**Semester Project Proposal: Connect 4 AI**

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Language: Python

## **1. Introduction**

Connect 4 is a two-player connection board game in which players take turns dropping colored discs into a seven-column, six-row grid. The goal is to connect four discs in a row, column, or diagonal before the opponent. The game is deterministic, has perfect information, and involves an adversarial AI approach.

**Heuristic, Rules, and Constraints:**

* Players drop discs alternately.
* A player wins by connecting four of their discs in a row, column, or diagonal.
* If the grid is full without a winner, the game ends in a draw.
* The AI should be able to make moves using various search and learning techniques discussed in the AI Lab.
* Unique mechanics such as power-ups, reinforcement learning, and AI tournaments will be included.

## **2. Implementation Strategy**

The project will incorporate multiple AI techniques to implement an intelligent agent that can play Connect 4 efficiently. The following algorithms and methods will be used:

### **A. Adversarial Search (Minimax Algorithm with Alpha-Beta Pruning)**

* Minimax will be used to evaluate the best possible move by maximizing the AI’s advantage while minimizing the opponent’s advantage.
* Alpha-Beta Pruning will optimize the search by eliminating branches that do not need to be explored, improving efficiency.

### **B. Reinforcement Learning (Q-Learning)**

* The AI can be trained using reinforcement learning to improve its gameplay over multiple sessions.
* The state-action reward system will be used to enhance learning and adaptability.

### **C. Power-Ups & Special Moves**

* **Destroyer Move:** Remove an opponent’s piece from the board once per game.
* **Double Drop:** AI or player can place two discs in one turn.
* **Gravity Flip:** Flips the board upside down, changing piece positions.
* These power-ups will be integrated into AI decision-making to create new challenges.

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### **D. AI vs. AI Tournament Mode**

* Multiple AI agents will compete against each other to determine the best-performing AI.
* Different AI strategies such as Minimax, Reinforcement Learning, and additional AI models may be included (e.g., Greedy Best-First Search, A\*, Monte Carlo Tree Search, Genetic Algorithm, Deep Q-Learning).
* The tournament will track AI win rates and performance.

## **3. Deliverables**

The following deliverables will be provided as part of the project:

### **A. Goal State**

* A fully functional AI-based Connect 4 game that allows human vs. AI and AI vs. AI gameplay.

### **B. Points System**

* Win: 10 points
* Draw: 5 points
* Loss: 0 points
* AI performance will be evaluated based on total points accumulated.

### **C. State Representation**

* Board state will be represented as a 6x7 matrix.
* AI will process state transitions based on selected algorithms.