4x4 TicTacToe Project Report

Introduction

The ultimate goal of this final project was to develop a 4x4 grid variation of the classic Tic-Tac-Toe game, presenting the users with an engaging experience of strategic battles competing against an AI opponent implementing the Min-Max algorithm. This extended version of Tic-Tac-Toe introduces a playing field that demands the user to adeptly navigate the intricacies of a larger grid while going up against an AI designed to make the optimal moves. Beside the adaptation of the Min-Max algorithm to the 4x4 grid, the project's challenge also lies in ensuring the AI's ability to intelligently traverse and make strategic decisions within the expanded game space. This is accomplished through a series of turns in which the player and AI each take turns placing the chosen X or O onto the grid that is most optimal for them. This intersection of classic gameplay and sophisticated AI algorithms not only form the core focus of this project but also provide an immersive exploration of strategic decision-making in the realm of human versus computer.

Background Information on the Problem

The traditional Tic-Tac-Toe game, played on a 3x3 grid has always been a staple in recreational gaming due to its simplicity and strategic depth. However, this project sought to elevate the gaming experience by developing a 4x4 grid variation. The motivation behind this final project idea was to introduce a heightened level of complexity, challenging the user to engage in more intricate strategic battles against an AI opponent and showcasing whether it is still possible for the player to win or not. The increased size of the grid adds a new layer that requires both the player and AI to navigate in a more expansive playing field and anticipate a broader range of potential moves. As the project delves into the background, it

aims to shed light on the rationale for extending the classic game and the inherent challenges posed by the transition to a larger grid.

Details on Learning Algorithm

The main algorithm for this project was to employ the Min-Max algorithm as the cornerstone of the AI opponent's decision-making process. The Min-Max algorithm is known for its effectiveness in two-player, zero-sum games which makes it the ideal choice for this strategic variation gameplay of Tic-Tac-Toe. In order to adapt this algorithm to the 4x4 grid involved fine-tuning parameters to strike a balance between computational efficiency and strategic depth. The algorithm systematically explored potential moves, assigning scores to outcomes and determining the best optimal path through the game tree. This section delves into the idea of implementing the Min-Max algorithm and highlighting the adjustments made in order to enhance the performance in the context of the extended 4x4 Tic-Tac-Toe grid.

Result Discussion and Conclusion

The result of the project showcased a successful implementation of the 4x4 Tic-Tac-Toe game with an AI opponent employing the Min-Max algorithm. Through a series of games played with the AI, I was only able to draw in the most optimal path while there were also cases in which the AI won multiple times. I noticed that whenever I was one grid away from winning the AI would block all my potential path toward winning, so I was only able to end with a draw or loss. I think sometime that I could do to improve the results is to handicap the AI a little bit, so that the chance of a player winning isn't 0% since I realized that even though the AI I built isn't the greatest for a mini project like this, but it is still efficient in making the best decision possible and stopping the player from winning. In addition, there were also cases in which the AI was able to have two possible outcomes of winning so even

if the player like myself was to block one possible outcome the AI would still win. While the project achieved its primary objectives, opportunities for improvement exist. Integration of the alpha-beta pruning could potentially enhance the computational efficiency and further refinement of the heuristic evaluation function could elevate the AI's strategic decision-making. Additionally, it is also possible to explore alternative algorithms or more advanced techniques like machine learning that could be considered in the future for implementing and providing avenues to enhance the AI's adaptability and decision-making capabilities better.

References

Erica. (2023). 8 Tic-Tac-Toe Variations. *What Do We Do All Day*?.https://www.whatdowedoallday.com/tic-tac-toe-variations/

JavaTpoint. (2021). Mini-Max Algorithm in Artificial Intelligence. *JavaTpoint*. https://www.javatpoint.com/mini-max-algorithm-in-ai

Sofela, O. (2020). MiniMax Algorithm Guide: How to Create an Unbeatable AI. *freeCodeCamp*.https://www.freecodecamp.org/news/minimax-algorithm-guide-how-to-create-an-unbeatable-ai/