

In []:

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import torch
import torch.nn as nn
import torch.nn.functional as F
import numpy as np
import gym
import math
import matplotlib.pyplot as plt

EPISODES = 500
BATCH_SIZE = 32
LR = 0.01 # learning rate
GAMMA = 0.9 # reward discount
TARGET_REPLACE_ITER = 100 # target update frequency
MEMORY_CAPACITY = 2000
env = gym.make('CartPole-v0')
env = env.unwrapped
RENDER=True
EPSILON=0.9
ENV_A_SHAPE = 0 if isinstance(env.action_space.sample(), int) else env.action_space.sample().shape

class Network(nn.Module):
    def __init__(self, ):
        nn.Module.__init__(self)
        self.fcl = nn.Linear(4, 50)
        self.fcl.weight.data.normal_(0, 0.1) # initialization
        self.out = nn.Linear(50, 2)
        self.out.weight.data.normal_(0, 0.1) # initialization
    def forward(self, x):
        x = self.fcl(x)
        x = F.relu(x)
        x = self.out(x)
        return x

class DQN(object):
    def __init__(self):
        self.model=Network()
        self.target = Network()
        self.counter = 0 # for target updating
        self.memory_counter = 0 # for storing memory
        self.memory = np.zeros((MEMORY_CAPACITY, 4 * 2 + 2)) # initialize memory
        self.optimizer = torch.optim.Adam(self.model.parameters(), lr=LR)
        self.loss_func = nn.MSELoss()
    def select_action(self, x):
        x = torch.unsqueeze(torch.FloatTensor(x), 0)
        if np.random.uniform() < EPSILON: # greedy
            actions_value = self.model.forward(x)
            action = torch.max(actions_value, 1)[1].data.numpy()
            action = action[0] if ENV_A_SHAPE == 0 else action.reshape(ENV_A_SHAPE)
        else: # random
            action = np.random.randint(0, 2)
            action = action if ENV_A_SHAPE == 0 else action.reshape(ENV_A_SHAPE)
        return action
    def store_transition(self, s, a, r, s_):
        transition = np.hstack((s, [a, r], s_))
        index = self.memory_counter % MEMORY_CAPACITY
        self.memory[index, :] = transition
        self.memory_counter += 1
    def learn(self):

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if self.counter % TARGET_REPLACE_ITER == 0:
    self.target.load_state_dict(self.model.state_dict())
self.counter += 1

sample_index = np.random.choice(MEMORY_CAPACITY, BATCH_SIZE)
b_memory = self.memory[sample_index, :]
batch_state = torch.FloatTensor(b_memory[:, :4])

batch_action = torch.LongTensor(b_memory[:, 4:5].astype(int))
batch_reward = torch.FloatTensor(b_memory[:, 5:6])
batch_next_state = torch.FloatTensor(b_memory[:, -4:])

current_q_values = self.model(batch_state).gather(1, batch_action) # shape (batch, 1)
max_next_q_values = self.target(batch_next_state).detach() # detach from graph, don't bac
kpropagate
expected_q_values = batch_reward + GAMMA * max_next_q_values.max(1)[0].view(BATCH_SIZE, 1)
# shape (batch, 1)
loss = self.loss_func(current_q_values, expected_q_values)
self.optimizer.zero_grad()
loss.backward()
self.optimizer.step()

def run_episode(e, environment, RENDER=True, epoch_reward=0, log_interval=10):
    state = env.reset()
    steps = 0
    epoch_reward = 0
    while True:
        env.render()
        action = dqn.select_action(state)
        next_state, reward, done, info = env.step(action)

        x, x_dot, theta, theta_dot = next_state
        r1 = (env.x_threshold - abs(x)) / env.x_threshold - 0.8
        r2 = (env.theta_threshold_radians - abs(theta)) / env.theta_threshold_radians - 0.5
        reward = r1 + r2

        dqn.store_transition(state, action, reward, next_state)
        epoch_reward += reward
        steps+=1

        if dqn.memory_counter > MEMORY_CAPACITY:
            dqn.learn()
            if done:
                print('Ep: ', e,
                    ' | Ep_r: ', round(epoch_reward, 2))
            if done:
                print(
                    "{2} Episode {0} finished after {1} steps".format(e, steps, '\033[92m' if steps
                    >= 195 else '\033[99m'))
                episode_durations.append(steps)
                plot_durations() # optional
                break
            state = next_state
def plot_durations():
    plt.figure(2)
    plt.clf()
    durations_t = torch.FloatTensor(episode_durations)
    plt.title('Training...')
    plt.xlabel('Episode')
    plt.ylabel('Duration')
    plt.plot(durations_t.numpy())

```

```
# take 100 episode averages and plot them too
if len(durations_t) >= 100:
    means = durations_t.unfold(0, 100, 1).mean(1).view(-1)
    means = torch.cat((torch.zeros(99), means))
    plt.plot(means.numpy())
plt.pause(0.001) # pause a bit so that plots are updated
if __name__ == '__main__':
    dqn = DQN()
    print('\nCollecting experience...')
    episode_durations = []
    for epoch in range(EPISODES):
        run_episode(epoch, env, RENDER, epoch_reward=0)
    print('Training Complete')
    env.render(close=True)
    env.close()
    plt.ioff()
    plt.show()
```

Collecting experience...

Episode 0 finished after 10 steps

<Figure size 640x480 with 1 Axes>

Episode 1 finished after 14 steps

<Figure size 640x480 with 1 Axes>

Episode 2 finished after 16 steps

<Figure size 640x480 with 1 Axes>

Episode 3 finished after 12 steps

<Figure size 640x480 with 1 Axes>

Episode 4 finished after 14 steps

<Figure size 640x480 with 1 Axes>

Episode 5 finished after 13 steps

<Figure size 640x480 with 1 Axes>

Episode 6 finished after 12 steps

<Figure size 640x480 with 1 Axes>

Episode 7 finished after 12 steps

<Figure size 640x480 with 1 Axes>

Episode 8 finished after 15 steps

<Figure size 640x480 with 1 Axes>

Episode 9 finished after 12 steps

<Figure size 640x480 with 1 Axes>

Episode 10 finished after 13 steps

<Figure size 640x480 with 1 Axes>

Episode 11 finished after 17 steps

<Figure size 640x480 with 1 Axes>

Episode 12 finished after 10 steps

<Figure size 640x480 with 1 Axes>

Episode 13 finished after 13 steps

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Episode 14 finished after 10 steps

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Episode 15 finished after 13 steps

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Episode 16 finished after 12 steps

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Episode 18 finished after 13 steps

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Episode 21 finished after 14 steps

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Episode 22 finished after 11 steps

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Episode 26 finished after 14 steps

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Episode 145 finished after 11 steps

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Episode 146 finished after 10 steps

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Episode 147 finished after 16 steps

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Episode 148 finished after 12 steps

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Episode 149 finished after 11 steps

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Episode 150 finished after 14 steps

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Episode 151 finished after 11 steps

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Episode 152 finished after 11 steps

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Episode 155 finished after 11 steps

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Episode 156 finished after 12 steps

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Episode 157 finished after 10 steps

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Episode 158 finished after 10 steps

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Episode 159 finished after 12 steps

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Episode 160 finished after 14 steps

<Figure size 640x480 with 1 Axes>

Episode 161 finished after 14 steps

<Figure size 640x480 with 1 Axes>

Episode 162 finished after 12 steps

<Figure size 640x480 with 1 Axes>

Ep: 163 | Ep_r: 2.43

Episode 163 finished after 9 steps

<Figure size 640x480 with 1 Axes>

Ep: 164 | Ep_r: 2.7

Episode 164 finished after 10 steps

<Figure size 640x480 with 1 Axes>

Ep: 165 | Ep_r: 2.37

Episode 165 finished after 10 steps

<Figure size 640x480 with 1 Axes>

Ep: 166 | Ep_r: 4.25

Episode 166 finished after 16 steps

<Figure size 640x480 with 1 Axes>

Ep: 167 | Ep_r: 1.94

Episode 167 finished after 10 steps

<Figure size 640x480 with 1 Axes>

Ep: 168 | Ep_r: 1.5
Episode 168 finished after 9 steps

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Ep: 169 | Ep_r: 2.82
Episode 169 finished after 12 steps

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Ep: 170 | Ep_r: 2.02
Episode 170 finished after 9 steps

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Ep: 171 | Ep_r: 2.88
Episode 171 finished after 13 steps

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Ep: 172 | Ep_r: 2.34
Episode 172 finished after 11 steps

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Ep: 173 | Ep_r: 1.59
Episode 173 finished after 10 steps

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Ep: 174 | Ep_r: 4.11
Episode 174 finished after 15 steps

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Ep: 175 | Ep_r: 2.17
Episode 175 finished after 9 steps

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Ep: 176 | Ep_r: 0.99
Episode 176 finished after 9 steps

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Ep: 177 | Ep_r: 2.51
Episode 177 finished after 12 steps

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Ep: 178 | Ep_r: 2.51
Episode 178 finished after 13 steps

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Ep: 179 | Ep_r: 3.79
Episode 179 finished after 17 steps

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Ep: 180 | Ep_r: 1.35
Episode 180 finished after 15 steps

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Ep: 181 | Ep_r: 0.89
Episode 181 finished after 18 steps

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Ep: 182 | Ep_r: 0.27
Episode 182 finished after 14 steps

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Ep: 183 | Ep_r: 4.29
Episode 183 finished after 13 steps

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Ep: 184 | Ep_r: 2.97
Episode 184 finished after 10 steps

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Ep: 185 | Ep_r: 0.96
Episode 185 finished after 9 steps

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Ep: 186 | Ep_r: 2.42
Episode 186 finished after 10 steps

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Ep: 187 | Ep_r: 3.19
Episode 187 finished after 12 steps

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Ep: 188 | Ep_r: 2.18
Episode 188 finished after 11 steps

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Ep: 189 | Ep_r: 9.47
Episode 189 finished after 69 steps

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Ep: 190 | Ep_r: 13.13
Episode 190 finished after 43 steps

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Ep: 191 | Ep_r: 2.52
Episode 191 finished after 11 steps

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Ep: 192 | Ep_r: 2.23
Episode 192 finished after 10 steps

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Ep: 193 | Ep_r: 6.72
Episode 193 finished after 21 steps

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Ep: 194 | Ep_r: 2.96
Episode 194 finished after 11 steps

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Ep: 195 | Ep_r: 12.72
Episode 195 finished after 46 steps

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Ep: 196 | Ep_r: 3.79
Episode 196 finished after 12 steps

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Ep: 197 | Ep_r: 8.9
Episode 197 finished after 20 steps

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Ep: 198 | Ep_r: 3.55
Episode 198 finished after 14 steps

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Ep: 199 | Ep_r: 2.07
Episode 199 finished after 24 steps

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Ep: 200 | Ep_r: 14.46
Episode 200 finished after 39 steps

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Ep: 201 | Ep_r: 1.33
Episode 201 finished after 24 steps

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Ep: 202 | Ep_r: 10.47
Episode 202 finished after 46 steps

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Ep: 203 | Ep_r: 5.75
Episode 203 finished after 25 steps

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Ep: 204 | Ep_r: 2.26
Episode 204 finished after 10 steps

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Ep: 205 | Ep_r: 5.14
Episode 205 finished after 40 steps

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Ep: 206 | Ep_r: 4.54
Episode 206 finished after 15 steps

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Ep: 207 | Ep_r: 10.05
Episode 207 finished after 38 steps

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Ep: 208 | Ep_r: 22.94
Episode 208 finished after 75 steps

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Ep: 209 | Ep_r: 14.93
Episode 209 finished after 69 steps

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Ep: 210 | Ep_r: 31.04
Episode 210 finished after 98 steps

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Ep: 211 | Ep_r: 69.95
Episode 211 finished after 157 steps

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Ep: 212 | Ep_r: 51.34
Episode 212 finished after 130 steps

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Ep: 213 | Ep_r: 45.82
Episode 213 finished after 188 steps

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Ep: 214 | Ep_r: 55.82
Episode 214 finished after 144 steps

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Ep: 215 | Ep_r: 57.1
Episode 215 finished after 211 steps

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Ep: 216 | Ep_r: 61.86
Episode 216 finished after 221 steps

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Ep: 217 | Ep_r: 43.08
Episode 217 finished after 188 steps

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Ep: 218 | Ep_r: 117.82
Episode 218 finished after 306 steps

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Ep: 219 | Ep_r: 99.42
Episode 219 finished after 286 steps

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Ep: 220 | Ep_r: 88.17
Episode 220 finished after 332 steps

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Ep: 221 | Ep_r: 30.64
Episode 221 finished after 360 steps

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Ep: 222 | Ep_r: 217.74
Episode 222 finished after 594 steps

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Ep: 223 | Ep_r: 112.22
Episode 223 finished after 360 steps

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Ep: 224 | Ep_r: 168.9
Episode 224 finished after 686 steps

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Ep: 225 | Ep_r: 162.35
Episode 225 finished after 613 steps

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Ep: 226 | Ep_r: 226.15
Episode 226 finished after 724 steps

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Ep: 227 | Ep_r: 336.46
Episode 227 finished after 824 steps

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Ep: 228 | Ep_r: 477.88
Episode 228 finished after 1235 steps

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Ep: 229 | Ep_r: 258.36
Episode 229 finished after 759 steps

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Ep: 230 | Ep_r: 349.79
Episode 230 finished after 863 steps

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Ep: 231 | Ep_r: 258.2
Episode 231 finished after 901 steps

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Ep: 232 | Ep_r: 200.62
Episode 232 finished after 553 steps

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Ep: 233 | Ep_r: 249.68
Episode 233 finished after 1239 steps

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Ep: 234 | Ep_r: 231.71
Episode 234 finished after 870 steps

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Ep: 235 | Ep_r: 214.46
Episode 235 finished after 671 steps

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In []: