

CPCS331 – Artificial Intelligence – Spring2020 -Project I

[ Using Alpha Beta, Minimax and MCTS algorithms]

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Part I: Proposal

1. Problem description

Dots and Boxes is a simple game for 2 players with a pencil and paper. The game problem starts with an empty grid of dots on paper. Each player takes turns adding a single vertical or horizontal line between two enjoined adjacent dots. When a player completes the fourth side of a 1×1 box earns one point and takes another turn. The game ends when no more lines can be placed.

1. AI Methods to solve Dots and Boxes Game

We are going to use 3 algorithms to solve dots and boxes game:

1. **MiniMax:** is a kind of backtracking algorithm that is used in decision making and game theory to find the optimal move for a player.
2. **Alpha Beta Pruning:** is a search algorithm that seeks to decrease the number of nodes that are evaluated by the minimax algorithm in its search tree.
3. **Monte Carlo Tree Search:** is a tree search algorithm that combines the classic tree search implementations alongside machine learning principles of reinforcement learning.
4. Performance Measurement

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| Algorithm | Completeness | optimal | Time complexity | Space complexity |
| Minimax | Yes (in finite trees) | Yes (if opponent is optimal) | O(bm) (branches a lot) | O(bm) |
| Alpha beta | Yes | Yes | O(bm/2) in best case,  O(bm) in worst case (no pruning) | O(bm) |
| MCTS | Yes | No | O(mkI/C) | O(mk) |

1. Implementation Code
2. For MinMax algorithm, the following Java code represent all the solutions of Dots and Boxes Game using MinMax.

<https://github.com/uchawada/DotsAndBoxes.git>

1. For Alpha Beta algorithm, the following Java code represent all the solutions of Dots and Boxes Game using Alpha Beta.

https://github.com/Armando8766/Dots-and-Boxes

1. For Monte Carlo Tree Search algorithm, the following Java code represent all the solutions of Dots and Boxes Game using [MCTS](https://github.com/zheminggu/Dot-and-Box-Chess).
2. MCTS Algorithm Description

Monte Carlo Tree Search (MCTS) is a tree search technique in the field of Artificial Intelligence. It is an algorithm that combines the classic tree search implementations alongside machine learning principles of reinforcement learning.

In tree search, there’s always the possibility that the current best action is actually not the most optimal action. In such cases, MCTS algorithm becomes useful as it continues to evaluate other alternatives periodically during the learning phase by executing them, instead of the current perceived optimal strategy. This is known as the “exploration-exploitation trade-off “.