**ABSTRACT**

This paper demonstrates the creation, testing and performance evaluation of a game Connect-Four with the help of three state-of-the art AI algorithms namely Minimax algorithm, Expectimax Algorithm with alpha-beta pruning and Depth-Limited Search for improved performance and Monte Carlo Tree Search algorithm. Connect-Four is a familiar and well-known board game whose objective is to get four slots in a row.

**INTRODUCTION**

Besides constructing intelligent systems, Artificial Intelligence is also the endeavour to understand them. It includes an assortment of applications ranging from general purpose areas to particular tasks like proving mathematical theorems and diagnosing diseases. Game playing is one of the oldest fields of ventures in AI. General Game Playing (GGP) is the composition of AI programs’ ability to play games successfully.

Connect-Four a two-player game, where the objective of the game is to win by making four or more discs of your colour in a line horizontally, vertically or diagonally. The board is fashioned with six rows and seven columns where the discs are dropped vertically down occupying the last available slot within that respective column by taking turns. Although it is a solved game, it has 10^13 possible positions on the board making it absurd and illogical to store the moves in memory. As ardent players of board games and an inclination towards working on Artificial Intelligence, in this paper, we aim to depict and illustrate the different ways the AI can be utilized to create gameplay agents for the Connect-Four board game. Agents in AI are entities which act and directs its movements towards accomplishing goals. However, goals alone are insufficient to develop high-quality behaviour. Utility based agents comprise of a utility function that maps a state onto a real number representing the associated degree of happiness (1). For the agent to achieve the goal, it needs to be equipped with the capability of knowing the states, possible actions, transition model, goal test and path cost. FigXXX depicts the factors that are to be defined to formulate the problem.

|  |
| --- |
| Factors – as a diagram |
| Initial State |
| States |
| Actions |
| Transition Model |
| Goal Test |
| Path Cost |

The Connect-Four environment (3) comprises of properties as illustrated in figXXX.

|  |  |
| --- | --- |
| Properties of Environments | Connect-Four environment |
| Accessible vs Inaccessible | Accessible – It is completely observable since it consists of the board with constant dimensions and discs belonging to either the player or opponent. |
| Deterministic vs Non-Deterministic | Deterministic – It is considered deterministic since no random elements are involved. |
| Static vs Dynamic | Static – Since the present state cannot be altered be changed until the agent performs a move it is static. |
| Discrete vs Continuous | Discrete – Since the number of states is finite it is discrete. |
| Episodic vs Non-Episodic | **DOUBT** |

There are many approaches that can be employed to solve the Connect-Four game based on the difficulty level set for the AI. As per (2) they are random, defensive and aggressive AI. Random AI as the name suggests randomly performs an action and is easiest to beat, Defensive AI prioritizes to oppose and block the opponents moves from winning and Aggressive AI gives precedence to only winning.

Connect-Four makes a good candidate for implementing and studying search algorithms to find the best possible solution from all the possible solutions. This paper demonstrates the creation, testing and performance evaluation Connect-Four with the help of three state-of-the art AI algorithms namely Minimax algorithm, Expectimax Algorithm with alpha-beta pruning and Depth-Limited Search for improved performance and Monte Carlo Tree Search algorithm. In this paper, we aim to demonstrate a variation to the program with a mixture of ways to select the type of players to play and solve the game. The possible combinations of players are Human versus Human, Human versus Agent and Agent versus Agent. Our experiment involves five types of agent-players namely: Agent1 – Random, Agent2 – Forward checking, Agent3 – Minimax algorithm with alpha-beta pruning and depth-limited search, Agent4 – Expectimax algorithm with alpha-beta pruning and depth-limited search and Agent5 – MCTS.

Search strategies are evaluated by measuring their effectiveness of performance in solving the problem. Ideally, effectiveness of a search is calculated using the search cost associated with the time and memory consumed to obtain the solution. For the Connect-Four game, we chose to record the time and number of moves taken by both the players.

The rest of the paper is organized as follows. In Section 2, we mention the Related Work on approaches used to solve the problem, Section 3 comprises of the Problem Definition and Algorithms implemented, Section 4 describes the Experimental Results obtained due to the utilised methodology and lastly, Section 5 includes the Conclusions and final discussions of the main results along with an acknowledgement of future work.

**NEED TO INCLUDE** a figure of how connect-four game looks like, may be a flowchart of overall flow of the game.

**REFERENCES**

1 - Artificial Intelligence A Modern Approach

2 - Real-Time Connect 4 Game Using Artificial Intelligence

3 - <https://0xadada.pub/2003/12/15/connect-four-playing-ai-agent/>