AI Project Proposal

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Classic Snake Game with a random enemy snake

[Github Link]

Problem Description

We all have played the snake game on a Nokia 3310. In this project, we build an AI agent to play a modified version of the classic snake game. In this version, a small enemy snake appears randomly on the grid for a few seconds. If our snake touches this enemy snake, the game ends. The agent needs to eat food to grow longer and survive as long as possible while avoiding itself, and this enemy.

Uncertainties Involved

The enemy snake appears at a random time and at a random location for a few seconds. The movement of the enemy snake also follows a random pattern. The agent does not know in advance when or where the enemy will appear. The size of the enemy snake will be small but also random. The size of the grid can be given by the user. These make the game unpredictable and more challenging for the AI to plan.

Why This Problem is Non-Trivial

The game becomes dynamic and unpredictable due to the random enemy. Basic search algorithms like BFS or A* cannot handle this kind of uncertainty well. The agent must make decisions over time, thinking not just about the current move but also about future risks and rewards. It needs to balance between eating food quickly and avoiding danger.

Existing Solution Methods

- Policy Iteration / Value Iteration: to find the best moves in a known environment.

- Utility-Based Agents: to make smart decisions based on rewards and risks.

Plan for modeling and solving the problem

State Space: Snake's position and direction, food location, enemy location (if visible), grid size.

Action Space: Turn Left, Move Forward, Turn Right.

Observations: Local view of the grid (like a 5x5 area around the snake), direction of food, enemy snake (if visible).

Rewards:

- +10 for eating food
- -100 for dying (crash or touching enemy)
- -1 for each time step (to avoid waiting too long)

Algorithm:

- Model the game as an MDP and solve using Policy Iteration or Value Iteration on a simplified/smaller grid.
- For larger or more complex grids, use Temporal Difference (TD) Learning to let the agent learn by playing.
- The agent will use utility-based decision-making to choose actions that give the best long-term reward.

State Space Description

Natural language description of state space

In this AI-controlled Snake Game, the agent (our snake) operates in a dynamic grid environment where it must navigate toward food, avoid colliding with itself, and evade a randomly appearing enemy snake. The agent's state is defined by:

- The position and direction of the snake's head and body.
- The location of the food pellet.
- The presence, position, and size of the enemy snake (if currently visible).
- The overall dimensions of the grid.

The agent has limited vision - typically a local 5×5 observation window, and must make decisions based on partial and dynamic information. The enemy's sudden and random appearances introduce uncertainty, making it necessary for the agent to plan with incomplete data.

Complete mathematical description of states, transitions, actions, and observations

Let the environment be a grid of size G = (W, H) where W is the width and H is the height.

State Space (S)

A state $s \in S$ can be defined as:

s = (p_snake, d_snake, p_food, p_enemy, t_enemy) where:

- p_snake = [p_1, p_2, ..., $p_{\square}$] is an ordered list of the snake's body positions (with p_1 being the head).
- d_snake $\in$ {N, E, S, W} is the current direction of the snake (North, East, South, West).
- p_food $\in$ G is the position of the food on the grid.
- p_enemy = [e_1, e_2, ..., $e_{\square}$] is the set of positions occupied by the enemy snake. If the enemy is not visible, p_enemy = null.
- t_enemy $\in$ {0, 1, ..., T} is a timer showing how many steps the enemy will remain visible (0 if not currently present).

Action Space (A)

A = {Turn Left, Move Forward, Turn Right}

Transition Function (T)

- The snake moves deterministically based on the action a.
- The appearance and movement of the enemy snake are stochastic (random).
- If the snake eats food, its body grows.
- If the snake hits the wall, itself, or the enemy snake, the game ends.

Observation Space (O)

At each step, the agent receives an observation:

o = (V_5(p1), d_food, d_enemy) where:

- V_5(p1) is a 5×5 grid centered at the snake's head p1.
- d_food is the relative direction to the food.
- d_enemy is the relative direction to the enemy snake (if visible).

Reward Function (R)

The reward function R(s, a) is defined as:

- +10 for eating food
- -100 for crashing into a wall, itself, or the enemy
- -1 for each time step (to encourage faster decisions)