Project Report: Quantum Snakes & Ladders with AI Integration

Submitted By:

Hamna Ahsan - K213558

Neha Khan - K214756

Shayan Qureshi - K213603

1. Project Overview

Quantum Snakes & Ladders is a modern reinterpretation of the classic board game, developed using Python. This enhanced version integrates artificial intelligence through the Minimax algorithm and features an interactive graphical interface built with Pygame. The game introduces new mechanics, such as power-ups and strategic AI decisions, delivering a richer and more engaging player experience.

2. Key Features

a. Board Design

- A 10x10 grid-based board comprising 100 tiles.

- Predefined positions for snakes, ladders, and power-ups:

  - Snakes: 16->6, 47->26, 49->11

  - Ladders: 3->38, 8->28, 20->42

  - Power-Ups (Reroll): Located at tiles 10, 30, and 50

b. Player Configuration

- Supports two modes: Human vs. Human and Human vs. AI.

- Each player has:

  - Unique ID and name

  - Current position on the board

  - Move history

  - Collected power-ups list

c. Power-Up System

- Introduces a "Reroll" power-up allowing players to roll the die again during their turn.

- Players can hold only one power-up at a time.

d. AI Integration

- AI opponent powered by the Minimax algorithm with alpha-beta pruning.

- AI evaluates moves based on:

  - Distance to goal

  - Presence of power-ups

  - Snake and ladder proximity

- Depth-limited to 1 for optimal real-time performance.

e. Game Mechanics

- Turn-based progression alternating between players.

- Game ends when a player reaches tile 100.

- Winner determined by reaching tile 100 using the fewest moves.

f. Graphical User Interface

- Developed using Pygame for rich visual interaction.

- Key interface elements include:

  - 100-tile board with labeled tiles

  - Snakes (red), Ladders (green), and Power-Ups (blue)

  - Players represented by colored circles

  - Action buttons (e.g., "Roll", "Reroll")

  - Real-time status updates for turns and power-up usage

3. Class Architecture

Config - Manages game settings like board size, screen dimensions, and FPS

Board - Maintains tile data including snakes, ladders, and power-up detection logic

Player - Encapsulates player-specific data (ID, name, position, moves, power-ups)

PowerUp - Implements logic for applying and consuming power-ups

MinimaxAI - Handles AI decision-making using Minimax with alpha-beta pruning

GameRules - Defines core mechanics: move resolution, power-up collection, and undo logic

PygameGUI - Controls all Pygame-related rendering, events, and interface elements

4. Challenges Encountered

- Integrating AI decision-making within the constraints of the GUI loop.

- Ensuring synchronization between simulated AI decisions and actual player movements.

- Designing an intuitive and visually scalable interface using Pygame.

5. Future Enhancements

- Increase Minimax algorithm depth while maintaining performance efficiency.

- Introduce new power-ups such as Teleport or Swap.

- Add sound effects, animations, and visual feedback.

- Implement persistent score tracking via database or file system.

6. Conclusion

Quantum Snakes & Ladders successfully revitalizes a traditional board game with advanced AI and graphical enhancements. By merging strategic decision-making with an engaging user interface, the project appeals to both casual players and AI enthusiasts, demonstrating the potential of integrating classic gameplay with modern computational intelligence.