ELEN_6885_HW4_Part_4

November 25, 2019

#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.

[1]:
```
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
```

```python
      self.batch_size = batch_size
      self.epsilon_increment = epsilon_increment
      self.epsilon = epsilon_start if epsilon_increment is not None else self.epsilon_min
      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, q_params)]

      # gpu setting
      config = tf.ConfigProto(log_device_placement=False, allow_soft_placement=True)
      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], name='state')
    self.q_target = tf.placeholder(tf.float32, [None, self.actions_num], name='Q_target')
    with tf.variable_scope('q_net'):
      # c_names(collections_names) are the collections to store variables
      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_initializer(0.1)

      # layer 1
      with tf.variable_scope('layer_1'):
        w_layer_1 = tf.get_variable('w_layer_1', [self.state_size, neurons_layer_1], initializer=w_initializer, collections=c_names)
        b_layer_1 = tf.get_variable('b_layer_1', [1, neurons_layer_1], initializer=b_initializer, collections=c_names)
```

```python
        layer_1 = tf.nn.relu(tf.matmul(self.state, w_layer_1) + b_layer_1)

      # layer 2
      with tf.variable_scope('layer_2'):
        w_layer_2 = tf.get_variable('w_layer_2', [neurons_layer_1, self.actions_num], initializer=w_initializer, collections=c_names)
        b_layer_2 = tf.get_variable('b_layer_2', [1, self.actions_num], initializer=b_initializer, collections=c_names)
        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, self.q_value))
    with tf.variable_scope('train'):
      self._train_op = tf.train.AdamOptimizer(self.lr).minimize(self.loss)

    # build target_net
    self.state_t = tf.placeholder(tf.float32, [None, self.state_size], name='state_t')    # input
    with tf.variable_scope('target_net'):
      # c_names(collections_names) are the collections to store variables
      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, neurons_layer_1], initializer=w_initializer, collections=c_names)
        b_layer_1 = tf.get_variable('b_layer_1', [1, neurons_layer_1], initializer=b_initializer, collections=c_names)
        layer_1 = tf.nn.relu(tf.matmul(self.state_t, w_layer_1) + b_layer_1)

      # layer 2

      ############################
      # YOUR CODE STARTS HERE

      with tf.variable_scope('layer_2'):
        w_layer_2 = tf.get_variable('w_layer_2', [neurons_layer_1, self.actions_num], initializer=w_initializer, collections=c_names)
        b_layer_2 = tf.get_variable('b_layer_2', [1, self.actions_num], initializer=b_initializer, collections=c_names)
        self.q_next = tf.matmul(layer_1, w_layer_2) + b_layer_2

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

```python
  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.state: observation})
      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.batch_size)
    else:
      sample_index = np.random.choice(self.memory_counter, size=self.batch_size)
    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],  # fixed params
        self.state: batch_memory[:, :self.state_size],  # newest params
      })

    # calculate q_target
    q_target = q_value.copy()

    # only change the action-values of this batch, because we only calculate loss on the batch observations
```

```
    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

    for batch in batch_index:
      q_target[batch, act_index[batch]] = reward[batch] + (0 if done[batch]␣
↪else (self.gamma * np.max(q_next[batch,:],axis=0)))

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

    # train q_net
    _, self.cost = self.sess.run([self._train_op, self.loss],
                                 feed_dict={self.state: batch_memory[:, :self.
↪state_size],
                                            self.q_target: q_target})
    # change epsilon
    self.epsilon = self.epsilon - self.epsilon_increment if self.epsilon > self.
↪epsilon_min else self.epsilon_min
    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)
```

[2]:
```
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([ 0.01000824,  0.2117136 ,  0.02151308, -0.25150414]), 1.0, False, {})
```

[3]:
```python
# 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

    if done:
        done = False
        new_state = env.reset()
        episode_length_set.append(episode_length_counter)
        print(step,episode_length_counter)
        episode_length_counter = 0
        continue
    else:
        # take action
        action = RL.choose_action(new_state)
        old_state = new_state
        new_state, reward, done, info = env.step(action)
        RL.store_transition(old_state, action, reward, new_state, done)

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

    if step > 200:
        RL.learn()
    episode_length_counter += 1
    if episode_length_counter == 500:
        RL.store()
# RL.store()
```

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29 29
44 14
89 44
119 29
```

148 28
160 11
177 16
189 11
203 13
219 15
234 14
300 65
343 42
368 24
381 12
394 12
416 21
428 11
440 11
455 14
478 22
493 14
505 11
537 31
561 23
574 12
596 21
610 13
626 15
643 16
671 27
698 26
716 17
729 12
745 15
760 14
777 16
797 19
812 14
828 15
866 37
897 30
910 12
928 17
938 9
949 10
968 18
985 16
1003 17
1016 12
1039 22
1057 17

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1739	21
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1828	42
1843	14
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1980	13
1997	16
2008	10
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2261	12
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4922	27
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4969	14
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24461	17
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24552	56
24592	39
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24661	46
24672	10
24743	70
24794	50
24832	37
24876	43
24898	21
24956	57
25007	50
25020	12
25043	22
25073	29
25097	23
25140	42
25191	50
25220	28
25255	34
25307	51
25340	32
25375	34
25395	19
25468	72
25529	60
25558	28
25582	23
25596	13
25613	16
25631	17
25655	23
25673	17

25717	43
25756	38
25820	63
25847	26
25979	131
25999	19
26035	35
26075	39
26142	66
26212	69
26259	46
26342	82
26384	41
26500	115
26615	114
26628	12
26681	52
26728	46
26753	24
26882	128
26954	71
26981	26
26994	12
27007	12
27075	67
27101	25
27134	32
27173	38
27245	71
27303	57
27433	129
27605	171
27691	85
27709	17
27727	17
27744	16
27814	69
27841	26
27863	21
27945	81
27961	15
28008	46
28061	52
28079	17
28090	10
28104	13
28166	61
28195	28

28212	16
28251	38
28262	10
28296	33
28330	33
28408	77
28427	18
28464	36
28570	105
28614	43
28751	136
28834	82
28924	89
28971	46
29061	89
29081	19
29103	21
29207	103
29228	20
29355	126
29382	26
29450	67
29525	74
29671	145
29822	150
29877	54
29966	88
30005	38
30027	21
30173	145
30269	95
30353	83
30433	79
30498	64
30513	14
30534	20
30553	18
30585	31
30609	23
30634	24
30739	104
30768	28
30804	35
30893	88
30981	87
31127	145
31203	75
31356	152

31425	68
31524	98
31543	18
31564	20
31661	96
31764	102
31832	67
31909	76
31928	18
32029	100
32048	18
32080	31
32172	91
32214	41
32229	14
32271	41
32418	146
32583	164
32608	24
32652	43
32691	38
32704	12
32748	43
32881	132
32995	113
33148	152
33248	99
33272	23
33328	55
33353	24
33510	156
33528	17
33713	184
33844	130
33867	22
33932	64
34074	141
34105	30
34127	21
34212	84
34282	69
34422	139
34551	128
34596	44
34658	61
34762	103
34826	63
34916	89

34992	75
35018	25
35158	139
35295	136
35344	48
35357	12
35457	99
35531	73
35631	99
35769	137
35866	96
35962	95
36104	141
36169	64
36243	73
36311	67
36373	61
36482	108
36613	130
36688	74
36713	24
36831	117
36904	72
36957	52
37008	50
37120	111
37169	48
37196	26
37236	39
37369	132
37451	81
37475	23
37503	27
37577	73
37646	68
37736	89
37795	58
37826	30
37870	43
37934	63
38011	76
38131	119
38182	50
38254	71
38312	57
38342	29
38368	25
38554	185

38805	250
38945	139
38999	53
39041	41
39086	44
39117	30
39143	25
39164	20
39201	36
39310	108
39420	109
39511	90
39667	155
39779	111
39821	41
39985	163
40011	25
40164	152
40350	185
40459	108
40632	172
40688	55
40884	195
40906	21
40925	18
41040	114
41074	33
41128	53
41209	80
41418	208
41543	124
41704	160
41733	28
41800	66
41881	80
41934	52
41957	22
42021	63
42047	25
42071	23
42132	60
42235	102
42438	202
42485	46
42596	110
42641	44
42755	113
42916	160

43058	141
43236	177
43305	68
43409	103
43423	13
43476	52
43576	99
43630	53
43854	223
43954	99
43985	30
44038	52
44104	65
44277	172
44321	43
44429	107
44682	252
44707	24
44730	22
44751	20
44890	138
45030	139
45112	81
45132	19
45261	128
45493	231
45512	18
45727	214
45899	171
45945	45
46148	202
46354	205
46400	45
46501	100
46515	13
46662	146
46807	144
46940	132
47124	183
47267	142
47369	101
47560	190
47612	51
47641	28
47734	92
47887	152
47937	49
48083	145

48234	150
48398	163
48695	296
48904	208
49053	148
49261	207
49325	63
49667	341
49784	116
49876	91
49962	85
50128	165
50210	81
50324	113
50442	117
50470	27
50661	190
50781	119
50864	82
50918	53
51143	224
51335	191
51365	29
51513	147
51796	282
51929	132
52194	264
52287	92
52334	46
52708	373
52973	264
53196	222
53429	232
53830	400
53982	151
54030	47
54383	352
54687	303
54753	65
55179	425
55250	70
55415	164
55647	231
55855	207
56061	205
56286	224
56606	319
56912	305

57413	500
57694	280
57932	237
58389	456
58582	192
58646	63
58920	273
59338	417
59768	429
60269	500
60334	64
60693	358
61062	368
61144	81
61279	134
61349	69
61620	270
62121	500
62228	106
62727	498
63085	357
63360	274
63575	214
63857	281
64358	500
64516	157
64880	363
64917	36
65092	174
65536	443
65850	313
65914	63
66415	500
66757	341
67006	248
67164	157
67391	226
67644	252
67830	185
68094	263
68295	200
68526	230
68727	200
68891	163
69086	194
69334	247
69556	221
69786	229

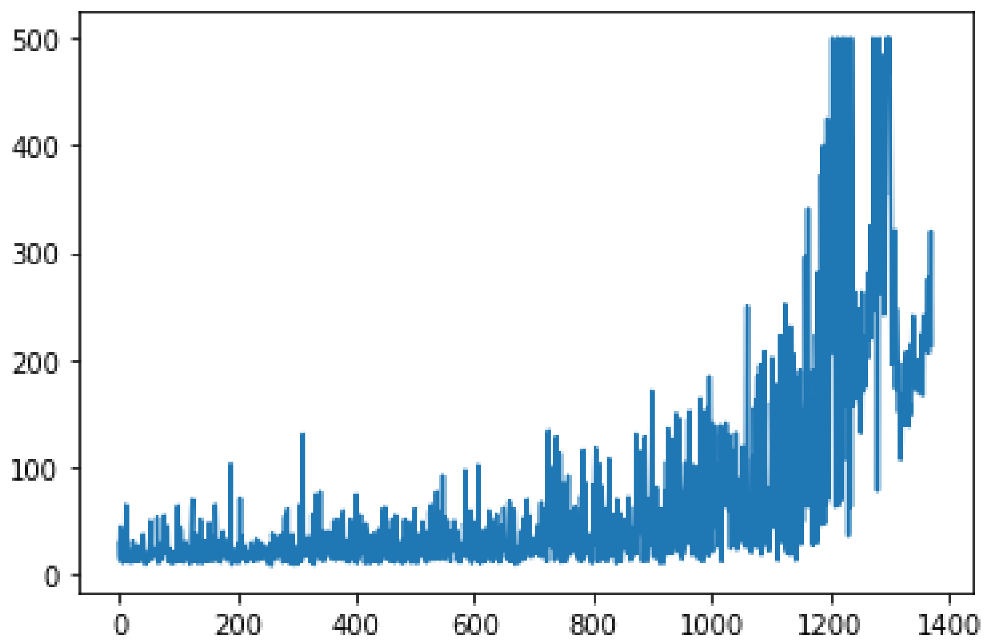
69919	132
70101	181
70365	263
70536	170
70720	183
70903	182
71109	205
71310	200
71486	175
71676	189
71900	223
72102	201
72384	281
72635	250
72912	276
73144	231
73470	325
73691	220
73953	261
74250	296
74496	245
74997	500
75267	269
75596	328
75887	290
76289	401
76715	425
77184	468
77263	78
77661	397
78066	404
78567	500
78873	305
79249	375
79735	485
80133	397
80395	261
80722	326
81088	365
81331	242
81641	309
81998	356
82354	355
82830	475
83331	500
83832	500
84301	468
84802	500

85303	500
85804	500
86221	416
86544	322
86741	196
86947	205
87186	238
87387	200
87674	286
87899	224
88221	321
88395	173
88644	248
88871	226
89070	198
89262	191
89414	151
89612	197
89778	165
89886	107
90012	125
90181	168
90321	139
90484	162
90631	146
90771	139
90932	160
91089	156
91291	201
91500	208
91666	165
91868	201
92021	152
92160	138
92319	158
92468	148
92619	150
92777	157
92993	215
93184	190
93426	241
93607	180
93815	207
93991	175
94172	180
94374	201
94548	173
94719	170

```
94890 170
95070 179
95245 174
95426 180
95615 188
95792 176
95993 200
96218 224
96386 167
96605 218
96847 241
97063 215
97282 218
97491 208
97718 226
97935 216
98165 229
98442 276
98649 206
98881 231
99143 261
99393 249
99714 320
99929 214
```

[5]:
```python
from matplotlib import pyplot as plt
plt.plot(episode_length_set)
```

[5]:
```
[<matplotlib.lines.Line2D at 0x639194a10>]
```



[6]:
```
# 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 for each␣
 ↪trail
for i in range(100):
  ############################
  # YOUR CODE STARTS HERE

  RL.epsilon = 0
  new_state = env.reset()
  done = False
  episode_length_counter = 0
  for step in range(500):
    if(done):
      print(step, episode_length_counter)
      break
    action = RL.choose_action(new_state)
    new_state, reward, done, info = env.step(action)
    episode_length_counter += 1
```

```
    if(episode_length_counter == 500):
      print(step, episode_length_counter)

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

```
INFO:tensorflow:Restoring parameters from ./weights/DQN_model.ckpt
499 500
499 500
499 500
491 491
499 500
424 424
499 500
499 500
499 500
499 500
499 500
499 500
436 436
499 500
499 500
499 500
499 500
416 416
499 500
499 500
370 370
424 424
499 500
499 500
499 500
447 447
499 500
499 500
499 500
499 500
394 394
374 374
499 500
499 500
435 435
499 500
499 500
499 500
499 500
```

499	500
499	500
457	457
499	500
499	500
499	500
499	500
411	411
499	500
499	500
499	500
499	500
499	500
499	500
499	500
499	500
499	500
499	500
499	500
499	500
499	500
499	500
499	500
499	500
499	500
446	446
499	500
499	500
499	500
499	500
499	500
499	500
499	500
499	500
475	475
499	500
499	500
420	420
499	500
499	500
499	500
499	500
499	500
499	500
499	500
499	500
499	500
499	500

```
499 500
499 500
499 500
465 465
499 500
499 500
499 500
499 500
382 382
483 483
499 500
432 432
499 500
```

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 if you are interested.