

cartpole_dqn

January 11, 2021

1 Simple DQN Agent

Modified version of <https://pylessons.com/CartPole-reinforcement-learning/>

To-Do:

- DDQN
- Dueling
- Different exploration strategies with ActionWrappers
- PER -> <https://pylessons.com/CartPole-PER/>

To-Do for safety: * Optimization: Bayesian, Genetic, or ant-colony * Monte Carlo tree search *
Importance sampling: Cross entropy method

2 Imports

```
[24]: import matplotlib
      %matplotlib inline

      import random
      import gym
      import numpy as np
      import matplotlib.pyplot as plt

      from collections import deque

      from keras.models import Sequential
      from keras.layers import Dense
      from keras.optimizers import Adam

      # Disable annoying tf2 warnings
      from warnings import simplefilter
      simplefilter(action='ignore', category=FutureWarning)
```

3 Agent Model

```
[2]: class DQNAgent:
    def __init__(self, state_size, action_size):
        self.state_size = state_size
        self.action_size = action_size

        self.memory = deque(maxlen=2000)  # history
        self.gamma = 0.95                 # discount rate
        self.epsilon = 1.0                 # exploration rate
        self.epsilon_min = 0.01            # minimum exploration probability
        self.epsilon_decay = 0.995         # exponential decay rate over time
        self.learning_rate = 0.001         # step size at each iteration

        self.model = self._build_model()

    def _build_model(self):
        model = Sequential()
        model.add(Dense(512, input_dim=self.state_size, activation='relu'))
        model.add(Dense(256, activation='relu'))
        model.add(Dense(64, activation='relu'))
        model.add(Dense(self.action_size, activation='linear'))
        model.compile(loss='mse', optimizer=Adam(lr=self.learning_rate))
        return model

    def memorize(self, state, action, reward, next_state, done):
        self.memory.append((state, action, reward, next_state, done))

    def act(self, state):
        if np.random.rand() <= self.epsilon:
            return random.randrange(self.action_size)
        act_values = self.model.predict(state)
        return np.argmax(act_values[0])

    def replay(self, batch_size):
        minibatch = random.sample(self.memory, batch_size)
        for state, action, reward, next_state, done in minibatch:
            target = reward
            if not done:
                target = (reward + self.gamma * np.amax(self.model.
→predict(next_state)[0]))
            target_f = self.model.predict(state)
            target_f[0][action] = target
            self.model.fit(state, target_f, epochs=1, verbose=0)
        if self.epsilon > self.epsilon_min:
            self.epsilon *= self.epsilon_decay
```

```

def load(self, name):
    self.model.load_weights(name)

def save(self, name):
    self.model.save_weights(name)

```

4 Training

```

[22]: EPISODES = 1000

def train_agent(env, agent):
    done = False
    batch_size = 32
    scores = []

    for e in range(EPISODES):
        state = env.reset()
        state = np.reshape(state, [1, state_size])
        for time in range(500):
            action = agent.act(state)
            next_state, reward, done, _ = env.step(action)
            reward = reward if not done else -10
            next_state = np.reshape(next_state, [1, state_size])
            agent.memorize(state, action, reward, next_state, done)
            state = next_state
            if done:
                scores.append(time)
                print(f"episode: {e}/{EPISODES}, score: {time}, e: {agent.epsilon}")
                break
            if len(agent.memory) > batch_size:
                agent.replay(batch_size)

    return agent

```

```

episode: 0/1000, score: 17, e: 1.0
episode: 1/1000, score: 34, e: 0.9046104802746175
episode: 2/1000, score: 11, e: 0.8560822709551227
episode: 3/1000, score: 20, e: 0.7744209942832988
episode: 4/1000, score: 20, e: 0.7005493475733617
episode: 5/1000, score: 13, e: 0.6563549768288433
episode: 6/1000, score: 35, e: 0.5507399854171277
episode: 7/1000, score: 15, e: 0.510849320360386
episode: 8/1000, score: 12, e: 0.4810273709480478
episode: 9/1000, score: 10, e: 0.457510005540005
episode: 10/1000, score: 18, e: 0.4180382776616619
episode: 11/1000, score: 7, e: 0.4036245882390106

```

episode: 12/1000, score: 13, e: 0.37816180712868996
episode: 13/1000, score: 15, e: 0.3507711574848344
episode: 14/1000, score: 9, e: 0.3352984938281715
episode: 15/1000, score: 12, e: 0.3157247089126454
episode: 16/1000, score: 8, e: 0.3033145315372582
episode: 17/1000, score: 15, e: 0.28134514724562876
episode: 18/1000, score: 17, e: 0.2583638820072446
episode: 19/1000, score: 9, e: 0.24696734223472733
episode: 20/1000, score: 7, e: 0.2384520680152932
episode: 21/1000, score: 11, e: 0.22566020663225933
episode: 22/1000, score: 8, e: 0.2167901907234072
episode: 23/1000, score: 9, e: 0.20722748400265262
episode: 24/1000, score: 9, e: 0.19808659230739353
episode: 25/1000, score: 9, e: 0.18934890919900021
episode: 26/1000, score: 11, e: 0.17919120740315364
episode: 27/1000, score: 8, e: 0.17214774642209296
episode: 28/1000, score: 11, e: 0.16291280823111093
episode: 29/1000, score: 11, e: 0.15417328217978102
episode: 30/1000, score: 9, e: 0.1473726336968319
episode: 31/1000, score: 8, e: 0.14157986400593744
episode: 32/1000, score: 9, e: 0.1353347165085562
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episode: 38/1000, score: 8, e: 0.10586201936274783
episode: 39/1000, score: 13, e: 0.09918368135888474
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episode: 954/1000, score: 216, e: 0.00998645168764533
episode: 955/1000, score: 108, e: 0.00998645168764533
episode: 956/1000, score: 136, e: 0.00998645168764533
episode: 957/1000, score: 92, e: 0.00998645168764533
episode: 958/1000, score: 81, e: 0.00998645168764533
episode: 959/1000, score: 16, e: 0.00998645168764533
episode: 960/1000, score: 16, e: 0.00998645168764533
episode: 961/1000, score: 151, e: 0.00998645168764533
episode: 962/1000, score: 146, e: 0.00998645168764533
episode: 963/1000, score: 499, e: 0.00998645168764533
episode: 964/1000, score: 89, e: 0.00998645168764533
episode: 965/1000, score: 124, e: 0.00998645168764533
episode: 966/1000, score: 134, e: 0.00998645168764533
episode: 967/1000, score: 169, e: 0.00998645168764533
episode: 968/1000, score: 109, e: 0.00998645168764533
episode: 969/1000, score: 247, e: 0.00998645168764533
episode: 970/1000, score: 248, e: 0.00998645168764533
episode: 971/1000, score: 87, e: 0.00998645168764533

```
episode: 972/1000, score: 499, e: 0.00998645168764533
episode: 973/1000, score: 173, e: 0.00998645168764533
episode: 974/1000, score: 437, e: 0.00998645168764533
episode: 975/1000, score: 185, e: 0.00998645168764533
episode: 976/1000, score: 499, e: 0.00998645168764533
episode: 977/1000, score: 189, e: 0.00998645168764533
episode: 978/1000, score: 83, e: 0.00998645168764533
episode: 979/1000, score: 50, e: 0.00998645168764533
episode: 980/1000, score: 117, e: 0.00998645168764533
episode: 981/1000, score: 41, e: 0.00998645168764533
episode: 982/1000, score: 56, e: 0.00998645168764533
episode: 983/1000, score: 106, e: 0.00998645168764533
episode: 984/1000, score: 122, e: 0.00998645168764533
episode: 985/1000, score: 430, e: 0.00998645168764533
episode: 986/1000, score: 499, e: 0.00998645168764533
episode: 987/1000, score: 499, e: 0.00998645168764533
episode: 988/1000, score: 499, e: 0.00998645168764533
episode: 989/1000, score: 178, e: 0.00998645168764533
episode: 990/1000, score: 499, e: 0.00998645168764533
episode: 991/1000, score: 288, e: 0.00998645168764533
episode: 992/1000, score: 265, e: 0.00998645168764533
episode: 993/1000, score: 351, e: 0.00998645168764533
episode: 994/1000, score: 182, e: 0.00998645168764533
episode: 995/1000, score: 96, e: 0.00998645168764533
episode: 996/1000, score: 209, e: 0.00998645168764533
episode: 997/1000, score: 118, e: 0.00998645168764533
episode: 998/1000, score: 95, e: 0.00998645168764533
episode: 999/1000, score: 36, e: 0.00998645168764533
```

5 Usage

```
[14]: env = gym.make('CartPole-v1')
      env.seed(0)
      np.random.seed(0)

      state_size = env.observation_space.shape[0]
      action_size = env.action_space.n
      agent = DQNAgent(state_size, action_size)

      #agent = train_agent(env, agent)
      #agent.save('dqn.h5')

      agent.load('dqn.h5')
```

```
[23]: # ToDo: averages
      plt.plot(scores)
```


[23]: [<matplotlib.lines.Line2D at 0x7f82505c57b8>]

