AI Solver for 2048 (8 x 8)

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Course

Artificial Intelligence (AI – 2002)
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1. Executive Summary

This project involves developing an AI solver for the game 2048 using Expectimax and heuristic-based strategies. The goal is to enable an AI to autonomously play and optimize performance in the game by making intelligent decisions. Innovations include heuristic evaluations, Expectimax-based future state predictions, and strategic tile placement techniques.

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2. Introduction

Background

2048 is a single-player sliding tile puzzle played on a 4x4 grid. Players combine like-numbered tiles by sliding them in four directions. The aim is to reach the 2048 tile. This project introduces an AI-driven approach using Expectimax and heuristic scoring to achieve higher scores on an **8×8 grid**.

Objectives

- Implement AI to play 2048.
- Explore Expectimax and Minimax algorithms.
- Design custom heuristics for optimal gameplay.
- Evaluate performance and refine AI strategy.

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3. Game Description

Original Rules

2048 is played by merging identical numbered tiles on a 4x4 grid. New tiles (2 or 4) spawn randomly after each move. The goal is to reach a tile with value 2048.

Innovations and Modifications

- AI-controlled gameplay using Expectimax.
- Heuristic-based evaluations (e.g., tile merging, empty tiles).
- Strategic tile organization (e.g., snake pattern).
- Emphasis on avoiding dead-ends and maximizing score.

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4. AI Approach and Methodology

Operational Logic

- **Initialization**: The solver uses NumPy arrays and a custom Grid class to create an 8x8 game state.
- **Move Prediction**: next_move_predictor() tests all directions and scores each resulting grid.
- **Heuristic Scoring**:
    - **Snake Pattern**: Encourages placing large tiles in a continuous flow.
    - **Adjacent Tile Scoring**: Prioritizes grouping similar tiles.
    - **Empty Tile Count**: More open tiles indicate more options and better survivability.
    - **Tile Smoothing**: Penalizes sharp differences between neighboring tile values.

Expectimax Algorithm

Simulates future board states probabilistically to handle randomness of new tile spawns. Prioritizes actions with the highest expected reward based on heuristic evaluations.

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5. Game Mechanics and Rules

Modified Game Rules

AI plays automatically using scoring functions. Special moves are available and strategically limited in use.

Turn-based Mechanics

1. AI evaluates the board state.
2. Considers regular and special moves.
3. Scores all outcomes.
4. Selects the best move.
5. Executes the move and inserts a new tile.
6. Repeats until game ends.

Winning Conditions

Reach tile 2048 or maximize score before the board fills.

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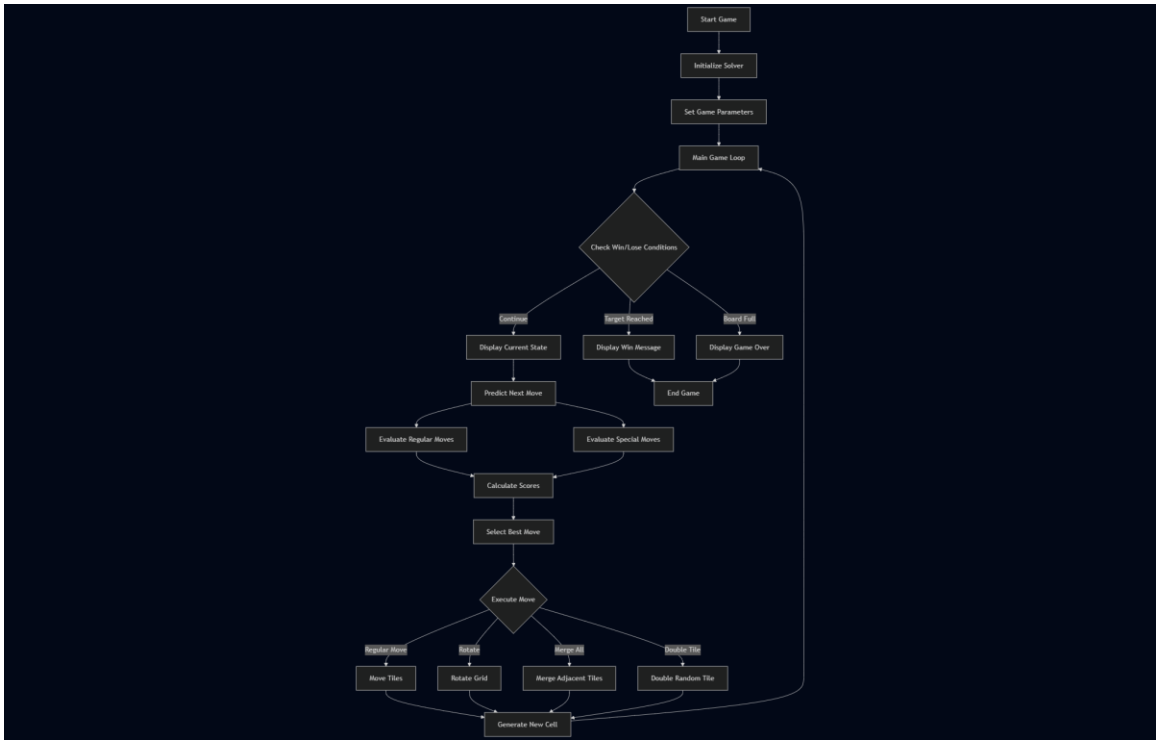
7. Project Flow



Challenges Encountered:

- Managing performance for deep Expectimax trees.
- Balancing heuristics to avoid repetitive loops.
- Ensuring correct game logic for tile merging.

7. Team Contributions

This project was completed by Khair Muhammad and Salman Haider.

8. Results and Discussion

The AI solver was able to achieve consistent performance in 2048, often reaching tiles of 1024 and above. The Expectimax approach showed high effectiveness, especially when paired with robust heuristics.

9. References

- https://www.quora.com/How-do-you-build-AI-for-solving-this-game-2048-game/

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- https://courses.grainger.illinois.edu/ece448/sp2021/slides/lec19.pdf