Overview

This project serves to give an introduction to Artificial Intelligence, and its use in problem solving. In this case, the problem is playing the game of Connect Four. In order to accomplish this task, multiple different fields of knowledge are used together, including programming, Computer Vision, and game-playing theory. A high-level overview of the system used can be seen below:

Minimax and Alpha-Beta Pruning

The Minimax algorithm is a game-playing algorithm that uses a heuristic to decide its next move. The Minimax search algorithm takes the form of a search tree, where each level of the tree represents each player's respective turn. Two players, Max and Min, favor high and low heuristic values respectively. Minimax algorithms are crucial to AI game-playing solutions because it provides the best move to make next after considering all of the possible moves the opponent can make as well. Using the algorithm, each player operates under the assumption that the opponent will play perfectly, and won't overlook moves or make any mistakes.

The Minimax tree seen below is a basic example of the Max player trying to decide their next move. By tracing through the tree, it is possible to see how the algorithm works, heuristic values are first assigned to each of the leaves of the tree. Then, working from bottom to top, the algorithm assigns each Max node the greatest value from its children, and assigns each Min node the smallest value from its children. In this case, being an example of the decision making process for Max, Max would pick the move that has the highest value that results from exploring each of its subtrees.

An important optimization of minimax is known as alpha beta pruning. Alpha Beta pruning works by reducing the number of nodes that need to be explored in the minimax tree. This is accomplished by working with the idea that player Min will try to pick the lowest value, and Max will try to pick the highest value. A visualization of this algorithm can be seen in the image below:

Future Work

If given more time and resources, there are a few additional features that could be implemented. For example, building a mechanical device that will allow the AI to put its piece into the appropriate column on the physical board. In addition, certain improvements could be made to the actual AI itself, to make it smarter. For example, enabling an offensive vs defensive mode, where the AI will make offensive or defensive moves depending on whether it is winning or losing. In addition, implementing more user interface features and quality of life improvements, such as building a GUI to prompt the user to input their move, or printing a message once the game has finished. Finally, it is well known that the game of Connect Four has been solved by Vrije Universiteit in The Netherlands in 1998. Ideally, it would be desired to implement some of Dr. Universiteit's findings into this Artificial Intelligence program.