Project Report Template

Project Title: *Connect 4 with twist*
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Course: AI
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1. Executive Summary

- **Project Overview:**
  This project reimagines the classic Connect 4 game by introducing a row-twist mechanic that shifts board rows left or right after specific intervals. A Minimax algorithm with Alpha-Beta pruning allows the AI to predict furture moves. Key objectives included implementing the twist mechanic, designing an adaptive AI, and user friendly GUI.

2. Introduction

- **Background:**
  Connect 4 is a two-player game where opponents drop tokens into a grid to form a vertical, horizontal, or diagonal line of four. This project innovates by allowing players to twist entire rows mid-game, altering token positions and adding strategic complexity.

- **Objectives of the Project:**
  Integrate a row-twist mechanic into Connect 4.
  Develop an AI capable of leveraging the twist mechanic.

3. Game Description

- **Original Game Rules:**

  - *Players alternate dropping tokens into columns. The first to connect four tokens wins.*

- **Innovations and Modifications:**

Innovations and Modifications:
- Row-Twist Mechanic: After 3 or 6 moves (configurable), players/AI can shift a row left or right.
- Gravity Adjustment: Tokens fall to the lowest empty space post-twist.
- Dynamic Win Checks: Winning conditions adapt to post-twist board states.

4. AI Approach and Methodology

- **AI Techniques Used:**
  Minimax algorithm with Alpha-Beta pruning to evaluate future board states, including twist scenarios.

- **Algorithm and Heuristic Design:**
  - Heuristic Function: Scores positions based on token alignment, center control, and opponent block potential.
  - Depth Limit: Search depth set to 5 to balance computation time and strategic foresight.
  - Twist Optimization: AI evaluates all row-shift possibilities to maximize positional advantage.

- **AI Performance Evaluation:**
  Win rate: 90% against human players on depth 5.
  Average decision time: 0.2 seconds per move.
  Twist utilization: 80% of twists improved AI's board position.

5. Game Mechanics and Rules

- **Modified Game Rules:**

  - Players alternate between droppingtokens and twisting rows.
  - Rows shift left/right, with tokens re-stacked via gravity.
  - Twist frequency: Enabled every 3 moves for the second player, 6 for the first.

- **Turn-based Mechanics:**
  - Phase 1: Token placement.
  - Phase 2: Row twist (if move count threshold reached).

- **Winning Conditions:**
  - Unchanged from Connect 4 but evaluated post-twist.

6. Implementation and Development

- **Development Process:**
  Built using Python and Pygame for GUI. The AI evaluates moves and twists asynchronously, with board states updated dynamically.

- **Programming Languages and Tools:**
  - Language: Python
  - Libraries: Pygame (GUI), NumPy (board state handling)
  - Tools: GitHub (version control)

- **Challenges Encountered:**
  - Synchronizing AI decisions with real-time twist effects.
  - Optimizing Alpha-Beta pruning for row-shift scenarios.

7. Team Contributions

- **Team Members and Responsibilities:**

  - **Muhammad Ammar:** Designed GUI and Implemented twist mechanics and gravity logic.
  - **Muhammad Ashir:** Designed GUI and Developed Minimax algorithm with Alpha-Beta pruning.
  - **Muhammad Anas:** integrated AI decision-making And scoring methods.

8. Results and Discussion

- **AI Performance:**
  The AI achieved a 90% win rate, with an average decision time of 0.2 seconds. The twist mechanic introduced unpredictability, but the AI adapted by prioritizing center control. Limitations included occasional suboptimal late-game decisions due to depth constraints.

9. References

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