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Кафедра «Системы обработки информации и управления»

Лабораторная работа №7
по дисциплине
«Методы машинного обучения»
на тему

«Алгоритмы Actor-Critic»

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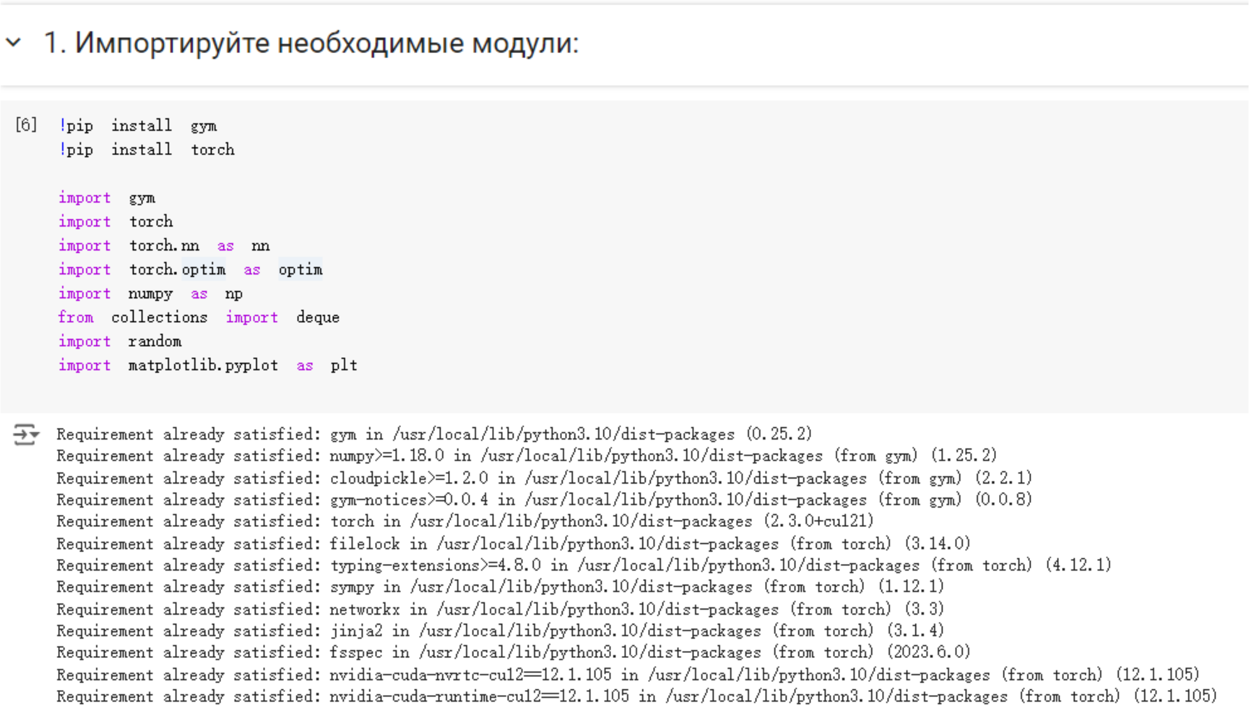
1. Цель лабораторной работы

Ознакомление с базовыми методами обучения с подкреплением на основе алгоритмов Actor-Critic.

2. Задание

- Реализуйте любой алгоритм семейства Actor-Critic для произвольной среды.

3. Текст программы

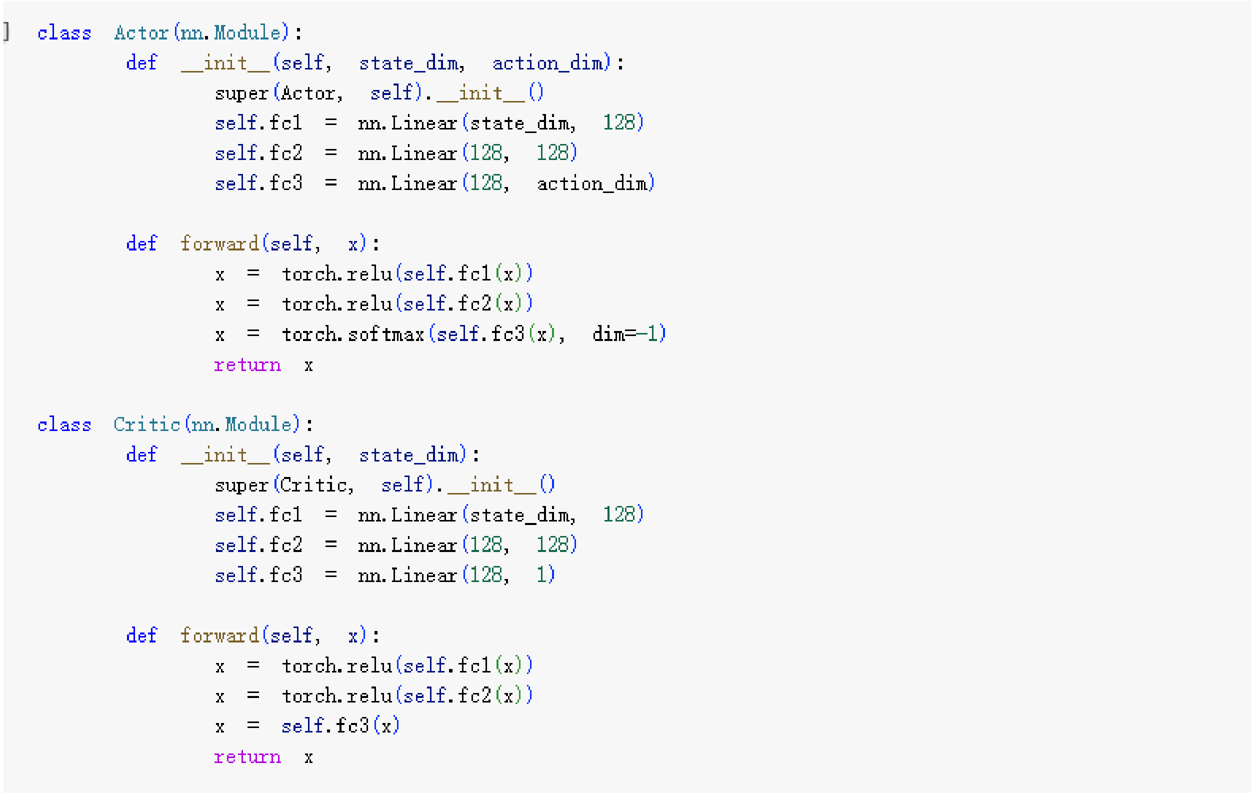


1. Импортируйте необходимые модули:

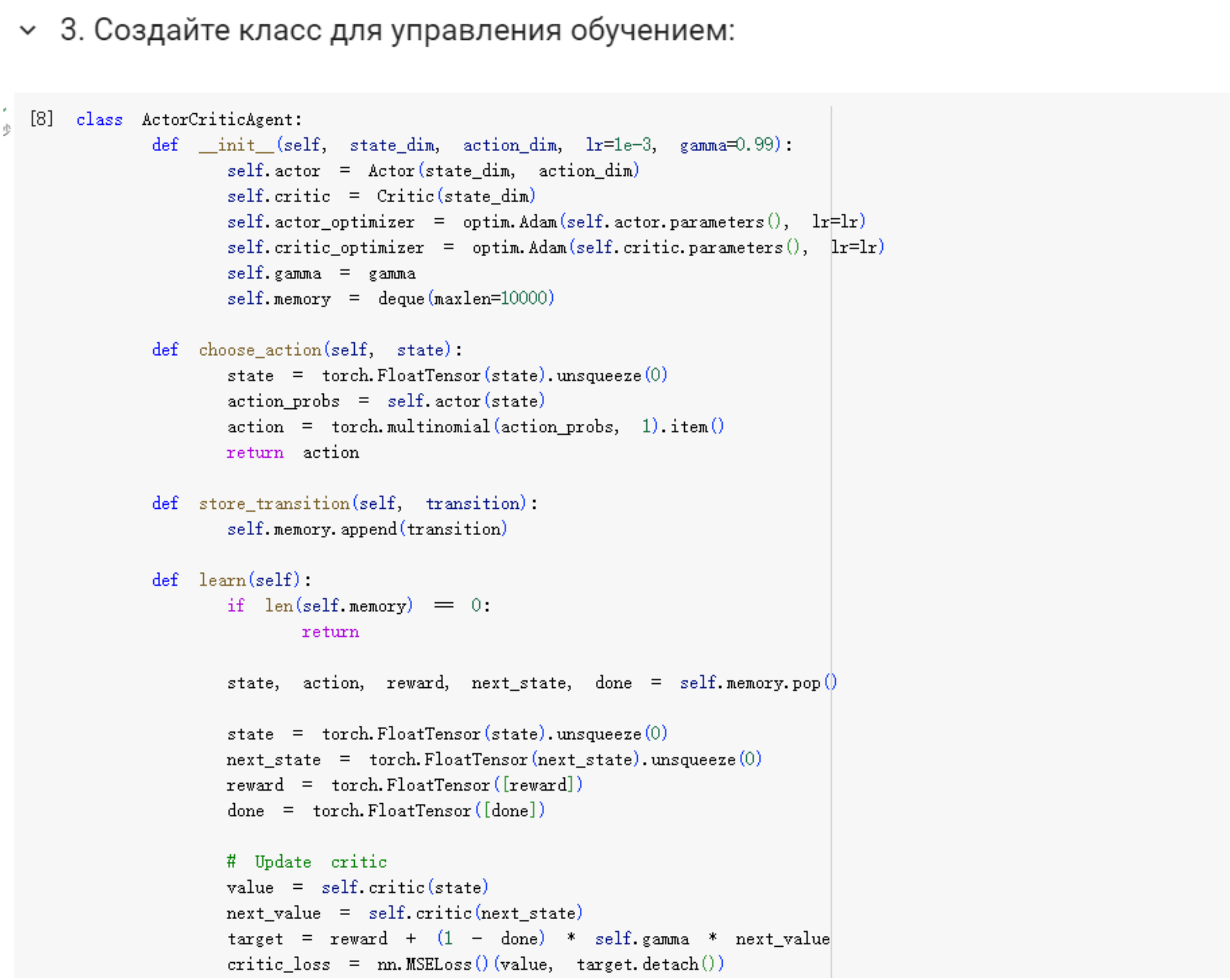
```
[6] !pip install gym
    !pip install torch

    import gym
    import torch
    import torch.nn as nn
    import torch.optim as optim
    import numpy as np
    from collections import deque
    import random
    import matplotlib.pyplot as plt
```

```
Requirement already satisfied: gym in /usr/local/lib/python3.10/dist-packages (0.25.2)
Requirement already satisfied: numpy>=1.18.0 in /usr/local/lib/python3.10/dist-packages (from gym) (1.25.2)
Requirement already satisfied: cloudpickle>=1.2.0 in /usr/local/lib/python3.10/dist-packages (from gym) (2.2.1)
Requirement already satisfied: gym-notices>=0.0.4 in /usr/local/lib/python3.10/dist-packages (from gym) (0.0.8)
Requirement already satisfied: torch in /usr/local/lib/python3.10/dist-packages (2.3.0+cu121)
Requirement already satisfied: filelock in /usr/local/lib/python3.10/dist-packages (from torch) (3.14.0)
Requirement already satisfied: typing-extensions>=4.8.0 in /usr/local/lib/python3.10/dist-packages (from torch) (4.12.1)
Requirement already satisfied: sympy in /usr/local/lib/python3.10/dist-packages (from torch) (1.12.1)
Requirement already satisfied: networkx in /usr/local/lib/python3.10/dist-packages (from torch) (3.3)
Requirement already satisfied: jinja2 in /usr/local/lib/python3.10/dist-packages (from torch) (3.1.4)
Requirement already satisfied: fsspec in /usr/local/lib/python3.10/dist-packages (from torch) (2023.6.0)
Requirement already satisfied: nvidia-cuda-nvrtc-cu12==12.1.105 in /usr/local/lib/python3.10/dist-packages (from torch) (12.1.105)
Requirement already satisfied: nvidia-cuda-runtime-cu12==12.1.105 in /usr/local/lib/python3.10/dist-packages (from torch) (12.1.105)
```

2. Создайте нейронные сети для актора и критика:

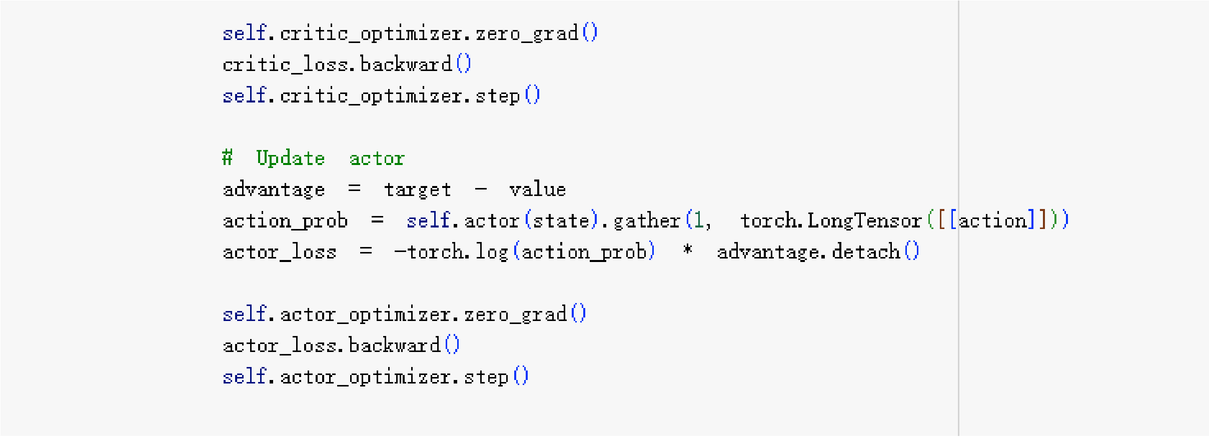


```
class Actor(nn.Module):
    def __init__(self, state_dim, action_dim):
        super(Actor, self).__init__()
        self.fc1 = nn.Linear(state_dim, 128)
        self.fc2 = nn.Linear(128, 128)
        self.fc3 = nn.Linear(128, action_dim)

    def forward(self, x):
        x = torch.relu(self.fc1(x))
        x = torch.relu(self.fc2(x))
        x = torch.softmax(self.fc3(x), dim=-1)
        return x

class Critic(nn.Module):
    def __init__(self, state_dim):
        super(Critic, self).__init__()
        self.fc1 = nn.Linear(state_dim, 128)
        self.fc2 = nn.Linear(128, 128)
        self.fc3 = nn.Linear(128, 1)

    def forward(self, x):
        x = torch.relu(self.fc1(x))
        x = torch.relu(self.fc2(x))
        x = self.fc3(x)
        return x
```



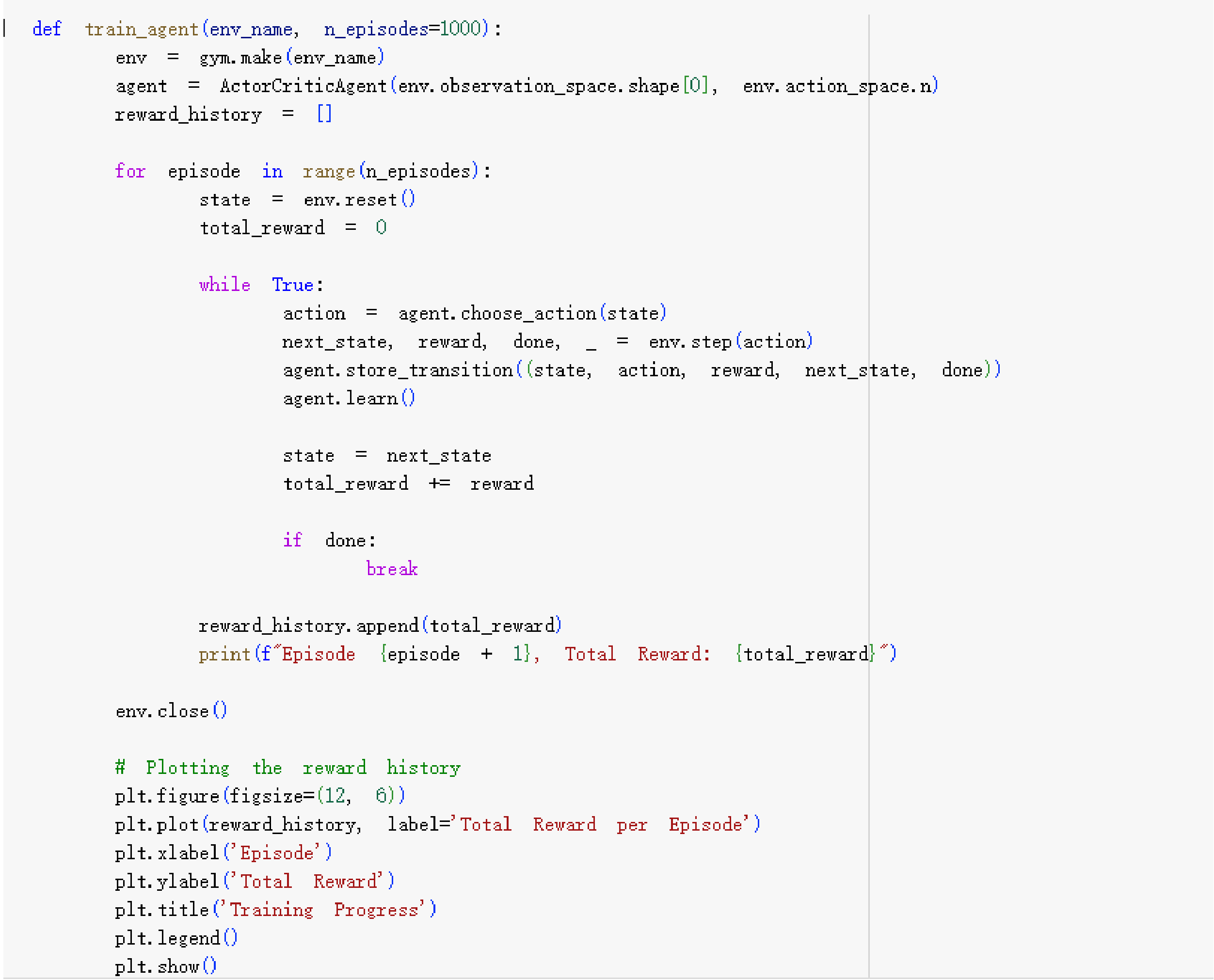
3. Создайте класс для управления обучением:

```
[8] class ActorCriticAgent:
        def __init__(self, state_dim, action_dim, lr=1e-3, gamma=0.99):
            self.actor = Actor(state_dim, action_dim)
            self.critic = Critic(state_dim)
            self.actor_optimizer = optim.Adam(self.actor.parameters(), lr=lr)
            self.critic_optimizer = optim.Adam(self.critic.parameters(), lr=lr)
            self.gamma = gamma
            self.memory = deque(maxlen=10000)

        def choose_action(self, state):
            state = torch.FloatTensor(state).unsqueeze(0)
            action_probs = self.actor(state)
            action = torch.multinomial(action_probs, 1).item()
            return action

        def store_transition(self, transition):
            self.memory.append(transition)

        def learn(self):
            if len(self.memory) == 0:
                return

            state, action, reward, next_state, done = self.memory.pop()

            state = torch.FloatTensor(state).unsqueeze(0)
            next_state = torch.FloatTensor(next_state).unsqueeze(0)
            reward = torch.FloatTensor([reward])
            done = torch.FloatTensor([done])

            # Update critic
            value = self.critic(state)
            next_value = self.critic(next_state)
            target = reward + (1 - done) * self.gamma * next_value
            critic_loss = nn.MSELoss()(value, target.detach())
```



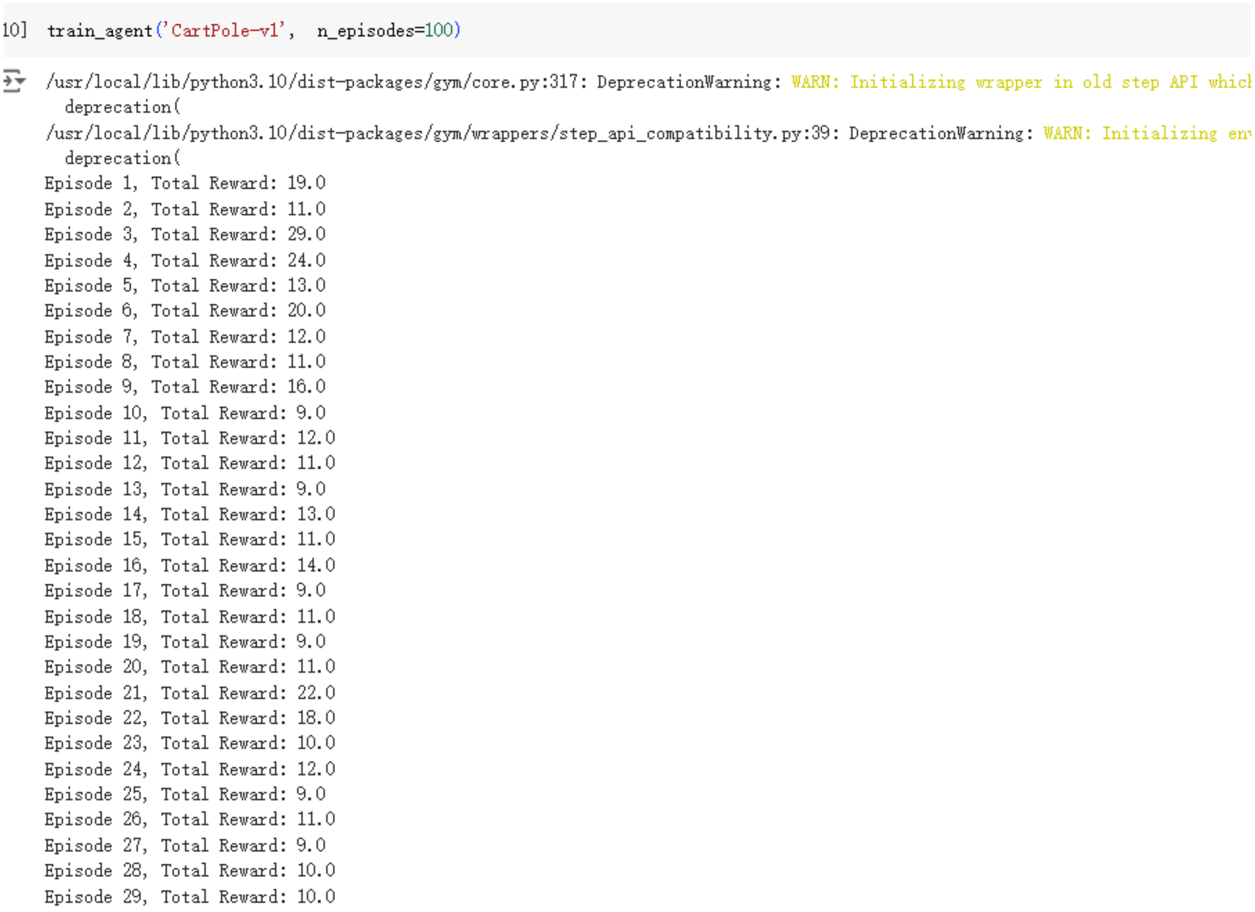
```
            self.critic_optimizer.zero_grad()
            critic_loss.backward()
            self.critic_optimizer.step()

            # Update actor
            advantage = target - value
            action_prob = self.actor(state).gather(1, torch.LongTensor([[action]]))
            actor_loss = -torch.log(action_prob) * advantage.detach()

            self.actor_optimizer.zero_grad()
            actor_loss.backward()
            self.actor_optimizer.step()
```

4. Создайте функцию для обучения агента:



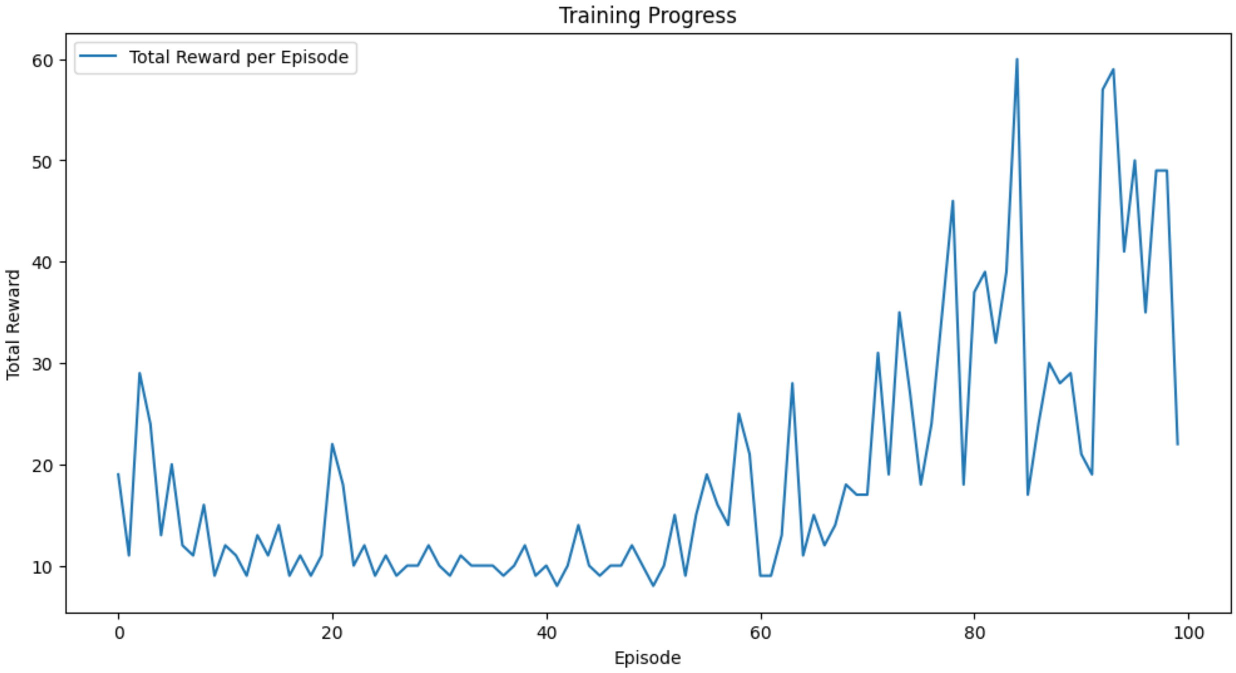
```python
def train_agent(env_name, n_episodes=1000):
    env = gym.make(env_name)
    agent = ActorCriticAgent(env.observation_space.shape[0], env.action_space.n)
    reward_history = []

    for episode in range(n_episodes):
        state = env.reset()
        total_reward = 0

        while True:
            action = agent.choose_action(state)
            next_state, reward, done, _ = env.step(action)
            agent.store_transition((state, action, reward, next_state, done))
            agent.learn()

            state = next_state
            total_reward += reward

            if done:
                break

        reward_history.append(total_reward)
        print(f"Episode {episode + 1}, Total Reward: {total_reward}")

    env.close()

    # Plotting the reward history
    plt.figure(figsize=(12, 6))
    plt.plot(reward_history, label='Total Reward per Episode')
    plt.xlabel('Episode')
    plt.ylabel('Total Reward')
    plt.title('Training Progress')
    plt.legend()
    plt.show()
```

5. Запустите обучение агента:



```
10]  train_agent('CartPole-v1',  n_episodes=100)
```

```
/usr/local/lib/python3.10/dist-packages/gym/core.py:317: DeprecationWarning: WARN: Initializing wrapper in old step API whicl
  deprecation(
/usr/local/lib/python3.10/dist-packages/gym/wrappers/step_api_compatibility.py:39: DeprecationWarning: WARN: Initializing env
  deprecation(
Episode 1, Total Reward: 19.0
Episode 2, Total Reward: 11.0
Episode 3, Total Reward: 29.0
Episode 4, Total Reward: 24.0
Episode 5, Total Reward: 13.0
Episode 6, Total Reward: 20.0
Episode 7, Total Reward: 12.0
Episode 8, Total Reward: 11.0
Episode 9, Total Reward: 16.0
Episode 10, Total Reward: 9.0
Episode 11, Total Reward: 12.0
Episode 12, Total Reward: 11.0
Episode 13, Total Reward: 9.0
Episode 14, Total Reward: 13.0
Episode 15, Total Reward: 11.0
Episode 16, Total Reward: 14.0
Episode 17, Total Reward: 9.0
Episode 18, Total Reward: 11.0
Episode 19, Total Reward: 9.0
Episode 20, Total Reward: 11.0
Episode 21, Total Reward: 22.0
Episode 22, Total Reward: 18.0
Episode 23, Total Reward: 10.0
Episode 24, Total Reward: 12.0
Episode 25, Total Reward: 9.0
Episode 26, Total Reward: 11.0
Episode 27, Total Reward: 9.0
Episode 28, Total Reward: 10.0
Episode 29, Total Reward: 10.0
```


Training Progress
Total Reward per Episode
Total Reward
Episode