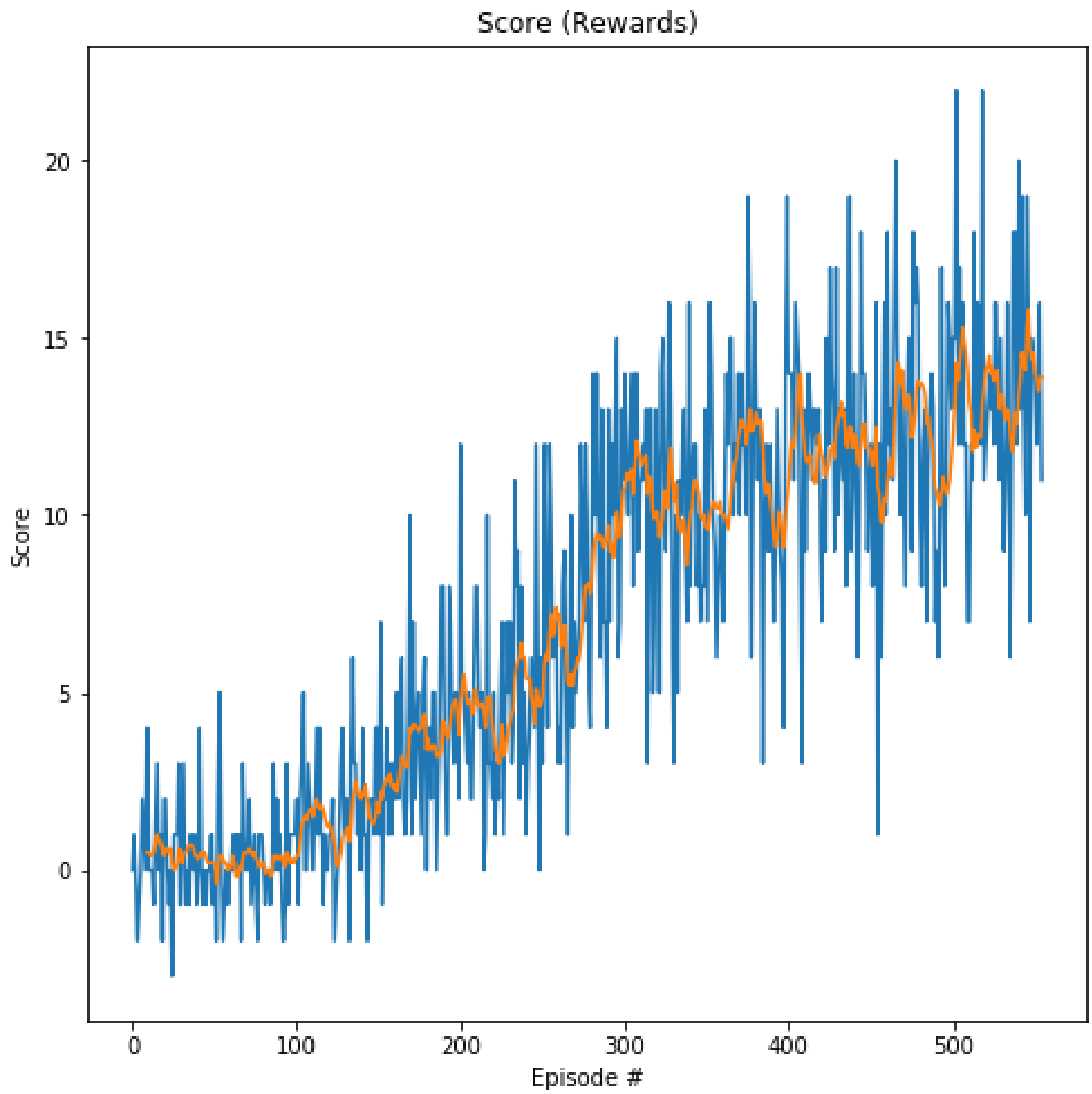
```
        #select the next state based on policy
        state = torch.from_numpy(state).float().unsqueeze(0).to(device)
        self.qnet_local.eval()
        with torch.no_grad():
            action_values = self.qnet_local(state)
        self.qnet_local.train()

        if random.random() > eps:
            # go greedy
            #when run in gpu mode, tensor's data cannot be converted to numpy
            return np.argmax(action_values.data.cpu().numpy())
        else:
            #random action
            return np.random.choice(np.arange(self.action_size))


    def step(self, state, action, reward, next_state, done):
        self.replay.add(state, action, reward, next_state, done)
        self.t_steps += 1
        if self.t_steps % UPDATE_EVERY == 0:
            # check if enough samples
            if self.replay.__len__() > BATCH_SIZE:
                subset = self.replay.sample()
                self.learn(subset, GAMMA)


    def learn(self, experience, gamma):
        state, action, reward, next_state, done = experience
        # Get max predicted Q values (for next states) from target model
        Q_targets_next = self.qnet_target(next_state).detach().max(1)[0].unsqueeze(1) #
        # Compute Q targets for current states
        Q_targets = reward + (gamma * Q_targets_next * (1 - done))
        Q_expected = self.qnet_local(state).gather(1, action) #view in details

        loss = nn.functional.mse_loss(Q_expected, Q_targets)

        self.optimizer.zero_grad()
        loss.backward()
        self.optimizer.step()

        self.soft_update(self.qnet_local, self.qnet_target)


    def soft_update(self, local_model, target_model, tau=TAU):
        for target_param, local_param in zip(target_model.parameters(), local_model.par
            target_param.data.copy_(tau*local_param.data + (1.0-tau)*target_param.data)
```

```
In [12]: agent = Agent(state_size=state_size, action_size=action_size, seed=10)

In [13]: def dqn(episodes, horizion_t, eps_start = 0.99, eps_end = 0.01, eps_decay = 0.995):
             scores = []
             scores_win = deque(maxlen=100) #last consecutive episode scores
             eps = eps_start
             for e in range(1, episodes):
                 env_info = env.reset(train_mode=True)[brain_name]
                 state = env_info.vector_observations[0]
                 score = 0
                 for t in range(horizion_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_win.append(score)
                 scores.append(score)
                 eps = max(eps_end, eps_decay * eps)
                 print('\rEpisode {}\tAverage Score: {:.2f}'.format(e, np.mean(scores_win)), end
                 if e % 100 == 0:
                     print('\rEpisode {}\tAverage Score: {:.2f}'.format(e, np.mean(scores_win)))
                 if np.mean(scores_win)>=13.0:
                     print('\nEnvironment solved in {:d} episodes!\tAverage Score: {:.2f}'.forma

                     torch.save(agent.qnet_local.state_dict(), 'checkpoint_navigation.pth')
                     break
             return scores

In [14]: scores = dqn(episodes=episodes, horizion_t=horizon_t)
```

```
Episode 100        Average Score: 0.32
Episode 200        Average Score: 2.55
Episode 300        Average Score: 6.44
Episode 400        Average Score: 10.77
Episode 500        Average Score: 12.10
Episode 555        Average Score: 13.09
Environment solved in 456 episodes!        Average Score: 13.09
```

```
In [15]: # plot the scores
         fig = plt.figure(figsize=(8,8))
         ax = fig.add_subplot(111)
         plt.plot(np.arange(len(scores)), scores)
```

```
plt.plot(pd.Series(scores).rolling(10).mean())
plt.title('Score (Rewards)')
plt.ylabel('Score')
plt.xlabel('Episode #')
plt.show()
```




```
In [16]: #when done, close the env
         env.close()

In [17]: ##
```