Shahid Beheshti University
Machine Learning
M.Sc - Fall 2024

Assignment 4

Objective

The goal of this exercise is to design and implement an intelligent agent using **Reinforcement Learning (RL)** to play the Snake Game. The agent should aim to maximize its score by eating food and avoiding collisions with walls or its own body.

Environment Description

We have provided a fully functional environment for the Snake Game, implemented using `OpenAI Gym` and `Pygame`. The environment includes game logic such as movement, food consumption, snake growth, and end conditions when the snake collides with a wall or itself. Additionally, it has a human play mode, allowing you to control the snake using arrow keys by invoking the `play_human()` method.

To interact programmatically, you can use the `reset()` function to initialize the game, the `step(action)` function to execute actions, and the `render()` function to visualize the game.

Your Task

Your task is to implement an RL agent that interacts with the provided environment. Instead of using the human play mode, your agent will control the snake using the `step()` function. The agent must learn to maximize rewards through training and improve its performance over multiple episodes.

The state representation can include the position of the snake, the position of the food, and the direction of movement. Actions are restricted to four possible moves: `UP`, `DOWN`, `LEFT`, and `RIGHT`. Rewards are designed to encourage eating food (+10) and penalize collisions (-10) and unnecessary steps (-1). Using these rules, your agent should learn an optimal policy.

You are required to use a basic RL algorithm such as **Q-Learning**. Define a Q-table to represent the state-action values and train the agent by interacting with the environment. Use an epsilon-greedy strategy to balance exploration and exploitation during the learning process. After training, evaluate the agent by running several test episodes and calculating its average score.

Requirements

To begin, you need to install the necessary libraries. Run the following command to install the dependencies:

```
pip install gym pygame numpy
```

Familiarize yourself with the provided `SnakeEnv` class. You only need to modify the control logic of the agent, as the environment is already implemented and ready to use.

Deliverables

You are expected to submit the following:

- **Source Code:** Provide the Python implementation of your RL agent.
- **Report:** The report should include the following sections:
  - **Objective:** Briefly describe the goal of the exercise.
  - **Approach:** Explain the RL algorithm used, including the state representation and reward function.
  - **Implementation Details:** Describe the training process, exploration strategy, and any challenges encountered.
  - **Results:** Present the performance of your agent, including metrics such as the average score over test episodes. Use graphs to show training progress (e.g., average reward vs. episodes).
  - **Discussion:** Discuss any challenges you faced and possible improvements for the agent.
  - **Conclusion:** Summarize your findings and insights.

Evaluation Criteria

Your submission will be evaluated based on the correctness and functionality of your RL agent, the clarity of your report, and the performance of the agent. Bonus points may be awarded for innovative approaches or significant improvements to the agent's performance.