Artificial Intelligence

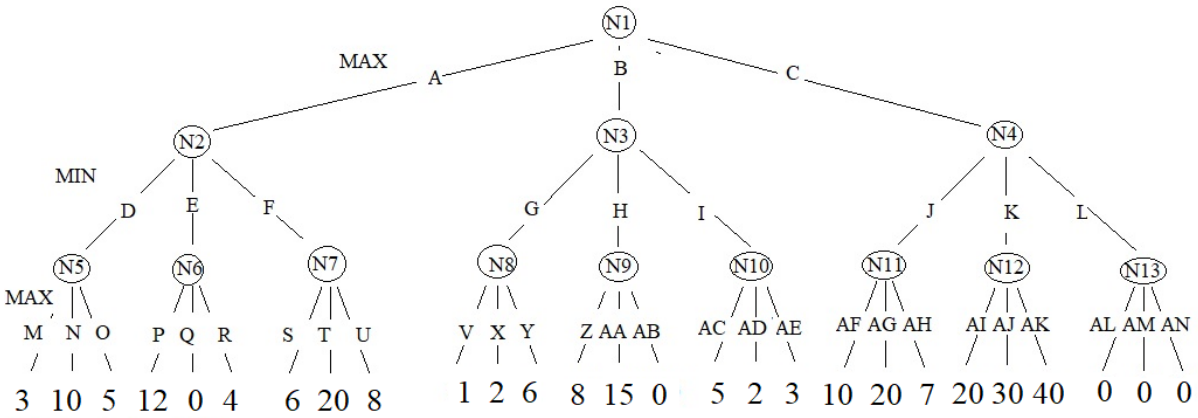
L.EIC – 3rd Year/2nd Semester

Exercise Sheet 2

Adversarial Search/Games

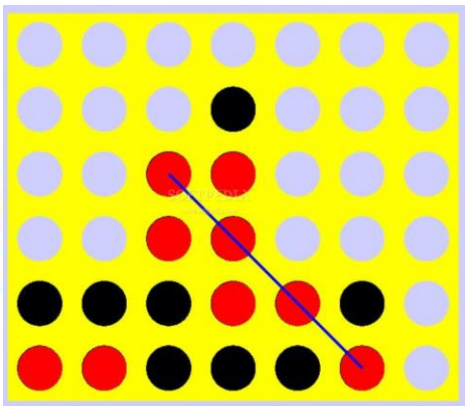
2.1 Operation of the Minimax Algorithm with Alpha-Beta Cuts

Apply the Minimax algorithm with alpha-beta cuts to the following tree that has a branch factor of 3 at the top level, 3 at the second level, and also 3 at the final level, and with the evaluation function values indicated for the final line. Indicate the final value of each node and which branches are cut by the Alpha-Beta cuts.



2.2 Connect-Four (“4 em Linha”) Game using Minimax with Alpha-Beta Cuts

A board game is characterized by the type of board and tiles, the rules of movement of the pieces (operators/possible moves) and the finishing conditions of the game with the respective score/result.



The game called "Connect Four" in the English language version (“4 em Linha” in the Portuguese version - https://en.wikipedia.org/wiki/Connect_Four) is played on a vertical board of 7x6 squares (i.e., 7 squares wide and 6 squares high), by two players, to which are

initially assigned 21 pieces to each (one of the players has white pieces and the other black pieces, or pieces "X" vs pieces "O").

The two players play alternately one of their pieces. The piece to be played is placed on the top of the board and slides either to the base of the board, or in a cell immediately above another one already occupied (see previous figure). The winner will be the player who manages to obtain a line of 4 pieces of its color/symbol horizontally, vertically, or diagonally. If the 42 pieces are played without any player getting a line, the final result will be a draw.

a) Formulate this game as an adversarial search problem, indicating the state representation, moves/operators (and respective names, preconditions, and effects), and the objective test.

b) Implement a simple version of the "Connect-Four" game using the Python language *(or other programming language of your choice although in this case it may be more difficult to use the supporting materials for the exercise).*

c) Implement the following functions:

c1) *int nlines4 (int Player)* that given the state of the board calculates the number of lines with 4 pieces (horizontal, vertical, diagonal) of a given player.

c2) *int nlines3 (int Player)*, similar to the previous function, but which calculates the number of sets of 4 consecutive spots that have three pieces of the player followed by an empty spot, i.e., that are possibilities to win the game.

c3) *int central (int Player)*, that assigns 2 points to each player piece in the center column of the board (column 4) and 1 point to each piece in the columns around it (columns 3 and 5).

d) Implement an agent to play the game using the minimax algorithm with alpha-beta cuts.

e) Compare the results of the implemented agents, playing 10 matches of this game with each other, using the minimax algorithm with alpha-beta cuts, with levels (2, 4, 6 and 8), and the following evaluation functions:

Agent1: EvalF1 = nlines4(1) - nlines4(2)
Agent2: EvalF2 = 100 EvalF1 + nlines3(1) - nlines3(2)*
Agent3: EvalF3 = 100 EvalF1 + central(1) - central(2)*
Agent4: EvalF4 = 5 EvalF2 + EvalF3*

f) Conclude about the effectiveness of each of the evaluation functions/agents and the effect of the depth used in the Minimax Algorithm.

g) How could you improve the evaluation function for this type of agent?

h) Create a simple graphical interface to play the game using for example tkinter or pygame libraries.

2.3 Ataxx Game using Minimax with Alpha-Beta Cuts

Ataxx is an abstract strategy board game and also a strategy video game that was published in arcades by The Leland Corporation in 1990 with the name Ataxx. It also appeared the same year as Spot: The Video Game and later as the Microscope Puzzle from the 1993 CD-ROM game The 7th Guest. The game was invented by Dave Crummack and Craig Galley in 1988 originally called Infection. It was first programmed on Amiga, Commodore 64, and Atari ST. Although Ataxx was originally sold as a video game and not with a physical game board it is also an abstract strategy board game that may be played with a physical board. Several online Ataxx online games are available. Figure 1 shows the original game and an Ataxx online game.

Ataxx is a game that involves play by two players originally on a seven-by-seven square grid although it may be played in a board of any dimension. The object of the game is for the player to make its own pieces to constitute a majority of the pieces on the board at the end of the game, by converting as many of their opponent's pieces as possible. Typically, each player begins with two pieces (although several variants exist), white and black, for the first player and second player respectively. The game starts with the four pieces on the four corners of the board (although again this may be flexible), with white on the top left and bottom right and black on the other two. White moves first as is typical in board games. During their turn, players move one of their pieces either one or two spaces in any direction. Diagonal distances are equivalent to orthogonal distances, i.e. it is legal to move to a square whose relative position is two squares away both vertically and horizontally. If the destination is adjacent to the source, a new piece is created on the empty departure square. Otherwise, the piece on the source moves to the destination. After the move, all the opponent player's pieces adjacent to the destination square are converted to the color of the moving player. Players must move unless no legal move is possible, in which case they must pass.

The board configuration may be altered by having certain squares filled (not playable by either player), using different board sizes or having distinct initial configurations instead of the typical 4 corner pieces start. The game ends when all squares have been filled or one of the players has no remaining pieces. The player with the most pieces wins the game. A draw may occur when the number of squares is even, either from non-playable squares or nonstandard sizes having an even number of squares. Some versions also implement the threefold repetition rule from chess.

a) Implement a simple version of the Ataxx game using the Python language *(or other programming language of your choice).*

b) Implement Human-human, Human-Computer and Computer-Computer game modes (with the Computer playing randomly.

c) Implement an agent to play the game using the minimax algorithm with alpha-beta cuts and using the difference between the number of white and red/black pieces as its evaluation function.

d) Test the Computer-Computer mode using different depth levels of Minimax for each PC player and analyse the results in terms of the outcome of the games (wins, draws, losses) and average time spent to obtain the moves.

e) Create a simple graphical interface to play the game using, for example, tkinter or pygame libraries.