

Snake Game with Q-Learning

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Introduction

- Objective: Implement a Snake game using Q-Learning
- Environment: 20x20 grid with fixed obstacles, food, and snake
- Tools: Python, Pygame, Pyodide (for browser execution)
- Learning: The snake learns to reach food while avoiding obstacles and itself

Environment Structure

- Grid: 400x400 pixels, divided into 20x20 cells
- Obstacles: Fixed at coordinates [(5,5), (5,6), (5,7), (10,10), (10,11)]
- Snake: Starts at the grid center, moves in four directions
- Food: Randomly spawned in positions free of obstacles or snake body

Q-Learning: Core Concepts

- **State:** Relative direction to food (x, y) and danger in four directions
- **Actions:** Up, down, left, right
- **Rewards:**
 - Eating food: +10
 - Collision with obstacle or body: -10
 - Each move: -0.1
- **Parameters:**
 - Learning rate (α): 0.1
 - Discount factor (γ): 0.9
 - Exploration rate (ϵ): 0.1

Q-Learning Algorithm

- Q-value update formula:

$$Q(s, a) \leftarrow Q(s, a) + \alpha \cdot (r + \gamma \cdot \max_{a'} Q(s', a') - Q(s, a))$$

- Action selection:
 - With probability ϵ : Random action
 - Otherwise: Action with highest Q-value
- Q-table: Stores Q-values for each state-action pair

Implementation

- **Snake Class:** Manages movement, growth, and collision detection
- **Food Class:** Generates random food positions
- **QLearningAgent Class:** Handles states, action selection, and Q-table updates
- **Graphics:** Displays snake (green), food (red), obstacles (blue), and score
- **Game Loop:** Standard Pygame loop with FPS=100 for fast learning

Results and Observations

- Early episodes: Snake moves randomly
- Over episodes, the snake learns to:
 - Navigate towards food
 - Avoid obstacles and its own body
- Score and episode number displayed in top-left corner
- Game resets after collisions

Possible Improvements

- Gradually decrease ϵ for better exploitation
- Add more complex states (e.g., exact distance to food)
- Use Deep Q-Learning (DQN) for larger environments
- Introduce dynamic obstacles for added challenge

Conclusion

- Successful implementation of Snake game with Q-Learning
- Effective learning for navigating to food and avoiding obstacles
- Code compatible with Pyodide using standard Pygame loop
- Extensible project for advanced reinforcement learning experiments