```
In [4]:
```
```python
from google.colab import drive
drive.mount('/content/drive')
```
```
Mounted at /content/drive
```

```
In [ ]:
```
```python
%cd drive/My\ Drive/Pong
```
```
/content/drive/My Drive/Pong
```

```
In [ ]:
```
```python
#Training DQN for pong

import gym
import numpy as np
from dqn import *
from utils import plot_learning_curve, make_env
from gym import wrappers



if __name__ == '__main__':
    env = make_env('PongNoFrameskip-v4')
    best_score = -np.inf
    load_checkpoint = True
    n_games = 500


    agent = DQN(states=env.observation_space, actions=env.action_space.n,alpha=0.0001,ga
mma=0.99,epsilon=1,
                epsilon_min=0.1,epsilon_decay=1e-5,replay_buffer_sz=10000,batch=32,path
= 'atari_model_eval.txt',
                path_pred = 'atari_model_target.txt')


    if load_checkpoint:
        agent.load_models()

    figure_file = 'plots/pong1.png'
    # if you want to record video of your agent playing, do a mkdir tmp && mkdir tmp/dqn-
video
    # and uncomment the following 2 lines.
    #env = wrappers.Monitor(env, "tmp/dqn-video",
    #                   video_callable=lambda episode_id: True, force=True)
    n_steps = 0
    scores, eps_history, steps_array = [], [], []

    count = 0
    for i in range(n_games):
        done = False
        observation = env.reset()

        score = 0
        while not done:
            action = agent.e_greedy_policy(observation)
            observation_, reward, done, info = env.step(action)
            score += reward

            count += 1
            if not load_checkpoint:
                agent.store(observation, action,
                                    reward, observation_, done)
                agent.learn()
```

```python
                observation = observation_
                n_steps += 1
            scores.append(score)
            steps_array.append(n_steps)

            avg_score = np.mean(scores[-100:])
            print('episode: ', i,'score: ', score,
                  ' average score %.1f' % avg_score, 'best score %.2f' % best_score,
                  'epsilon %.2f' % agent.epsilon, 'steps', n_steps)

            if avg_score > best_score:
                if not load_checkpoint:
                    agent.save_models()
                best_score = avg_score

            eps_history.append(agent.epsilon)

        x = [i+1 for i in range(len(scores))]
        plot_learning_curve(steps_array, scores, eps_history, figure_file)
```

```
episode:  0 score:  -20.0  average score -20.0 best score -inf epsilon 0.99 steps 1019
saving checkpoint
saving checkpoint
episode:  1 score:  -20.0  average score -20.0 best score -20.00 epsilon 0.98 steps 1938
episode:  2 score:  -21.0  average score -20.3 best score -20.00 epsilon 0.97 steps 2882
episode:  3 score:  -20.0  average score -20.2 best score -20.00 epsilon 0.96 steps 3875
episode:  4 score:  -21.0  average score -20.4 best score -20.00 epsilon 0.95 steps 4762
episode:  5 score:  -20.0  average score -20.3 best score -20.00 epsilon 0.94 steps 5709
episode:  6 score:  -21.0  average score -20.4 best score -20.00 epsilon 0.94 steps 6529
episode:  7 score:  -18.0  average score -20.1 best score -20.00 epsilon 0.92 steps 7785
episode:  8 score:  -21.0  average score -20.2 best score -20.00 epsilon 0.91 steps 8756
episode:  9 score:  -21.0  average score -20.3 best score -20.00 epsilon 0.90 steps 9550
episode:  10 score:  -21.0  average score -20.4 best score -20.00 epsilon 0.90 steps 1037
5
episode:  11 score:  -21.0  average score -20.4 best score -20.00 epsilon 0.89 steps 1122
7
episode:  12 score:  -19.0  average score -20.3 best score -20.00 epsilon 0.88 steps 1234
3
episode:  13 score:  -18.0  average score -20.1 best score -20.00 epsilon 0.87 steps 1347
6
episode:  14 score:  -20.0  average score -20.1 best score -20.00 epsilon 0.86 steps 1439
7
episode:  15 score:  -18.0  average score -20.0 best score -20.00 epsilon 0.84 steps 1568
4
episode:  16 score:  -21.0  average score -20.1 best score -20.00 epsilon 0.83 steps 1656
8
episode:  17 score:  -19.0  average score -20.0 best score -20.00 epsilon 0.82 steps 1764
6
episode:  18 score:  -21.0  average score -20.1 best score -20.00 epsilon 0.82 steps 1847
0
episode:  19 score:  -20.0  average score -20.1 best score -20.00 epsilon 0.81 steps 1935
9
episode:  20 score:  -21.0  average score -20.1 best score -20.00 epsilon 0.80 steps 2023
1
episode:  21 score:  -19.0  average score -20.0 best score -20.00 epsilon 0.79 steps 2129
9
episode:  22 score:  -21.0  average score -20.1 best score -20.00 epsilon 0.78 steps 2214
4
episode:  23 score:  -21.0  average score -20.1 best score -20.00 epsilon 0.77 steps 2302
5
episode:  24 oscore:  -21.0  oaverage score -20.2 best score -20.00 epsilon 0.76 steps 2402
0
episode:  25 score:  -21.0  average score -20.2 best score -20.00 epsilon 0.75 steps 2511
4
episode:  26 score:  -19.0  average score -20.1 best score -20.00 epsilon 0.74 steps 2623
1
episode:  27 score:  -20.0  avarage score -20.1 best score -20.00 epsilon 0.73 steps 2737
4
episode:  28 score:  -19.0  average score -20.1 best score -20.00 epsilon 0.72 steps 2848
1
episode:  29 score:  -21.0  average score -20.1 best score -20.00 epsilon 0.71 steps 2930
3
```

```
episode:  30 score:  -20.0  average score -20.1 best score -20.00 epsilon 0.70 steps 3032
8
episode:  31 score:  -18.0  average score -20.1 best score -20.00 epsilon 0.69 steps 3148
5
episode:  32 score:  -20.0  average score -20.1 best score -20.00 epsilon 0.67 steps 3265
3
episode:  33 score:  -19.0  average score -20.0 best score -20.00 epsilon 0.66 steps 3394
6
episode:  34 score:  -18.0  average score -20.0 best score -20.00 epsilon 0.65 steps 3518
6
saving checkpoint
saving checkpoint
episode:  35 score:  -21.0  average score -20.0 best score -19.97 epsilon 0.64 steps 3631
3
episode:  36 score:  -18.0  average score -19.9 best score -19.97 epsilon 0.63 steps 3752
9
saving checkpoint
saving checkpoint
episode:  37 score:  -18.0  average score -19.9 best score -19.95 epsilon 0.61 steps 3881
3
saving checkpoint
saving checkpoint
episode:  38 score:  -20.0  average score -19.9 best score -19.89 epsilon 0.60 steps 3989
9
episode:  39 score:  -21.0  average score -19.9 best score -19.89 epsilon 0.59 steps 4132
0
episode:  40 score:  -21.0  average score -20.0 best score -19.89 epsilon 0.57 steps 4255
5
episode:  41 score:  -19.0  average score -19.9 best score -19.89 epsilon 0.56 steps 4396
9
episode:  42 score:  -18.0  average score -19.9 best score -19.89 epsilon 0.55 steps 4525
2
saving checkpoint
saving checkpoint
episode:  43 score:  -21.0  average score -19.9 best score -19.88 epsilon 0.54 steps 4651
9
episode:  44 score:  -18.0  average score -19.9 best score -19.88 epsilon 0.52 steps 4786
9
saving checkpoint
saving checkpoint
episode:  45 score:  -20.0  average score -19.9 best score -19.87 epsilon 0.51 steps 4929
4
episode:  46 score:  -17.0  average score -19.8 best score -19.87 epsilon 0.49 steps 5109
8
saving checkpoint
saving checkpoint
episode:  47 score:  -15.0  average score -19.7 best score -19.81 epsilon 0.47 steps 5300
9
saving checkpoint
saving checkpoint
episode:  48 score:  -18.0  average score -19.7 best score -19.71 epsilon 0.45 steps 5466
2
saving checkpoint
saving checkpoint
episode:  49 score:  -18.0  average score -19.6 best score -19.67 epsilon 0.44 steps 5623
4
saving checkpoint
saving checkpoint
episode:  50 score:  -12.0  average score -19.5 best score -19.64 epsilon 0.42 steps 5846
6
saving checkpoint
saving checkpoint
episode:  51 score:  -18.0  average score -19.5 best score -19.49 epsilon 0.40 steps 6005
0
saving checkpoint
saving checkpoint
episode:  52 score:  -15.0  average score -19.4 best score -19.46 epsilon 0.38 steps 6167
1
saving checkpoint
saving checkpoint
episode:  53 score:  -17.0  average score -19.3 best score -19.38 epsilon 0.37 steps 6328
8
```

```
saving checkpoint
saving checkpoint
episode:  54 score:  -17.0  average score -19.3 best score -19.33 epsilon 0.35 steps 6504
0
saving checkpoint
saving checkpoint
episode:  55 score:  -20.0  average score -19.3 best score -19.29 epsilon 0.34 steps 6628
4
episode:  56 score:  -20.0  average score -19.3 best score -19.29 epsilon 0.32 steps 6803
9
episode:  57 score:  -16.0  average score -19.3 best score -19.29 epsilon 0.30 steps 6979
4
saving checkpoint
saving checkpoint
episode:  58 score:  -20.0  average score -19.3 best score -19.26 epsilon 0.29 steps 7092
3
episode:  59 score:  -16.0  average score -19.2 best score -19.26 epsilon 0.27 steps 7277
0
saving checkpoint
saving checkpoint
episode:  60 score:  -19.0  average score -19.2 best score -19.22 epsilon 0.26 steps 7433
4
saving checkpoint
saving checkpoint
episode:  61 score:  -17.0  average score -19.2 best score -19.21 epsilon 0.24 steps 7596
0
saving checkpoint
saving checkpoint
episode:  62 score:  -15.0  average score -19.1 best score -19.18 epsilon 0.22 steps 7828
5
saving checkpoint
saving checkpoint
episode:  63 score:  -13.0  average score -19.0 best score -19.11 epsilon 0.20 steps 8014
9
saving checkpoint
saving checkpoint
episode:  64 score:  -14.0  average score -18.9 best score -19.02 epsilon 0.18 steps 8227
2
saving checkpoint
saving checkpoint
episode:  65 score:  -11.0  average score -18.8 best score -18.94 epsilon 0.16 steps 8432
8
saving checkpoint
saving checkpoint
episode:  66 score:  -19.0  average score -18.8 best score -18.82 epsilon 0.14 steps 8602
8
episode:  67 score:  -18.0  average score -18.8 best score -18.82 epsilon 0.12 steps 8790
7
saving checkpoint
saving checkpoint
episode:  68 score:  -12.0  average score -18.7 best score -18.81 epsilon 0.10 steps 9019
4
saving checkpoint
saving checkpoint
episode:  69 score:  -17.0  average score -18.7 best score -18.71 epsilon 0.10 steps 9204
3
saving checkpoint
saving checkpoint
episode:  70 score:  -17.0  average score -18.7 best score -18.69 epsilon 0.10 steps 9419
6
saving checkpoint
saving checkpoint
episode:  71 score:  -15.0  average score -18.6 best score -18.66 epsilon 0.10 steps 9639
1
saving checkpoint
saving checkpoint
episode:  72 score:  -17.0  average score -18.6 best score -18.61 epsilon 0.10 steps 9849
3
saving checkpoint
saving checkpoint
episode:  73 score:  -15.0  average score -18.5 best score -18.59 epsilon 0.10 steps 1007
27
```

```
saving checkpoint
saving checkpoint
episode:  74 score:   -17.0   average score -18.5 best score -18.54 epsilon 0.10 steps 1031
06
saving checkpoint
saving checkpoint
episode:  75 score:   -19.0   average score -18.5 best score -18.52 epsilon 0.10 steps 1046
44
episode:  76 score:   -14.0   average score -18.5 best score -18.52 epsilon 0.10 steps 1070
14
saving checkpoint
saving checkpoint
episode:  77 score:   -13.0   average score -18.4 best score -18.47 epsilon 0.10 steps 1091
59
saving checkpoint
saving checkpoint
episode:  78 score:   -9.0   average score -18.3 best score -18.40 epsilon 0.10 steps 11181
0
saving checkpoint
saving checkpoint
episode:  79 score:   -10.0   average score -18.2 best score -18.28 epsilon 0.10 steps 1143
02
saving checkpoint
saving checkpoint
episode:  80 score:   -10.0   average score -18.1 best score -18.18 epsilon 0.10 steps 1166
52
saving checkpoint
saving checkpoint
episode:  81 score:   -13.0   average score -18.0 best score -18.07 epsilon 0.10 steps 1189
62
saving checkpoint
saving checkpoint
episode:  82 score:   -15.0   average score -18.0 best score -18.01 epsilon 0.10 steps 1212
44
saving checkpoint
saving checkpoint
episode:  83 score:   -9.0   average score -17.9 best score -17.98 epsilon 0.10 steps 12360
2
saving checkpoint
saving checkpoint
episode:  84 score:   -10.0   average score -17.8 best score -17.87 epsilon 0.10 steps 1262
31
saving checkpoint
saving checkpoint
episode:  85 score:   -8.0   average score -17.7 best score -17.78 epsilon 0.10 steps 12903
5
saving checkpoint
saving checkpoint
episode:  86 score:   -14.0   average score -17.6 best score -17.66 epsilon 0.10 steps 1310
91
saving checkpoint
saving checkpoint
episode:  87 score:   -13.0   average score -17.6 best score -17.62 epsilon 0.10 steps 1331
50
saving checkpoint
saving checkpoint
episode:  88 score:   -14.0   average score -17.5 best score -17.57 epsilon 0.10 steps 1354
73
saving checkpoint
saving checkpoint
episode:  89 score:   -9.0   average score -17.4 best score -17.53 epsilon 0.10 steps 13856
8
saving checkpoint
saving checkpoint
episode:  90 score:   -8.0   average score -17.3 best score -17.43 epsilon 0.10 steps 14128
3
saving checkpoint
saving checkpoint
episode:  91 score:   -5.0   average score -17.2 best score -17.33 epsilon 0.10 steps 14434
0
saving checkpoint
saving checkpoint
```

```
episode:  92 score:  -12.0   average score -17.1 best score -17.20 epsilon 0.10 steps 1465
36
saving checkpoint
saving checkpoint
episode:  93 score:  -12.0   average score -17.1 best score -17.14 epsilon 0.10 steps 1487
69
saving checkpoint
saving checkpoint
episode:  94 score:  -8.0   average score -17.0 best score -17.09 epsilon 0.10 steps 15130
5
saving checkpoint
saving checkpoint
episode:  95 score:  -8.0   average score -16.9 best score -16.99 epsilon 0.10 steps 15387
5
saving checkpoint
saving checkpoint
episode:  96 score:  -10.0   average score -16.8 best score -16.90 epsilon 0.10 steps 1562
58
saving checkpoint
saving checkpoint
episode:  97 score:  -9.0   average score -16.7 best score -16.82 epsilon 0.10 steps 15856
4
saving checkpoint
saving checkpoint
episode:  98 score:  -3.0   average score -16.6 best score -16.74 epsilon 0.10 steps 16153
9
saving checkpoint
saving checkpoint
episode:  99 score:  -3.0   average score -16.5 best score -16.61 epsilon 0.10 steps 16453
2
saving checkpoint
saving checkpoint
episode:  100 score:  -10.0   average score -16.4 best score -16.47 epsilon 0.10 steps 167
005
saving checkpoint
saving checkpoint
episode:  101 score:  -5.0   average score -16.2 best score -16.37 epsilon 0.10 steps 1697
33
saving checkpoint
saving checkpoint
episode:  102 score:  -6.0   average score -16.1 best score -16.22 epsilon 0.10 steps 1727
99
saving checkpoint
saving checkpoint
episode:  103 score:  -7.0   average score -15.9 best score -16.07 epsilon 0.10 steps 1757
29
saving checkpoint
saving checkpoint
episode:  104 score:  2.0   average score -15.7 best score -15.94 epsilon 0.10 steps 17907
3
saving checkpoint
saving checkpoint
episode:  105 score:  -7.0   average score -15.6 best score -15.71 epsilon 0.10 steps 1818
64
saving checkpoint
saving checkpoint
episode:  106 score:  -7.0   average score -15.4 best score -15.58 epsilon 0.10 steps 1848
58
saving checkpoint
saving checkpoint
episode:  107 score:  -4.0   average score -15.3 best score -15.44 epsilon 0.10 steps 1878
35
saving checkpoint
saving checkpoint
episode:  108 score:  -6.0   average score -15.2 best score -15.30 epsilon 0.10 steps 1907
74
saving checkpoint
saving checkpoint
episode:  109 score:  -8.0   average score -15.0 best score -15.15 epsilon 0.10 steps 1932
79
saving checkpoint
saving checkpoint
```

```
episode:  110 score:  -8.0  average score -14.9 best score -15.02 epsilon 0.10 steps 1957
82
saving checkpoint
saving checkpoint
episode:  111 score:  -2.0  average score -14.7 best score -14.89 epsilon 0.10 steps 1989
34
saving checkpoint
saving checkpoint
episode:  112 score:  -8.0  average score -14.6 best score -14.70 epsilon 0.10 steps 2014
00
saving checkpoint
saving checkpoint
episode:  113 score:  -8.0  average score -14.5 best score -14.59 epsilon 0.10 steps 2038
96
saving checkpoint
saving checkpoint
episode:  114 score:  -3.0  average score -14.3 best score -14.49 epsilon 0.10 steps 2068
57
saving checkpoint
saving checkpoint
episode:  115 score:  -8.0  average score -14.2 best score -14.32 epsilon 0.10 steps 2094
24
saving checkpoint
saving checkpoint
episode:  116 score:  -4.0  average score -14.1 best score -14.22 epsilon 0.10 steps 2123
82
saving checkpoint
saving checkpoint
episode:  117 score:  -1.0  average score -13.9 best score -14.05 epsilon 0.10 steps 2157
30
saving checkpoint
saving checkpoint
episode:  118 score:  1.0  average score -13.7 best score -13.87 epsilon 0.10 steps 21871
4
saving checkpoint
saving checkpoint
episode:  119 score:  -2.0  average score -13.5 best score -13.65 epsilon 0.10 steps 2217
34
saving checkpoint
saving checkpoint
episode:  120 score:  -8.0  average score -13.3 best score -13.47 epsilon 0.10 steps 2244
02
saving checkpoint
saving checkpoint
episode:  121 score:  -9.0  average score -13.2 best score -13.34 epsilon 0.10 steps 2266
41
saving checkpoint
saving checkpoint
episode:  122 score:  -5.0  average score -13.1 best score -13.24 epsilon 0.10 steps 2293
21
saving checkpoint
saving checkpoint
episode:  123 score:  4.0  average score -12.8 best score -13.08 epsilon 0.10 steps 23205
3
saving checkpoint
saving checkpoint
episode:  124 score:  8.0  average score -12.5 best score -12.83 epsilon 0.10 steps 23475
5
saving checkpoint
saving checkpoint
episode:  125 score:  1.0  average score -12.3 best score -12.54 epsilon 0.10 steps 23825
8
saving checkpoint
saving checkpoint
episode:  126 score:  -1.0  average score -12.1 best score -12.32 epsilon 0.10 steps 2415
74
saving checkpoint
saving checkpoint
episode:  127 score:  1.0  average score -11.9 best score -12.14 epsilon 0.10 steps 24472
1
saving checkpoint
saving checkpoint
```

```
episode:  128 score:  -7.0  average score -11.8 best score -11.93 epsilon 0.10 steps 2472
72
saving checkpoint
saving checkpoint
episode:  129 score:  3.0  average score -11.6 best score -11.81 epsilon 0.10 steps 25008
3
saving checkpoint
saving checkpoint
episode:  130 score:  3.0  average score -11.3 best score -11.57 epsilon 0.10 steps 25300
5
saving checkpoint
saving checkpoint
episode:  131 score:  -3.0  average score -11.2 best score -11.34 epsilon 0.10 steps 2559
34
saving checkpoint
saving checkpoint
episode:  132 score:  3.0  average score -11.0 best score -11.19 epsilon 0.10 steps 25877
4
saving checkpoint
saving checkpoint
episode:  133 score:  -4.0  average score -10.8 best score -10.96 epsilon 0.10 steps 2615
08
saving checkpoint
saving checkpoint
episode:  134 score:  1.0  average score -10.6 best score -10.81 epsilon 0.10 steps 26440
9
saving checkpoint
saving checkpoint
episode:  135 score:  11.0  average score -10.3 best score -10.62 epsilon 0.10 steps 2667
45
saving checkpoint
saving checkpoint
episode:  136 score:  3.0  average score -10.1 best score -10.30 epsilon 0.10 steps 26955
4
saving checkpoint
saving checkpoint
episode:  137 score:  -5.0  average score -10.0 best score -10.09 epsilon 0.10 steps 2723
21
saving checkpoint
saving checkpoint
episode:  138 score:  -4.0  average score -9.8 best score -9.96 epsilon 0.10 steps 275220
saving checkpoint
saving checkpoint
episode:  139 score:  8.0  average score -9.5 best score -9.80 epsilon 0.10 steps 277839
saving checkpoint
saving checkpoint
episode:  140 score:  4.0  average score -9.3 best score -9.51 epsilon 0.10 steps 280902
saving checkpoint
saving checkpoint
episode:  141 score:  6.0  average score -9.0 best score -9.26 epsilon 0.10 steps 283573
saving checkpoint
saving checkpoint
episode:  142 score:  12.0  average score -8.7 best score -9.01 epsilon 0.10 steps 286117
saving checkpoint
saving checkpoint
episode:  143 score:  -3.0  average score -8.5 best score -8.71 epsilon 0.10 steps 288980
saving checkpoint
saving checkpoint
episode:  144 score:  6.0  average score -8.3 best score -8.53 epsilon 0.10 steps 292036
saving checkpoint
saving checkpoint
episode:  145 score:  2.0  average score -8.1 best score -8.29 epsilon 0.10 steps 295413
saving checkpoint
saving checkpoint
episode:  146 score:  7.0  average score -7.8 best score -8.07 epsilon 0.10 steps 298212
saving checkpoint
saving checkpoint
episode:  147 score:  11.0  average score -7.6 best score -7.83 epsilon 0.10 steps 300578
saving checkpoint
saving checkpoint
episode:  148 score:  11.0  average score -7.3 best score -7.57 epsilon 0.10 steps 302766
saving checkpoint
```

```
saving checkpoint
episode:  149 score:   4.0  average score -7.1 best score -7.28 epsilon 0.10 steps 305614
saving checkpoint
saving checkpoint
episode:  150 score:  11.0  average score -6.8 best score -7.06 epsilon 0.10 steps 307898
saving checkpoint
saving checkpoint
episode:  151 score:  12.0  average score -6.5 best score -6.83 epsilon 0.10 steps 310196
saving checkpoint
saving checkpoint
episode:  152 score:   3.0  average score -6.3 best score -6.53 epsilon 0.10 steps 313168
saving checkpoint
saving checkpoint
episode:  153 score:  10.0  average score -6.1 best score -6.35 epsilon 0.10 steps 315785
saving checkpoint
saving checkpoint
episode:  154 score:  11.0  average score -5.8 best score -6.08 epsilon 0.10 steps 318399
saving checkpoint
saving checkpoint
episode:  155 score:  11.0  average score -5.5 best score -5.80 epsilon 0.10 steps 320778
saving checkpoint
saving checkpoint
episode:  156 score:  12.0  average score -5.2 best score -5.49 epsilon 0.10 steps 323079
saving checkpoint
saving checkpoint
episode:  157 score:  12.0  average score -4.9 best score -5.17 epsilon 0.10 steps 325452
saving checkpoint
saving checkpoint
episode:  158 score:   9.0  average score -4.6 best score -4.89 epsilon 0.10 steps 327815
saving checkpoint
saving checkpoint
episode:  159 score:  17.0  average score -4.3 best score -4.60 epsilon 0.10 steps 329693
saving checkpoint
saving checkpoint
episode:  160 score:   8.0  average score -4.0 best score -4.27 epsilon 0.10 steps 332102
saving checkpoint
saving checkpoint
episode:  161 score:   1.0  average score -3.8 best score -4.00 epsilon 0.10 steps 335106
saving checkpoint
saving checkpoint
episode:  162 score:   7.0  average score -3.6 best score -3.82 epsilon 0.10 steps 337841
saving checkpoint
saving checkpoint
episode:  163 score:  11.0  average score -3.4 best score -3.60 epsilon 0.10 steps 340147
saving checkpoint
saving checkpoint
episode:  164 score:  12.0  average score -3.1 best score -3.36 epsilon 0.10 steps 342413
saving checkpoint
saving checkpoint
episode:  165 score:  14.0  average score -2.9 best score -3.10 epsilon 0.10 steps 345062
saving checkpoint
saving checkpoint
episode:  166 score:  14.0  average score -2.5 best score -2.85 epsilon 0.10 steps 347135
saving checkpoint
saving checkpoint
episode:  167 score:  10.0  average score -2.2 best score -2.52 epsilon 0.10 steps 349493
saving checkpoint
saving checkpoint
episode:  168 score:   8.0  average score -2.0 best score -2.24 epsilon 0.10 steps 352434
saving checkpoint
saving checkpoint
episode:  169 score:  11.0  average score -1.8 best score -2.04 epsilon 0.10 steps 354809
saving checkpoint
saving checkpoint
episode:  170 score:  14.0  average score -1.4 best score -1.76 epsilon 0.10 steps 356875
saving checkpoint
saving checkpoint
episode:  171 score:  10.0  average score -1.2 best score -1.45 epsilon 0.10 steps 359324
saving checkpoint
saving checkpoint
episode:  172 score:   5.0  average score -1.0 best score -1.20 epsilon 0.10 steps 361993
saving checkpoint
```

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saving checkpoint
episode:  173 score:  14.0  average score -0.7 best score -0.98 epsilon 0.10 steps 364309
saving checkpoint
saving checkpoint
episode:  174 score:  -1.0  average score -0.5 best score -0.69 epsilon 0.10 steps 367265
saving checkpoint
saving checkpoint
episode:  175 score:  4.0  average score -0.3 best score -0.53 epsilon 0.10 steps 370281
saving checkpoint
saving checkpoint
episode:  176 score:  3.0  average score -0.1 best score -0.30 epsilon 0.10 steps 372996
saving checkpoint
saving checkpoint
episode:  177 score:  9.0  average score 0.1 best score -0.13 epsilon 0.10 steps 375686
saving checkpoint
saving checkpoint
episode:  178 score:  2.0  average score 0.2 best score 0.09 epsilon 0.10 steps 378456
saving checkpoint
saving checkpoint
episode:  179 score:  13.0  average score 0.4 best score 0.20 epsilon 0.10 steps 381212
saving checkpoint
saving checkpoint
episode:  180 score:  5.0  average score 0.6 best score 0.43 epsilon 0.10 steps 384094
saving checkpoint
saving checkpoint
episode:  181 score:  12.0  average score 0.8 best score 0.58 epsilon 0.10 steps 386463
saving checkpoint
saving checkpoint
episode:  182 score:  11.0  average score 1.1 best score 0.83 epsilon 0.10 steps 388840
saving checkpoint
saving checkpoint
episode:  183 score:  11.0  average score 1.3 best score 1.09 epsilon 0.10 steps 391187
saving checkpoint
saving checkpoint
episode:  184 score:  8.0  average score 1.5 best score 1.29 epsilon 0.10 steps 393786
saving checkpoint
saving checkpoint
episode:  185 score:  10.0  average score 1.6 best score 1.47 epsilon 0.10 steps 396189
saving checkpoint
saving checkpoint
episode:  186 score:  10.0  average score 1.9 best score 1.65 epsilon 0.10 steps 398568
saving checkpoint
saving checkpoint
episode:  187 score:  -1.0  average score 2.0 best score 1.89 epsilon 0.10 steps 401536
saving checkpoint
saving checkpoint
episode:  188 score:  12.0  average score 2.3 best score 2.01 epsilon 0.10 steps 403763
saving checkpoint
saving checkpoint
episode:  189 score:  8.0  average score 2.4 best score 2.27 epsilon 0.10 steps 406527
saving checkpoint
saving checkpoint
episode:  190 score:  8.0  average score 2.6 best score 2.44 epsilon 0.10 steps 409071
saving checkpoint
saving checkpoint
episode:  191 score:  5.0  average score 2.7 best score 2.60 epsilon 0.10 steps 411763
saving checkpoint
saving checkpoint
episode:  192 score:  16.0  average score 3.0 best score 2.70 epsilon 0.10 steps 413853
saving checkpoint
saving checkpoint
episode:  193 score:  16.0  average score 3.3 best score 2.98 epsilon 0.10 steps 415852
saving checkpoint
saving checkpoint
episode:  194 score:  10.0  average score 3.4 best score 3.26 epsilon 0.10 steps 418298
saving checkpoint
saving checkpoint
episode:  195 score:  -1.0  average score 3.5 best score 3.44 epsilon 0.10 steps 421214
saving checkpoint
saving checkpoint
episode:  196 score:  12.0  average score 3.7 best score 3.51 epsilon 0.10 steps 423699
saving checkpoint
```

```
saving checkpoint
episode:  197 score:  10.0  average score 3.9 best score 3.73 epsilon 0.10 steps 426213
saving checkpoint
saving checkpoint
episode:  198 score:  5.0  average score 4.0 best score 3.92 epsilon 0.10 steps 429019
saving checkpoint
saving checkpoint
episode:  199 score:  8.0  average score 4.1 best score 4.00 epsilon 0.10 steps 431624
saving checkpoint
saving checkpoint
episode:  200 score:  10.0  average score 4.3 best score 4.11 epsilon 0.10 steps 433996
saving checkpoint
saving checkpoint
episode:  201 score:  15.0  average score 4.5 best score 4.31 epsilon 0.10 steps 436185
saving checkpoint
saving checkpoint
episode:  202 score:  16.0  average score 4.7 best score 4.51 epsilon 0.10 steps 438181
saving checkpoint
saving checkpoint
episode:  203 score:  15.0  average score 5.0 best score 4.73 epsilon 0.10 steps 440353
saving checkpoint
saving checkpoint
episode:  204 score:  11.0  average score 5.0 best score 4.95 epsilon 0.10 steps 442627
saving checkpoint
saving checkpoint
episode:  205 score:  6.0  average score 5.2 best score 5.04 epsilon 0.10 steps 445729
saving checkpoint
saving checkpoint
episode:  206 score:  1.0  average score 5.2 best score 5.17 epsilon 0.10 steps 448416
saving checkpoint
saving checkpoint
episode:  207 score:  10.0  average score 5.4 best score 5.25 epsilon 0.10 steps 450854
saving checkpoint
saving checkpoint
episode:  208 score:  11.0  average score 5.6 best score 5.39 epsilon 0.10 steps 453361
saving checkpoint
saving checkpoint
episode:  209 score:  17.0  average score 5.8 best score 5.56 epsilon 0.10 steps 455294
saving checkpoint
saving checkpoint
episode:  210 score:  13.0  average score 6.0 best score 5.81 epsilon 0.10 steps 457423
saving checkpoint
saving checkpoint
episode:  211 score:  12.0  average score 6.2 best score 6.02 epsilon 0.10 steps 459623
saving checkpoint
saving checkpoint
episode:  212 score:  11.0  average score 6.3 best score 6.16 epsilon 0.10 steps 462026
saving checkpoint
saving checkpoint
episode:  213 score:  9.0  average score 6.5 best score 6.35 epsilon 0.10 steps 464758
saving checkpoint
saving checkpoint
episode:  214 score:  12.0  average score 6.7 best score 6.52 epsilon 0.10 steps 467017
saving checkpoint
saving checkpoint
episode:  215 score:  9.0  average score 6.8 best score 6.67 epsilon 0.10 steps 469475
saving checkpoint
saving checkpoint
episode:  216 score:  10.0  average score 7.0 best score 6.84 epsilon 0.10 steps 471770
saving checkpoint
saving checkpoint
episode:  217 score:  12.0  average score 7.1 best score 6.98 epsilon 0.10 steps 474252
saving checkpoint
saving checkpoint
episode:  218 score:  14.0  average score 7.2 best score 7.11 epsilon 0.10 steps 476694
saving checkpoint
saving checkpoint
episode:  219 score:  18.0  average score 7.4 best score 7.24 epsilon 0.10 steps 478481
saving checkpoint
saving checkpoint
episode:  220 score:  8.0  average score 7.6 best score 7.44 epsilon 0.10 steps 480969
saving checkpoint
```

```
saving checkpoint
episode:  221 score:  12.0  average score 7.8 best score 7.60 epsilon 0.10 steps 483182
saving checkpoint
saving checkpoint
episode:  222 score:  16.0  average score 8.0 best score 7.81 epsilon 0.10 steps 485085
saving checkpoint
saving checkpoint
episode:  223 score:  17.0  average score 8.2 best score 8.02 epsilon 0.10 steps 486986
saving checkpoint
saving checkpoint
episode:  224 score:  16.0  average score 8.2 best score 8.15 epsilon 0.10 steps 489101
saving checkpoint
saving checkpoint
episode:  225 score:  15.0  average score 8.4 best score 8.23 epsilon 0.10 steps 491392
saving checkpoint
saving checkpoint
episode:  226 score:  15.0  average score 8.5 best score 8.37 epsilon 0.10 steps 493564
saving checkpoint
saving checkpoint
episode:  227 score:  15.0  average score 8.7 best score 8.53 epsilon 0.10 steps 495745
saving checkpoint
saving checkpoint
episode:  228 score:  14.0  average score 8.9 best score 8.67 epsilon 0.10 steps 498047
saving checkpoint
saving checkpoint
episode:  229 score:  6.0  average score 8.9 best score 8.88 epsilon 0.10 steps 501097
saving checkpoint
saving checkpoint
episode:  230 score:  18.0  average score 9.1 best score 8.91 epsilon 0.10 steps 502902
saving checkpoint
saving checkpoint
episode:  231 score:  16.0  average score 9.2 best score 9.06 epsilon 0.10 steps 505034
saving checkpoint
saving checkpoint
episode:  232 score:  18.0  average score 9.4 best score 9.25 epsilon 0.10 steps 506831
saving checkpoint
saving checkpoint
episode:  233 score:  17.0  average score 9.6 best score 9.40 epsilon 0.10 steps 508766
saving checkpoint
saving checkpoint
episode:  234 score:  11.0  average score 9.7 best score 9.61 epsilon 0.10 steps 511186
saving checkpoint
saving checkpoint
episode:  235 score:  13.0  average score 9.7 best score 9.71 epsilon 0.10 steps 513467
saving checkpoint
saving checkpoint
episode:  236 score:  16.0  average score 9.9 best score 9.73 epsilon 0.10 steps 515419
saving checkpoint
saving checkpoint
episode:  237 score:  15.0  average score 10.1 best score 9.86 epsilon 0.10 steps 517378
saving checkpoint
saving checkpoint
episode:  238 score:  16.0  average score 10.3 best score 10.06 epsilon 0.10 steps 519428
saving checkpoint
saving checkpoint
episode:  239 score:  14.0  average score 10.3 best score 10.26 epsilon 0.10 steps 521666
saving checkpoint
saving checkpoint
episode:  240 score:  13.0  average score 10.4 best score 10.32 epsilon 0.10 steps 523813
saving checkpoint
saving checkpoint
episode:  241 score:  -1.0  average score 10.3 best score 10.41 epsilon 0.10 steps 526821
episode:  242 score:  20.0  average score 10.4 best score 10.41 epsilon 0.10 steps 528580
saving checkpoint
saving checkpoint
episode:  243 score:  9.0  average score 10.5 best score 10.42 epsilon 0.10 steps 530893
saving checkpoint
saving checkpoint
episode:  244 score:  17.0  average score 10.7 best score 10.54 epsilon 0.10 steps 532808
saving checkpoint
saving checkpoint
episode:  245 score:  17.0  average score 10.8 best score 10.65 epsilon 0.10 steps 534884
```

```
saving checkpoint
saving checkpoint
episode:  246 score:   8.0  average score 10.8 best score 10.80 epsilon 0.10 steps 537386
saving checkpoint
saving checkpoint
episode:  247 score:  15.0  average score 10.8 best score 10.81 epsilon 0.10 steps 539370
saving checkpoint
saving checkpoint
episode:  248 score:  12.0  average score 10.9 best score 10.85 epsilon 0.10 steps 541756
saving checkpoint
saving checkpoint
episode:  249 score:  14.0  average score 11.0 best score 10.86 epsilon 0.10 steps 543945
saving checkpoint
saving checkpoint
episode:  250 score:  16.0  average score 11.0 best score 10.96 epsilon 0.10 steps 546028
saving checkpoint
saving checkpoint
episode:  251 score:  18.0  average score 11.1 best score 11.01 epsilon 0.10 steps 548046
saving checkpoint
saving checkpoint
episode:  252 score:  11.0  average score 11.2 best score 11.07 epsilon 0.10 steps 550404
saving checkpoint
saving checkpoint
episode:  253 score:  17.0  average score 11.2 best score 11.15 epsilon 0.10 steps 552532
saving checkpoint
saving checkpoint
episode:  254 score:   9.0  average score 11.2 best score 11.22 epsilon 0.10 steps 555428
episode:  255 score:  15.0  average score 11.2 best score 11.22 epsilon 0.10 steps 557564
saving checkpoint
saving checkpoint
episode:  256 score:  13.0  average score 11.2 best score 11.24 epsilon 0.10 steps 559974
saving checkpoint
saving checkpoint
episode:  257 score:  11.0  average score 11.2 best score 11.25 epsilon 0.10 steps 562533
episode:  258 score:  11.0  average score 11.3 best score 11.25 epsilon 0.10 steps 565021
saving checkpoint
saving checkpoint
episode:  259 score:  18.0  average score 11.3 best score 11.26 epsilon 0.10 steps 567004
saving checkpoint
saving checkpoint
episode:  260 score:  14.0  average score 11.3 best score 11.27 epsilon 0.10 steps 569050
saving checkpoint
saving checkpoint
episode:  261 score:  17.0  average score 11.5 best score 11.33 epsilon 0.10 steps 571137
saving checkpoint
saving checkpoint
episode:  262 score:  17.0  average score 11.6 best score 11.49 epsilon 0.10 steps 573167
saving checkpoint
saving checkpoint
episode:  263 score:  16.0  average score 11.6 best score 11.59 epsilon 0.10 steps 575297
saving checkpoint
saving checkpoint
episode:  264 score:  15.0  average score 11.7 best score 11.64 epsilon 0.10 steps 577455
saving checkpoint
saving checkpoint
episode:  265 score:  15.0  average score 11.7 best score 11.67 epsilon 0.10 steps 579541
saving checkpoint
saving checkpoint
episode:  266 score:  17.0  average score 11.7 best score 11.68 epsilon 0.10 steps 581732
saving checkpoint
saving checkpoint
episode:  267 score:  13.0  average score 11.7 best score 11.71 epsilon 0.10 steps 584123
saving checkpoint
saving checkpoint
episode:  268 score:  -1.0  average score 11.7 best score 11.74 epsilon 0.10 steps 587150
episode:  269 score:  12.0  average score 11.7 best score 11.74 epsilon 0.10 steps 589383
episode:  270 score:  -4.0  average score 11.5 best score 11.74 epsilon 0.10 steps 591860
episode:  271 score:  17.0  average score 11.6 best score 11.74 epsilon 0.10 steps 593951
episode:  272 score:  11.0  average score 11.6 best score 11.74 epsilon 0.10 steps 596593
episode:  273 score:  18.0  average score 11.7 best score 11.74 epsilon 0.10 steps 598659
episode:  274 score:  15.0  average score 11.8 best score 11.74 epsilon 0.10 steps 600921
saving checkpoint
```

```
saving checkpoint
episode:  275 score:  10.0   average score 11.9 best score 11.81 epsilon 0.10 steps 603293
saving checkpoint
saving checkpoint
episode:  276 score:  12.0   average score 12.0 best score 11.87 epsilon 0.10 steps 605742
saving checkpoint
saving checkpoint
episode:  277 score:  8.0   average score 11.9 best score 11.96 epsilon 0.10 steps 608565
episode:  278 score:  9.0   average score 12.0 best score 11.96 epsilon 0.10 steps 611060
saving checkpoint
saving checkpoint
episode:  279 score:  1.0   average score 11.9 best score 12.02 epsilon 0.10 steps 613700
episode:  280 score:  11.0   average score 12.0 best score 12.02 epsilon 0.10 steps 615884
episode:  281 score:  6.0   average score 11.9 best score 12.02 epsilon 0.10 steps 618351
episode:  282 score:  9.0   average score 11.9 best score 12.02 epsilon 0.10 steps 620645
episode:  283 score:  16.0   average score 11.9 best score 12.02 epsilon 0.10 steps 622581
episode:  284 score:  11.0   average score 12.0 best score 12.02 epsilon 0.10 steps 624927
episode:  285 score:  13.0   average score 12.0 best score 12.02 epsilon 0.10 steps 627180
episode:  286 score:  13.0   average score 12.0 best score 12.02 epsilon 0.10 steps 629480
episode:  287 score:  16.0   average score 12.2 best score 12.02 epsilon 0.10 steps 631549
saving checkpoint
saving checkpoint
episode:  288 score:  12.0   average score 12.2 best score 12.19 epsilon 0.10 steps 633918
episode:  289 score:  18.0   average score 12.3 best score 12.19 epsilon 0.10 steps 635694
saving checkpoint
saving checkpoint
episode:  290 score:  12.0   average score 12.3 best score 12.29 epsilon 0.10 steps 638168
saving checkpoint
saving checkpoint
episode:  291 score:  11.0   average score 12.4 best score 12.33 epsilon 0.10 steps 640638
saving checkpoint
saving checkpoint
episode:  292 score:  15.0   average score 12.4 best score 12.39 epsilon 0.10 steps 642641
episode:  293 score:  14.0   average score 12.4 best score 12.39 epsilon 0.10 steps 644885
episode:  294 score:  18.0   average score 12.4 best score 12.39 epsilon 0.10 steps 646944
saving checkpoint
saving checkpoint
episode:  295 score:  11.0   average score 12.6 best score 12.44 epsilon 0.10 steps 649629
saving checkpoint
saving checkpoint
episode:  296 score:  15.0   average score 12.6 best score 12.56 epsilon 0.10 steps 651778
saving checkpoint
saving checkpoint
episode:  297 score:  11.0   average score 12.6 best score 12.59 epsilon 0.10 steps 654400
saving checkpoint
saving checkpoint
episode:  298 score:  6.0   average score 12.6 best score 12.60 epsilon 0.10 steps 656898
saving checkpoint
saving checkpoint
episode:  299 score:  18.0   average score 12.7 best score 12.61 epsilon 0.10 steps 658733
saving checkpoint
saving checkpoint
episode:  300 score:  17.0   average score 12.8 best score 12.71 epsilon 0.10 steps 660865
saving checkpoint
saving checkpoint
episode:  301 score:  14.0   average score 12.8 best score 12.78 epsilon 0.10 steps 663167
episode:  302 score:  14.0   average score 12.8 best score 12.78 epsilon 0.10 steps 665451
episode:  303 score:  19.0   average score 12.8 best score 12.78 epsilon 0.10 steps 667201
saving checkpoint
saving checkpoint
episode:  304 score:  16.0   average score 12.8 best score 12.79 epsilon 0.10 steps 669308
saving checkpoint
saving checkpoint
episode:  305 score:  16.0   average score 12.9 best score 12.84 epsilon 0.10 steps 671482
saving checkpoint
saving checkpoint
episode:  306 score:  17.0   average score 13.1 best score 12.94 epsilon 0.10 steps 673535
saving checkpoint
saving checkpoint
episode:  307 score:  9.0   average score 13.1 best score 13.10 epsilon 0.10 steps 676348
episode:  308 score:  12.0   average score 13.1 best score 13.10 epsilon 0.10 steps 678571
episode:  309 score:  10.0   average score 13.0 best score 13.10 epsilon 0.10 steps 681186
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episode:  310 score:   9.0   average score 13.0 best score 13.10 epsilon 0.10 steps 683524
episode:  311 score:   4.0   average score 12.9 best score 13.10 epsilon 0.10 steps 686456
episode:  312 score:  13.0   average score 12.9 best score 13.10 epsilon 0.10 steps 688743
episode:  313 score:  12.0   average score 13.0 best score 13.10 epsilon 0.10 steps 691028
episode:  314 score:  15.0   average score 13.0 best score 13.10 epsilon 0.10 steps 693266
episode:  315 score:  15.0   average score 13.1 best score 13.10 epsilon 0.10 steps 695786
episode:  316 score:  11.0   average score 13.1 best score 13.10 epsilon 0.10 steps 698137
episode:  317 score:   9.0   average score 13.0 best score 13.10 epsilon 0.10 steps 700633
episode:  318 score:  20.0   average score 13.1 best score 13.10 epsilon 0.10 steps 702473
episode:  319 score:  15.0   average score 13.1 best score 13.10 epsilon 0.10 steps 704544
episode:  320 score:  17.0   average score 13.2 best score 13.10 epsilon 0.10 steps 706436
saving checkpoint
saving checkpoint
episode:  321 score:  16.0   average score 13.2 best score 13.15 epsilon 0.10 steps 708476
saving checkpoint
saving checkpoint
episode:  322 score:  11.0   average score 13.1 best score 13.19 epsilon 0.10 steps 710904
episode:  323 score:   2.0   average score 13.0 best score 13.19 epsilon 0.10 steps 713454
episode:  324 score:  15.0   average score 13.0 best score 13.19 epsilon 0.10 steps 715526
episode:  325 score:  14.0   average score 13.0 best score 13.19 epsilon 0.10 steps 717723
episode:  326 score:  15.0   average score 13.0 best score 13.19 epsilon 0.10 steps 719932
episode:  327 score:  14.0   average score 13.0 best score 13.19 epsilon 0.10 steps 722270
episode:  328 score:  15.0   average score 13.0 best score 13.19 epsilon 0.10 steps 724312
episode:  329 score:  16.0   average score 13.1 best score 13.19 epsilon 0.10 steps 726364
episode:  330 score:  14.0   average score 13.0 best score 13.19 epsilon 0.10 steps 728569
episode:  331 score:  12.0   average score 13.0 best score 13.19 epsilon 0.10 steps 730848
episode:  332 score:  18.0   average score 13.0 best score 13.19 epsilon 0.10 steps 732883
episode:  333 score:  17.0   average score 13.0 best score 13.19 epsilon 0.10 steps 734794
episode:  334 score:   9.0   average score 13.0 best score 13.19 epsilon 0.10 steps 737376
episode:  335 score:  14.0   average score 13.0 best score 13.19 epsilon 0.10 steps 739566
episode:  336 score:  10.0   average score 12.9 best score 13.19 epsilon 0.10 steps 741846
episode:  337 score:  10.0   average score 12.9 best score 13.19 epsilon 0.10 steps 744320
episode:  338 score:  15.0   average score 12.9 best score 13.19 epsilon 0.10 steps 746469
episode:  339 score:  11.0   average score 12.8 best score 13.19 epsilon 0.10 steps 748806
episode:  340 score:  14.0   average score 12.8 best score 13.19 epsilon 0.10 steps 750820
episode:  341 score:  13.0   average score 13.0 best score 13.19 epsilon 0.10 steps 753065
episode:  342 score:  12.0   average score 12.9 best score 13.19 epsilon 0.10 steps 755473
episode:  343 score:  18.0   average score 13.0 best score 13.19 epsilon 0.10 steps 757473
episode:  344 score:  18.0   average score 13.0 best score 13.19 epsilon 0.10 steps 759469
episode:  345 score:  16.0   average score 13.0 best score 13.19 epsilon 0.10 steps 761479
episode:  346 score:  16.0   average score 13.1 best score 13.19 epsilon 0.10 steps 763458
episode:  347 score:  18.0   average score 13.1 best score 13.19 epsilon 0.10 steps 765807
episode:  348 score:   9.0   average score 13.1 best score 13.19 epsilon 0.10 steps 768393
episode:  349 score:  11.0   average score 13.0 best score 13.19 epsilon 0.10 steps 770593
episode:  350 score:  17.0   average score 13.1 best score 13.19 epsilon 0.10 steps 772700
episode:  351 score:  19.0   average score 13.1 best score 13.19 epsilon 0.10 steps 774466
episode:  352 score:  11.0   average score 13.1 best score 13.19 epsilon 0.10 steps 776829
episode:  353 score:  14.0   average score 13.0 best score 13.19 epsilon 0.10 steps 779082
episode:  354 score:  14.0   average score 13.1 best score 13.19 epsilon 0.10 steps 781275
episode:  355 score:  17.0   average score 13.1 best score 13.19 epsilon 0.10 steps 783273
episode:  356 score:  12.0   average score 13.1 best score 13.19 epsilon 0.10 steps 785814
episode:  357 score:  14.0   average score 13.1 best score 13.19 epsilon 0.10 steps 788066
episode:  358 score:  11.0   average score 13.1 best score 13.19 epsilon 0.10 steps 790423
episode:  359 score:  15.0   average score 13.1 best score 13.19 epsilon 0.10 steps 792646
episode:  360 score:  18.0   average score 13.1 best score 13.19 epsilon 0.10 steps 794408
episode:  361 score:  14.0   average score 13.1 best score 13.19 epsilon 0.10 steps 796833
episode:  362 score:  16.0   average score 13.1 best score 13.19 epsilon 0.10 steps 798803
episode:  363 score:   5.0   average score 13.0 best score 13.19 epsilon 0.10 steps 801523
episode:  364 score:  11.0   average score 12.9 best score 13.19 epsilon 0.10 steps 804024
episode:  365 score:  12.0   average score 12.9 best score 13.19 epsilon 0.10 steps 806279
episode:  366 score:  15.0   average score 12.9 best score 13.19 epsilon 0.10 steps 808431
episode:  367 score:  14.0   average score 12.9 best score 13.19 epsilon 0.10 steps 810708
episode:  368 score:  19.0   average score 13.1 best score 13.19 epsilon 0.10 steps 812534
episode:  369 score:  19.0   average score 13.2 best score 13.19 epsilon 0.10 steps 814495
episode:  370 score:  11.0   average score 13.3 best score 13.19 epsilon 0.10 steps 816857
saving checkpoint
saving checkpoint
episode:  371 score:  15.0   average score 13.3 best score 13.32 epsilon 0.10 steps 819055
episode:  372 score:  16.0   average score 13.3 best score 13.32 epsilon 0.10 steps 821003
saving checkpoint
saving checkpoint
episode:  373 score:  15.0   average score 13.3 best score 13.35 epsilon 0.10 steps 823001
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episode:  374 score:   3.0  average score 13.2 best score 13.35 epsilon 0.10 steps 825900
episode:  375 score:  14.0  average score 13.2 best score 13.35 epsilon 0.10 steps 828064
episode:  376 score:  11.0  average score 13.2 best score 13.35 epsilon 0.10 steps 830618
episode:  377 score:  15.0  average score 13.3 best score 13.35 epsilon 0.10 steps 832933
episode:  378 score:  14.0  average score 13.3 best score 13.35 epsilon 0.10 steps 835017
episode:  379 score:  13.0  average score 13.5 best score 13.35 epsilon 0.10 steps 837070
saving checkpoint
saving checkpoint
episode:  380 score:  12.0  average score 13.5 best score 13.47 epsilon 0.10 steps 839332
saving checkpoint
saving checkpoint
episode:  381 score:  12.0  average score 13.5 best score 13.48 epsilon 0.10 steps 841649
saving checkpoint
saving checkpoint
episode:  382 score:  17.0  average score 13.6 best score 13.54 epsilon 0.10 steps 843577
saving checkpoint
saving checkpoint
episode:  383 score:  12.0  average score 13.6 best score 13.62 epsilon 0.10 steps 845843
episode:  384 score:  19.0  average score 13.7 best score 13.62 epsilon 0.10 steps 847625
saving checkpoint
saving checkpoint
episode:  385 score:  16.0  average score 13.7 best score 13.66 epsilon 0.10 steps 849815
saving checkpoint
saving checkpoint
episode:  386 score:  15.0  average score 13.7 best score 13.69 epsilon 0.10 steps 851921
saving checkpoint
saving checkpoint
episode:  387 score:  17.0  average score 13.7 best score 13.71 epsilon 0.10 steps 853804
saving checkpoint
saving checkpoint
episode:  388 score:  17.0  average score 13.8 best score 13.72 epsilon 0.10 steps 855707
saving checkpoint
saving checkpoint
episode:  389 score:  19.0  average score 13.8 best score 13.77 epsilon 0.10 steps 857630
saving checkpoint
saving checkpoint
episode:  390 score:  16.0  average score 13.8 best score 13.78 epsilon 0.10 steps 859738
saving checkpoint
saving checkpoint
episode:  391 score:  18.0  average score 13.9 best score 13.82 epsilon 0.10 steps 861675
saving checkpoint
saving checkpoint
episode:  392 score:  13.0  average score 13.9 best score 13.89 epsilon 0.10 steps 863863
episode:  393 score:  19.0  average score 13.9 best score 13.89 epsilon 0.10 steps 865741
saving checkpoint
saving checkpoint
episode:  394 score:  16.0  average score 13.9 best score 13.92 epsilon 0.10 steps 867909
episode:  395 score:  12.0  average score 13.9 best score 13.92 epsilon 0.10 steps 870544
episode:  396 score:  14.0  average score 13.9 best score 13.92 epsilon 0.10 steps 872556
episode:  397 score:   6.0  average score 13.8 best score 13.92 epsilon 0.10 steps 875138
episode:  398 score:  17.0  average score 14.0 best score 13.92 epsilon 0.10 steps 877160
saving checkpoint
saving checkpoint
episode:  399 score:  14.0  average score 13.9 best score 13.96 epsilon 0.10 steps 879347
episode:  400 score:  14.0  average score 13.9 best score 13.96 epsilon 0.10 steps 881785
episode:  401 score:  13.0  average score 13.9 best score 13.96 epsilon 0.10 steps 884109
episode:  402 score:  19.0  average score 13.9 best score 13.96 epsilon 0.10 steps 885864
episode:  403 score:  15.0  average score 13.9 best score 13.96 epsilon 0.10 steps 887939
episode:  404 score:  15.0  average score 13.9 best score 13.96 epsilon 0.10 steps 890214
episode:  405 score:  18.0  average score 13.9 best score 13.96 epsilon 0.10 steps 892278
episode:  406 score:  18.0  average score 13.9 best score 13.96 epsilon 0.10 steps 894290
episode:  407 score:  10.0  average score 13.9 best score 13.96 epsilon 0.10 steps 896978
episode:  408 score:  18.0  average score 14.0 best score 13.96 epsilon 0.10 steps 898912
saving checkpoint
saving checkpoint
episode:  409 score:  18.0  average score 14.1 best score 13.98 epsilon 0.10 steps 900834
saving checkpoint
saving checkpoint
episode:  410 score:  14.0  average score 14.1 best score 14.06 epsilon 0.10 steps 903011
saving checkpoint
saving checkpoint
episode:  411 score:  17.0  average score 14.2 best score 14.11 epsilon 0.10 steps 904917
```
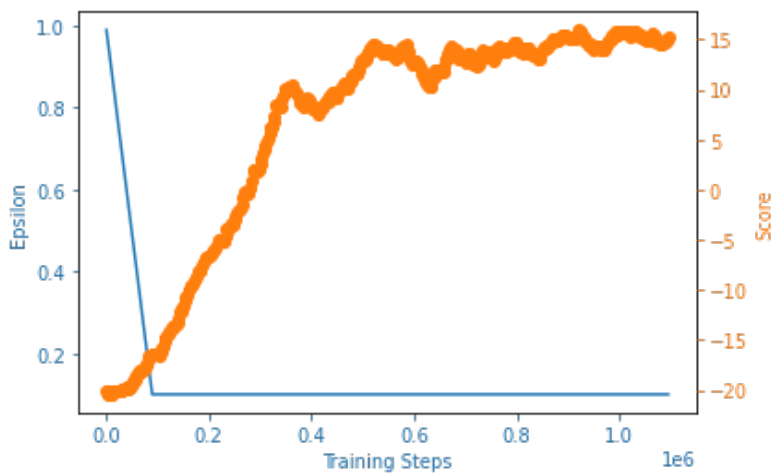
```
saving checkpoint
saving checkpoint
episode:  412 score:   18.0  average score 14.3 best score 14.24 epsilon 0.10 steps 906758
saving checkpoint
saving checkpoint
episode:  413 score:   15.0  average score 14.3 best score 14.29 epsilon 0.10 steps 909131
saving checkpoint
saving checkpoint
episode:  414 score:   15.0  average score 14.3 best score 14.32 epsilon 0.10 steps 911331
episode:  415 score:   16.0  average score 14.3 best score 14.32 epsilon 0.10 steps 913395
saving checkpoint
saving checkpoint
episode:  416 score:   18.0  average score 14.4 best score 14.33 epsilon 0.10 steps 915581
saving checkpoint
saving checkpoint
episode:  417 score:   13.0  average score 14.4 best score 14.40 epsilon 0.10 steps 917849
saving checkpoint
saving checkpoint
episode:  418 score:   20.0  average score 14.4 best score 14.44 epsilon 0.10 steps 919674
episode:  419 score:   13.0  average score 14.4 best score 14.44 epsilon 0.10 steps 921957
episode:  420 score:   14.0  average score 14.4 best score 14.44 epsilon 0.10 steps 924358
episode:  421 score:   6.0  average score 14.3 best score 14.44 epsilon 0.10 steps 927033
episode:  422 score:   12.0  average score 14.3 best score 14.44 epsilon 0.10 steps 929424
episode:  423 score:   10.0  average score 14.4 best score 14.44 epsilon 0.10 steps 931913
episode:  424 score:   14.0  average score 14.4 best score 14.44 epsilon 0.10 steps 934169
episode:  425 score:   12.0  average score 14.3 best score 14.44 epsilon 0.10 steps 936545
episode:  426 score:   15.0  average score 14.3 best score 14.44 epsilon 0.10 steps 938716
episode:  427 score:   13.0  average score 14.3 best score 14.44 epsilon 0.10 steps 940937
episode:  428 score:   15.0  average score 14.3 best score 14.44 epsilon 0.10 steps 943371
episode:  429 score:   14.0  average score 14.3 best score 14.44 epsilon 0.10 steps 945657
episode:  430 score:   11.0  average score 14.3 best score 14.44 epsilon 0.10 steps 948035
episode:  431 score:   20.0  average score 14.4 best score 14.44 epsilon 0.10 steps 949995
episode:  432 score:   17.0  average score 14.4 best score 14.44 epsilon 0.10 steps 951944
episode:  433 score:   13.0  average score 14.3 best score 14.44 epsilon 0.10 steps 954081
episode:  434 score:   17.0  average score 14.4 best score 14.44 epsilon 0.10 steps 956134
episode:  435 score:   18.0  average score 14.4 best score 14.44 epsilon 0.10 steps 958194
episode:  436 score:   14.0  average score 14.5 best score 14.44 epsilon 0.10 steps 960520
saving checkpoint
saving checkpoint
episode:  437 score:   14.0  average score 14.5 best score 14.48 epsilon 0.10 steps 962678
saving checkpoint
saving checkpoint
episode:  438 score:   15.0  average score 14.5 best score 14.52 epsilon 0.10 steps 964925
episode:  439 score:   16.0  average score 14.6 best score 14.52 epsilon 0.10 steps 966904
saving checkpoint
saving checkpoint
episode:  440 score:   14.0  average score 14.6 best score 14.57 epsilon 0.10 steps 969068
episode:  441 score:   19.0  average score 14.6 best score 14.57 epsilon 0.10 steps 970933
saving checkpoint
saving checkpoint
episode:  442 score:   8.0  average score 14.6 best score 14.63 epsilon 0.10 steps 973495
episode:  443 score:   17.0  average score 14.6 best score 14.63 epsilon 0.10 steps 975383
episode:  444 score:   15.0  average score 14.6 best score 14.63 epsilon 0.10 steps 977614
episode:  445 score:   14.0  average score 14.5 best score 14.63 epsilon 0.10 steps 979657
episode:  446 score:   14.0  average score 14.5 best score 14.63 epsilon 0.10 steps 981948
episode:  447 score:   17.0  average score 14.5 best score 14.63 epsilon 0.10 steps 983875
episode:  448 score:   21.0  average score 14.6 best score 14.63 epsilon 0.10 steps 985726
episode:  449 score:   11.0  average score 14.6 best score 14.63 epsilon 0.10 steps 988291
episode:  450 score:   20.0  average score 14.7 best score 14.63 epsilon 0.10 steps 990113
saving checkpoint
saving checkpoint
episode:  451 score:   20.0  average score 14.7 best score 14.65 epsilon 0.10 steps 992182
saving checkpoint
saving checkpoint
episode:  452 score:   11.0  average score 14.7 best score 14.66 epsilon 0.10 steps 994569
episode:  453 score:   17.0  average score 14.7 best score 14.66 epsilon 0.10 steps 996519
saving checkpoint
saving checkpoint
episode:  454 score:   20.0  average score 14.8 best score 14.69 epsilon 0.10 steps 998387
saving checkpoint
saving checkpoint
episode:  455 score:   19.0  average score 14.8 best score 14.75 epsilon 0.10 steps 100037
```

```
1
saving checkpoint
saving checkpoint
episode:  456 score:  13.0  average score 14.8 best score 14.77 epsilon 0.10 steps 100277
1
saving checkpoint
saving checkpoint
episode:  457 score:  16.0  average score 14.8 best score 14.78 epsilon 0.10 steps 100508
6
saving checkpoint
saving checkpoint
episode:  458 score:  11.0  average score 14.8 best score 14.80 epsilon 0.10 steps 100761
8
episode:  459 score:  19.0  average score 14.8 best score 14.80 epsilon 0.10 steps 100951
8
saving checkpoint
saving checkpoint
episode:  460 score:  11.0  average score 14.8 best score 14.84 epsilon 0.10 steps 101183
5
episode:  461 score:  21.0  average score 14.8 best score 14.84 epsilon 0.10 steps 101362
5
episode:  462 score:  17.0  average score 14.8 best score 14.84 epsilon 0.10 steps 101561
7
saving checkpoint
saving checkpoint
episode:  463 score:  4.0  average score 14.8 best score 14.85 epsilon 0.10 steps 1018272
episode:  464 score:  9.0  average score 14.8 best score 14.85 epsilon 0.10 steps 1020652
episode:  465 score:  18.0  average score 14.9 best score 14.85 epsilon 0.10 steps 102250
8
saving checkpoint
saving checkpoint
episode:  466 score:  18.0  average score 14.9 best score 14.88 epsilon 0.10 steps 102457
1
saving checkpoint
saving checkpoint
episode:  467 score:  20.0  average score 15.0 best score 14.91 epsilon 0.10 steps 102645
0
saving checkpoint
saving checkpoint
episode:  468 score:  17.0  average score 14.9 best score 14.97 epsilon 0.10 steps 102841
0
episode:  469 score:  16.0  average score 14.9 best score 14.97 epsilon 0.10 steps 103043
6
episode:  470 score:  14.0  average score 14.9 best score 14.97 epsilon 0.10 steps 103267
7
episode:  471 score:  16.0  average score 15.0 best score 14.97 epsilon 0.10 steps 103481
9
episode:  472 score:  15.0  average score 14.9 best score 14.97 epsilon 0.10 steps 103694
4
episode:  473 score:  13.0  average score 14.9 best score 14.97 epsilon 0.10 steps 103922
8
episode:  474 score:  17.0  average score 15.1 best score 14.97 epsilon 0.10 steps 104125
7
saving checkpoint
saving checkpoint
episode:  475 score:  17.0  average score 15.1 best score 15.07 epsilon 0.10 steps 104315
0
saving checkpoint
saving checkpoint
episode:  476 score:  14.0  average score 15.1 best score 15.10 epsilon 0.10 steps 104536
4
saving checkpoint
saving checkpoint
episode:  477 score:  14.0  average score 15.1 best score 15.13 epsilon 0.10 steps 104755
0
episode:  478 score:  14.0  average score 15.1 best score 15.13 epsilon 0.10 steps 104991
6
episode:  479 score:  10.0  average score 15.1 best score 15.13 epsilon 0.10 steps 105230
4
episode:  480 score:  18.0  average score 15.2 best score 15.13 epsilon 0.10 steps 105420
2
saving checkpoint
```

```
saving checkpoint
episode:  481 score:  17.0  average score 15.2 best score 15.15 epsilon 0.10 steps 105624
9
saving checkpoint
saving checkpoint
episode:  482 score:  14.0  average score 15.2 best score 15.20 epsilon 0.10 steps 105853
7
episode:  483 score:  17.0  average score 15.2 best score 15.20 epsilon 0.10 steps 106057
9
saving checkpoint
saving checkpoint
episode:  484 score:  16.0  average score 15.2 best score 15.22 epsilon 0.10 steps 106268
9
episode:  485 score:  14.0  average score 15.2 best score 15.22 epsilon 0.10 steps 106480
7
episode:  486 score:  14.0  average score 15.2 best score 15.22 epsilon 0.10 steps 106689
9
episode:  487 score:  10.0  average score 15.1 best score 15.22 epsilon 0.10 steps 106933
2
episode:  488 score:  12.0  average score 15.0 best score 15.22 epsilon 0.10 steps 107177
0
episode:  489 score:  20.0  average score 15.1 best score 15.22 epsilon 0.10 steps 107350
8
episode:  490 score:  15.0  average score 15.0 best score 15.22 epsilon 0.10 steps 107592
1
episode:  491 score:  9.0  average score 14.9 best score 15.22 epsilon 0.10 steps 1078628
episode:  492 score:  14.0  average score 15.0 best score 15.22 epsilon 0.10 steps 108081
2
episode:  493 score:  16.0  average score 14.9 best score 15.22 epsilon 0.10 steps 108281
7
episode:  494 score:  16.0  average score 14.9 best score 15.22 epsilon 0.10 steps 108491
4
episode:  495 score:  17.0  average score 15.0 best score 15.22 epsilon 0.10 steps 108678
3
episode:  496 score:  18.0  average score 15.0 best score 15.22 epsilon 0.10 steps 108872
1
episode:  497 score:  16.0  average score 15.1 best score 15.22 epsilon 0.10 steps 109078
8
episode:  498 score:  18.0  average score 15.1 best score 15.22 epsilon 0.10 steps 109285
3
episode:  499 score:  18.0  average score 15.2 best score 15.22 epsilon 0.10 steps 109471
8
```


In [ ]:

```
!pwd
```

/content/drive/My Drive/Pong

In [ ]:

```python
# DQN after training

import gym
import numpy as np
```

```python
from dqn import *
from utils import plot_learning_curve, make_env
from gym import wrappers
import cv2
import matplotlib.pyplot as plt
from google.colab.patches import cv2_imshow


if __name__ == '__main__':
    env = make_env('PongNoFrameskip-v4')
    best_score = -np.inf
    load_checkpoint = True
    n_games = 100


    #setting epsilon-> 0.1
    agent = DQN(states=env.observation_space, actions=env.action_space.n,alpha=0.0001,ga
mma=0.99,epsilon=0.1,
                epsilon_min=0.1,epsilon_decay=1e-5,replay_buffer_sz=10000,batch=32,path
= 'atari_model_eval.txt',
                path_pred = 'atari_model_target.txt')


    if load_checkpoint:
        agent.load_models()

    figure_file = 'plots/pong2.png'
    # if you want to record video of your agent playing, do a mkdir tmp && mkdir tmp/dqn-
video
    # and uncomment the following 2 lines.
    #env = wrappers.Monitor(env, "tmp/dqn-video",
    #                   video_callable=lambda episode_id: True, force=True)
    n_steps = 0
    scores, eps_history, steps_array = [], [], []

    count = 0
    for i in range(n_games):
        done = False
        observation = env.reset()

        score = 0
        while not done:
            action = agent.e_greedy_policy(observation)
            observation_, reward, done, info = env.step(action)

            score += reward

            count += 1
            if not load_checkpoint:
                agent.store(observation, action,
                                    reward, observation_, done)
                agent.learn()
            observation = observation_
            n_steps += 1
            # cv2_imshow(observation[0,:,:])
            # cv2.waitKey(0)
        scores.append(score)
        steps_array.append(n_steps)

        avg_score = np.mean(scores[-100:])
        print('episode: ', i,'score: ', score,
            ' average score %.1f' % avg_score, 'best score %.2f' % best_score,
            'epsilon %.2f' % agent.epsilon, 'steps', n_steps)

        if avg_score > best_score:
            if not load_checkpoint:
                agent.save_models()
            best_score = avg_score

        eps_history.append(agent.epsilon)

    x = [i+1 for i in range(len(scores))]
```

```
    plot_learning_curve(steps_array, scores, eps_history, figure_file)
```

```
loading checkpoint
loading checkpoint
episode:  0 score:   17.0  average score 17.0 best score -inf epsilon 0.10 steps 1981
episode:  1 score:   13.0  average score 15.0 best score 17.00 epsilon 0.10 steps 4308
episode:  2 score:   -1.0  average score 9.7 best score 17.00 epsilon 0.10 steps 6943
episode:  3 score:   19.0  average score 12.0 best score 17.00 epsilon 0.10 steps 8870
episode:  4 score:   17.0  average score 13.0 best score 17.00 epsilon 0.10 steps 10757
episode:  5 score:   18.0  average score 13.8 best score 17.00 epsilon 0.10 steps 12680
episode:  6 score:   17.0  average score 14.3 best score 17.00 epsilon 0.10 steps 14680
episode:  7 score:   13.0  average score 14.1 best score 17.00 epsilon 0.10 steps 16907
episode:  8 score:   13.0  average score 14.0 best score 17.00 epsilon 0.10 steps 19224
episode:  9 score:   17.0  average score 14.3 best score 17.00 epsilon 0.10 steps 21228
episode:  10 score:  18.0   average score 14.6 best score 17.00 epsilon 0.10 steps 23205
episode:  11 score:  16.0   average score 14.8 best score 17.00 epsilon 0.10 steps 25245
episode:  12 score:  16.0   average score 14.8 best score 17.00 epsilon 0.10 steps 27419
episode:  13 score:  17.0   average score 15.0 best score 17.00 epsilon 0.10 steps 29486
episode:  14 score:  17.0   average score 15.1 best score 17.00 epsilon 0.10 steps 31639
episode:  15 score:  15.0   average score 15.1 best score 17.00 epsilon 0.10 steps 33724
episode:  16 score:  13.0   average score 15.0 best score 17.00 epsilon 0.10 steps 35955
episode:  17 score:  19.0   average score 15.2 best score 17.00 epsilon 0.10 steps 37786
episode:  18 score:  19.0   average score 15.4 best score 17.00 epsilon 0.10 steps 39711
episode:  19 score:  17.0   average score 15.5 best score 17.00 epsilon 0.10 steps 41741
episode:  20 score:  17.0   average score 15.6 best score 17.00 epsilon 0.10 steps 43911
episode:  21 score:  16.0   average score 15.6 best score 17.00 epsilon 0.10 steps 45932
episode:  22 score:  18.0   average score 15.7 best score 17.00 epsilon 0.10 steps 47889
episode:  23 score:  20.0   average score 15.9 best score 17.00 epsilon 0.10 steps 49701
episode:  24 score:  17.0   average score 15.9 best score 17.00 epsilon 0.10 steps 51674
episode:  25 score:  20.0   average score 16.1 best score 17.00 epsilon 0.10 steps 53506
episode:  26 score:  17.0   average score 16.1 best score 17.00 epsilon 0.10 steps 55551
episode:  27 score:  13.0   average score 16.0 best score 17.00 epsilon 0.10 steps 57844
episode:  28 score:  13.0   average score 15.9 best score 17.00 epsilon 0.10 steps 60094
episode:  29 score:  17.0   average score 15.9 best score 17.00 epsilon 0.10 steps 61970
episode:  30 score:  16.0   average score 15.9 best score 17.00 epsilon 0.10 steps 64307
episode:  31 score:  10.0   average score 15.8 best score 17.00 epsilon 0.10 steps 66804
episode:  32 score:  20.0   average score 15.9 best score 17.00 epsilon 0.10 steps 68743
episode:  33 score:  14.0   average score 15.8 best score 17.00 epsilon 0.10 steps 70973
episode:  34 score:  16.0   average score 15.8 best score 17.00 epsilon 0.10 steps 72933
episode:  35 score:  17.0   average score 15.9 best score 17.00 epsilon 0.10 steps 74944
episode:  36 score:  17.0   average score 15.9 best score 17.00 epsilon 0.10 steps 76811
episode:  37 score:  18.0   average score 15.9 best score 17.00 epsilon 0.10 steps 78773
episode:  38 score:  19.0   average score 16.0 best score 17.00 epsilon 0.10 steps 80770
episode:  39 score:  18.0   average score 16.1 best score 17.00 epsilon 0.10 steps 82633
episode:  40 score:  18.0   average score 16.1 best score 17.00 epsilon 0.10 steps 84699
episode:  41 score:  19.0   average score 16.2 best score 17.00 epsilon 0.10 steps 86502
episode:  42 score:  16.0   average score 16.2 best score 17.00 epsilon 0.10 steps 88486
episode:  43 score:  13.0   average score 16.1 best score 17.00 epsilon 0.10 steps 91043
episode:  44 score:  15.0   average score 16.1 best score 17.00 epsilon 0.10 steps 93438
episode:  45 score:  18.0   average score 16.1 best score 17.00 epsilon 0.10 steps 95581
episode:  46 score:  16.0   average score 16.1 best score 17.00 epsilon 0.10 steps 97522
episode:  47 score:  18.0   average score 16.2 best score 17.00 epsilon 0.10 steps 99564
episode:  48 score:  20.0   average score 16.2 best score 17.00 epsilon 0.10 steps 101420
episode:  49 score:  14.0   average score 16.2 best score 17.00 epsilon 0.10 steps 103469
episode:  50 score:  14.0   average score 16.2 best score 17.00 epsilon 0.10 steps 105610
episode:  51 score:  14.0   average score 16.1 best score 17.00 epsilon 0.10 steps 107770
episode:  52 score:  20.0   average score 16.2 best score 17.00 epsilon 0.10 steps 109536
episode:  53 score:  15.0   average score 16.2 best score 17.00 epsilon 0.10 steps 111613
episode:  54 score:  13.0   average score 16.1 best score 17.00 epsilon 0.10 steps 113946
episode:  55 score:  19.0   average score 16.2 best score 17.00 epsilon 0.10 steps 115807
episode:  56 score:  16.0   average score 16.2 best score 17.00 epsilon 0.10 steps 117950
episode:  57 score:  14.0   average score 16.1 best score 17.00 epsilon 0.10 steps 120195
episode:  58 score:  16.0   average score 16.1 best score 17.00 epsilon 0.10 steps 122222
episode:  59 score:  17.0   average score 16.1 best score 17.00 epsilon 0.10 steps 124327
episode:  60 score:  19.0   average score 16.2 best score 17.00 epsilon 0.10 steps 126269
episode:  61 score:  17.0   average score 16.2 best score 17.00 epsilon 0.10 steps 128245
episode:  62 score:  15.0   average score 16.2 best score 17.00 epsilon 0.10 steps 130283
episode:  63 score:  14.0   average score 16.1 best score 17.00 epsilon 0.10 steps 132582
episode:  64 score:  12.0   average score 16.1 best score 17.00 epsilon 0.10 steps 135005
episode:  65 score:  15.0   average score 16.1 best score 17.00 epsilon 0.10 steps 137083
episode:  66 score:  17.0   average score 16.1 best score 17.00 epsilon 0.10 steps 139112
episode:  67 score:  18.0   average score 16.1 best score 17.00 epsilon 0.10 steps 141028
```
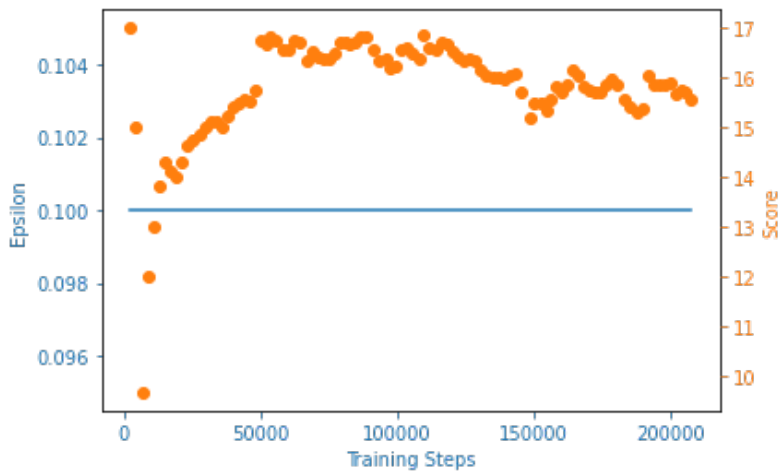
```
episode:  68 score:  19.0   average score 16.1 best score 17.00 epsilon 0.10 steps 142823
episode:  69 score:  12.0   average score 16.1 best score 17.00 epsilon 0.10 steps 145458
episode:  70 score:   3.0   average score 15.9 best score 17.00 epsilon 0.10 steps 148269
episode:  71 score:  20.0   average score 16.0 best score 17.00 epsilon 0.10 steps 150180
episode:  72 score:  14.0   average score 15.9 best score 17.00 epsilon 0.10 steps 152387
episode:  73 score:  17.0   average score 15.9 best score 17.00 epsilon 0.10 steps 154318
episode:  74 score:  20.0   average score 16.0 best score 17.00 epsilon 0.10 steps 156105
episode:  75 score:  18.0   average score 16.0 best score 17.00 epsilon 0.10 steps 157957
episode:  76 score:  17.0   average score 16.0 best score 17.00 epsilon 0.10 steps 160193
episode:  77 score:  19.0   average score 16.1 best score 17.00 epsilon 0.10 steps 162016
episode:  78 score:  20.0   average score 16.1 best score 17.00 epsilon 0.10 steps 163790
episode:  79 score:  14.0   average score 16.1 best score 17.00 epsilon 0.10 steps 165762
episode:  80 score:  12.0   average score 16.0 best score 17.00 epsilon 0.10 steps 168260
episode:  81 score:  18.0   average score 16.1 best score 17.00 epsilon 0.10 steps 170215
episode:  82 score:  16.0   average score 16.1 best score 17.00 epsilon 0.10 steps 172312
episode:  83 score:  15.0   average score 16.1 best score 17.00 epsilon 0.10 steps 174347
episode:  84 score:  17.0   average score 16.1 best score 17.00 epsilon 0.10 steps 176300
episode:  85 score:  14.0   average score 16.0 best score 17.00 epsilon 0.10 steps 178346
episode:  86 score:  13.0   average score 16.0 best score 17.00 epsilon 0.10 steps 180495
episode:  87 score:  11.0   average score 16.0 best score 17.00 epsilon 0.10 steps 182878
episode:  88 score:  15.0   average score 15.9 best score 17.00 epsilon 0.10 steps 185121
episode:  89 score:  16.0   average score 15.9 best score 17.00 epsilon 0.10 steps 187395
episode:  90 score:  14.0   average score 15.9 best score 17.00 epsilon 0.10 steps 189554
episode:  91 score:  17.0   average score 15.9 best score 17.00 epsilon 0.10 steps 191656
episode:  92 score:  16.0   average score 15.9 best score 17.00 epsilon 0.10 steps 193718
episode:  93 score:  14.0   average score 15.9 best score 17.00 epsilon 0.10 steps 195868
episode:  94 score:  17.0   average score 15.9 best score 17.00 epsilon 0.10 steps 197840
episode:  95 score:  21.0   average score 16.0 best score 17.00 epsilon 0.10 steps 199572
episode:  96 score:  13.0   average score 15.9 best score 17.00 epsilon 0.10 steps 201758
episode:  97 score:  19.0   average score 16.0 best score 17.00 epsilon 0.10 steps 203689
episode:  98 score:  18.0   average score 16.0 best score 17.00 epsilon 0.10 steps 205525
episode:  99 score:  17.0   average score 16.0 best score 17.00 epsilon 0.10 steps 207466
```


In [ ]:

In [6]:

```
%cd drive/My\ Drive/Pong
```

```
[Errno 2] No such file or directory: 'drive/My Drive/Pong'
/content/drive/My Drive/Pong
```

In [10]:

```python
# DQN after training

import gym
import numpy as np
from dqn import *
from utils import plot_learning_curve, make_env
from gym import wrappers
import cv2
import matplotlib.pyplot as plt
```

```python
from google.colab.patches import cv2_imshow


def fgsm_attack(data,action,reward,done, epsilon, agent,iter):
    if(iter == 1):
      print(f"epsilon value of {epsilon}")
      "================================="
      cv2_imshow(data[3,:,:]*255)
      print("========================")

    data = torch.from_numpy(data)
    data = data.type(torch.FloatTensor)
    data = torch.unsqueeze(data,0)
    data = data.to(agent.Q.device)
    data.requires_grad = True

    agent.Q.optimizer.zero_grad()

    q_pred = agent.Q.forward(data)[0, action]
    q_next = agent.Q_pred.forward(data).max(dim=1)[0]

    q_next[done] = 0.0
    q_target = reward + agent.gamma*q_next

    loss = agent.Q.loss(q_target, q_pred).to(agent.Q.device)
    loss.backward()

    data_grad = data.grad.data

    # Collect the element-wise sign of the data gradient
    sign_data_grad = data_grad.sign()
    # Create the perturbed image by adjusting each pixel of the input image
    perturbed_image = data + epsilon*sign_data_grad
    # Adding clipping to maintain [0,1] range
    perturbed_image = perturbed_image.squeeze()

    perturbed_image = torch.clamp(perturbed_image, 0, 1).detach().cpu().numpy()
    #perturbed_image = perturbed_image.detach().cpu().numpy()

    if(iter == 1):
      cv2_imshow(perturbed_image[3,:,:]*255)
      print("#####################################")
      #print(a)

    # Return the perturbed image
    return perturbed_image




if __name__ == '__main__':
    env = make_env('PongNoFrameskip-v4')
    best_score = -np.inf
    load_checkpoint = True
    n_games = 100


    #setting epsilon-> 0.1
    agent = DQN(states=env.observation_space, actions=env.action_space.n,alpha=0.0001,ga
mma=0.99,epsilon=0.1,
                epsilon_min=0.1,epsilon_decay=1e-5,replay_buffer_sz=10000,batch=32,path
= 'atari_model_eval.txt',
                path_pred = 'atari_model_target.txt')


    if load_checkpoint:
        agent.load_models()

    figure_file = 'plots/pong3.png'
    # if you want to record video of your agent playing, do a mkdir tmp && mkdir tmp/dqn-
video
```

```python
        # and uncomment the following 2 lines.
        #env = wrappers.Monitor(env, "tmp/dqn-video",
        #                  video_callable=lambda episode_id: True, force=True)
    n_steps = 0
    scores, eps_history, steps_array = [], [], []

    peturb_eps = [0.007,0.008, 0.009, 0.01]
    for eps in peturb_eps:
      count = 0
      for i in range(n_games):
          done = False
          observation = env.reset()                                     #se
tting initial action to peturb
          action = 0
          reward = 0
          score = 0
          while not done:
              observation= fgsm_attack(observation,action,reward,done, eps,agent,count)
# peturb observation
              action = agent.e_greedy_policy(observation)
              observation_, reward, done, info = env.step(action)

              score += reward

              count += 1
              if not load_checkpoint:
                  agent.store(observation, action,
                                    reward, observation_, done)
                  agent.learn()
              observation = observation_
              n_steps += 1
              # cv2_imshow(observation[0,:,:])
              # cv2.waitKey(0)
          scores.append(score)
          steps_array.append(n_steps)

          avg_score = np.mean(scores[-100:])
          print('episode: ', i,'score: ', score,
              ' average score %.1f' % avg_score, 'best score %.2f' % best_score,
              'epsilon %.2f' % agent.epsilon, 'steps', n_steps)

          if avg_score > best_score:
              if not load_checkpoint:
                  agent.save_models()
              best_score = avg_score

          eps_history.append(agent.epsilon)

    x = [i+1 for i in range(len(scores))]
    plot_learning_curve(steps_array, scores, eps_history, figure_file)
```

```
loading checkpoint
loading checkpoint
epsilon value of 0.007
```

```
/usr/local/lib/python3.6/dist-packages/torch/nn/modules/loss.py:445: UserWarning: Using a
target size (torch.Size([])) that is different to the input size (torch.Size([1])). This
will likely lead to incorrect results due to broadcasting. Please ensure they have the sa
me size.
  return F.mse_loss(input, target, reduction=self.reduction)
```



```
=========================
```

```
########################################
episode:  0 score:  -21.0   average score -21.0 best score -inf epsilon 0.10 steps 764
episode:  1 score:  -21.0   average score -21.0 best score -21.00 epsilon 0.10 steps 1528
episode:  2 score:  -21.0   average score -21.0 best score -21.00 epsilon 0.10 steps 2352
episode:  3 score:  -21.0   average score -21.0 best score -21.00 epsilon 0.10 steps 3116
episode:  4 score:  -20.0   average score -20.8 best score -21.00 epsilon 0.10 steps 4035
episode:  5 score:  -19.0   average score -20.5 best score -20.80 epsilon 0.10 steps 5144
episode:  6 score:  -21.0   average score -20.6 best score -20.50 epsilon 0.10 steps 5936
episode:  7 score:  -21.0   average score -20.6 best score -20.50 epsilon 0.10 steps 6700
episode:  8 score:  -21.0   average score -20.7 best score -20.50 epsilon 0.10 steps 7554
episode:  9 score:  -21.0   average score -20.7 best score -20.50 epsilon 0.10 steps 8408
episode:  10 score:  -20.0   average score -20.6 best score -20.50 epsilon 0.10 steps 9370
episode:  11 score:  -20.0   average score -20.6 best score -20.50 epsilon 0.10 steps 10395
episode:  12 score:  -21.0   average score -20.6 best score -20.50 epsilon 0.10 steps 11275
episode:  13 score:  -21.0   average score -20.6 best score -20.50 epsilon 0.10 steps 12039
episode:  14 score:  -21.0   average score -20.7 best score -20.50 epsilon 0.10 steps 12803
episode:  15 score:  -19.0   average score -20.6 best score -20.50 epsilon 0.10 steps 13800
episode:  16 score:  -21.0   average score -20.6 best score -20.50 epsilon 0.10 steps 14564
episode:  17 score:  -20.0   average score -20.6 best score -20.50 epsilon 0.10 steps 15461
episode:  18 score:  -21.0   average score -20.6 best score -20.50 epsilon 0.10 steps 16313
episode:  19 score:  -21.0   average score -20.6 best score -20.50 epsilon 0.10 steps 17277
episode:  20 score:  -21.0   average score -20.6 best score -20.50 epsilon 0.10 steps 18101
episode:  21 score:  -21.0   average score -20.6 best score -20.50 epsilon 0.10 steps 18893
episode:  22 score:  -21.0   average score -20.7 best score -20.50 epsilon 0.10 steps 19657
episode:  23 score:  -21.0   average score -20.7 best score -20.50 epsilon 0.10 steps 20500
episode:  24 score:  -21.0   average score -20.7 best score -20.50 epsilon 0.10 steps 21311
episode:  25 score:  -21.0   average score -20.7 best score -20.50 epsilon 0.10 steps 22075
episode:  26 score:  -21.0   average score -20.7 best score -20.50 epsilon 0.10 steps 22839
episode:  27 score:  -20.0   average score -20.7 best score -20.50 epsilon 0.10 steps 23788
episode:  28 score:  -21.0   average score -20.7 best score -20.50 epsilon 0.10 steps 24642
episode:  29 score:  -21.0   average score -20.7 best score -20.50 epsilon 0.10 steps 25496
episode:  30 score:  -21.0   average score -20.7 best score -20.50 epsilon 0.10 steps 26260
episode:  31 score:  -21.0   average score -20.7 best score -20.50 epsilon 0.10 steps 27024
episode:  32 score:  -21.0   average score -20.7 best score -20.50 epsilon 0.10 steps 27788
episode:  33 score:  -21.0   average score -20.7 best score -20.50 epsilon 0.10 steps 28552
episode:  34 score:  -21.0   average score -20.7 best score -20.50 epsilon 0.10 steps 29376
episode:  35 score:  -21.0   average score -20.8 best score -20.50 epsilon 0.10 steps 30230
episode:  36 score:  -21.0   average score -20.8 best score -20.50 epsilon 0.10 steps 30994
episode:  37 score:  -21.0   average score -20.8 best score -20.50 epsilon 0.10 steps 31758
episode:  38 score:  -20.0   average score -20.7 best score -20.50 epsilon 0.10 steps 32796
episode:  39 score:  -21.0   average score -20.8 best score -20.50 epsilon 0.10 steps 33560
episode:  40 score:  -21.0   average score -20.8 best score -20.50 epsilon 0.10 steps 3432
```

```
episode:   40 score:   -21.0  average score -20.8 best score -20.50 epsilon 0.10 steps 3432
4
episode:   41 score:   -21.0  average score -20.8 best score -20.50 epsilon 0.10 steps 3508
8
episode:   42 score:   -20.0  average score -20.7 best score -20.50 epsilon 0.10 steps 3595
8
episode:   43 score:   -21.0  average score -20.8 best score -20.50 epsilon 0.10 steps 3679
0
episode:   44 score:   -21.0  average score -20.8 best score -20.50 epsilon 0.10 steps 3761
4
episode:   45 score:   -21.0  average score -20.8 best score -20.50 epsilon 0.10 steps 3843
8
episode:   46 score:   -21.0  average score -20.8 best score -20.50 epsilon 0.10 steps 3926
2
episode:   47 score:   -20.0  average score -20.8 best score -20.50 epsilon 0.10 steps 4014
8
episode:   48 score:   -21.0  average score -20.8 best score -20.50 epsilon 0.10 steps 4097
2
episode:   49 score:   -19.0  average score -20.7 best score -20.50 epsilon 0.10 steps 4191
0
episode:   50 score:   -21.0  average score -20.7 best score -20.50 epsilon 0.10 steps 4270
2
episode:   51 score:   -21.0  average score -20.7 best score -20.50 epsilon 0.10 steps 4346
6
episode:   52 score:   -21.0  average score -20.7 best score -20.50 epsilon 0.10 steps 4442
8
episode:   53 score:   -21.0  average score -20.7 best score -20.50 epsilon 0.10 steps 4519
2
episode:   54 score:   -21.0  average score -20.7 best score -20.50 epsilon 0.10 steps 4595
6
episode:   55 score:   -20.0  average score -20.7 best score -20.50 epsilon 0.10 steps 4696
6
episode:   56 score:   -20.0  average score -20.7 best score -20.50 epsilon 0.10 steps 4797
4
episode:   57 score:   -21.0  average score -20.7 best score -20.50 epsilon 0.10 steps 4873
8
episode:   58 score:   -21.0  average score -20.7 best score -20.50 epsilon 0.10 steps 4950
2
episode:   59 score:   -21.0  average score -20.7 best score -20.50 epsilon 0.10 steps 5026
6
episode:   60 score:   -21.0  average score -20.7 best score -20.50 epsilon 0.10 steps 5109
0
episode:   61 score:   -21.0  average score -20.7 best score -20.50 epsilon 0.10 steps 5188
2
episode:   62 score:   -21.0  average score -20.7 best score -20.50 epsilon 0.10 steps 5264
6
episode:   63 score:   -21.0  average score -20.8 best score -20.50 epsilon 0.10 steps 5343
8
episode:   64 score:   -21.0  average score -20.8 best score -20.50 epsilon 0.10 steps 5420
2
episode:   65 score:   -21.0  average score -20.8 best score -20.50 epsilon 0.10 steps 5508
8
episode:   66 score:   -21.0  average score -20.8 best score -20.50 epsilon 0.10 steps 5585
2
episode:   67 score:   -21.0  average score -20.8 best score -20.50 epsilon 0.10 steps 5667
6
episode:   68 score:   -21.0  average score -20.8 best score -20.50 epsilon 0.10 steps 5748
7
episode:   69 score:   -21.0  average score -20.8 best score -20.50 epsilon 0.10 steps 5831
1
episode:   70 score:   -19.0  average score -20.7 best score -20.50 epsilon 0.10 steps 5927
9
episode:   71 score:   -21.0  average score -20.8 best score -20.50 epsilon 0.10 steps 6013
3
episode:   72 score:   -21.0  average score -20.8 best score -20.50 epsilon 0.10 steps 6089
7
episode:   73 score:   -21.0  average score -20.8 best score -20.50 epsilon 0.10 steps 6166
1
episode:   74 score:   -21.0  average score -20.8 best score -20.50 epsilon 0.10 steps 6250
4
episode:   75 score:   -18.0  average score -20.7 best score -20.50 epsilon 0.10 steps 6371
9
episode:   76 score:   -20.0  average score -20.7 best score -20.50 epsilon 0.10 steps 6456
```
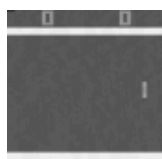
```
episode:  76 score:  -20.0  average score -20.7 best score -20.50 epsilon 0.10 steps 6456
1
episode:  77 score:  -21.0  average score -20.7 best score -20.50 epsilon 0.10 steps 6532
5
episode:  78 score:  -21.0  average score -20.7 best score -20.50 epsilon 0.10 steps 6622
9
episode:  79 score:  -21.0  average score -20.7 best score -20.50 epsilon 0.10 steps 6714
3
episode:  80 score:  -21.0  average score -20.7 best score -20.50 epsilon 0.10 steps 6802
3
episode:  81 score:  -21.0  average score -20.7 best score -20.50 epsilon 0.10 steps 6878
7
episode:  82 score:  -21.0  average score -20.7 best score -20.50 epsilon 0.10 steps 6955
1
episode:  83 score:  -21.0  average score -20.7 best score -20.50 epsilon 0.10 steps 7043
2
episode:  84 score:  -21.0  average score -20.7 best score -20.50 epsilon 0.10 steps 7125
6
episode:  85 score:  -21.0  average score -20.7 best score -20.50 epsilon 0.10 steps 7202
0
episode:  86 score:  -21.0  average score -20.7 best score -20.50 epsilon 0.10 steps 7284
5
episode:  87 score:  -21.0  average score -20.8 best score -20.50 epsilon 0.10 steps 7377
7
episode:  88 score:  -20.0  average score -20.7 best score -20.50 epsilon 0.10 steps 7475
4
episode:  89 score:  -21.0  average score -20.7 best score -20.50 epsilon 0.10 steps 7551
8
episode:  90 score:  -21.0  average score -20.7 best score -20.50 epsilon 0.10 steps 7628
2
episode:  91 score:  -21.0  average score -20.8 best score -20.50 epsilon 0.10 steps 7710
6
episode:  92 score:  -20.0  average score -20.7 best score -20.50 epsilon 0.10 steps 7799
5
episode:  93 score:  -21.0  average score -20.7 best score -20.50 epsilon 0.10 steps 7881
6
episode:  94 score:  -21.0  average score -20.7 best score -20.50 epsilon 0.10 steps 7958
0
episode:  95 score:  -21.0  average score -20.8 best score -20.50 epsilon 0.10 steps 8045
1
episode:  96 score:  -21.0  average score -20.8 best score -20.50 epsilon 0.10 steps 8121
5
episode:  97 score:  -19.0  average score -20.7 best score -20.50 epsilon 0.10 steps 8221
8
episode:  98 score:  -21.0  average score -20.7 best score -20.50 epsilon 0.10 steps 8298
2
episode:  99 score:  -21.0  average score -20.7 best score -20.50 epsilon 0.10 steps 8383
6
epsilon value of 0.008
```



```
===========================
```



```
#####################################
episode:  0 score:  -21.0  average score -20.7 best score -20.50 epsilon 0.10 steps 84628
episode:  1 score:  -21.0  average score -20.7 best score -20.50 epsilon 0.10 steps 85392
episode:  2 score:  -21.0  average score -20.7 best score -20.50 epsilon 0.10 steps 86156
episode:  3 score:  -20.0  average score -20.7 best score -20.50 epsilon 0.10 steps 87058
episode:  4 score:  -16.0  average score -20.7 best score -20.50 epsilon 0.10 steps 88396
episode:  5 score:  -21.0  average score -20.7 best score -20.50 epsilon 0.10 steps 89160
episode:  6 score:  -21.0  average score -20.7 best score -20.50 epsilon 0.10 steps 89924
episode:  7 score:  -21.0  average score -20.7 best score -20.50 epsilon 0.10 steps 90688
episode:  8 score:  -21.0  average score -20.7 best score -20.50 epsilon 0.10 steps 91452
```

```
episode:   8 score:   -21.0   average score  -20.7 best score  -20.50 epsilon 0.10 steps 91452
episode:   9 score:   -20.0   average score  -20.7 best score  -20.50 epsilon 0.10 steps 92322
episode:  10 score:   -21.0   average score  -20.7 best score  -20.50 epsilon 0.10 steps 9317
6
episode:  11 score:   -21.0   average score  -20.7 best score  -20.50 epsilon 0.10 steps 9394
0
episode:  12 score:   -21.0   average score  -20.7 best score  -20.50 epsilon 0.10 steps 9485
2
episode:  13 score:   -21.0   average score  -20.7 best score  -20.50 epsilon 0.10 steps 9561
6
episode:  14 score:   -21.0   average score  -20.7 best score  -20.50 epsilon 0.10 steps 9638
0
episode:  15 score:   -21.0   average score  -20.7 best score  -20.50 epsilon 0.10 steps 9717
2
episode:  16 score:   -21.0   average score  -20.7 best score  -20.50 epsilon 0.10 steps 9793
6
episode:  17 score:   -20.0   average score  -20.7 best score  -20.50 epsilon 0.10 steps 9880
7
episode:  18 score:   -21.0   average score  -20.7 best score  -20.50 epsilon 0.10 steps 9957
1
episode:  19 score:   -21.0   average score  -20.7 best score  -20.50 epsilon 0.10 steps 1003
35
episode:  20 score:   -21.0   average score  -20.7 best score  -20.50 epsilon 0.10 steps 1010
99
episode:  21 score:   -21.0   average score  -20.7 best score  -20.50 epsilon 0.10 steps 1018
63
episode:  22 score:   -21.0   average score  -20.7 best score  -20.50 epsilon 0.10 steps 1026
27
episode:  23 score:   -21.0   average score  -20.7 best score  -20.50 epsilon 0.10 steps 1033
91
episode:  24 score:   -21.0   average score  -20.7 best score  -20.50 epsilon 0.10 steps 1041
55
episode:  25 score:   -21.0   average score  -20.7 best score  -20.50 epsilon 0.10 steps 1049
49
episode:  26 score:   -21.0   average score  -20.7 best score  -20.50 epsilon 0.10 steps 1057
41
episode:  27 score:   -21.0   average score  -20.8 best score  -20.50 epsilon 0.10 steps 1065
05
episode:  28 score:   -21.0   average score  -20.8 best score  -20.50 epsilon 0.10 steps 1073
31
episode:  29 score:   -21.0   average score  -20.8 best score  -20.50 epsilon 0.10 steps 1080
95
episode:  30 score:   -21.0   average score  -20.8 best score  -20.50 epsilon 0.10 steps 1088
59
episode:  31 score:   -21.0   average score  -20.8 best score  -20.50 epsilon 0.10 steps 1096
85
episode:  32 score:   -21.0   average score  -20.8 best score  -20.50 epsilon 0.10 steps 1104
49
episode:  33 score:   -21.0   average score  -20.8 best score  -20.50 epsilon 0.10 steps 1112
13
episode:  34 score:   -21.0   average score  -20.8 best score  -20.50 epsilon 0.10 steps 1119
77
episode:  35 score:   -21.0   average score  -20.8 best score  -20.50 epsilon 0.10 steps 1127
41
episode:  36 score:   -21.0   average score  -20.8 best score  -20.50 epsilon 0.10 steps 1135
63
episode:  37 score:   -21.0   average score  -20.8 best score  -20.50 epsilon 0.10 steps 1143
27
episode:  38 score:   -21.0   average score  -20.8 best score  -20.50 epsilon 0.10 steps 1151
70
episode:  39 score:   -21.0   average score  -20.8 best score  -20.50 epsilon 0.10 steps 1159
34
episode:  40 score:   -21.0   average score  -20.8 best score  -20.50 epsilon 0.10 steps 1166
98
episode:  41 score:   -21.0   average score  -20.8 best score  -20.50 epsilon 0.10 steps 1175
22
episode:  42 score:   -21.0   average score  -20.8 best score  -20.50 epsilon 0.10 steps 1182
86
episode:  43 score:   -21.0   average score  -20.8 best score  -20.50 epsilon 0.10 steps 1191
08
episode:  44 score:   -21.0   average score  -20.8 best score  -20.50 epsilon 0.10 steps 1198
72
episode:  45 score:   -21.0   average score  -20.8 best score  -20.50 epsilon 0.10 steps 1206
```

episode: 45 score: -21.0 average score -20.8 best score -20.50 epsilon 0.10 steps 1200
36
episode: 46 score: -21.0 average score -20.8 best score -20.50 epsilon 0.10 steps 1214
90
episode: 47 score: -21.0 average score -20.8 best score -20.50 epsilon 0.10 steps 1222
54
episode: 48 score: -21.0 average score -20.8 best score -20.50 epsilon 0.10 steps 1230
18
episode: 49 score: -21.0 average score -20.8 best score -20.50 epsilon 0.10 steps 1237
82
episode: 50 score: -20.0 average score -20.8 best score -20.50 epsilon 0.10 steps 1246
85
episode: 51 score: -21.0 average score -20.8 best score -20.50 epsilon 0.10 steps 1254
49
episode: 52 score: -21.0 average score -20.8 best score -20.50 epsilon 0.10 steps 1262
13
episode: 53 score: -21.0 average score -20.8 best score -20.50 epsilon 0.10 steps 1269
77
episode: 54 score: -21.0 average score -20.8 best score -20.50 epsilon 0.10 steps 1278
01
episode: 55 score: -21.0 average score -20.8 best score -20.50 epsilon 0.10 steps 1285
93
episode: 56 score: -20.0 average score -20.8 best score -20.50 epsilon 0.10 steps 1295
53
episode: 57 score: -21.0 average score -20.8 best score -20.50 epsilon 0.10 steps 1303
45
episode: 58 score: -21.0 average score -20.8 best score -20.50 epsilon 0.10 steps 1311
09
episode: 59 score: -21.0 average score -20.8 best score -20.50 epsilon 0.10 steps 1318
73
episode: 60 score: -21.0 average score -20.8 best score -20.50 epsilon 0.10 steps 1327
82
episode: 61 score: -21.0 average score -20.8 best score -20.50 epsilon 0.10 steps 1335
46
episode: 62 score: -21.0 average score -20.8 best score -20.50 epsilon 0.10 steps 1343
10
episode: 63 score: -21.0 average score -20.8 best score -20.50 epsilon 0.10 steps 1350
74
episode: 64 score: -18.0 average score -20.8 best score -20.50 epsilon 0.10 steps 1362
40
episode: 65 score: -21.0 average score -20.8 best score -20.50 epsilon 0.10 steps 1370
04
episode: 66 score: -21.0 average score -20.8 best score -20.50 epsilon 0.10 steps 1377
68
episode: 67 score: -21.0 average score -20.8 best score -20.50 epsilon 0.10 steps 1385
32
episode: 68 score: -21.0 average score -20.8 best score -20.50 epsilon 0.10 steps 1392
96
episode: 69 score: -16.0 average score -20.7 best score -20.50 epsilon 0.10 steps 1404
98
episode: 70 score: -21.0 average score -20.7 best score -20.50 epsilon 0.10 steps 1412
62
episode: 71 score: -20.0 average score -20.7 best score -20.50 epsilon 0.10 steps 1421
33
episode: 72 score: -21.0 average score -20.7 best score -20.50 epsilon 0.10 steps 1428
97
episode: 73 score: -18.0 average score -20.7 best score -20.50 epsilon 0.10 steps 1439
92
episode: 74 score: -21.0 average score -20.7 best score -20.50 epsilon 0.10 steps 1447
56
episode: 75 score: -18.0 average score -20.7 best score -20.50 epsilon 0.10 steps 1460
50
episode: 76 score: -20.0 average score -20.7 best score -20.50 epsilon 0.10 steps 1470
00
episode: 77 score: -21.0 average score -20.7 best score -20.50 epsilon 0.10 steps 1477
64
episode: 78 score: -21.0 average score -20.7 best score -20.50 epsilon 0.10 steps 1485
76
episode: 79 score: -21.0 average score -20.7 best score -20.50 epsilon 0.10 steps 1493
40
episode: 80 score: -21.0 average score -20.7 best score -20.50 epsilon 0.10 steps 1501
63
episode: 81 score: -21.0 average score -20.7 best score -20.50 epsilon 0.10 steps 1509

episode: 81 score: -21.0 average score -20.7 best score -20.50 epsilon 0.10 steps 1509
27
episode: 82 score: -21.0 average score -20.7 best score -20.50 epsilon 0.10 steps 1516
91
episode: 83 score: -21.0 average score -20.7 best score -20.50 epsilon 0.10 steps 1525
64
episode: 84 score: -21.0 average score -20.7 best score -20.50 epsilon 0.10 steps 1533
88
episode: 85 score: -21.0 average score -20.7 best score -20.50 epsilon 0.10 steps 1541
52
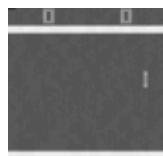episode: 86 score: -21.0 average score -20.7 best score -20.50 epsilon 0.10 steps 1549
16
episode: 87 score: -21.0 average score -20.7 best score -20.50 epsilon 0.10 steps 1556
80
episode: 88 score: -21.0 average score -20.7 best score -20.50 epsilon 0.10 steps 1564
44
episode: 89 score: -21.0 average score -20.7 best score -20.50 epsilon 0.10 steps 1572
08
episode: 90 score: -21.0 average score -20.7 best score -20.50 epsilon 0.10 steps 1579
72
episode: 91 score: -21.0 average score -20.7 best score -20.50 epsilon 0.10 steps 1587
36
episode: 92 score: -21.0 average score -20.7 best score -20.50 epsilon 0.10 steps 1595
19
episode: 93 score: -20.0 average score -20.7 best score -20.50 epsilon 0.10 steps 1603
91
episode: 94 score: -21.0 average score -20.7 best score -20.50 epsilon 0.10 steps 1611
55
episode: 95 score: -20.0 average score -20.7 best score -20.50 epsilon 0.10 steps 1621
18
episode: 96 score: -21.0 average score -20.7 best score -20.50 epsilon 0.10 steps 1628
82
episode: 97 score: -21.0 average score -20.7 best score -20.50 epsilon 0.10 steps 1636
46
episode: 98 score: -21.0 average score -20.7 best score -20.50 epsilon 0.10 steps 1644
10
episode: 99 score: -21.0 average score -20.7 best score -20.50 epsilon 0.10 steps 1651
74
epsilon value of 0.009

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#######################################
episode: 0 score: -21.0 average score -20.7 best score -20.50 epsilon 0.10 steps 16612
0
episode: 1 score: -21.0 average score -20.7 best score -20.50 epsilon 0.10 steps 16715
6
episode: 2 score: -21.0 average score -20.7 best score -20.50 epsilon 0.10 steps 16798
0
episode: 3 score: -21.0 average score -20.7 best score -20.50 epsilon 0.10 steps 16874
4
episode: 4 score: -21.0 average score -20.8 best score -20.50 epsilon 0.10 steps 16950
8
episode: 5 score: -20.0 average score -20.8 best score -20.50 epsilon 0.10 steps 17037
8
episode: 6 score: -21.0 average score -20.8 best score -20.50 epsilon 0.10 steps 17114
2
episode: 7 score: -21.0 average score -20.8 best score -20.50 epsilon 0.10 steps 17190
6
episode: 8 score: -21.0 average score -20.8 best score -20.50 epsilon 0.10 steps 17274
9
episode: 9 score: -21.0 average score -20.8 best score -20.50 epsilon 0.10 steps 17357

episode: 9 score: -21.0 average score -20.8 best score -20.50 epsilon 0.10 steps 1733
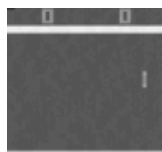5
episode: 10 score: -21.0 average score -20.8 best score -20.50 epsilon 0.10 steps 1743
39
episode: 11 score: -21.0 average score -20.8 best score -20.50 epsilon 0.10 steps 1751
03
episode: 12 score: -20.0 average score -20.8 best score -20.50 epsilon 0.10 steps 1759
45
episode: 13 score: -20.0 average score -20.8 best score -20.50 epsilon 0.10 steps 1768
48
episode: 14 score: -20.0 average score -20.8 best score -20.50 epsilon 0.10 steps 1778
87
episode: 15 score: -21.0 average score -20.8 best score -20.50 epsilon 0.10 steps 1786
51
episode: 16 score: -20.0 average score -20.7 best score -20.50 epsilon 0.10 steps 1796
62
episode: 17 score: -21.0 average score -20.8 best score -20.50 epsilon 0.10 steps 1806
36
episode: 18 score: -21.0 average score -20.8 best score -20.50 epsilon 0.10 steps 1814
00
episode: 19 score: -21.0 average score -20.8 best score -20.50 epsilon 0.10 steps 1822
24
episode: 20 score: -21.0 average score -20.8 best score -20.50 epsilon 0.10 steps 1829
88
episode: 21 score: -19.0 average score -20.7 best score -20.50 epsilon 0.10 steps 1839
46
episode: 22 score: -21.0 average score -20.7 best score -20.50 epsilon 0.10 steps 1848
00
episode: 23 score: -21.0 average score -20.7 best score -20.50 epsilon 0.10 steps 1855
92
episode: 24 score: -21.0 average score -20.7 best score -20.50 epsilon 0.10 steps 1863
56
episode: 25 score: -21.0 average score -20.7 best score -20.50 epsilon 0.10 steps 1873
31
episode: 26 score: -21.0 average score -20.7 best score -20.50 epsilon 0.10 steps 1880
95
episode: 27 score: -21.0 average score -20.7 best score -20.50 epsilon 0.10 steps 1889
47
episode: 28 score: -21.0 average score -20.7 best score -20.50 epsilon 0.10 steps 1897
11
episode: 29 score: -21.0 average score -20.7 best score -20.50 epsilon 0.10 steps 1904
75
episode: 30 score: -19.0 average score -20.7 best score -20.50 epsilon 0.10 steps 1914
57
episode: 31 score: -21.0 average score -20.7 best score -20.50 epsilon 0.10 steps 1922
21
episode: 32 score: -21.0 average score -20.7 best score -20.50 epsilon 0.10 steps 1929
85
episode: 33 score: -17.0 average score -20.7 best score -20.50 epsilon 0.10 steps 1940
57
episode: 34 score: -21.0 average score -20.7 best score -20.50 epsilon 0.10 steps 1948
21
episode: 35 score: -21.0 average score -20.7 best score -20.50 epsilon 0.10 steps 1955
85
episode: 36 score: -21.0 average score -20.7 best score -20.50 epsilon 0.10 steps 1963
49
episode: 37 score: -21.0 average score -20.7 best score -20.50 epsilon 0.10 steps 1971
73
episode: 38 score: -21.0 average score -20.7 best score -20.50 epsilon 0.10 steps 1979
37
episode: 39 score: -21.0 average score -20.7 best score -20.50 epsilon 0.10 steps 1987
61
episode: 40 score: -21.0 average score -20.7 best score -20.50 epsilon 0.10 steps 1995
25
episode: 41 score: -21.0 average score -20.7 best score -20.50 epsilon 0.10 steps 2002
89
episode: 42 score: -21.0 average score -20.7 best score -20.50 epsilon 0.10 steps 2011
43
episode: 43 score: -20.0 average score -20.7 best score -20.50 epsilon 0.10 steps 2020
45
episode: 44 score: -21.0 average score -20.7 best score -20.50 epsilon 0.10 steps 2028
69
episode: 45 score: -21.0 average score -20.7 best score -20.50 epsilon 0.10 steps 2036

```
episode:    45 score:    -21.0   average score -20.7 best score -20.50 epsilon 0.10 steps 2030
93
episode:    46 score:    -21.0   average score -20.7 best score -20.50 epsilon 0.10 steps 2046
68
episode:    47 score:    -21.0   average score -20.7 best score -20.50 epsilon 0.10 steps 2054
32
episode:    48 score:    -21.0   average score -20.7 best score -20.50 epsilon 0.10 steps 2061
96
episode:    49 score:    -20.0   average score -20.6 best score -20.50 epsilon 0.10 steps 2071
45
episode:    50 score:    -21.0   average score -20.7 best score -20.50 epsilon 0.10 steps 2079
09
episode:    51 score:    -20.0   average score -20.6 best score -20.50 epsilon 0.10 steps 2088
71
episode:    52 score:    -20.0   average score -20.6 best score -20.50 epsilon 0.10 steps 2098
30
episode:    53 score:    -21.0   average score -20.6 best score -20.50 epsilon 0.10 steps 2107
16
episode:    54 score:    -21.0   average score -20.6 best score -20.50 epsilon 0.10 steps 2114
80
episode:    55 score:    -21.0   average score -20.6 best score -20.50 epsilon 0.10 steps 2123
04
episode:    56 score:    -21.0   average score -20.6 best score -20.50 epsilon 0.10 steps 2130
68
episode:    57 score:    -21.0   average score -20.6 best score -20.50 epsilon 0.10 steps 2138
60
episode:    58 score:    -21.0   average score -20.6 best score -20.50 epsilon 0.10 steps 2146
52
episode:    59 score:    -21.0   average score -20.6 best score -20.50 epsilon 0.10 steps 2154
16
episode:    60 score:    -21.0   average score -20.6 best score -20.50 epsilon 0.10 steps 2161
80
episode:    61 score:    -21.0   average score -20.6 best score -20.50 epsilon 0.10 steps 2169
44
episode:    62 score:    -20.0   average score -20.6 best score -20.50 epsilon 0.10 steps 2181
04
episode:    63 score:    -21.0   average score -20.6 best score -20.50 epsilon 0.10 steps 2188
96
episode:    64 score:    -21.0   average score -20.7 best score -20.50 epsilon 0.10 steps 2196
60
episode:    65 score:    -21.0   average score -20.7 best score -20.50 epsilon 0.10 steps 2204
24
episode:    66 score:    -21.0   average score -20.7 best score -20.50 epsilon 0.10 steps 2211
88
episode:    67 score:    -21.0   average score -20.7 best score -20.50 epsilon 0.10 steps 2219
52
episode:    68 score:    -20.0   average score -20.7 best score -20.50 epsilon 0.10 steps 2228
55
episode:    69 score:    -21.0   average score -20.7 best score -20.50 epsilon 0.10 steps 2236
19
episode:    70 score:    -21.0   average score -20.7 best score -20.50 epsilon 0.10 steps 2243
83
episode:    71 score:    -21.0   average score -20.7 best score -20.50 epsilon 0.10 steps 2251
47
episode:    72 score:    -21.0   average score -20.7 best score -20.50 epsilon 0.10 steps 2259
11
episode:    73 score:    -21.0   average score -20.8 best score -20.50 epsilon 0.10 steps 2266
75
episode:    74 score:    -21.0   average score -20.8 best score -20.50 epsilon 0.10 steps 2274
99
episode:    75 score:    -20.0   average score -20.8 best score -20.50 epsilon 0.10 steps 2284
65
episode:    76 score:    -20.0   average score -20.8 best score -20.50 epsilon 0.10 steps 2294
14
episode:    77 score:    -21.0   average score -20.8 best score -20.50 epsilon 0.10 steps 2302
06
episode:    78 score:    -21.0   average score -20.8 best score -20.50 epsilon 0.10 steps 2309
70
episode:    79 score:    -21.0   average score -20.8 best score -20.50 epsilon 0.10 steps 2317
62
episode:    80 score:    -20.0   average score -20.8 best score -20.50 epsilon 0.10 steps 2326
32
episode:    81 score:    -21.0   average score -20.8 best score -20.50 epsilon 0.10 steps 2334
```

```
episode:  81 score:  -21.0  average score -20.8 best score -20.50 epsilon 0.10 steps 2351
24
episode:  82 score:  -21.0  average score -20.8 best score -20.50 epsilon 0.10 steps 2341
88
episode:  83 score:  -21.0  average score -20.8 best score -20.50 epsilon 0.10 steps 2349
52
episode:  84 score:  -21.0  average score -20.8 best score -20.50 epsilon 0.10 steps 2357
16
episode:  85 score:  -20.0  average score -20.8 best score -20.50 epsilon 0.10 steps 2366
48
episode:  86 score:  -19.0  average score -20.7 best score -20.50 epsilon 0.10 steps 2377
05
episode:  87 score:  -21.0  average score -20.7 best score -20.50 epsilon 0.10 steps 2384
69
episode:  88 score:  -21.0  average score -20.7 best score -20.50 epsilon 0.10 steps 2392
33
episode:  89 score:  -20.0  average score -20.7 best score -20.50 epsilon 0.10 steps 2401
03
episode:  90 score:  -21.0  average score -20.7 best score -20.50 epsilon 0.10 steps 2408
67
episode:  91 score:  -21.0  average score -20.7 best score -20.50 epsilon 0.10 steps 2417
11
episode:  92 score:  -20.0  average score -20.7 best score -20.50 epsilon 0.10 steps 2426
14
episode:  93 score:  -21.0  average score -20.7 best score -20.50 epsilon 0.10 steps 2433
78
episode:  94 score:  -21.0  average score -20.7 best score -20.50 epsilon 0.10 steps 2442
90
episode:  95 score:  -21.0  average score -20.7 best score -20.50 epsilon 0.10 steps 2450
54
episode:  96 score:  -21.0  average score -20.7 best score -20.50 epsilon 0.10 steps 2458
18
episode:  97 score:  -21.0  average score -20.7 best score -20.50 epsilon 0.10 steps 2465
82
episode:  98 score:  -19.0  average score -20.7 best score -20.50 epsilon 0.10 steps 2476
56
episode:  99 score:  -21.0  average score -20.7 best score -20.50 epsilon 0.10 steps 2484
20
epsilon value of 0.01
```
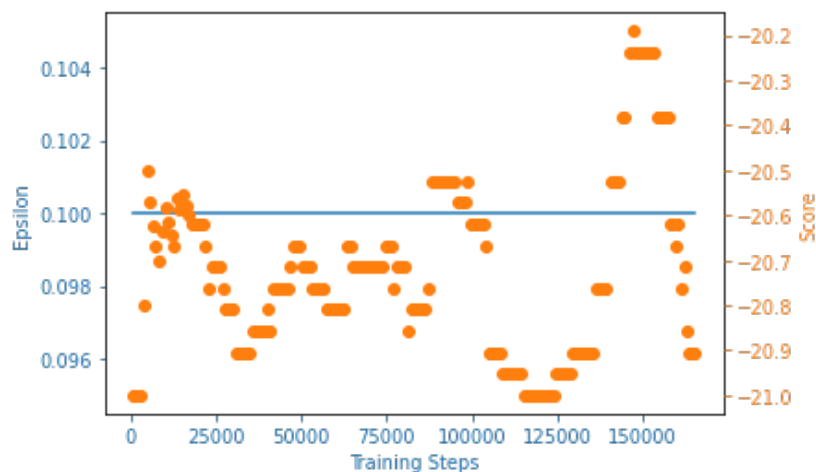


```
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```
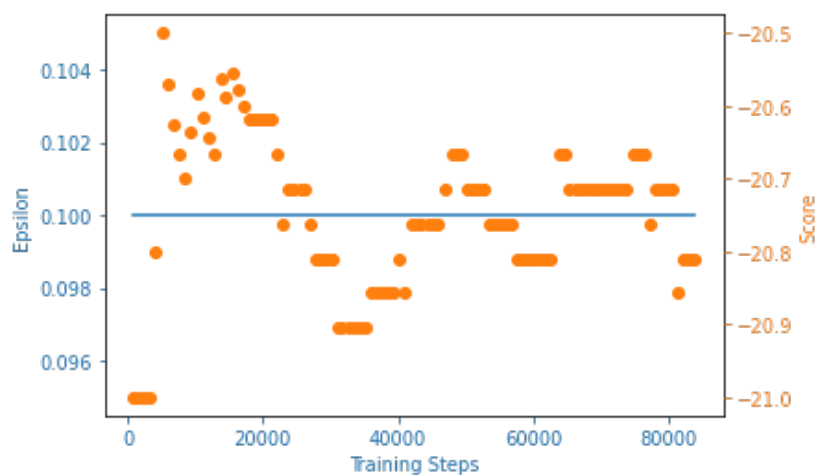


```
#######################################
episode:  0 score:  -21.0  average score -20.7 best score -20.50 epsilon 0.10 steps 24918
4
episode:  1 score:  -21.0  average score -20.7 best score -20.50 epsilon 0.10 steps 24994
8
episode:  2 score:  -21.0  average score -20.7 best score -20.50 epsilon 0.10 steps 25071
2
episode:  3 score:  -21.0  average score -20.7 best score -20.50 epsilon 0.10 steps 25167
4
episode:  4 score:  -21.0  average score -20.7 best score -20.50 epsilon 0.10 steps 25243
8
episode:  5 score:  -21.0  average score -20.7 best score -20.50 epsilon 0.10 steps 25320
2
episode:  6 score:  -21.0  average score -20.7 best score -20.50 epsilon 0.10 steps 25405
6
episode:  7 score:  -21.0  average score -20.7 best score -20.50 epsilon 0.10 steps 25482
0
episode:  8 score:  -21.0  average score -20.7 best score -20.50 epsilon 0.10 steps 25558
4
episode:  9 score:  -21.0  average score -20.7 best score -20.50 epsilon 0.10 steps 25634
```
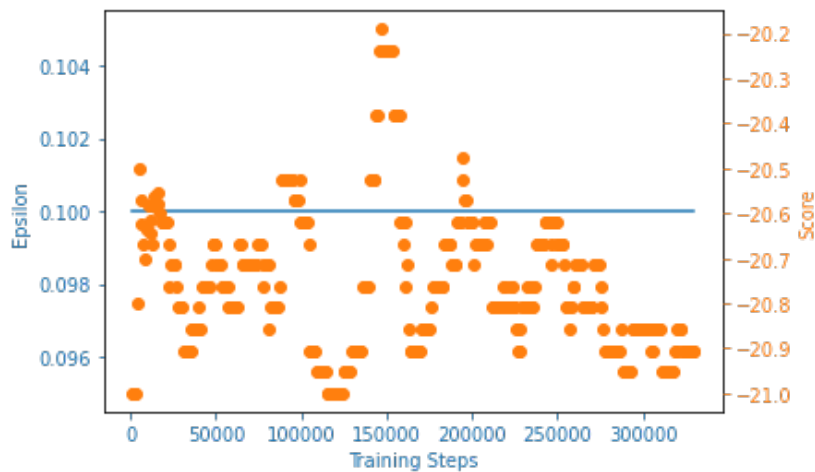
    episode: 10 score: -21.0   average score -20.7 best score -20.50 epsilon 0.10 steps 2571
12
    episode: 11 score: -20.0   average score -20.7 best score -20.50 epsilon 0.10 steps 2579
99
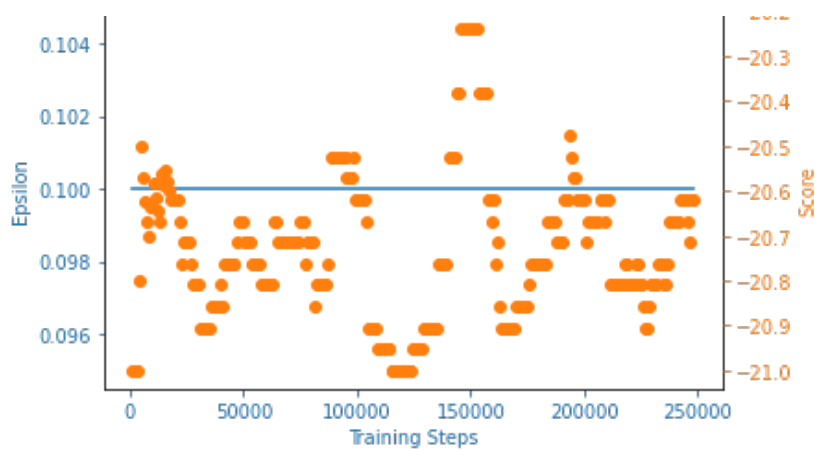   episode: 12 score: -20.0   average score -20.7 best score -20.50 epsilon 0.10 steps 2588
41
    episode: 13 score: -20.0   average score -20.7 best score -20.50 epsilon 0.10 steps 2597
72
    episode: 14 score: -20.0   average score -20.7 best score -20.50 epsilon 0.10 steps 2606
74
    episode: 15 score: -21.0   average score -20.7 best score -20.50 epsilon 0.10 steps 2614
98
    episode: 16 score: -21.0   average score -20.7 best score -20.50 epsilon 0.10 steps 2622
90
    episode: 17 score: -21.0   average score -20.7 best score -20.50 epsilon 0.10 steps 2631
42
    episode: 18 score: -21.0   average score -20.7 best score -20.50 epsilon 0.10 steps 2639
06
    episode: 19 score: -21.0   average score -20.7 best score -20.50 epsilon 0.10 steps 2646
70
    episode: 20 score: -21.0   average score -20.7 best score -20.50 epsilon 0.10 steps 2655
84
    episode: 21 score: -21.0   average score -20.7 best score -20.50 epsilon 0.10 steps 2663
48
    episode: 22 score: -21.0   average score -20.7 best score -20.50 epsilon 0.10 steps 2671
12
    episode: 23 score: -21.0   average score -20.7 best score -20.50 epsilon 0.10 steps 2678
76
    episode: 24 score: -21.0   average score -20.7 best score -20.50 epsilon 0.10 steps 2686
40
    episode: 25 score: -21.0   average score -20.7 best score -20.50 epsilon 0.10 steps 2694
04
    episode: 26 score: -21.0   average score -20.7 best score -20.50 epsilon 0.10 steps 2701
68
    episode: 27 score: -19.0   average score -20.7 best score -20.50 epsilon 0.10 steps 2712
48
    episode: 28 score: -21.0   average score -20.7 best score -20.50 epsilon 0.10 steps 2720
12
    episode: 29 score: -21.0   average score -20.7 best score -20.50 epsilon 0.10 steps 2727
76
    episode: 30 score: -21.0   average score -20.7 best score -20.50 epsilon 0.10 steps 2735
40
    episode: 31 score: -21.0   average score -20.7 best score -20.50 epsilon 0.10 steps 2743
04
    episode: 32 score: -21.0   average score -20.7 best score -20.50 epsilon 0.10 steps 2751
88
    episode: 33 score: -21.0   average score -20.8 best score -20.50 epsilon 0.10 steps 2759
52
    episode: 34 score: -21.0   average score -20.8 best score -20.50 epsilon 0.10 steps 2768
66
    episode: 35 score: -21.0   average score -20.8 best score -20.50 epsilon 0.10 steps 2776
90
    episode: 36 score: -21.0   average score -20.8 best score -20.50 epsilon 0.10 steps 2785
15
    episode: 37 score: -21.0   average score -20.8 best score -20.50 epsilon 0.10 steps 2793
07
    episode: 38 score: -21.0   average score -20.8 best score -20.50 epsilon 0.10 steps 2801
33
    episode: 39 score: -21.0   average score -20.8 best score -20.50 epsilon 0.10 steps 2808
97
    episode: 40 score: -21.0   average score -20.8 best score -20.50 epsilon 0.10 steps 2816
61
    episode: 41 score: -21.0   average score -20.8 best score -20.50 epsilon 0.10 steps 2824
25
    episode: 42 score: -21.0   average score -20.8 best score -20.50 epsilon 0.10 steps 2832
68
    episode: 43 score: -21.0   average score -20.8 best score -20.50 epsilon 0.10 steps 2840
32
    episode: 44 score: -21.0   average score -20.8 best score -20.50 epsilon 0.10 steps 2847
96
    episode: 45 score: -21.0   average score -20.8 best score -20.50 epsilon 0.10 steps 2855

episode: 46 score: -21.0 average score -20.8 best score -20.50 epsilon 0.10 steps 2863
84
episode: 47 score: -20.0 average score -20.8 best score -20.50 epsilon 0.10 steps 2873
74
episode: 48 score: -21.0 average score -20.8 best score -20.50 epsilon 0.10 steps 2881
98
episode: 49 score: -21.0 average score -20.8 best score -20.50 epsilon 0.10 steps 2890
70
episode: 50 score: -21.0 average score -20.8 best score -20.50 epsilon 0.10 steps 2898
34
episode: 51 score: -21.0 average score -20.8 best score -20.50 epsilon 0.10 steps 2905
98
episode: 52 score: -21.0 average score -20.8 best score -20.50 epsilon 0.10 steps 2913
62
episode: 53 score: -21.0 average score -20.8 best score -20.50 epsilon 0.10 steps 2921
26
episode: 54 score: -21.0 average score -20.8 best score -20.50 epsilon 0.10 steps 2929
48
episode: 55 score: -19.0 average score -20.8 best score -20.50 epsilon 0.10 steps 2939
91
episode: 56 score: -21.0 average score -20.8 best score -20.50 epsilon 0.10 steps 2948
15
episode: 57 score: -21.0 average score -20.8 best score -20.50 epsilon 0.10 steps 2955
79
episode: 58 score: -21.0 average score -20.8 best score -20.50 epsilon 0.10 steps 2963
71
episode: 59 score: -21.0 average score -20.8 best score -20.50 epsilon 0.10 steps 2971
35
episode: 60 score: -21.0 average score -20.8 best score -20.50 epsilon 0.10 steps 2978
99
episode: 61 score: -21.0 average score -20.8 best score -20.50 epsilon 0.10 steps 2986
63
episode: 62 score: -21.0 average score -20.8 best score -20.50 epsilon 0.10 steps 2995
49
episode: 63 score: -21.0 average score -20.8 best score -20.50 epsilon 0.10 steps 3003
75
episode: 64 score: -21.0 average score -20.8 best score -20.50 epsilon 0.10 steps 3012
49
episode: 65 score: -21.0 average score -20.8 best score -20.50 epsilon 0.10 steps 3021
35
episode: 66 score: -21.0 average score -20.8 best score -20.50 epsilon 0.10 steps 3029
59
episode: 67 score: -21.0 average score -20.8 best score -20.50 epsilon 0.10 steps 3037
23
episode: 68 score: -21.0 average score -20.8 best score -20.50 epsilon 0.10 steps 3045
47
episode: 69 score: -21.0 average score -20.8 best score -20.50 epsilon 0.10 steps 3053
11
episode: 70 score: -20.0 average score -20.8 best score -20.50 epsilon 0.10 steps 3062
15
episode: 71 score: -21.0 average score -20.8 best score -20.50 epsilon 0.10 steps 3070
39
episode: 72 score: -21.0 average score -20.8 best score -20.50 epsilon 0.10 steps 3078
03
episode: 73 score: -21.0 average score -20.8 best score -20.50 epsilon 0.10 steps 3086
25
episode: 74 score: -21.0 average score -20.8 best score -20.50 epsilon 0.10 steps 3095
09
episode: 75 score: -21.0 average score -20.8 best score -20.50 epsilon 0.10 steps 3102
73
episode: 76 score: -21.0 average score -20.8 best score -20.50 epsilon 0.10 steps 3110
97
episode: 77 score: -21.0 average score -20.8 best score -20.50 epsilon 0.10 steps 3120
47
episode: 78 score: -21.0 average score -20.8 best score -20.50 epsilon 0.10 steps 3128
73
episode: 79 score: -21.0 average score -20.8 best score -20.50 epsilon 0.10 steps 3136
97
episode: 80 score: -21.0 average score -20.8 best score -20.50 epsilon 0.10 steps 3144
61
episode: 81 score: -21.0 average score -20.8 best score -20.50 epsilon 0.10 steps 3152

87
episode: 82 score: -21.0 average score -20.8 best score -20.50 epsilon 0.10 steps 3161
11
episode: 83 score: -21.0 average score -20.8 best score -20.50 epsilon 0.10 steps 3168
75
episode: 84 score: -21.0 average score -20.8 best score -20.50 epsilon 0.10 steps 3176
39
episode: 85 score: -20.0 average score -20.8 best score -20.50 epsilon 0.10 steps 3185
41
episode: 86 score: -21.0 average score -20.9 best score -20.50 epsilon 0.10 steps 3193
05
episode: 87 score: -20.0 average score -20.8 best score -20.50 epsilon 0.10 steps 3202
06
episode: 88 score: -21.0 average score -20.8 best score -20.50 epsilon 0.10 steps 3209
70
episode: 89 score: -21.0 average score -20.9 best score -20.50 epsilon 0.10 steps 3217
34
episode: 90 score: -21.0 average score -20.9 best score -20.50 epsilon 0.10 steps 3224
98
episode: 91 score: -21.0 average score -20.9 best score -20.50 epsilon 0.10 steps 3232
62
episode: 92 score: -21.0 average score -20.9 best score -20.50 epsilon 0.10 steps 3241
95
episode: 93 score: -21.0 average score -20.9 best score -20.50 epsilon 0.10 steps 3249
59
episode: 94 score: -21.0 average score -20.9 best score -20.50 epsilon 0.10 steps 3257
83
episode: 95 score: -21.0 average score -20.9 best score -20.50 epsilon 0.10 steps 3268
19
episode: 96 score: -21.0 average score -20.9 best score -20.50 epsilon 0.10 steps 3275
83
episode: 97 score: -21.0 average score -20.9 best score -20.50 epsilon 0.10 steps 3283
47
episode: 98 score: -21.0 average score -20.9 best score -20.50 epsilon 0.10 steps 3291
11
episode: 99 score: -21.0 average score -20.9 best score -20.50 epsilon 0.10 steps 3298
75

```
%cd drive/My\ Drive/Pong
```

```
/content/drive/My Drive/Pong
```

```python
# DQN after training

import gym
import numpy as np
from dqn import *
from utils import plot_learning_curve, make_env
from gym import wrappers
import cv2
import matplotlib.pyplot as plt
from google.colab.patches import cv2_imshow


def fgsm_attack(data,action,reward,done, epsilon, agent,iter):
    if(iter == 1):
      print(f"epsilon value of {epsilon}")
      "================================="
      cv2_imshow(data[3,:,:]*255)
      print("=========================")

    data = torch.from_numpy(data)
    data = data.type(torch.FloatTensor)
    data = torch.unsqueeze(data,0)
    data = data.to(agent.Q.device)
    data.requires_grad = True

    agent.Q.optimizer.zero_grad()

    q_pred = agent.Q.forward(data)[0, action]
    q_next = agent.Q_pred.forward(data).max(dim=1)[0]

    q_next[done] = 0.0
```

```python
        q_target = reward + agent.gamma*q_next

        loss = agent.Q.loss(q_target, q_pred).to(agent.Q.device)
        loss.backward()

        data_grad = data.grad.data

        # Collect the element-wise sign of the data gradient
        sign_data_grad = data_grad.sign()
        # Create the perturbed image by adjusting each pixel of the input image
        perturbed_image = data + epsilon*sign_data_grad
        # Adding clipping to maintain [0,1] range
        perturbed_image = perturbed_image.squeeze()

        perturbed_image = torch.clamp(perturbed_image, 0, 1).detach().cpu().numpy()
        #perturbed_image = perturbed_image.detach().cpu().numpy()

        if(iter == 1):
          cv2_imshow(perturbed_image[3,:,:]*255)
          print("######################################")
          #print(a)

        # Return the perturbed image
        return perturbed_image



if __name__ == '__main__':
    env = make_env('PongNoFrameskip-v4')
    best_score = -np.inf
    load_checkpoint = True
    n_games = 100


    #setting epsilon-> 0.1
    agent = DQN(states=env.observation_space, actions=env.action_space.n,alpha=0.0001,ga
mma=0.99,epsilon=0.1,
                epsilon_min=0.1,epsilon_decay=1e-5,replay_buffer_sz=10000,batch=32,path
= 'atari_model_eval.txt',
                path_pred = 'atari_model_target.txt')


    if load_checkpoint:
        agent.load_models()

    figure_file = 'plots/pong3.png'
    # if you want to record video of your agent playing, do a mkdir tmp && mkdir tmp/dqn-
video
    # and uncomment the following 2 lines.
    #env = wrappers.Monitor(env, "tmp/dqn-video",
    #                 video_callable=lambda episode_id: True, force=True)
    n_steps = 0
    scores, eps_history, steps_array = [], [], []

    peturb_eps = [0.001,0.002, 0.003]
    for eps in peturb_eps:
      count = 0
      for i in range(n_games):
          done = False
          observation = env.reset()                                              #se
tting initial action to peturb
          action = 0
          reward = 0
          score = 0
          while not done:
              observation= fgsm_attack(observation,action,reward,done, eps,agent,count)
# peturb observation
              action = agent.e_greedy_policy(observation)
              observation_, reward, done, info = env.step(action)

              score += reward
```

```
                count += 1
                if not load_checkpoint:
                    agent.store(observation, action,
                                      reward, observation_, done)
                    agent.learn()
                observation = observation_
                n_steps += 1
                # cv2_imshow(observation[0,:,:])
                # cv2.waitKey(0)
            scores.append(score)
            steps_array.append(n_steps)

            avg_score = np.mean(scores[-100:])
            print('episode: ', i,'score: ', score,
                ' average score %.1f' % avg_score, 'best score %.2f' % best_score,
                'epsilon %.2f' % agent.epsilon, 'steps', n_steps)

            if avg_score > best_score:
                if not load_checkpoint:
                    agent.save_models()
                best_score = avg_score

            eps_history.append(agent.epsilon)

        x = [i+1 for i in range(len(scores))]
        plot_learning_curve(steps_array, scores, eps_history, figure_file)
```

```
loading checkpoint
loading checkpoint
epsilon value of 0.001
```

/usr/local/lib/python3.6/dist-packages/torch/nn/modules/loss.py:446: UserWarning: Using a
target size (torch.Size([])) that is different to the input size (torch.Size([1])). This
will likely lead to incorrect results due to broadcasting. Please ensure they have the sa
me size.
  return F.mse_loss(input, target, reduction=self.reduction)

==========================

```
####################################
episode:  0 score:   16.0   average score 16.0 best score -inf epsilon 0.10 steps 2372
episode:  1 score:   15.0   average score 15.5 best score 16.00 epsilon 0.10 steps 4583
episode:  2 score:   15.0   average score 15.3 best score 16.00 epsilon 0.10 steps 6840
episode:  3 score:   17.0   average score 15.8 best score 16.00 epsilon 0.10 steps 8919
episode:  4 score:   14.0   average score 15.4 best score 16.00 epsilon 0.10 steps 11101
episode:  5 score:   16.0   average score 15.5 best score 16.00 epsilon 0.10 steps 13138
episode:  6 score:   13.0   average score 15.1 best score 16.00 epsilon 0.10 steps 15400
episode:  7 score:   16.0   average score 15.2 best score 16.00 epsilon 0.10 steps 17718
episode:  8 score:   16.0   average score 15.3 best score 16.00 epsilon 0.10 steps 19791
episode:  9 score:   10.0   average score 14.8 best score 16.00 epsilon 0.10 steps 22123
episode:  10 score:   10.0   average score 14.4 best score 16.00 epsilon 0.10 steps 24852
episode:  11 score:   19.0   average score 14.8 best score 16.00 epsilon 0.10 steps 26718
episode:  12 score:   19.0   average score 15.1 best score 16.00 epsilon 0.10 steps 28565
episode:  13 score:   4.0   average score 14.3 best score 16.00 epsilon 0.10 steps 31270
episode:  14 score:   6.0   average score 13.7 best score 16.00 epsilon 0.10 steps 33856
episode:  15 score:   10.0   average score 13.5 best score 16.00 epsilon 0.10 steps 36140
episode:  16 score:   16.0   average score 13.6 best score 16.00 epsilon 0.10 steps 38253
episode:  17 score:   18.0   average score 13.9 best score 16.00 epsilon 0.10 steps 40137
episode:  18 score:   16.0   average score 14.0 best score 16.00 epsilon 0.10 steps 42523
episode:  19 score:   9.0   average score 13.8 best score 16.00 epsilon 0.10 steps 45160
episode:  20 score:   16.0   average score 13.9 best score 16.00 epsilon 0.10 steps 47314
```

```
episode:   20 score:   16.0   average score 13.9 best score 16.00 epsilon 0.10 steps 47214
episode:   21 score:   18.0   average score 14.0 best score 16.00 epsilon 0.10 steps 49207
episode:   22 score:   15.0   average score 14.1 best score 16.00 epsilon 0.10 steps 51372
episode:   23 score:   13.0   average score 14.0 best score 16.00 epsilon 0.10 steps 53755
episode:   24 score:   16.0   average score 14.1 best score 16.00 epsilon 0.10 steps 55826
episode:   25 score:   12.0   average score 14.0 best score 16.00 epsilon 0.10 steps 58189
episode:   26 score:   14.0   average score 14.0 best score 16.00 epsilon 0.10 steps 60348
episode:   27 score:   17.0   average score 14.1 best score 16.00 epsilon 0.10 steps 62272
episode:   28 score:   21.0   average score 14.4 best score 16.00 epsilon 0.10 steps 63982
episode:   29 score:   16.0   average score 14.4 best score 16.00 epsilon 0.10 steps 66103
episode:   30 score:   10.0   average score 14.3 best score 16.00 epsilon 0.10 steps 68713
episode:   31 score:   11.0   average score 14.2 best score 16.00 epsilon 0.10 steps 71178
episode:   32 score:   14.0   average score 14.2 best score 16.00 epsilon 0.10 steps 73501
episode:   33 score:   15.0   average score 14.2 best score 16.00 epsilon 0.10 steps 75829
episode:   34 score:   2.0   average score 13.9 best score 16.00 epsilon 0.10 steps 78791
episode:   35 score:   18.0   average score 14.0 best score 16.00 epsilon 0.10 steps 80845
episode:   36 score:   12.0   average score 13.9 best score 16.00 epsilon 0.10 steps 83233
episode:   37 score:   12.0   average score 13.9 best score 16.00 epsilon 0.10 steps 85561
episode:   38 score:   11.0   average score 13.8 best score 16.00 epsilon 0.10 steps 88146
episode:   39 score:   12.0   average score 13.8 best score 16.00 epsilon 0.10 steps 90633
episode:   40 score:   14.0   average score 13.8 best score 16.00 epsilon 0.10 steps 92907
episode:   41 score:   12.0   average score 13.7 best score 16.00 epsilon 0.10 steps 95625
episode:   42 score:   17.0   average score 13.8 best score 16.00 epsilon 0.10 steps 97600
episode:   43 score:   17.0   average score 13.9 best score 16.00 epsilon 0.10 steps 99590
episode:   44 score:   17.0   average score 13.9 best score 16.00 epsilon 0.10 steps 101644
episode:   45 score:   12.0   average score 13.9 best score 16.00 epsilon 0.10 steps 104217
episode:   46 score:   12.0   average score 13.9 best score 16.00 epsilon 0.10 steps 106488
episode:   47 score:   10.0   average score 13.8 best score 16.00 epsilon 0.10 steps 108968
episode:   48 score:   13.0   average score 13.8 best score 16.00 epsilon 0.10 steps 111319
episode:   49 score:   16.0   average score 13.8 best score 16.00 epsilon 0.10 steps 113484
episode:   50 score:   14.0   average score 13.8 best score 16.00 epsilon 0.10 steps 115935
episode:   51 score:   15.0   average score 13.8 best score 16.00 epsilon 0.10 steps 117973
episode:   52 score:   15.0   average score 13.8 best score 16.00 epsilon 0.10 steps 120124
episode:   53 score:   -20.0   average score 13.2 best score 16.00 epsilon 0.10 steps 121193
episode:   54 score:   17.0   average score 13.3 best score 16.00 epsilon 0.10 steps 123356
episode:   55 score:   14.0   average score 13.3 best score 16.00 epsilon 0.10 steps 125466
episode:   56 score:   15.0   average score 13.3 best score 16.00 epsilon 0.10 steps 127724
episode:   57 score:   17.0   average score 13.4 best score 16.00 epsilon 0.10 steps 129716
episode:   58 score:   13.0   average score 13.4 best score 16.00 epsilon 0.10 steps 131947
episode:   59 score:   12.0   average score 13.4 best score 16.00 epsilon 0.10 steps 134240
episode:   60 score:   16.0   average score 13.4 best score 16.00 epsilon 0.10 steps 136252
episode:   61 score:   13.0   average score 13.4 best score 16.00 epsilon 0.10 steps 138383
episode:   62 score:   17.0   average score 13.5 best score 16.00 epsilon 0.10 steps 140321
episode:   63 score:   18.0   average score 13.5 best score 16.00 epsilon 0.10 steps 142375
episode:   64 score:   14.0   average score 13.5 best score 16.00 epsilon 0.10 steps 144667
episode:   65 score:   17.0   average score 13.6 best score 16.00 epsilon 0.10 steps 146745
episode:   66 score:   12.0   average score 13.6 best score 16.00 epsilon 0.10 steps 149098
episode:   67 score:   7.0   average score 13.5 best score 16.00 epsilon 0.10 steps 151762
episode:   68 score:   17.0   average score 13.5 best score 16.00 epsilon 0.10 steps 153801
episode:   69 score:   21.0   average score 13.6 best score 16.00 epsilon 0.10 steps 155555
episode:   70 score:   15.0   average score 13.6 best score 16.00 epsilon 0.10 steps 157670
episode:   71 score:   15.0   average score 13.7 best score 16.00 epsilon 0.10 steps 159878
episode:   72 score:   12.0   average score 13.6 best score 16.00 epsilon 0.10 steps 162237
episode:   73 score:   16.0   average score 13.7 best score 16.00 epsilon 0.10 steps 164198
episode:   74 score:   16.0   average score 13.7 best score 16.00 epsilon 0.10 steps 166310
episode:   75 score:   14.0   average score 13.7 best score 16.00 epsilon 0.10 steps 168475
episode:   76 score:   13.0   average score 13.7 best score 16.00 epsilon 0.10 steps 170842
episode:   77 score:   17.0   average score 13.7 best score 16.00 epsilon 0.10 steps 172811
episode:   78 score:   18.0   average score 13.8 best score 16.00 epsilon 0.10 steps 174753
episode:   79 score:   16.0   average score 13.8 best score 16.00 epsilon 0.10 steps 176917
episode:   80 score:   16.0   average score 13.9 best score 16.00 epsilon 0.10 steps 179108
episode:   81 score:   17.0   average score 13.9 best score 16.00 epsilon 0.10 steps 181133
episode:   82 score:   16.0   average score 13.9 best score 16.00 epsilon 0.10 steps 183160
episode:   83 score:   18.0   average score 14.0 best score 16.00 epsilon 0.10 steps 185291
episode:   84 score:   17.0   average score 14.0 best score 16.00 epsilon 0.10 steps 187172
episode:   85 score:   16.0   average score 14.0 best score 16.00 epsilon 0.10 steps 189155
episode:   86 score:   13.0   average score 14.0 best score 16.00 epsilon 0.10 steps 191473
episode:   87 score:   16.0   average score 14.0 best score 16.00 epsilon 0.10 steps 193397
episode:   88 score:   13.0   average score 14.0 best score 16.00 epsilon 0.10 steps 195671
episode:   89 score:   17.0   average score 14.1 best score 16.00 epsilon 0.10 steps 197695
episode:   90 score:   18.0   average score 14.1 best score 16.00 epsilon 0.10 steps 199730
episode:   91 score:   13.0   average score 14.1 best score 16.00 epsilon 0.10 steps 202127
episode:   92 score:   13.0   average score 14.1 best score 16.00 epsilon 0.10 steps 204529
```

```
episode:   92 score:    13.0   average score 14.1 best score 16.00 epsilon 0.10 steps 204529
episode:   93 score:    14.0   average score 14.1 best score 16.00 epsilon 0.10 steps 206553
episode:   94 score:    16.0   average score 14.1 best score 16.00 epsilon 0.10 steps 208707
episode:   95 score:    18.0   average score 14.1 best score 16.00 epsilon 0.10 steps 210519
episode:   96 score:    17.0   average score 14.2 best score 16.00 epsilon 0.10 steps 212550
episode:   97 score:    12.0   average score 14.1 best score 16.00 epsilon 0.10 steps 214913
episode:   98 score:    9.0   average score 14.1 best score 16.00 epsilon 0.10 steps 217479
episode:   99 score:    20.0   average score 14.2 best score 16.00 epsilon 0.10 steps 219247
epsilon value of 0.002
```



```
=========================
```



```
#######################################
episode:    0 score:    8.0   average score 14.1 best score 16.00 epsilon 0.10 steps 221797
episode:    1 score:   -1.0   average score 13.9 best score 16.00 epsilon 0.10 steps 225068
episode:    2 score:    7.0   average score 13.8 best score 16.00 epsilon 0.10 steps 227744
episode:    3 score:    10.0   average score 13.8 best score 16.00 epsilon 0.10 steps 230127
episode:    4 score:   -1.0   average score 13.6 best score 16.00 epsilon 0.10 steps 232831
episode:    5 score:    7.0   average score 13.5 best score 16.00 epsilon 0.10 steps 235625
episode:    6 score:    15.0   average score 13.5 best score 16.00 epsilon 0.10 steps 237808
episode:    7 score:    13.0   average score 13.5 best score 16.00 epsilon 0.10 steps 240004
episode:    8 score:    6.0   average score 13.4 best score 16.00 epsilon 0.10 steps 242871
episode:    9 score:    2.0   average score 13.3 best score 16.00 epsilon 0.10 steps 245875
episode:   10 score:   -4.0   average score 13.2 best score 16.00 epsilon 0.10 steps 248610
episode:   11 score:    12.0   average score 13.1 best score 16.00 epsilon 0.10 steps 250931
episode:   12 score:    9.0   average score 13.0 best score 16.00 epsilon 0.10 steps 253400
episode:   13 score:   -2.0   average score 13.0 best score 16.00 epsilon 0.10 steps 256311
episode:   14 score:    12.0   average score 13.0 best score 16.00 epsilon 0.10 steps 258788
episode:   15 score:    11.0   average score 13.0 best score 16.00 epsilon 0.10 steps 261275
episode:   16 score:    1.0   average score 12.9 best score 16.00 epsilon 0.10 steps 264414
episode:   17 score:   -1.0   average score 12.7 best score 16.00 epsilon 0.10 steps 267269
episode:   18 score:    8.0   average score 12.6 best score 16.00 epsilon 0.10 steps 269807
episode:   19 score:    7.0   average score 12.6 best score 16.00 epsilon 0.10 steps 272625
episode:   20 score:    9.0   average score 12.5 best score 16.00 epsilon 0.10 steps 275140
episode:   21 score:    9.0   average score 12.4 best score 16.00 epsilon 0.10 steps 277573
episode:   22 score:    7.0   average score 12.3 best score 16.00 epsilon 0.10 steps 280159
episode:   23 score:    12.0   average score 12.3 best score 16.00 epsilon 0.10 steps 282479
episode:   24 score:   -8.0   average score 12.1 best score 16.00 epsilon 0.10 steps 284799
episode:   25 score:    4.0   average score 12.0 best score 16.00 epsilon 0.10 steps 287400
episode:   26 score:    10.0   average score 12.0 best score 16.00 epsilon 0.10 steps 289859
episode:   27 score:    9.0   average score 11.9 best score 16.00 epsilon 0.10 steps 292281
episode:   28 score:    3.0   average score 11.7 best score 16.00 epsilon 0.10 steps 295187
episode:   29 score:    1.0   average score 11.6 best score 16.00 epsilon 0.10 steps 298186
episode:   30 score:   -4.0   average score 11.4 best score 16.00 epsilon 0.10 steps 301054
episode:   31 score:   -7.0   average score 11.2 best score 16.00 epsilon 0.10 steps 303731
episode:   32 score:    7.0   average score 11.2 best score 16.00 epsilon 0.10 steps 306380
episode:   33 score:   -1.0   average score 11.0 best score 16.00 epsilon 0.10 steps 309171
episode:   34 score:    15.0   average score 11.2 best score 16.00 epsilon 0.10 steps 311323
episode:   35 score:    15.0   average score 11.1 best score 16.00 epsilon 0.10 steps 313548
episode:   36 score:    13.0   average score 11.1 best score 16.00 epsilon 0.10 steps 315738
episode:   37 score:    13.0   average score 11.1 best score 16.00 epsilon 0.10 steps 317969
episode:   38 score:    11.0   average score 11.1 best score 16.00 epsilon 0.10 steps 320538
episode:   39 score:    5.0   average score 11.1 best score 16.00 epsilon 0.10 steps 323286
episode:   40 score:   -1.0   average score 10.9 best score 16.00 epsilon 0.10 steps 326286
episode:   41 score:    13.0   average score 10.9 best score 16.00 epsilon 0.10 steps 328600
episode:   42 score:    5.0   average score 10.8 best score 16.00 epsilon 0.10 steps 331617
episode:   43 score:    4.0   average score 10.7 best score 16.00 epsilon 0.10 steps 334481
episode:   44 score:    15.0   average score 10.7 best score 16.00 epsilon 0.10 steps 336730
episode:   45 score:    14.0   average score 10.7 best score 16.00 epsilon 0.10 steps 338937
episode:   46 score:    17.0   average score 10.7 best score 16.00 epsilon 0.10 steps 341164
episode:   47 score:   -8.0   average score 10.6 best score 16.00 epsilon 0.10 steps 343455
episode:   48 score:    12.0   average score 10.5 best score 16.00 epsilon 0.10 steps 346000
```
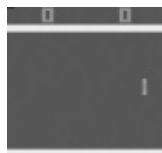
episode: 48 score: 12.0   average score 10.5 best score 16.00 epsilon 0.10 steps 346000
episode: 49 score: 7.0   average score 10.4 best score 16.00 epsilon 0.10 steps 348776
episode: 50 score: -7.0   average score 10.2 best score 16.00 epsilon 0.10 steps 351472
episode: 51 score: 10.0   average score 10.2 best score 16.00 epsilon 0.10 steps 353883
episode: 52 score: 10.0   average score 10.1 best score 16.00 epsilon 0.10 steps 356329
episode: 53 score: 17.0   average score 10.5 best score 16.00 epsilon 0.10 steps 358356
episode: 54 score: 13.0   average score 10.5 best score 16.00 epsilon 0.10 steps 360650
episode: 55 score: -1.0   average score 10.3 best score 16.00 epsilon 0.10 steps 363538
episode: 56 score: -1.0   average score 10.2 best score 16.00 epsilon 0.10 steps 366417
episode: 57 score: -4.0   average score 9.9 best score 16.00 epsilon 0.10 steps 368786
episode: 58 score: 17.0   average score 10.0 best score 16.00 epsilon 0.10 steps 370762
episode: 59 score: 7.0   average score 9.9 best score 16.00 epsilon 0.10 steps 373494
episode: 60 score: 9.0   average score 9.9 best score 16.00 epsilon 0.10 steps 376189
episode: 61 score: 9.0   average score 9.8 best score 16.00 epsilon 0.10 steps 378842
episode: 62 score: 9.0   average score 9.8 best score 16.00 epsilon 0.10 steps 381253
episode: 63 score: 9.0   average score 9.7 best score 16.00 epsilon 0.10 steps 383730
episode: 64 score: 14.0   average score 9.7 best score 16.00 epsilon 0.10 steps 385809
episode: 65 score: 15.0   average score 9.6 best score 16.00 epsilon 0.10 steps 388034
episode: 66 score: 9.0   average score 9.6 best score 16.00 epsilon 0.10 steps 390584
episode: 67 score: 12.0   average score 9.7 best score 16.00 epsilon 0.10 steps 392884
episode: 68 score: 12.0   average score 9.6 best score 16.00 epsilon 0.10 steps 395212
episode: 69 score: 10.0   average score 9.5 best score 16.00 epsilon 0.10 steps 397735
episode: 70 score: -1.0   average score 9.3 best score 16.00 epsilon 0.10 steps 400537
episode: 71 score: -1.0   average score 9.2 best score 16.00 epsilon 0.10 steps 403690
episode: 72 score: 11.0   average score 9.2 best score 16.00 epsilon 0.10 steps 406327
episode: 73 score: -1.0   average score 9.0 best score 16.00 epsilon 0.10 steps 409640
episode: 74 score: 10.0   average score 8.9 best score 16.00 epsilon 0.10 steps 412277
episode: 75 score: 8.0   average score 8.9 best score 16.00 epsilon 0.10 steps 415055
episode: 76 score: 13.0   average score 8.9 best score 16.00 epsilon 0.10 steps 417300
episode: 77 score: 8.0   average score 8.8 best score 16.00 epsilon 0.10 steps 419832
episode: 78 score: 4.0   average score 8.7 best score 16.00 epsilon 0.10 steps 422514
episode: 79 score: 12.0   average score 8.6 best score 16.00 epsilon 0.10 steps 424956
episode: 80 score: -21.0   average score 8.2 best score 16.00 epsilon 0.10 steps 425767
episode: 81 score: 14.0   average score 8.2 best score 16.00 epsilon 0.10 steps 427975
episode: 82 score: 4.0   average score 8.1 best score 16.00 epsilon 0.10 steps 430857
episode: 83 score: 8.0   average score 8.0 best score 16.00 epsilon 0.10 steps 433158
episode: 84 score: 17.0   average score 8.0 best score 16.00 epsilon 0.10 steps 435251
episode: 85 score: 8.0   average score 7.9 best score 16.00 epsilon 0.10 steps 437898
episode: 86 score: 5.0   average score 7.8 best score 16.00 epsilon 0.10 steps 440485
episode: 87 score: -1.0   average score 7.7 best score 16.00 epsilon 0.10 steps 443102
episode: 88 score: 2.0   average score 7.5 best score 16.00 epsilon 0.10 steps 445956
episode: 89 score: 11.0   average score 7.5 best score 16.00 epsilon 0.10 steps 448300
episode: 90 score: 13.0   average score 7.4 best score 16.00 epsilon 0.10 steps 450532
episode: 91 score: 9.0   average score 7.4 best score 16.00 epsilon 0.10 steps 453254
episode: 92 score: 17.0   average score 7.4 best score 16.00 epsilon 0.10 steps 455302
episode: 93 score: 13.0   average score 7.4 best score 16.00 epsilon 0.10 steps 457717
episode: 94 score: 11.0   average score 7.4 best score 16.00 epsilon 0.10 steps 460026
episode: 95 score: 14.0   average score 7.3 best score 16.00 epsilon 0.10 steps 462343
episode: 96 score: 13.0   average score 7.3 best score 16.00 epsilon 0.10 steps 464561
episode: 97 score: 12.0   average score 7.3 best score 16.00 epsilon 0.10 steps 466959
episode: 98 score: 1.0   average score 7.2 best score 16.00 epsilon 0.10 steps 469609
episode: 99 score: -1.0   average score 7.0 best score 16.00 epsilon 0.10 steps 472368
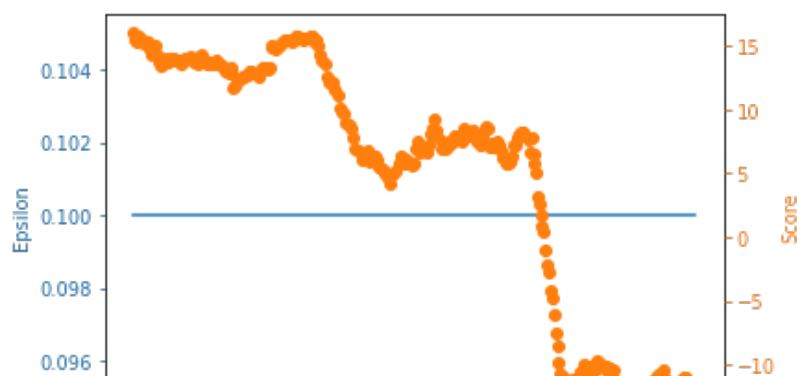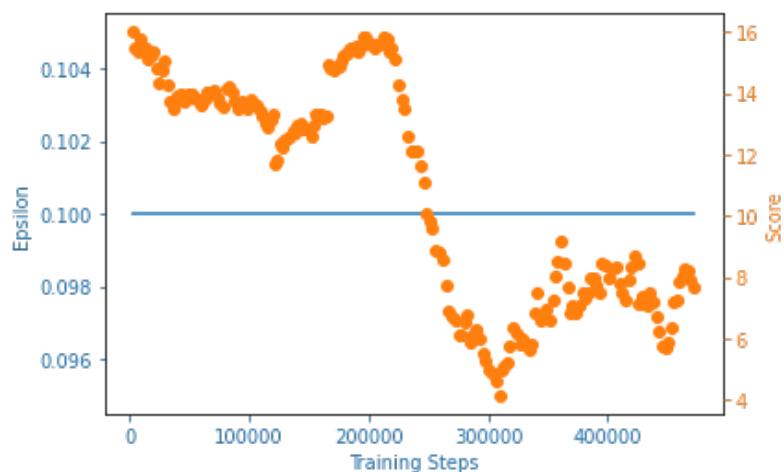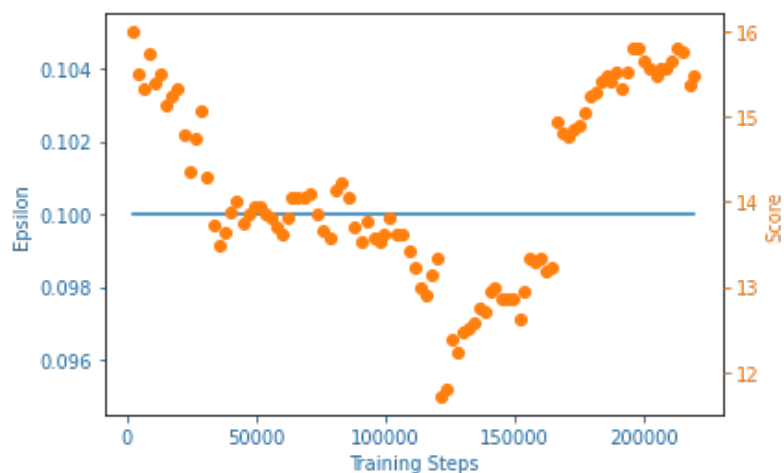epsilon value of 0.003

```
=========================
```

#####################################
episode: 0 score: -10.0   average score 6.8 best score 16.00 epsilon 0.10 steps 474377
episode: 1 score: 5.0   average score 6.9 best score 16.00 epsilon 0.10 steps 477173
episode: 2 score: -15.0   average score 6.7 best score 16.00 epsilon 0.10 steps 478658
episode: 3 score: -12.0   average score 6.5 best score 16.00 epsilon 0.10 steps 480496
episode: 4 score: -7.0   average score 6.4 best score 16.00 epsilon 0.10 steps 482769

```
episode:    1 score:     7.0  average score 6.1 best score 16.00 epsilon 0.10 steps 482709
episode:    5 score:   -21.0  average score 6.1 best score 16.00 epsilon 0.10 steps 483701
episode:    6 score:    -5.0  average score 5.9 best score 16.00 epsilon 0.10 steps 486212
episode:    7 score:   -12.0  average score 5.7 best score 16.00 epsilon 0.10 steps 488019
episode:    8 score:   -21.0  average score 5.4 best score 16.00 epsilon 0.10 steps 488892
episode:    9 score:    -7.0  average score 5.3 best score 16.00 epsilon 0.10 steps 491595
episode:   10 score:   -17.0  average score 5.2 best score 16.00 epsilon 0.10 steps 492888
episode:   11 score:   -14.0  average score 4.9 best score 16.00 epsilon 0.10 steps 494642
episode:   12 score:    -1.0  average score 4.8 best score 16.00 epsilon 0.10 steps 497516
episode:   13 score:   -13.0  average score 4.7 best score 16.00 epsilon 0.10 steps 499508
episode:   14 score:    -1.0  average score 4.6 best score 16.00 epsilon 0.10 steps 502294
episode:   15 score:   -17.0  average score 4.3 best score 16.00 epsilon 0.10 steps 503848
episode:   16 score:   -14.0  average score 4.1 best score 16.00 epsilon 0.10 steps 505571
episode:   17 score:    -9.0  average score 4.1 best score 16.00 epsilon 0.10 steps 507447
episode:   18 score:   -17.0  average score 3.8 best score 16.00 epsilon 0.10 steps 508907
episode:   19 score:   -17.0  average score 3.6 best score 16.00 epsilon 0.10 steps 510331
episode:   20 score:   -12.0  average score 3.4 best score 16.00 epsilon 0.10 steps 512369
episode:   21 score:    -5.0  average score 3.2 best score 16.00 epsilon 0.10 steps 515109
episode:   22 score:    -6.0  average score 3.1 best score 16.00 epsilon 0.10 steps 517889
episode:   23 score:   -11.0  average score 2.9 best score 16.00 epsilon 0.10 steps 519667
episode:   24 score:   -14.0  average score 2.8 best score 16.00 epsilon 0.10 steps 521201
episode:   25 score:    -7.0  average score 2.7 best score 16.00 epsilon 0.10 steps 523468
episode:   26 score:   -14.0  average score 2.5 best score 16.00 epsilon 0.10 steps 525039
episode:   27 score:   -17.0  average score 2.2 best score 16.00 epsilon 0.10 steps 526345
episode:   28 score:    -6.0  average score 2.1 best score 16.00 epsilon 0.10 steps 528755
episode:   29 score:   -15.0  average score 1.9 best score 16.00 epsilon 0.10 steps 530297
episode:   30 score:    -3.0  average score 1.9 best score 16.00 epsilon 0.10 steps 532859
episode:   31 score:    -9.0  average score 1.9 best score 16.00 epsilon 0.10 steps 535328
episode:   32 score:    -3.0  average score 1.8 best score 16.00 epsilon 0.10 steps 538296
episode:   33 score:   -15.0  average score 1.7 best score 16.00 epsilon 0.10 steps 539893
episode:   34 score:   -15.0  average score 1.4 best score 16.00 epsilon 0.10 steps 541380
episode:   35 score:    -5.0  average score 1.2 best score 16.00 epsilon 0.10 steps 543848
episode:   36 score:    -5.0  average score 1.0 best score 16.00 epsilon 0.10 steps 546326
episode:   37 score:    -7.0  average score 0.8 best score 16.00 epsilon 0.10 steps 548597
episode:   38 score:   -16.0  average score 0.5 best score 16.00 epsilon 0.10 steps 550382
episode:   39 score:   -16.0  average score 0.3 best score 16.00 epsilon 0.10 steps 551838
episode:   40 score:    -3.0  average score 0.3 best score 16.00 epsilon 0.10 steps 554633
episode:   41 score:   -14.0  average score 0.0 best score 16.00 epsilon 0.10 steps 556565
episode:   42 score:    -8.0  average score -0.1 best score 16.00 epsilon 0.10 steps 558970
episode:   43 score:   -11.0  average score -0.2 best score 16.00 epsilon 0.10 steps 561135
episode:   44 score:   -13.0  average score -0.5 best score 16.00 epsilon 0.10 steps 563243
episode:   45 score:   -12.0  average score -0.8 best score 16.00 epsilon 0.10 steps 565153
episode:   46 score:   -16.0  average score -1.1 best score 16.00 epsilon 0.10 steps 566816
episode:   47 score:   -13.0  average score -1.2 best score 16.00 epsilon 0.10 steps 568543
episode:   48 score:   -11.0  average score -1.4 best score 16.00 epsilon 0.10 steps 570612
episode:   49 score:   -17.0  average score -1.6 best score 16.00 epsilon 0.10 steps 572395
episode:   50 score:    -7.0  average score -1.6 best score 16.00 epsilon 0.10 steps 574539
episode:   51 score:   -20.0  average score -1.9 best score 16.00 epsilon 0.10 steps 575589
episode:   52 score:   -15.0  average score -2.2 best score 16.00 epsilon 0.10 steps 577421
episode:   53 score:    -7.0  average score -2.4 best score 16.00 epsilon 0.10 steps 579946
episode:   54 score:   -11.0  average score -2.7 best score 16.00 epsilon 0.10 steps 581983
episode:   55 score:   -17.0  average score -2.8 best score 16.00 epsilon 0.10 steps 583417
episode:   56 score:    -5.0  average score -2.9 best score 16.00 epsilon 0.10 steps 586088
episode:   57 score:   -16.0  average score -3.0 best score 16.00 epsilon 0.10 steps 587736
episode:   58 score:   -16.0  average score -3.3 best score 16.00 epsilon 0.10 steps 589338
episode:   59 score:    -7.0  average score -3.5 best score 16.00 epsilon 0.10 steps 591621
episode:   60 score:   -12.0  average score -3.7 best score 16.00 epsilon 0.10 steps 593483
episode:   61 score:   -10.0  average score -3.9 best score 16.00 epsilon 0.10 steps 595570
episode:   62 score:    -8.0  average score -4.0 best score 16.00 epsilon 0.10 steps 597704
episode:   63 score:   -15.0  average score -4.3 best score 16.00 epsilon 0.10 steps 599034
episode:   64 score:   -14.0  average score -4.5 best score 16.00 epsilon 0.10 steps 600583
episode:   65 score:    -9.0  average score -4.8 best score 16.00 epsilon 0.10 steps 602640
episode:   66 score:   -15.0  average score -5.0 best score 16.00 epsilon 0.10 steps 604538
episode:   67 score:    -9.0  average score -5.2 best score 16.00 epsilon 0.10 steps 606715
episode:   68 score:   -11.0  average score -5.5 best score 16.00 epsilon 0.10 steps 609009
episode:   69 score:   -21.0  average score -5.8 best score 16.00 epsilon 0.10 steps 609896
episode:   70 score:   -15.0  average score -5.9 best score 16.00 epsilon 0.10 steps 611399
episode:   71 score:    -1.0  average score -5.9 best score 16.00 epsilon 0.10 steps 614419
episode:   72 score:    -9.0  average score -6.1 best score 16.00 epsilon 0.10 steps 616593
episode:   73 score:    -9.0  average score -6.2 best score 16.00 epsilon 0.10 steps 619127
episode:   74 score:    -9.0  average score -6.4 best score 16.00 epsilon 0.10 steps 621642
episode:   75 score:    -4.0  average score -6.5 best score 16.00 epsilon 0.10 steps 624245
episode:   76 score:   -14.0  average score -6.8 best score 16.00 epsilon 0.10 steps 626092
```

episode: 77 score: -2.0   average score -6.9 best score 16.00 epsilon 0.10 steps 629057
episode: 78 score: -15.0   average score -7.1 best score 16.00 epsilon 0.10 steps 630629
episode: 79 score: -11.0   average score -7.3 best score 16.00 epsilon 0.10 steps 632591
episode: 80 score: -17.0   average score -7.2 best score 16.00 epsilon 0.10 steps 634027
episode: 81 score: -17.0   average score -7.6 best score 16.00 epsilon 0.10 steps 635676
episode: 82 score: -19.0   average score -7.8 best score 16.00 epsilon 0.10 steps 636820
episode: 83 score: -18.0   average score -8.1 best score 16.00 epsilon 0.10 steps 637995
episode: 84 score: -7.0   average score -8.3 best score 16.00 epsilon 0.10 steps 640257
episode: 85 score: -16.0   average score -8.5 best score 16.00 epsilon 0.10 steps 641853
episode: 86 score: -21.0   average score -8.8 best score 16.00 epsilon 0.10 steps 642847
episode: 87 score: -10.0   average score -8.9 best score 16.00 epsilon 0.10 steps 644757
episode: 88 score: -7.0   average score -9.0 best score 16.00 epsilon 0.10 steps 646973
episode: 89 score: -2.0   average score -9.1 best score 16.00 epsilon 0.10 steps 649743
episode: 90 score: -17.0   average score -9.4 best score 16.00 epsilon 0.10 steps 651146
episode: 91 score: -12.0   average score -9.6 best score 16.00 epsilon 0.10 steps 652994
episode: 92 score: -1.0   average score -9.8 best score 16.00 epsilon 0.10 steps 655807
episode: 93 score: -4.0   average score -10.0 best score 16.00 epsilon 0.10 steps 658468
episode: 94 score: -9.0   average score -10.2 best score 16.00 epsilon 0.10 steps 660544
episode: 95 score: -14.0   average score -10.4 best score 16.00 epsilon 0.10 steps 66239
2
episode: 96 score: -14.0   average score -10.7 best score 16.00 epsilon 0.10 steps 66423
5
episode: 97 score: -8.0   average score -10.9 best score 16.00 epsilon 0.10 steps 666508
episode: 98 score: -1.0   average score -10.9 best score 16.00 epsilon 0.10 steps 669616
episode: 99 score: -15.0   average score -11.1 best score 16.00 epsilon 0.10 steps 67136
8

0   100000 200000 300000 400000 500000 600000 700000

Training Steps

In [17]:

```
!jupyter nbconvert --to pdf Adversarial.ipynb
```

```
[NbConvertApp] WARNING | pattern u'Adversarial.ipynb' matched no files
This application is used to convert notebook files (*.ipynb) to various other
formats.

WARNING: THE COMMANDLINE INTERFACE MAY CHANGE IN FUTURE RELEASES.

Options
-------

Arguments that take values are actually convenience aliases to full
Configurables, whose aliases are listed on the help line. For more information
on full configurables, see '--help-all'.

--execute
    Execute the notebook prior to export.
--allow-errors
    Continue notebook execution even if one of the cells throws an error and include the
error message in the cell output (the default behaviour is to abort conversion). This fla
g is only relevant if '--execute' was specified, too.
--no-input
    Exclude input cells and output prompts from converted document.
    This mode is ideal for generating code-free reports.
--stdout
    Write notebook output to stdout instead of files.
--stdin
    read a single notebook file from stdin. Write the resulting notebook with default bas
ename 'notebook.*'
--inplace
    Run nbconvert in place, overwriting the existing notebook (only
    relevant when converting to notebook format)
-y
    Answer yes to any questions instead of prompting.
--clear-output
    Clear output of current file and save in place,
    overwriting the existing notebook.
--debug
    set log level to logging.DEBUG (maximize logging output)
--no-prompt
    Exclude input and output prompts from converted document.
--generate-config
    generate default config file
--nbformat=<Enum> (NotebookExporter.nbformat_version)
    Default: 4
    Choices: [1, 2, 3, 4]
    The nbformat version to write. Use this to downgrade notebooks.
--output-dir=<Unicode> (FilesWriter.build_directory)
    Default: ''
    Directory to write output(s) to. Defaults to output to the directory of each
    notebook. To recover previous default behaviour (outputting to the current
    working directory) use . as the flag value.
--writer=<DottedObjectName> (NbConvertApp.writer_class)
    Default: 'FilesWriter'
    Writer class used to write the  results of the conversion
--log-level=<Enum> (Application.log_level)
    Default: 30
    Choices: (0, 10, 20, 30, 40, 50, 'DEBUG', 'INFO', 'WARN', 'ERROR', 'CRITICAL')
    Set the log level by value or name.
--reveal-prefix=<Unicode> (SlidesExporter.reveal_url_prefix)
    Default: u''
    The URL prefix for reveal.js (version 3.x). This defaults to the reveal CDN,
    but can be any url pointing to a copy  of reveal.js.
    For speaker notes to work, this must be a relative path to a local  copy of
    reveal.js: e.g., "reveal.js".
    If a relative path is given, it must be a subdirectory of the current
```

```
      If a relative path is given, it must be a subdirectory of the current
      directory (from which the server is run).
      See the usage documentation
      (https://nbconvert.readthedocs.io/en/latest/usage.html#reveal-js-html-
      slideshow) for more details.
--to=<Unicode> (NbConvertApp.export_format)
      Default: 'html'
      The export format to be used, either one of the built-in formats
      ['asciidoc', 'custom', 'html', 'latex', 'markdown', 'notebook', 'pdf',
      'python', 'rst', 'script', 'slides'] or a dotted object name that represents
      the import path for an `Exporter` class
--template=<Unicode> (TemplateExporter.template_file)
      Default: u''
      Name of the template file to use
--output=<Unicode> (NbConvertApp.output_base)
      Default: ''
      overwrite base name use for output files. can only be used when converting
      one notebook at a time.
--post=<DottedOrNone> (NbConvertApp.postprocessor_class)
      Default: u''
      PostProcessor class used to write the results of the conversion
--config=<Unicode> (JupyterApp.config_file)
      Default: u''
      Full path of a config file.

To see all available configurables, use `--help-all`

Examples
--------

    The simplest way to use nbconvert is

    > jupyter nbconvert mynotebook.ipynb

    which will convert mynotebook.ipynb to the default format (probably HTML).

    You can specify the export format with `--to`.
    Options include ['asciidoc', 'custom', 'html', 'latex', 'markdown', 'notebook', 'pdf'
, 'python', 'rst', 'script', 'slides'].

    > jupyter nbconvert --to latex mynotebook.ipynb

    Both HTML and LaTeX support multiple output templates. LaTeX includes
    'base', 'article' and 'report'.  HTML includes 'basic' and 'full'. You
    can specify the flavor of the format used.

    > jupyter nbconvert --to html --template basic mynotebook.ipynb

    You can also pipe the output to stdout, rather than a file

    > jupyter nbconvert mynotebook.ipynb --stdout

    PDF is generated via latex

    > jupyter nbconvert mynotebook.ipynb --to pdf

    You can get (and serve) a Reveal.js-powered slideshow

    > jupyter nbconvert myslides.ipynb --to slides --post serve

    Multiple notebooks can be given at the command line in a couple of
    different ways:

    > jupyter nbconvert notebook*.ipynb
    > jupyter nbconvert notebook1.ipynb notebook2.ipynb

    or you can specify the notebooks list in a config file, containing::

        c.NbConvertApp.notebooks = ["my_notebook.ipynb"]

    > jupyter nbconvert --config mycfg.py
```