Artificial Intelligence and Knowledge Engineering Laboratory

Task 3. Game Playing Algorithm

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Task Objectives

Getting familiar with min-max algorithm and its extension called alpha-beta pruning in practice through individual implementation of a two player board game. The implementation has to focus on human versus computer play.

Subtasks

- Get familiar with min-max algorithm.
- Get familiar with game board evaluation techniques.
- Choose one simple, two player board game (suggestion: choose a game you already know).
- Build min-max algorithm:
  - build a game board representation,
  - build a two game board evaluation functions,
  - build a function for the generation of available moves,
  - build a min-max algorithm in a recursive way.
- Build a simple user interface for the game (text or GUI, it does not need to be advanced, the user interface will not be evaluated by itself).
- Test the implementation playing against the computer (for both evaluation functions).
- Test the implementation of both evaluation functions (run both against each other).
- Expand the solution with alpha-beta pruning algorithm.
- Test the implementation playing against the computer.
- Compare the min-max algorithm and the expanded solution with alpha-beta algorithm from the point of view of the effective branching factor and depth of searching with respect to time needed.

Report
- Short description of the rules for chosen game.
- Short description of min-max algorithm with pseudocode.
- Short description of alpha-beta algorithm with pseudocode.
- Short description of chosen evaluation functions.
- Short description of chosen available move generation function.
- Analysis of performed tests (tests described in subtasks).

Task rating

2 points – implementation of the min-max algorithm for the selected game.
2 points – building an evaluation functions for the selected game.
2 points – building an available move generation function for selected game.
2 points – implementation of the alpha-beta pruning algorithm for the selected game.
2 points – an analysis of the implemented algorithms.
Extra 3 points: implementation of selected heuristics for improving the complexity of the game playing algorithm based on alpha-beta pruning scheme.

Suggested games (choose one):

Reversi:
strategy board game for two players, played on an 8×8 uncheckered board. There are sixty-four identical game pieces called disks, which are light on one side and dark on the other. Players take turns placing disks on the board with their assigned color facing up. During a play, any disks of the opponent's color that are in a straight line and bounded by the disk just placed and another disk of the current player's color are turned over to the current player's color. The object of the game is to have the majority of disks turned to display your color when the last playable empty square is filled.

Draughts(checkers):
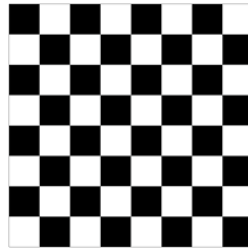
strategy board game for two players, played on an 10×10 uncheckered board. Only black fields are in game. Players start on opposite sides of the gameboard. One player has the dark pieces; the other has the light pieces. Players alternate turns. A player may not move an opponent's piece. Players start with 20 uncrowned pieces which can move one step diagonally forwards/backwards, and capture an opponent's piece by moving two consecutive steps in the same line, jumping over the piece on the first step. Multiple enemy pieces can be captured in a single turn provided this is done by successive jumps made by a single piece; the jumps do not need to be in the same line and may "zigzag" (change diagonal direction). When uncrowned piece reaches the farthest it becomes a king. Kings move any distance along unblocked diagonals, and may capture an opposing uncrowned any distance away by jumping to any of the unoccupied squares immediately beyond it. The object of the game is to remove all opponents pieces from the board.

Gomoku:
strategy board game for two players, played on an 15×15 uncheckered board. There are 2 colours of the stones . Players take turns placing stones on the board with their assigned color. The object of the game is to have 5 stones of your color in a row(horizontally, vertically, diagonally).

Halma:
From Wikipedia (https://en.wikipedia.org/wiki/Halma)
> "The gameboard is checkered and divided into 16×16 squares. Pieces may be small checkers or counters, or wooden or plastic cones or men resembling small chess pawns. Piece colors are typically black and white for two-player games, and various colors or other distinction in games for four players."
> "The game is played by two or four players seated at opposing corners of the board. The game is won by being first to transfer all of one's pieces from one's own camp into the camp in the opposing corner. For four-player games played in teams, the winner is the first team to race both sets of pieces into opposing camps. On each turn, a player either moves a single piece to an adjacent open square, or jumps over one or more pieces in sequence."

Other choices are also possible after discussion with your tutor.

Important: Tic-Tac-Toe or Connect-Four and similar are <u>too simple</u> and thus forbidden.

Bibliography

1. *See the lecture*
2. J. Schaeffer et al.: Checkers Is Solved, Science (14), September 2007
3. https://en.wikipedia.org/wiki/Minimax
4. https://en.wikipedia.org/wiki/Alpha%E2%80%93beta_pruning
5. http://en.wikipedia.org/wiki/Reversi
6. http://en.wikipedia.org/wiki/Gomoku
7. https://en.wikipedia.org/wiki/Draughts
8. https://en.wikipedia.org/wiki/Go_(game)