**PROJECT PROPOSAL**

**Project Title:** AI-Powered Connect Four Plus

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**Course:** AI  
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**Submission Date:** 08/03/2025

**1. Project Overview**

**Project Topic:**

The project focuses on the game Connect Four, a strategic board game where players take turns dropping discs into a grid, aiming to align four in a row, column, or diagonal. This project enhances the game with an AI-driven opponent that utilizes advanced decision-making strategies.

**Objective:**

The primary goal of this project is to develop a strategic AI for Connect Four using the Minimax Algorithm with Alpha-Beta Pruning. The AI will be optimized for efficient decision-making, improving response time and strategic depth. The project also explores heuristic evaluation to strengthen AI gameplay.

**2. Game Description**

**Original Game Background:**

Connect Four is a two-player game played on a 6x7 grid. Players alternate turns, dropping colored discs into columns. The first player to form a horizontal, vertical, or diagonal sequence of four wins. If the grid is filled without a winner, the game ends in a draw.

**Innovations Introduced:**

* AI Opponent with Minimax & Alpha-Beta Pruning: The AI will make optimal moves using these techniques to simulate human-like intelligence.
* Dynamic Heuristics: Instead of using a simple evaluation function, the AI will analyze board position, potential threats, and winning opportunities.
* Difficulty Levels: Users can choose AI difficulty, altering its depth of lookahead and aggressiveness in play.
* Improved User Interface: A visually appealing GUI will enhance the playing experience.

These innovations will increase gameplay complexity by making the AI more challenging and realistic while improving the game’s strategic depth.

**3. AI Approach and Methodology**

**AI Techniques to be Used:**

* Minimax Algorithm: The AI will simulate possible moves and select the best one based on an evaluation function.
* Alpha-Beta Pruning: This will optimize Minimax by eliminating redundant calculations, improving efficiency.
* Heuristic Evaluation: Custom heuristics will be implemented to evaluate game states based on board positioning and potential threats.
* Optional Future Expansion: Reinforcement Learning could be explored to improve AI decision-making through self-play.

**Heuristic Design:**

* Assign scores based on the number of connected pieces in a row, column, or diagonal.
* Prioritize moves that block an opponent’s winning move.
* Favor center column moves for positional advantage.

**Complexity Analysis:**

* The basic Minimax algorithm runs in **O(b^d)** time complexity, where **b** is the branching factor and **d** is the depth of the search tree.
* Alpha-Beta Pruning significantly reduces this complexity, improving performance.
* Challenges include managing computational efficiency while maintaining strong AI performance.

**4. Game Rules and Mechanics**

**Modified Rules:**

* The original rules of Connect Four remain intact.
* AI difficulty levels are introduced, altering the depth of decision-making.

**Winning Conditions:**

* The first player to connect **four discs** in a row, column, or diagonal wins.
* If the board is filled without a four-in-a-row, the game is a draw.

**Turn Sequence:**

* Players alternate turns, choosing a column to drop their disc.
* The AI will make calculated moves based on Minimax and heuristic evaluation.

**5. Implementation Plan**

Programming Language:

* Python

Libraries and Tools:

* Pygame (for GUI)
* NumPy (for data handling)
* AI Libraries (optional future expansions like TensorFlow for reinforcement learning)

Milestones and Timeline:

* Week 1-2: Game design and rule finalization.
* Week 3-4: AI strategy development (Minimax, Alpha-Beta Pruning, heuristics).
* Week 5-6: Coding and testing game mechanics.
* Week 7: AI integration and testing.
* Week 8: Final testing and report preparation.

**6. References**

* <https://www.researchgate.net/publication/26623095_Real-Time_Connect_4_Game_Using_Artificial_Intelligence>
* <https://dl.acm.org/doi/abs/10.1145/3461702.3462523>
* <https://www.scirp.org/html/1-9601415_90972.htm>