#ELEN 6885 Reinforcement Learning Coding Assignment (Part 4)# There are a lot of official and unofficial tutorials about Tensorflow, and there are also many open-source projects written in Tensorflow. You can refer to those resources according to your interest. In this part of homework 4, only knowledge of Deep Reinforcement Learning and basic programming skills will be needed.

Please put your code into the block marked by\ #############################\ # YOUR CODE STARTS HERE\ # YOUR CODE ENDS HERE\ #############################\ Normally you don't need to edit anything outside of the block. If you do want to edit something, please use a similar manner to mark you edits.

In [0]:

```
import numpy as np
import tensorflow as tf

# DQN
class DQN:
  def __init__(
        self,
        actions_num,
        state_size,
        learning_rate = 0.001,
        gamma = 0.99,
        epsilon_min = 0.05,
        epsilon_start = 0.9,
        replace_target_iter = 300,
        memory_size = 500,
        batch_size = 2,
        epsilon_increment = None,
  ):
        self.actions_num = actions_num
        self.state_size = state_size
        self.lr = learning_rate
        self.gamma = gamma
        self.epsilon_min = epsilon_min
        self.replace_target_iter = replace_target_iter
        self.memory_size = memory_size
        self.batch_size = batch_size
        self.epsilon_increment = epsilon_increment
        self.epsilon = epsilon_start if epsilon_increment is not None e
        self.save_model_path = './weights/DQN_model.ckpt'
        self.memory_counter = 0

        # learned steps counter
        self.steps_counter = 0

        # initialize memory [s, a, r, s_, done]
        self.memory = np.zeros((self.memory_size, state_size * 2 + 3))

        # build target_net and q_net
        self.build_net()
        t_params = tf.get_collection('target_net_params')
        q_params = tf.get_collection('q_net_params')
        self.replace_target = [tf.assign(t, q) for t, q in zip(t_params

        # gpu setting
        config = tf.ConfigProto(log_device_placement=False, allow_soft_
        config.gpu_options.per_process_gpu_memory_fraction = 0.6
        self.sess = tf.Session(config=config)

        self.sess.run(tf.global_variables_initializer())

  def build_net(self):
      # build q_net
      self.state = tf.placeholder(tf.float32, [None, self.state_size],
      self.q_target = tf.placeholder(tf.float32, [None, self.actions_nu
      with tf.variable_scope('q_net'):
        # c_names(collections_names) are the collections to store varia
```

```
      c_names, neurons_layer_1, w_initializer, b_initializer = \
        ['q_net_params', tf.GraphKeys.GLOBAL_VARIABLES], 100, \
        tf.random_normal_initializer(0., 0.3), tf.constant_initialize

      # layer 1
      with tf.variable_scope('layer_1'):
        w_layer_1 = tf.get_variable('w_layer_1', [self.state_size, ne
        b_layer_1 = tf.get_variable('b_layer_1', [1, neurons_layer_1]
        layer_1 = tf.nn.relu(tf.matmul(self.state, w_layer_1) + b_lay

      # layer 2
      with tf.variable_scope('layer_2'):
        w_layer_2 = tf.get_variable('w_layer_2', [neurons_layer_1, se
        b_layer_2 = tf.get_variable('b_layer_2', [1, self.actions_num
        self.q_value = tf.matmul(layer_1, w_layer_2) + b_layer_2

    with tf.variable_scope('loss'):
      self.loss = tf.reduce_mean(tf.squared_difference(self.q_target,
    with tf.variable_scope('train'):
      self._train_op = tf.train.AdamOptimizer(self.lr).minimize(self.

    # build target_net
    self.state_t = tf.placeholder(tf.float32, [None, self.state_size]
    with tf.variable_scope('target_net'):
      # c_names(collections_names) are the collections to store varia
      c_names = ['target_net_params', tf.GraphKeys.GLOBAL_VARIABLES]

      # layer 1
      with tf.variable_scope('layer_1'):
        w_layer_1 = tf.get_variable('w_layer_1', [self.state_size, ne
        b_layer_1 = tf.get_variable('b_layer_1', [1, neurons_layer_1]
        layer_1 = tf.nn.relu(tf.matmul(self.state_t, w_layer_1) + b_l

      # layer 2

      ############################
      # YOUR CODE STARTS HERE
      with tf.variable_scope('layer_2'):
        w_layer_2 = tf.get_variable('w_layer_2', [neurons_layer_1, se
        b_layer_2 = tf.get_variable('b_layer_2', [1, self.actions_num
        self.q_next = tf.matmul(layer_1, w_layer_2) + b_layer_2

      # YOUR CODE ENDS HERE
      ############################

  def store_transition(self, s, a, r, s_, done):
    s=s.reshape(-1)
    s_=s_.reshape(-1)
    transition = np.hstack((s, [a, r], s_, done))
    # replace the old memory with new observations
    index = self.memory_counter % self.memory_size
    self.memory[index, :] = transition

    self.memory_counter += 1

  def choose_action(self, observation):
    # to have batch dimension when fed into tf placeholder
```

```
        observation = observation[np.newaxis, :]
        # epsilon-greedy
        if np.random.uniform() > self.epsilon:
          action_values = self.sess.run(self.q_value, feed_dict={self.sta
          action = np.argmax(action_values)
        else:
          action = np.random.randint(0, self.actions_num)
        return action

      def learn(self):
        # replace target parameters every once a while
        if self.steps_counter % self.replace_target_iter == 0:
          self.sess.run(self.replace_target)

        # sample a batch from the memory
        if self.memory_counter > self.memory_size:
          sample_index = np.random.choice(self.memory_size, size=self.bat
        else:
          sample_index = np.random.choice(self.memory_counter, size=self.
        batch_memory = self.memory[sample_index, :]

        q_next, q_value = self.sess.run(
          [self.q_next, self.q_value],
          feed_dict={
            self.state_t: batch_memory[:, -self.state_size-1:-1],  # fixe
            self.state: batch_memory[:, :self.state_size],  # newest para
          })

        # calculate q_target
        q_target = q_value.copy()


        # only change the action-values of this batch, because we only ca
        batch_index = np.arange(self.batch_size, dtype=np.int32)
        act_index = batch_memory[:, self.state_size].astype(int)
        reward = batch_memory[:, self.state_size + 1]
        done = batch_memory[:, -1]
        ###########################
        # YOUR CODE STARTS HERE
        q_target[batch_index, act_index] = reward + self.gamma * np.max(q
        for i in range(done.shape[0]):
          if done[i] == 1.0:
            q_target[i,:] = reward[i]

        # YOUR CODE ENDS HERE
        ###########################

        # train q_net
        _, self.cost = self.sess.run([self._train_op, self.loss],
                                     feed_dict={self.state: batch_memory
                                                self.q_target: q_target})
        # change epsilon
        self.epsilon = self.epsilon - self.epsilon_increment if self.epsi
        self.steps_counter += 1

      def store(self):
        saver = tf.train.Saver()
```

```
      saver.save(self.sess, self.save_model_path)

    def restore(self):
      saver = tf.train.Saver()
      saver.restore(self.sess, self.save_model_path)
```

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In [0]:

```
import gym
# cart pole gym environment
env = gym.make("CartPole-v0")
env._max_episode_steps = 500
# state and action space
print(env.action_space)
print(env.observation_space)
# observation
env.reset()
# state, reward, done, info
print(env.step(1))
```

```
Discrete(2)
Box(4,)
(array([ 0.03984107,  0.17240988, -0.04123799, -0.2650715 ]), 1.0, False,
{})
```

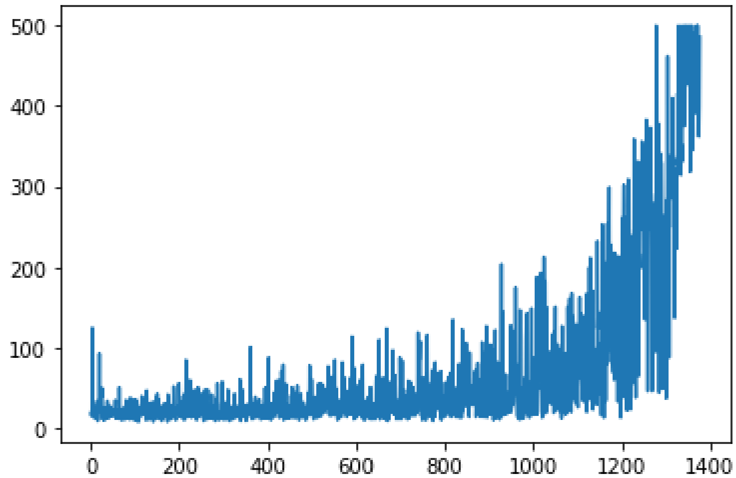
In [0]:

```
# play the game and train the network
np.set_printoptions(threshold=np.inf)
episode_length_set = []
tf.reset_default_graph()
total_time_steps = 100000

RL = DQN(actions_num = 2, gamma = 0.99,
         state_size = 4, epsilon_start = 1,
         learning_rate = 1e-3, epsilon_min = 0.01,
         replace_target_iter = 100, memory_size = 5000,
         epsilon_increment = 0.00001,)

new_state = env.reset()
done = False
episode_length_counter = 0
for step in range(total_time_steps):
  ##########################
  # YOUR CODE STARTS HERE
  action = RL.choose_action(new_state)
  next_state, reward, done,_ = env.step(action)
  RL.store_transition(new_state, action, reward, next_state, done)
  if done:
      new_state = env.reset()
      episode_length_set.append(episode_length_counter)
      episode_length_counter =0
  else:
      new_state = next_state

  # YOUR CODE ENDS HERE
  ##########################
  #print(step)
  if step > 200:
    RL.learn()
  episode_length_counter += 1
  if episode_length_counter == 500:
    print('we hit 500')
    RL.store()
```

```
we hit 500
we hit 500
we hit 500
we hit 500
we hit 500
we hit 500
we hit 500
we hit 500
we hit 500
```

In [0]:
```
from matplotlib import pyplot as plt
plt.plot(episode_length_set)
```

Out[146]: [<matplotlib.lines.Line2D at 0x7f5fc28c7978>]



In [0]:

```
# test our network
tf.reset_default_graph()
RL = DQN(actions_num = 2, gamma = 1,
         state_size = 4, epsilon_start = 1,
         learning_rate = 1e-3, epsilon_min = 0,
         replace_target_iter = 100, memory_size = 5000,
         epsilon_increment = None,)
# load saved parameters
RL.restore()
# run 100 trails and print how long can the agent hold the cart pole f
length_counter = []
for i in range(100):
  ###########################
  # YOUR CODE STARTS HERE
  new_state = env.reset()
  episode_length = 0
  done = False
  while not done:
    action = RL.choose_action(new_state)
    next_state, reward, done,_ = env.step(action)
    RL.store_transition(new_state, action, reward, next_state, done)
    episode_length += 1
    if done:
        new_state = env.reset()
        length_counter.append(episode_length)
    else:
        new_state = next_state

  # YOUR CODE ENDS HERE
  ###########################

```

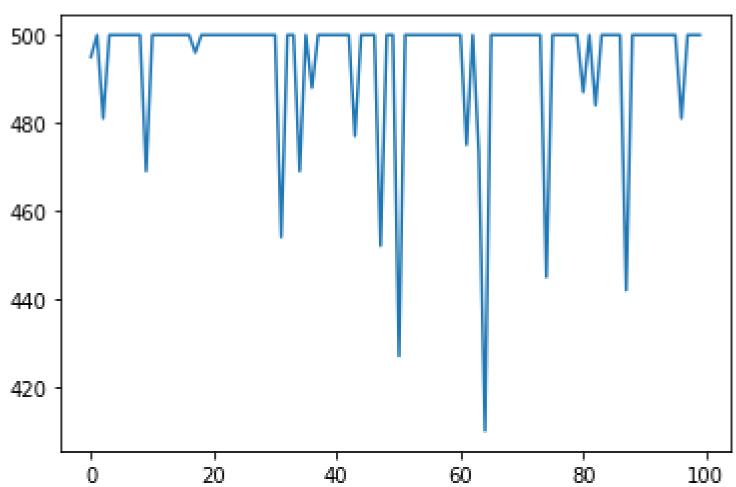
```
INFO:tensorflow:Restoring parameters from ./weights/DQN_model.ckpt
```

In [0]:

```
plt.plot(length_counter)
```

Out[148]:

```
[<matplotlib.lines.Line2D at 0x7f5fc1533a20>]
```



In [0]:
```
print(length_counter)
```

```
[495, 500, 481, 500, 500, 500, 500, 500, 500, 469, 500, 500, 500, 500, 50
0, 500, 500, 496, 500, 500, 500, 500, 500, 500, 500, 500, 500, 500, 500,
500, 500, 454, 500, 500, 469, 500, 488, 500, 500, 500, 500, 500, 500, 47
7, 500, 500, 500, 452, 500, 500, 427, 500, 500, 500, 500, 500, 500, 500,
500, 500, 500, 475, 500, 473, 410, 500, 500, 500, 500, 500, 500, 500, 50
0, 500, 445, 500, 500, 500, 500, 500, 487, 500, 484, 500, 500, 500, 500,
442, 500, 500, 500, 500, 500, 500, 500, 500, 481, 500, 500, 500]
```

You may find that the episode length doesn't stably improve as more training time is given. You can read chapter 3.2 of this paper [https://arxiv.org/pdf/1711.07478.pdf (https://arxiv.org/pdf/1711.07478.pdf)](https://arxiv.org/pdf/1711.07478.pdf) if you are interested.