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Федеральное государственное бюджетное образовательное учреждение высшего образования
«Московский государственный технический университет имени Н.Э. Баумана (национальный исследовательский университет)»
(МГТУ им. Н.Э. Баумана)

Факультет «Информатика и системы управления»

Кафедра ИУ5 «Системы обработки информации и управления»

Курс «Методы машинного обучения»

Отчет по лабораторной работе 6

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Лабораторная работа 6.

На основе рассмотренных на лекции примеров реализуйте алгоритм DQN. В качестве среды можно использовать классические среды (в этом случае используется полносвязная архитектура нейронной сети). В качестве среды можно использовать игры Atari (в этом случае используется сверточная

а

```
%matplotlib inline
 import sys
import logging
import itertools
import copy

import numpy as np
np.random.seed(0) import
pandas as pd
import gym
import matplotlib.pyplot as plt
import torch import
torch.nn as nn import
torch.optim as optim
torch.manual_seed(0)
```

и

ронной сети).

In [9]:

<

torch._C.Generator at 0x7a61d2d0cd10>

Out[9]:

In

```
env = gym.make('MountainCar-v0')

# Вывод информации о переменных среды
env_vars = vars(env) for key in
env_vars:     print(f"{key}:
{env_vars[key]}")

# Вывод информации о переменных спецификации среды
spec_vars = vars(env.spec) for key in spec_vars:
print(f"{key}: {spec_vars[key]}")
```

[10]:

```
env: <OrderEnforcing<PassiveEnvChecker<MountainCarEnv<MountainCar-v0>>>>
_action_space: None
_observation_space: None
_reward_range: None
_metadata: None
_max_episode_steps: 200
_elapsed_steps: None id:
MountainCar-v0
entry_point: gym.envs.classic_control.mountain_car:MountainCarEnv
reward_threshold: -110.0 nondeterministic: False
max_episode_steps: 200 order_enforce: True autoreset: False
disable_env_checker: False apply_api_compatibility: False kwargs:
{} namespace: None name: MountainCar version: 0
```

In [11]:
```
class DQNReplayer:     def __init__(self, capacity):
self.memory = pd.DataFrame(index=range(capacity),
                columns=['state', 'action', 'reward', 'next_state', 'terminated'])
self.i = 0          self.count = 0
        self.capacity = capacity
     def store(self, *args):          self.memory.loc[self.i] =
np.asarray(args, dtype=object)          self.i = (self.i + 1) %
self.capacity
        self.count = min(self.count + 1, self.capacity)
     def sample(self, size):          indices =
np.random.choice(self.count, size=size)
        return (np.stack(self.memory.loc[indices, field]) for field in
self.memory.columns)
 class DQNAgent:     def __init__(self,
env):          self.action_n =
env.action_space.n
        self.gamma = 0.99

        self.replayer = DQNReplayer(10000)

        self.device = torch.device("cuda" if torch.cuda.is_available() else "cpu")

        self.evaluate_net = self.build_net(
            input_size=env.observation_space.shape[0],
hidden_sizes=[64, 64], output_size=self.action_n
        ).to(self.device)
        self.optimizer = optim.Adam(self.evaluate_net.parameters(), lr=0.001)
self.loss = nn.MSELoss()
     def build_net(self, input_size, hidden_sizes, output_size):
layers = []
        for input_size, output_size in zip(
                [input_size,] + hidden_sizes, hidden_sizes + [output_size,]):
layers.append(nn.Linear(input_size, output_size))
layers.append(nn.ReLU())          layers = layers[:-1]
        model = nn.Sequential(*layers).to(self.device)
return model
     def reset(self,
mode=None):
        self.mode = mode
if self.mode == 'train':
self.trajectory = []
            self.target_net = copy.deepcopy(self.evaluate_net)
     def step(self, observation, reward, terminated):
if self.mode == 'train' and np.random.rand() < 0.001:
            # epsilon-greedy policy in train mode             action =
np.random.randint(self.action_n)          else:              state_tensor =
torch.as_tensor(observation, dtype=torch.float).squeeze(0).to(             q_tensor =
self.evaluate_net(state_tensor)              action_tensor = torch.argmax(q_tensor)
            action = action_tensor.item()
if self.mode == 'train':
            self.trajectory += [observation, reward, terminated, action]
if len(self.trajectory) >= 8:                  state, _, _, act,
next_state, reward, terminated, _ = \
self.trajectory[-8:]
```

s

```
player.store(state, act, reward, next_state, terminated)            if
self.replayer.count >= self.replayer.capacity * 0.95:
# skip first few episodes for speed
self.learn()          return action
def close(self):
pass
def learn(self):
# replay
states, actions, rewards, next_states, terminateds = \
self.replayer.sample(1024)
state_tensor = torch.as_tensor(states, dtype=torch.float).to(self.device)
action_tensor = torch.as_tensor(actions, dtype=torch.long).to(self.device)
reward_tensor = torch.as_tensor(rewards, dtype=torch.float).to(self.device)
next_state_tensor = torch.as_tensor(next_states, dtype=torch.float).to(self.device
terminated_tensor = torch.as_tensor(terminateds, dtype=torch.float).to(self.device

# update value net
next_q_tensor = self.target_net(next_state_tensor)
next_max_q_tensor, _ = next_q_tensor.max(axis=-1)
target_tensor = reward_tensor + self.gamma * \
(1. - terminated_tensor) * next_max_q_tensor
pred_tensor = self.evaluate_net(state_tensor)
q_tensor = pred_tensor.gather(1, action_tensor.unsqueeze(1)).squeeze(1)
loss_tensor = self.loss(target_tensor, q_tensor)
self.optimizer.zero_grad()
loss_tensor.backward()
self.optimizer.step()

agent = DQNAgent(env)
def play_episode(env, agent, seed=None, mode=None,
render=False):     observation, _ = env.reset(seed=seed)
reward, terminated, truncated = 0., False, False
agent.reset(mode=mode)
episode_reward, elapsed_steps = 0., 0
while True:
action = agent.step(observation, reward, terminated)
if render:
env.render()          if
terminated or truncated:
break
observation, reward, terminated, truncated, _ = env.step(action)
episode_reward += reward          elapsed_steps += 1     agent.close()
return episode_reward, elapsed_steps

print('==== train ====') episode_rewards = [] for episode in itertools.count():
episode_reward, elapsed_steps = play_episode(env, agent, seed=episode, mode='train')
episode_rewards.append(episode_reward)
print(f'train episode {episode}: reward = {episode_reward:.2f}, steps = {elapsed_steps
if np.mean(episode_rewards[-10:]) > -110:          break
plt.plot(episode_rewards)

print('==== test ====') episode_rewards = [] for episode in
range(100):     episode_reward, elapsed_steps =
play_episode(env, agent) }
)


==== train ====
t    episode_rewards.append(episode_reward)
r    print(f'test episode {episode}: reward = {episode_reward:.2f}, steps = {elapsed_steps
print(f'average episode reward = {np.mean(episode_rewards):.2f} ± {np.std(episode_rewards
i
n
episode 0: reward = -200.00, steps = 200
train episode 1: reward = -200.00, steps =
200 train episode 2: reward = -200.00, steps
= 200 train episode 3: reward = -200.00,
steps = 200 train episode 4: reward = -
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173.00, steps = 173 train episode 259: reward = -
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186.00, steps = 186 train episode 262: reward = -
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113.00, steps = 113 train episode 297: reward = -
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111.00, steps = 111 train episode 300: reward = -
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114.00, steps = 114 train episode 304: reward = -
108.00, steps = 108
==== test ====
test episode 0: reward = -85.00, steps = 85 test
episode 1: reward = -111.00, steps = 111 test
episode 2: reward = -108.00, steps = 108 test
episode 3: reward = -114.00, steps = 114 test
episode 4: reward = -90.00, steps = 90 test
episode 5: reward = -115.00, steps = 115 test
episode 6: reward = -113.00, steps = 113 test
episode 7: reward = -112.00, steps = 112 test
episode 8: reward = -114.00, steps = 114 test
episode 9: reward = -113.00, steps = 113 test
episode 10: reward = -113.00, steps = 113 test
episode 11: reward = -112.00, steps = 112 test
episode 12: reward = -113.00, steps = 113 test
episode 13: reward = -110.00, steps = 110 test
episode 14: reward = -111.00, steps = 111 test
episode 15: reward = -114.00, steps = 114 test
episode 16: reward = -107.00, steps = 107 test
episode 17: reward = -114.00, steps = 114 test
episode 18: reward = -107.00, steps = 107 test
episode 19: reward = -115.00, steps = 115 test
episode 20: reward = -113.00, steps = 113 test
episode 21: reward = -87.00, steps = 87 test
episode 22: reward = -107.00, steps = 107 test
episode 23: reward = -110.00, steps = 110 test
episode 24: reward = -108.00, steps = 108 test
episode 25: reward = -115.00, steps = 115 test
episode 26: reward = -112.00, steps = 112 test
episode 27: reward = -110.00, steps = 110 test
episode 28: reward = -114.00, steps = 114 test
episode 29: reward = -84.00, steps = 84 test
episode 30: reward = -86.00, steps = 86 test
episode 31: reward = -107.00, steps = 107 test
episode 32: reward = -115.00, steps = 115 test
episode 33: reward = -114.00, steps = 114 test
episode 34: reward = -115.00, steps = 115 test
episode 35: reward = -112.00, steps = 112 test
episode 36: reward = -98.00, steps = 98 test
```
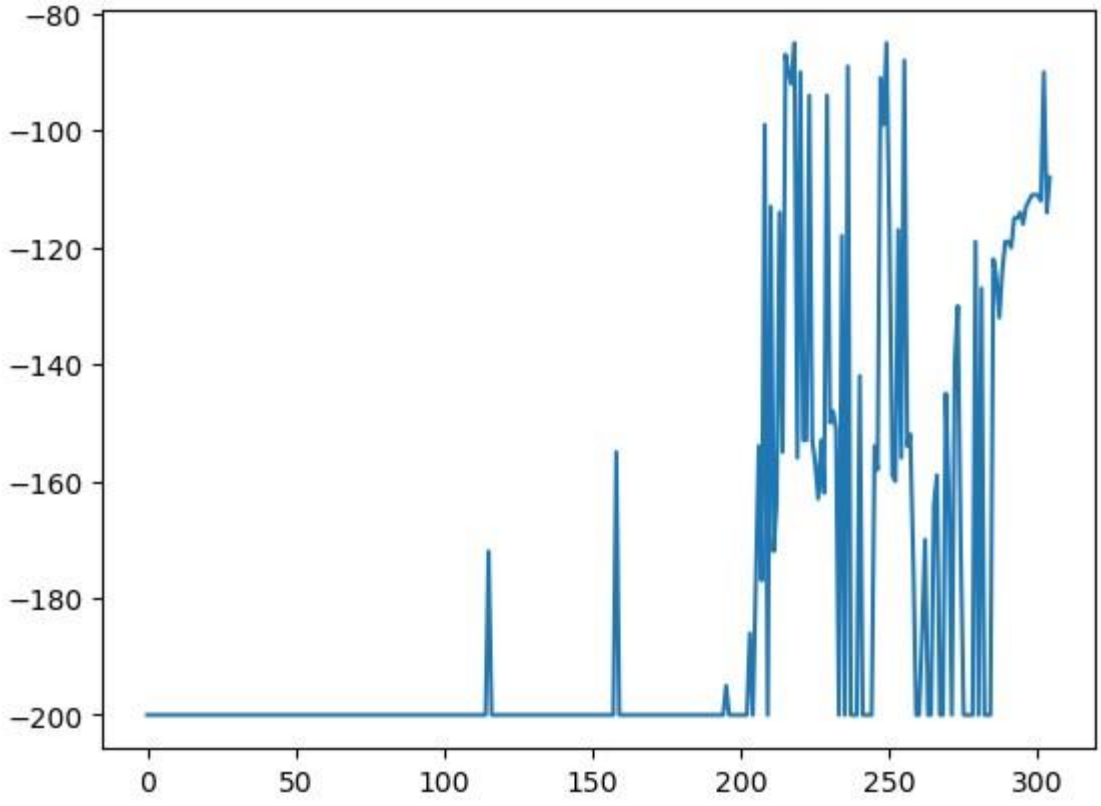

```
episode 37: reward = -112.00, steps = 112 test
episode 38: reward = -111.00, steps = 111 test
episode 39: reward = -114.00, steps = 114 test
episode 40: reward = -115.00, steps = 115 test
episode 41: reward = -111.00, steps = 111 test
episode 42: reward = -113.00, steps = 113 test
episode 43: reward = -108.00, steps = 108 test
episode 44: reward = -83.00, steps = 83 test
episode 45: reward = -115.00, steps = 115 test
episode 46: reward = -113.00, steps = 113 test
episode 47: reward = -110.00, steps = 110 test
episode 48: reward = -97.00, steps = 97 test
episode 49: reward = -111.00, steps = 111 test
episode 50: reward = -88.00, steps = 88 test
episode 51: reward = -114.00, steps = 114 test
episode 52: reward = -108.00, steps = 108 test
episode 53: reward = -85.00, steps = 85 test
episode 54: reward = -108.00, steps = 108 test
episode 55: reward = -113.00, steps = 113 test
episode 56: reward = -108.00, steps = 108 test
episode 57: reward = -112.00, steps = 112 test
episode 58: reward = -114.00, steps = 114 test
episode 59: reward = -108.00, steps = 108 test
episode 60: reward = -112.00, steps = 112 test
episode 61: reward = -115.00, steps = 115 test
episode 62: reward = -113.00, steps = 113 test
episode 63: reward = -114.00, steps = 114 test
episode 64: reward = -108.00, steps = 108 test
episode 65: reward = -98.00, steps = 98 test
episode 66: reward = -113.00, steps = 113 test
episode 67: reward = -110.00, steps = 110 test
episode 68: reward = -114.00, steps = 114 test
episode 69: reward = -84.00, steps = 84 test
episode 70: reward = -115.00, steps = 115 test
episode 71: reward = -102.00, steps = 102 test
episode 72: reward = -113.00, steps = 113 test
episode 73: reward = -115.00, steps = 115 test
episode 74: reward = -108.00, steps = 108 test
episode 75: reward = -114.00, steps = 114 test
episode 76: reward = -98.00, steps = 98 test
episode 77: reward = -114.00, steps = 114 test
episode 78: reward = -114.00, steps = 114 test
episode 79: reward = -108.00, steps = 108 test
episode 80: reward = -84.00, steps = 84 test
episode 81: reward = -88.00, steps = 88 test
episode 82: reward = -113.00, steps = 113 test
episode 83: reward = -111.00, steps = 111 test
episode 84: reward = -88.00, steps = 88 test
episode 85: reward = -84.00, steps = 84 test
episode 86: reward = -115.00, steps = 115 test
episode 87: reward = -108.00, steps = 108 test
episode 88: reward = -87.00, steps = 87 test
episode 89: reward = -109.00, steps = 109 test
episode 90: reward = -113.00, steps = 113 test
episode 91: reward = -110.00, steps = 110 test
episode 92: reward = -109.00, steps = 109 test
episode 93: reward = -113.00, steps = 113 test
episode 94: reward = -108.00, steps = 108 test
episode 95: reward = -113.00, steps = 113 test
episode 96: reward = -91.00, steps = 91 test
episode 97: reward = -86.00, steps = 86 test
episode 98: reward = -110.00, steps = 110 test
episode 99: reward = -83.00, steps = 83 average
episode reward = -106.74 ± 10.10
```


−80
−100
−120
−140
−160
−180
−200
0
50
100
150
200
250
300