ARTIFICIAL INTELLIGENCE

Evaluation of the Artificial Intelligence Agents in the Mancala Game

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12 Slots

6 for each player

48 Seeds

24 for each player

2 Buckets

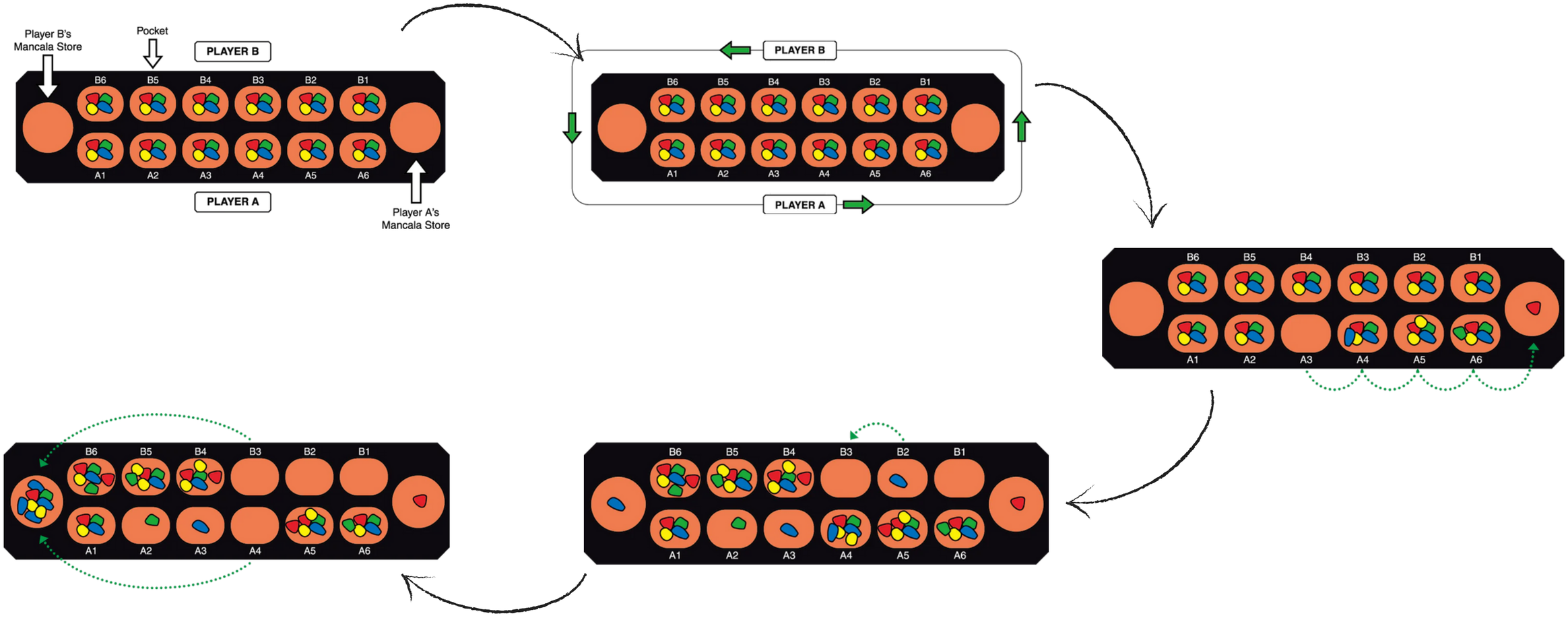
1 for each player

2 Players

Mancala Game

Is a traditional two-player strategy board game that could be used as an example to illustrate adversarial search methods in action

Mancala Rules



Topics of Discussion

Problem Formulation

Before we jump on to finding the solution for the problem, we first need to define and formulate the problem

Implementation Details

Describes the requirements that the software should meet to better understand its strengths and weaknesses

Approach

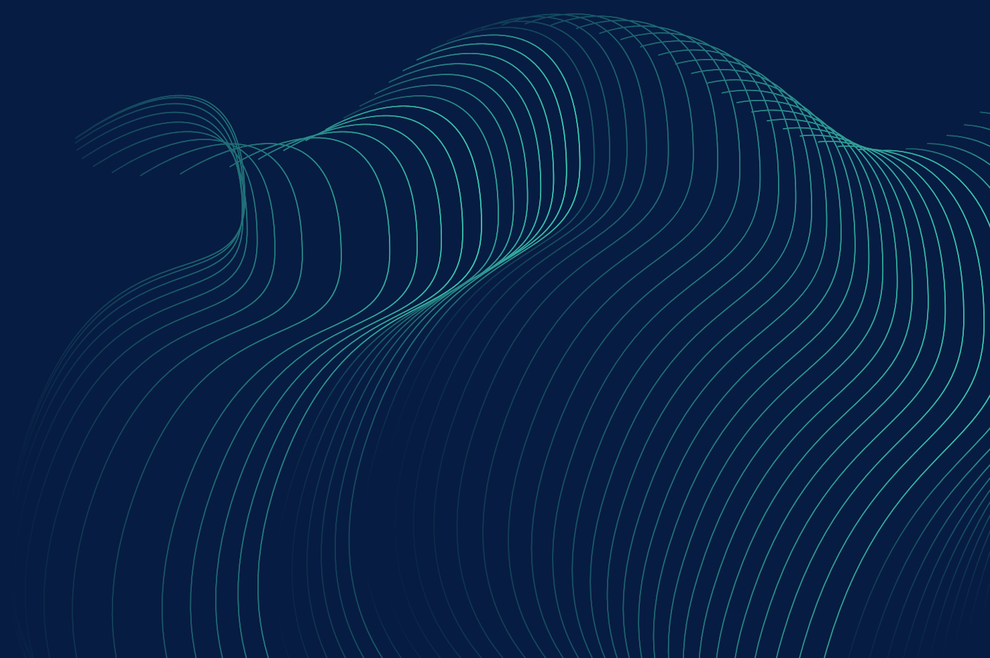
Evaluation functions are used to estimate the value of a position in a game tree and difficulty levels are set to determine the maximum depth of the game tree

Algoritmhs Implemented

The fields of decision-making and game theory have been revolutionized by two algorithms - Minimax and Alpha-Beta Pruning

Problem Formulation

- **State Representation**
  - Specifies the positions of the seeds in the slots
- **Initial State**
  - [4,4,4,4,4,4,0,4,4,4,4,4,4,0]
- **Objective test**
  - Determine when the game has ended
- **Actions**
  - Moving the stones in a counter-clockwise direction
- **Solution Cost**
  - Number of moves required to reach the goal state



Implementation Details

Requirements for a strong AI

- Minimax
- Alpha-Beta Pruning
- Depth of the search tree and the number of moves

Game modes

- Human vs Human
- Human vs AI
- AI vs AI
- Random vs AI

Approach

4 Difficulty levels

Difficulty levels determines the maximum depth of the game tree that can be explored by the AI algorithm in each move (chosen by the players)

- Easy
- Medium
- Hard
- World Champion

3 Evaluation functions

Evaluation functions allow the player to choose to face different type of opponents. In this case the evaluation functions can have a more agressive game or a more defensive one.

- Evaluation Extra-Turn and Capture
- Evaluation Moves
- Evaluation Board

Algoritmhs

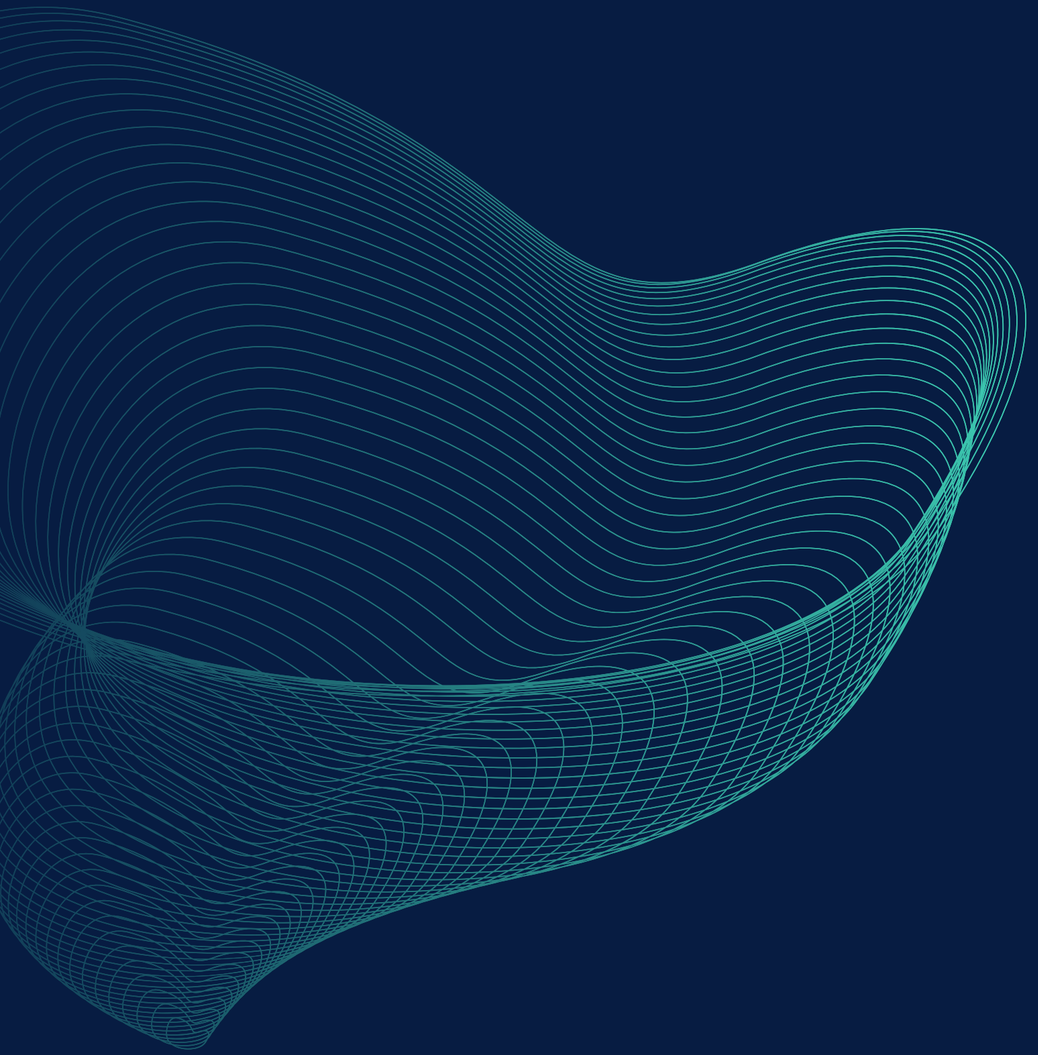
Algorithms Implemented

- **Minimax**

  A backtracking algorithm that helps in decision-making and is widely used in game-playing Artificial Intelligence. It determines the optimal move for a player while assuming that the opponent is also playing optimally

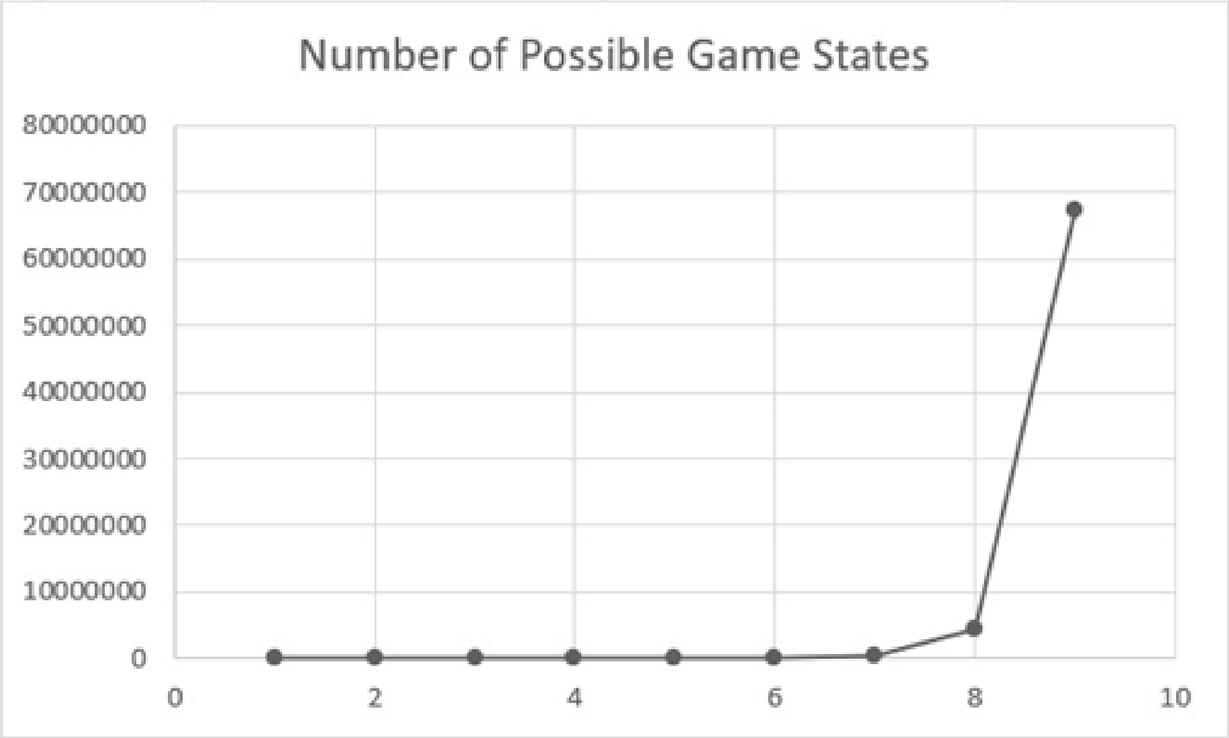
- **Alpha-Beta Pruning**

  An optimization technique for the Minimax algorithm, that reduces the number of game states that need to be examined, making the algorithm faster and more practical for real-time games



Experimental Results

Do you know how hard is to compute the depth of 9 for the Mancala Game?



Values to consider:

- **Depth 1** - 2 Possible Game States
- **Depth 5** - 2 848 Possible Game States
- **Depth 9** - 67 386 240 Possible Game States

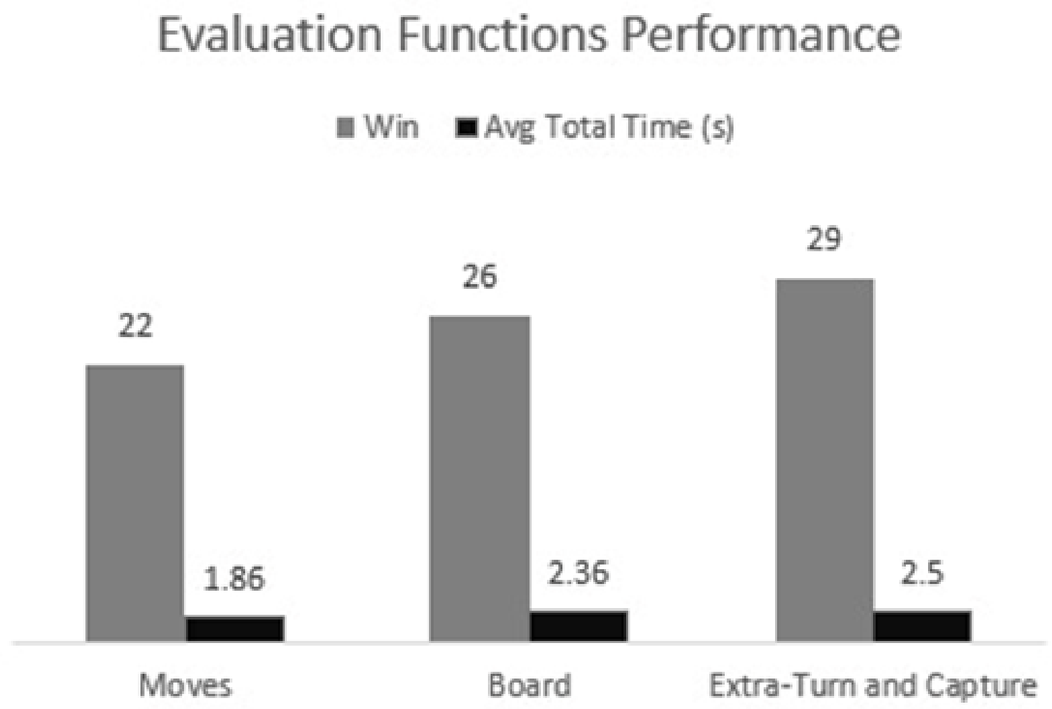
Measure the performance of the Random Agent vs AI

Random Agent vs Minimax (Easy)	
Wins by Minimax	45
Wins by Random Agent	1
Number of Ties	4
Random Agent vs Alpha-Beta Pruning (Easy)	
Wins by Alpha-Beta Pruning	47
Wins by Random Agent	0
Number of Ties	3
Random Agent vs Minimax (Medium)	
Wins by Minimax	48
Wins by Random Agent	0
Number of Ties	2
Random Agent vs Alpha-Beta Pruning (Medium)	
Wins by Alpha-Beta Pruning	50
Wins by Random Agent	0
Number of Ties	0

Average number of moves and time per player between the Random Agent and Search Algorithms

Random Agent vs Minimax (Easy)	
Avg. number of moves per Player	15
Avg. time per move of Minimax	0.061 seconds
Random Agent vs Alpha-Beta Pruning (Easy)	
Avg. number of moves per Player	13
Avg. time per move of Alpha-Beta Pruning	0.032 seconds
Random Agent vs Minimax (Medium)	
Avg. number of moves per Player	22
Avg. time per move of Minimax	1.02 seconds
Random Agent vs Alpha-Beta Pruning (Medium)	
Avg. number of moves per Player	19
Avg. time per move of Alpha-Beta Pruning	0.09 seconds
Random Agent vs Minimax (Hard)	
Avg. number of moves per Player	25
Avg. time per move of Minimax	15 seconds
Random Agent vs Alpha-Beta Pruning (Hard)	
Avg. number of moves per Player	21
Avg. time per move of Alpha-Beta Pruning	1.12 seconds

Evaluate and compare the performance of the 3 Evaluation Functions



Values to consider:

- **Best** - Extra-Turn and Capture
- **Worst** - Moves

Conclusions & Discussion

User experience

A game will be attractive to a user if it is fast, competitive (but not impossible) and its AI inteligent.

Combination of methods

The combination of a good depth tree, different evaluation functions and a optimized algorithm can lead to fast game with different levels of difficulty and an AI with different strategies.

New tests & Powerful computers

With better computers, a stronger AI can be implemented and new tests could be conducted.