MA410 Artificial Intelligence - Games & Searching Problem Sheet

1. Name the role artificial intelligence has in solving games. Are there any historical successes for AI?

2. Define the following:

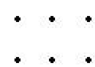
   (a) Depth-first searching (b) Breadth-first searching
   (c) Best-first searching (d) Alpha-beta pruning

3. A variant of Nim starts with one pile of tokens, and the two players take turns to move. A move consists of taking one, two or three tokens from the pile, and the player taking the last token loses. Draw the complete game tree starting from a pile of

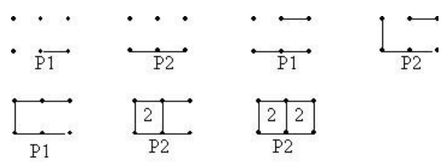
   (i) 3, (ii) 4, (iii) 5, (iv) 6, (v) 7

   tokens respectively and use minimax to decide which player has a winning strategy in each case.

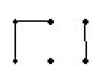
4. Consider the following two-player game. The game begins with six dots as shown below:



Players take turns to connect adjacent dots either horizontally or vertically: If a move completes a square then the player wins the square, marks it, and takes an extra turn. The object is to win both squares. A typical game might be:



The outcome from a game is win, lose or draw. Player 2 (P2) has won this game. This question concerns a game in the following state - Player 2 is to move next.



(a) Draw the game tree for this game starting from the state shown above.

(b) Use the game tree and the minimax algorithm to show the outcome for each of the four possible moves. Assume an ideal opponent.

(c) Redraw the game tree and indicate which nodes in the tree are visited by an algorithm using Minimax and Alpha-Beta Pruning to find any winning move.

(d) Describe an evaluation function that could be used to help find the winning move for a version of this game with a ten by ten grid of dots. What are the limitations of your function?

5. (a) Consider "the 4 puzzle" as a variant of the 8-puzzle, played on a 2×2 board with 4 tiles numbered $1, ..., 4$. In each move, a row or column is chosen, and the tiles in that row (column) swap places.

   i. Define *Algorithm A** and use it with the heuristic function

   $$h(X) = \text{the number of tiles not in their final position.}$$

   to find a sequence of moves that takes you

   from the board

1	2
4	3

   to the board

4	1
3	2

   Draw the search tree, showing the nodes generated and their f-cost values.

(b) Consider another variant "the 5 puzzle" of the 8-puzzle, played on a 2×3 board with 5 tiles numbered $1, ..., 5$. In each move, a tile may be slid horizontally or vertically into an adjacent empty position.

   i. Use *Algorithm A** with the heuristic function

   $$h(X) = \text{the number of tiles not in their final position.}$$

   to find a sequence of moves that takes you

   from the board

4	1	3
2		5

   to the board

1	2	3
4	5	

(c) Consider the problem of moving tiles on the board from

5	4	1	3	2

to

1	2	3	4	5

where a move consists of swapping adjacent tiles.

   i. Find the minimum no. of swaps required to sort using *Algorithm A** with the heuristic function

   $$h(x) = d(1) + d(2) + d(3) + d(4)$$

   where d denotes the (manhattan) distance of a tile from its goal position. Draw the search tree, showing the nodes generated and their f-cost values.

(d) What is the definition for a heuristic function to be montone? Is $h(X)$ monotone in each of the above cases? Motivate your answer.

(e) Define predicate `tiles(L)` where `L` is a list representing a legal configuration of the board. (e.g. in 5a above, we may have `L = [[1,4],[2,3]]` which would mean that tile 1 is in row 1, col 1, tile 4 in row 1 col 2, tile 2 in row 2 col 1 and tile 3 in row 2, col 2.)

   i. Write down the initial position using `tiles`.

   ii. Write the predicate to allow all legal moves.

   iii. What query would you use to see if final position was possible?