Minimax algorithm

With alpha-beta pruning

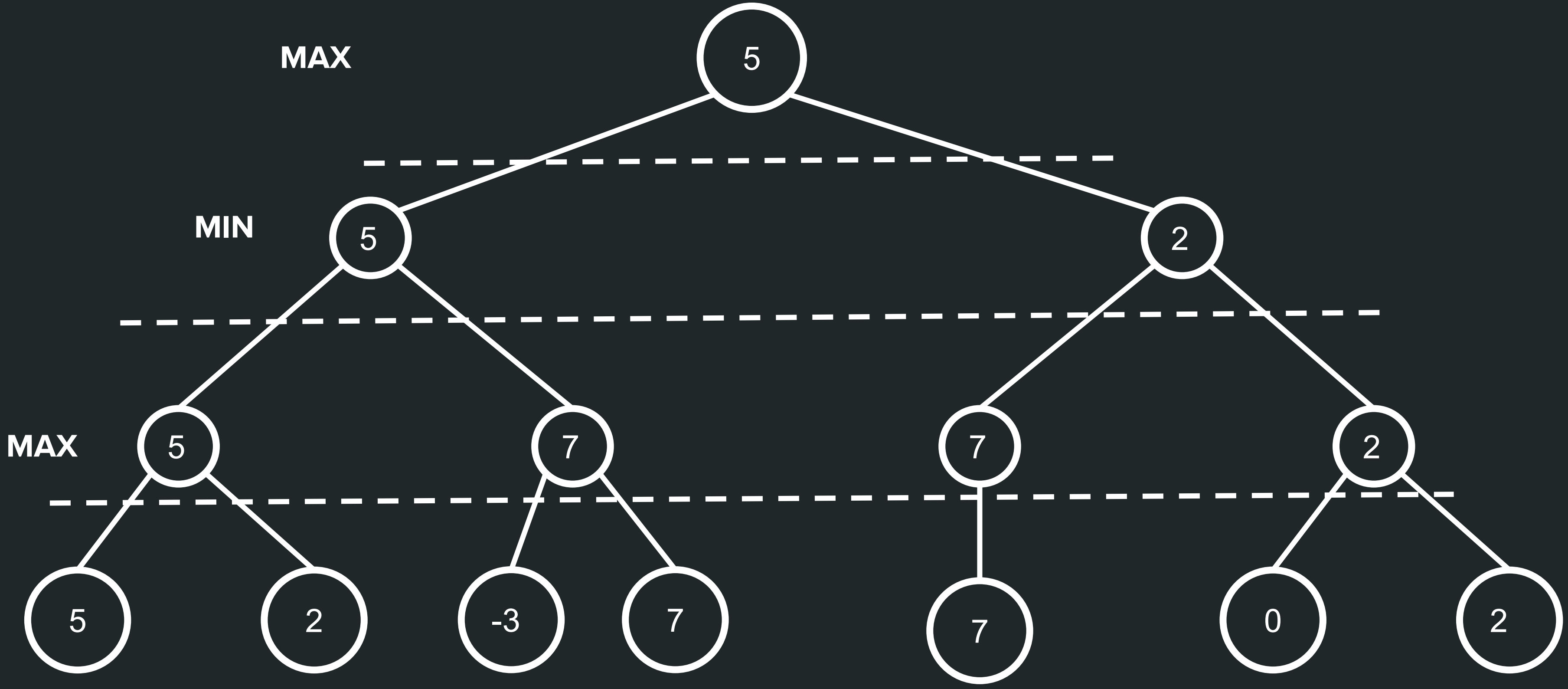
Adversarial Search

- Adversarial search, is a type of search where there’s some kind of opposition,an adversarial problem require us to understand and counteract the actions of the opponent in pursuit of a goal.
- Examples of adversarial problems include two-player turn-based games such as Tic-Tac-Toe and Connect Four. The players take turns for the opportunity to change the state of the environment of the game to their favor. A set of rules dictates how the environment may be changed and what the winning and end states are.
- Minimax is a decision-making strategy employed in two-player, turn-based games, Its objective is to find the optimal move for the player who aims to maximize their advantage while considering the opponent's attempts to minimize it.
- we will use Connect Four as a simple adversarial problem to illustrate key concepts.

Minimax

- The minimax search algorithm aims to create a tree of potential outcomes by considering the moves available to each player and prioritizing paths that benefit the agent while avoiding paths that benefit the opponent.
- This type of search involves simulating moves and assigning scores to states based on a heuristic after each move is made.
- While it would be ideal to explore the entire game tree, memory and computational limitations often make this impractical. Instead, the search is limited to a specified depth.
- The depth in min-max search corresponds to the number of turns taken by both players.

Minimax search tree



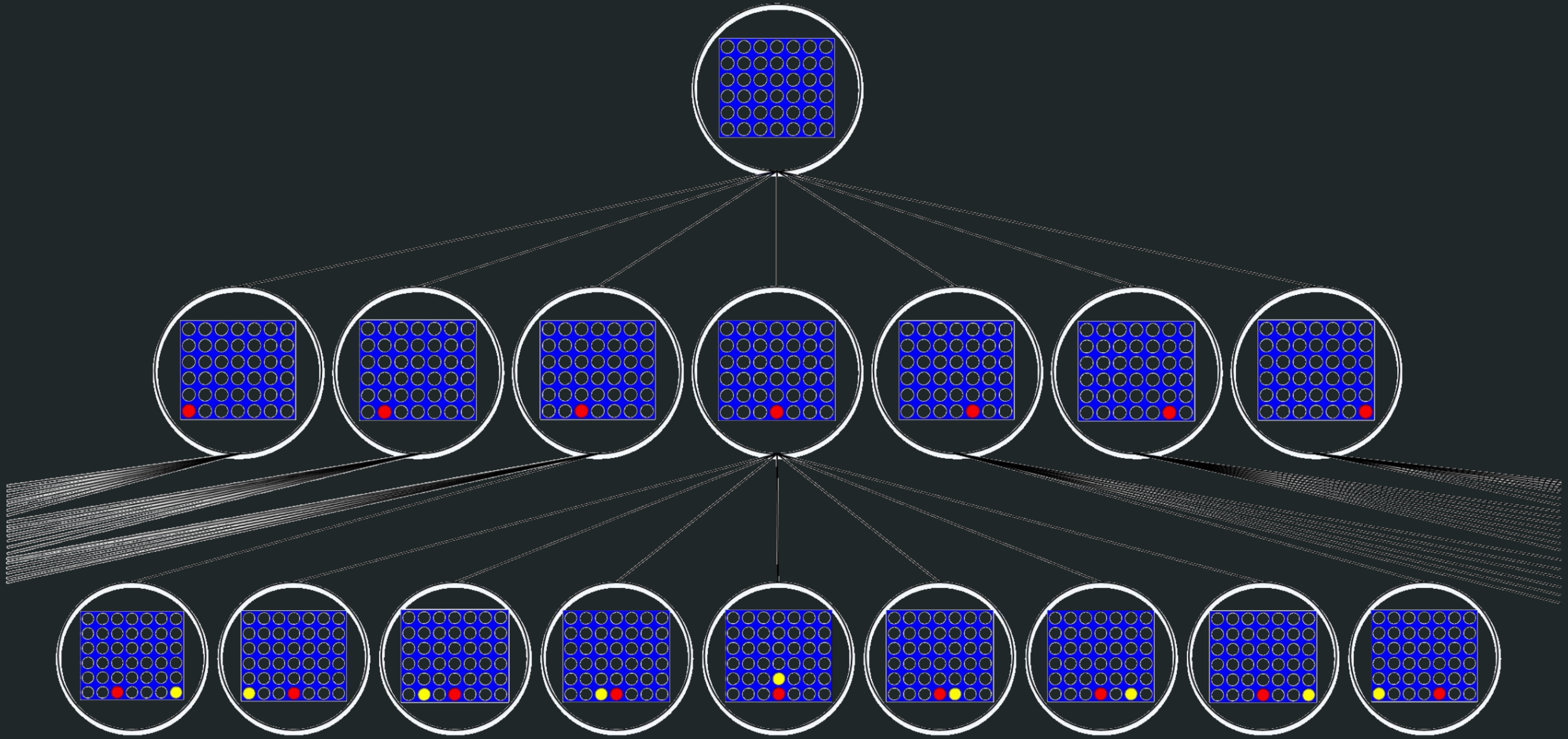
Assigning Scores to Connect Four

- In the context of the Connect Four example, minimax search involves exploring all potential moves from the current game state and considering the possible moves from each resultant state, aiming to identify the most advantageous path.
- Game states leading to a win for the agent are assigned a score of 100
- states leading to the agent having 3 pieces in a row and 1 empty place receive a score of 5.
- states leading to the agent having 2 pieces in a row and 2 empty places receive a score of 2
- states leading to the opponent having 3 pieces in a row and 1 empty place receive a score of -5.
- The objective of the min-max search is to maximize the positive score for the agent, thereby seeking the most favorable outcome

The problem with minimax

- In games with numerous choices, the min-max search algorithm faces a challenge due to the exponential growth of the game tree.
- This becomes particularly evident in games like Connect Four played on a 6x7 board, where the number of possibilities rapidly increases. Exploring the entire game tree at each turn becomes computationally expensive and inefficient.
- Therefore, it becomes impractical to examine every possible outcome within a reasonable timeframe using the min-max search algorithm in the context of a 6x7 Connect Four game.

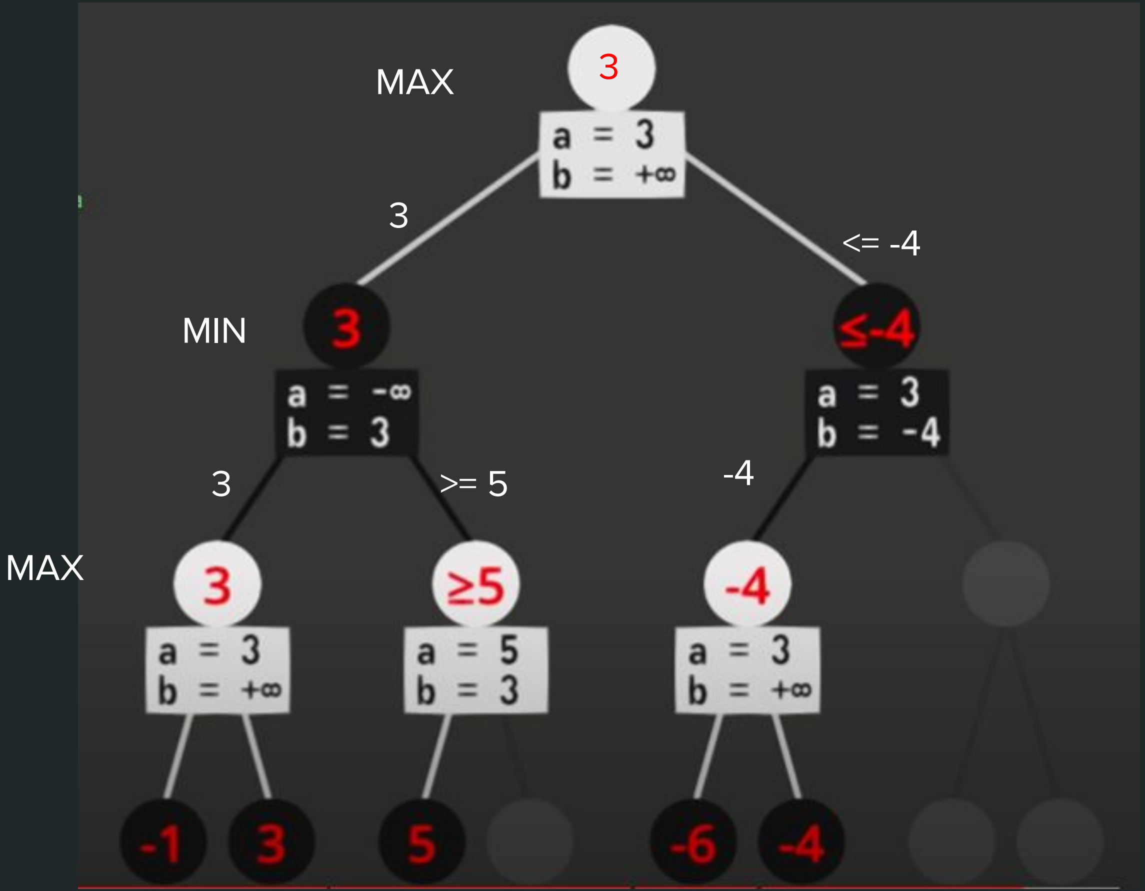
Minimax search tree for 6x7 Connect Four



Alpha-Beta Pruning

- Alpha-beta pruning is a strategy used with the minimax algorithm to efficiently explore the game tree by disregarding branches that are unlikely to yield better outcomes.
- By implementing this technique, minimax algorithm can avoid unnecessary computations and focus on more promising paths.
- It involves maintaining the best score for the maximizing player (alpha) and the best score for the minimizing player (beta). At the beginning, alpha is set to negative infinity, and beta is set to positive infinity, representing the worst possible scores for each player.
- During the search, if the best score for the minimizing player is lower than the best score for the maximizing player, exploring other child paths of the already visited nodes would not impact the best score. Therefore, those paths can be pruned or disregarded to improve the efficiency of the algorithm.

Minimax search tree (with alpha beta pruning)


MAX
3
a = 3
b = +∞
3
<= -4
MIN
3
a = -∞
b = 3
≤-4
a = 3
b = -4
3
>= 5
-4
MAX
3
a = 3
b = +∞
≥5
a = 5
b = 3
-4
a = 3
b = +∞
-1
3
5
-6
-4