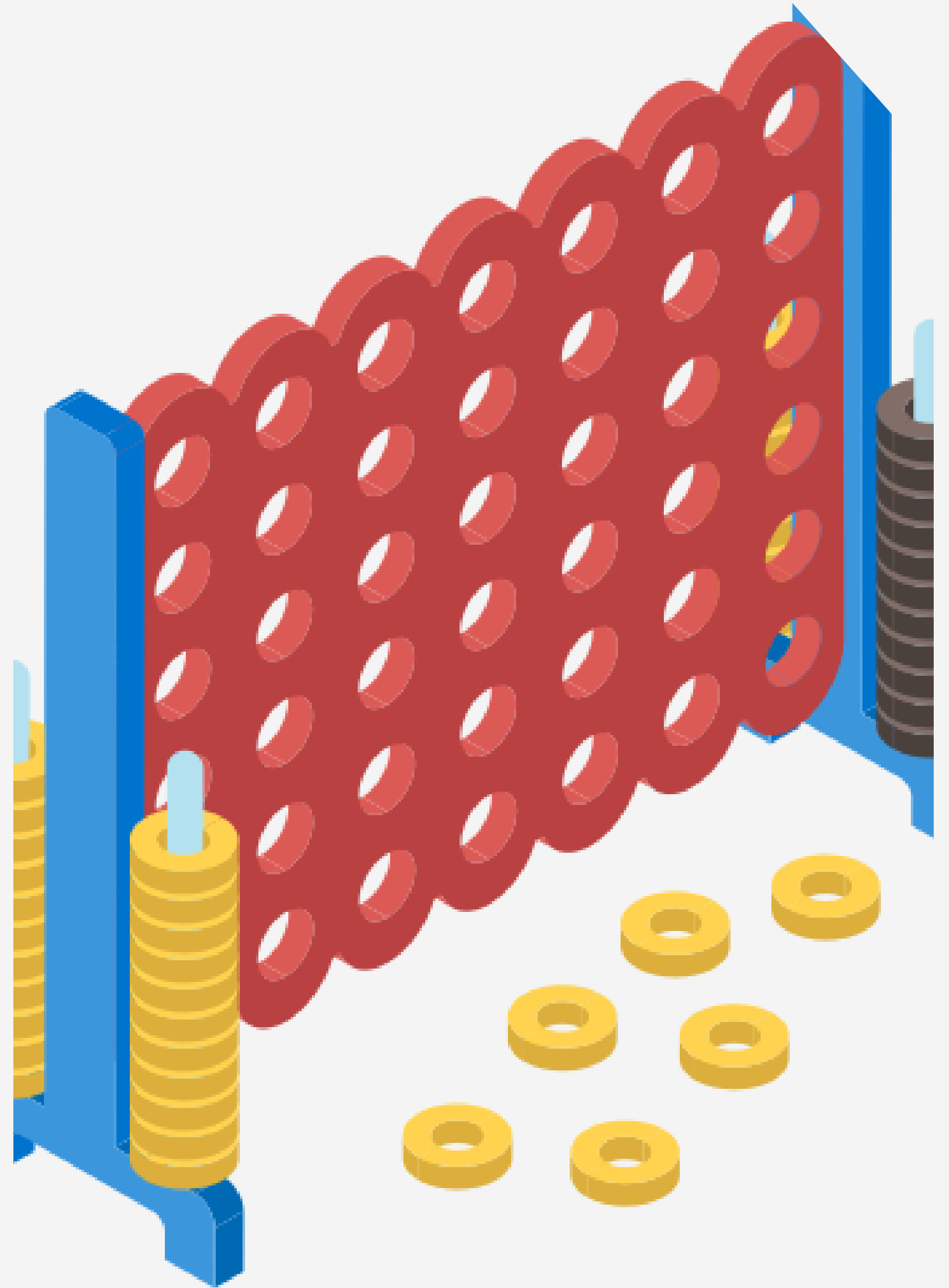# Connect-4 Simulator With Minimax

Taeyoon Kim, Allen Solomon, Arthur Lee, Hengyi Liu

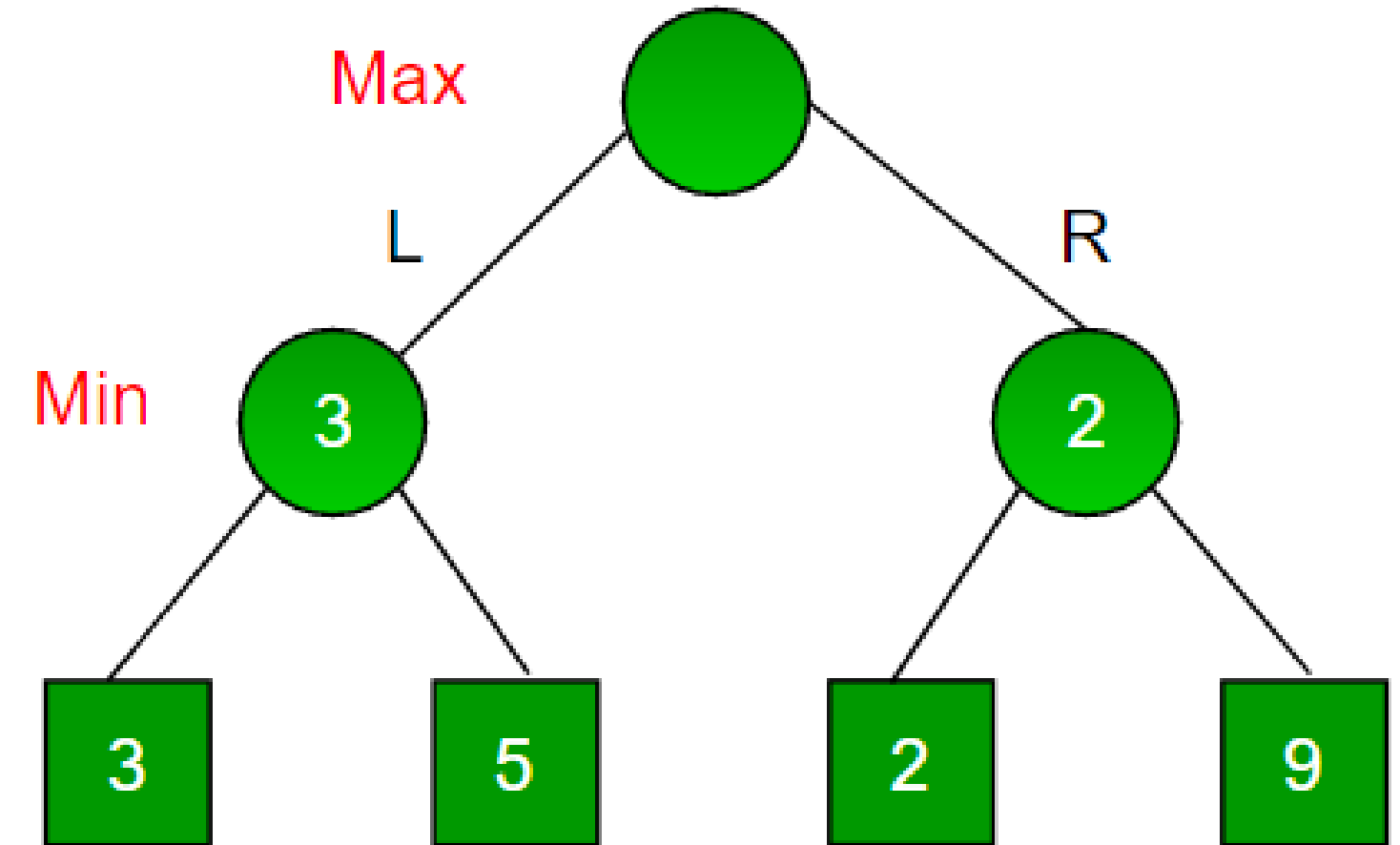# Introduction to Minimax & Connect-4

## Problem Context:
- Zero-sum: one player's gain is the opponent's loss.
- AI must plan multiple moves ahead to make optimal decisions.
- Connect-4 is a classic solved zero-sum game.

## Minimax Algorithm
- A fundamental adversarial search algorithm for zero-sum games.
- Alternates between a maximizing and minimizing player.
- Evaluates future game states recursively.

## Research Goal
- Implement Minimax in Connect-4 and measure its performance.
- Improve efficiency using Alpha-Beta Pruning.
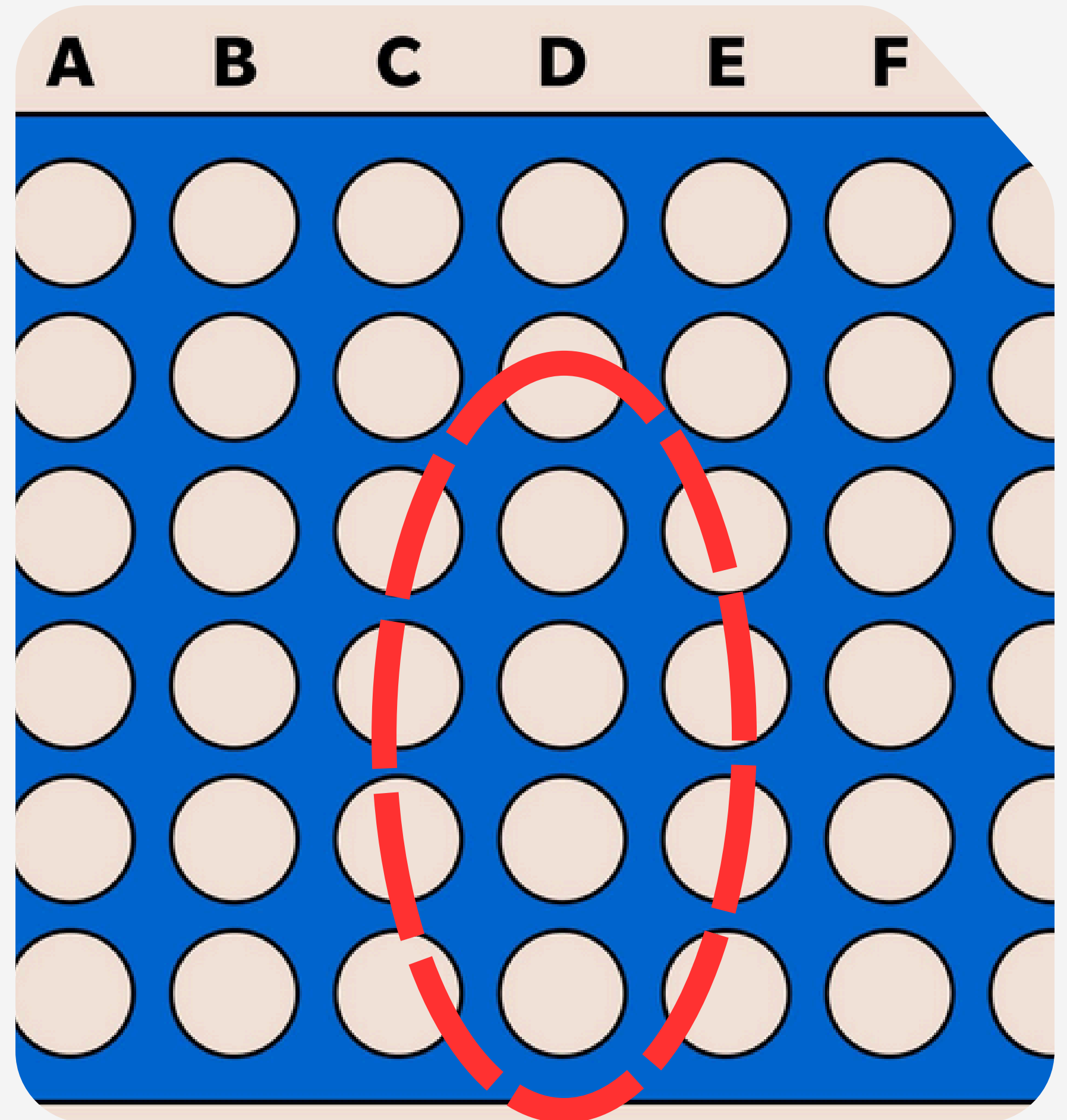- Compare naive Minimax vs. pruned Minimax and evaluate performance against humans.

# Evaluation Function

- Winning +1,000,000, Loosing -1,000,000, Draw: 0
- Heuristics - Unblocked # of 1, 2, 3s
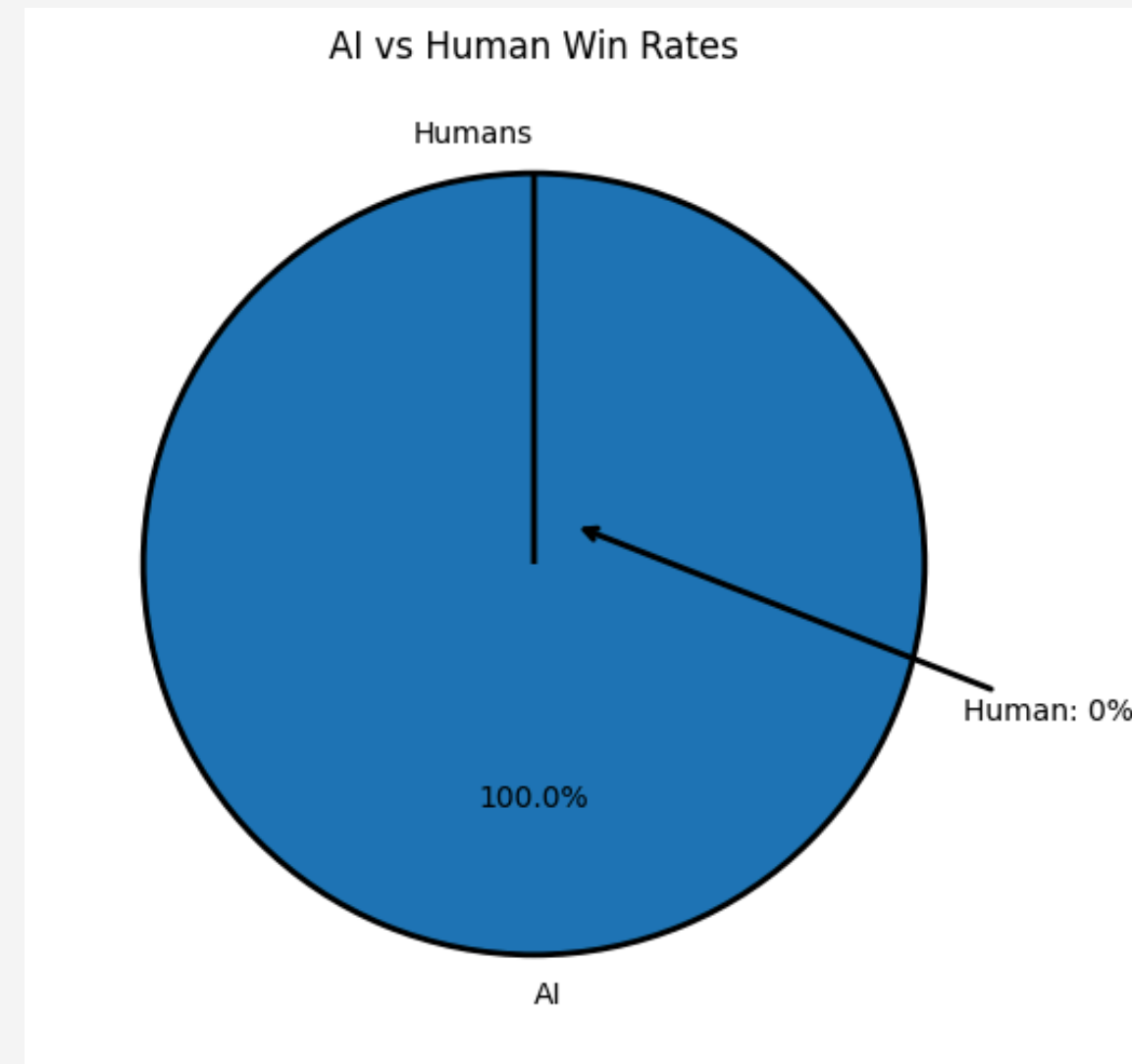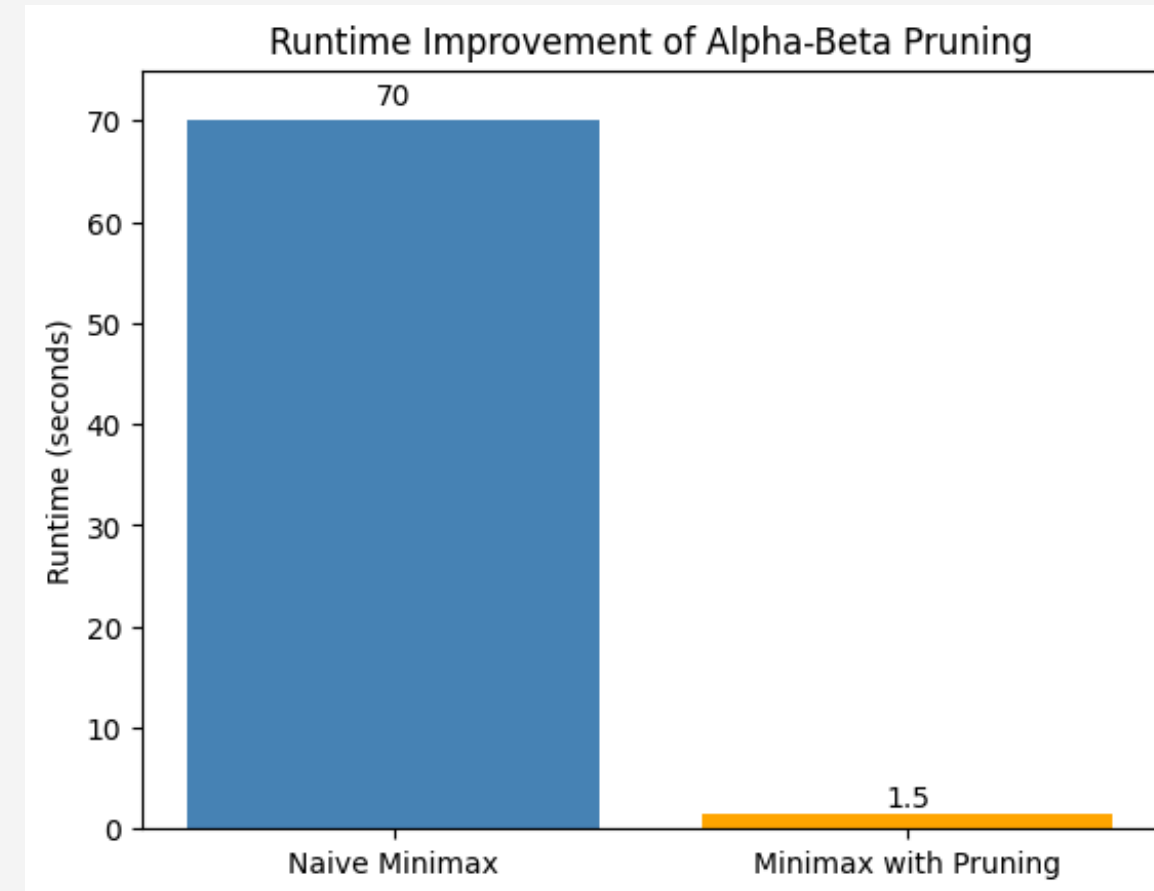- Weighted sum = 0.01 * #1 + 0.04 * #2 + 0.10 * #3

# Move Ordering

- Center Importance and the heuristic.
- Improve searching alpha beta pruning from traversing from center outwards

# Experiments & Results

- Experiment 1: Runtime Measurement
  - Measured the runtime of Naive Minimax and Alpha-Beta Pruning
  - Kept both board configuration and search depth the same.
- Result: Alpha-Beta Pruning improved the runtime of Minimax algorithm by a factor of 47.

- Experiment 2: Human vs AI Gameplay
  - Invited friends and classmates to play against our AI
  - In total played 50 games.
- Result: 100% win rate for AI, 0% for human.



Runtime Improvement of Alpha-Beta Pruning



AI vs Human Win Rates

# Thank You!