Assignment 2 (Week 12)
[for Edgbaston campus students]
Class Test worth 50% of the final mark

Artificial Intelligence 1/Artificial Intelligence & Machine Learning
School of Computer Science, University of Birmingham

Q1: Uninformed & informed search (BFS/DFS, A*) – 20 marks, 30 minutes

1.a

Consider a state space graph with a branching factor of 2. The root node of the search tree corresponding to this graph is considered to be at depth 0. There is a goal state at depth 10 and another goal at depth 12 of the search tree. Assume also that the graph is finite, that the maximum search tree depth is 15 and that the cost of each action is 3. Consider the following questions for breadth-first search.

(i) What is the maximum number of nodes that the breadth-first algorithm will expand by the time it terminates? Show your working. [4 marks]

(ii) Will the algorithm find a goal state? Briefly justify your answer. [2 marks]

(iii) Will the algorithm definitely find the goal state by the cheapest route? Briefly justify your answer.

[2 marks]

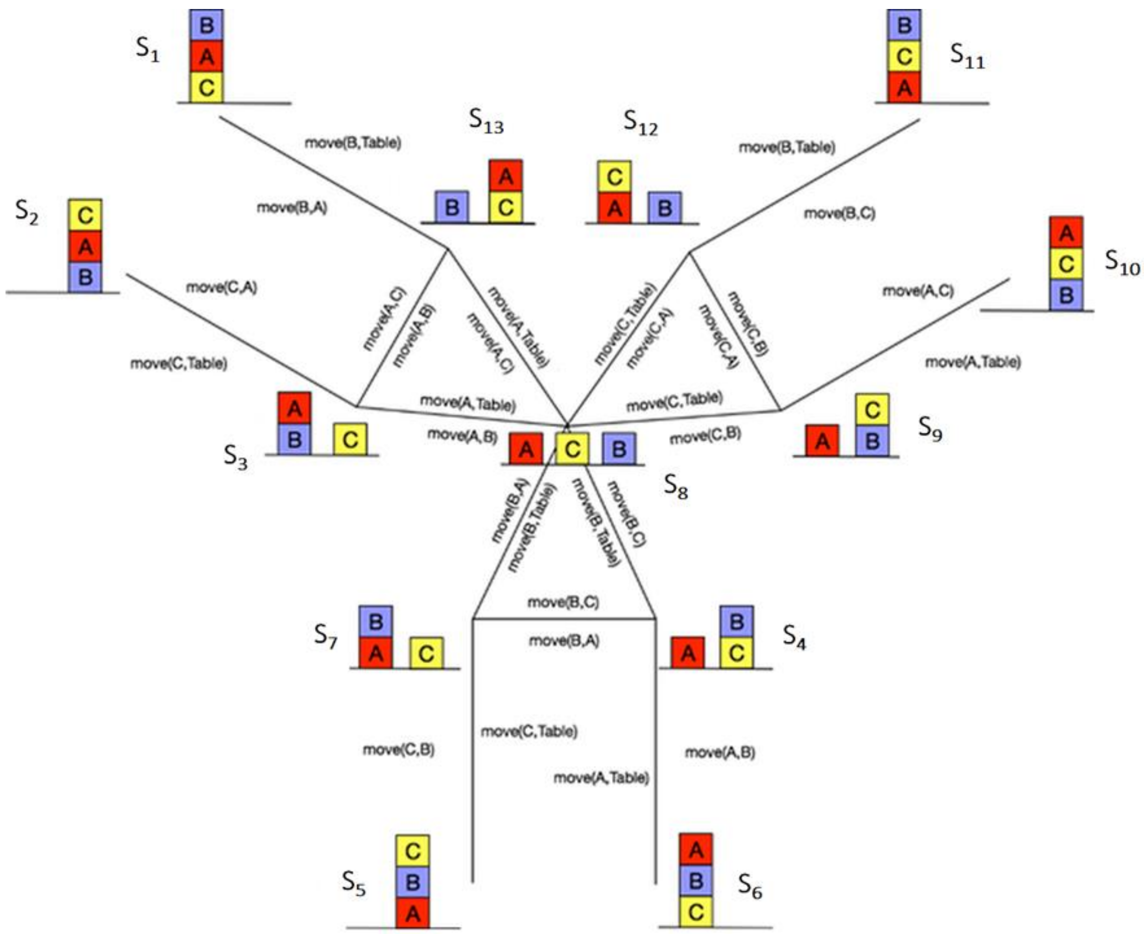
1.b

Consider the state space graph shown on next page for a three-blocks world where blocks are shown as A, B, and C.

The initial node is node S_1. The goal node is node S_6. The possible moves are all move(X,Y), shown in the edges of the state space graph above, where move(X,Y) means move block X from where it is to sit on top of block Y. Assume that the cost of each move is 1.

A possible heuristic function for the three-blocks world problem is to set h(X) for some node X as the number of blocks that are not at the right level with respect to the table, where C should be on the table, B should be one level above the table and A should be two levels above the table as shown in the goal node S6. For example, the heuristic cost for node S_3 is 2 as it has 2 blocks (B and A) which are not at the right level.

Apply this heuristic with A* search to produce a search tree to reach goal node S_6 from start node S_1.



Write down the following information:

(i) Search tree produced by A*, indicating the following: heuristic cost h(n), actual cost g(n) and total cost f(n) for each node n. [8 marks]

> If there are ties when choosing which frontier node to visit first, pick the node with smaller identifier first. For creating the A* search tree, write the letters as the node labels (S_1, S_2, S_3, etc.) and not the pictures of the states.

(ii) Sequence of nodes visited by A*. Note: you can identify a node through its state. [2 marks]

(iii) Solution retrieved by A*. [1 mark]

(iv) The cost of the solution retrieved by A*. [1 mark]

Q2: Local search (hill-climbing) and clustering – 20 marks, 30 minutes

2.a

Consider the 8-puzzle below with initial and goal states shown, where 0 corresponds to an empty space and the other numbers correspond to number tiles. The number tiles can move left, right, up, or down into the empty space (where available). The neighborhood operator consists of applying a possible move to the current state. Using hill climbing search algorithm and Manhattan distance (see Note below) as the objective, show the first two moves of hill climbing algorithm starting from the initial state while showing all the nodes generated at each step and their corresponding objective value.

Note: In a 2D plane with point p_1 at coordinates (x_1, y_1) and point p_2 at coordinates (x_2, y_2), the Manhattan distance between points p_1 and p_2 is computed as $|x_1 - x_2| + |y_1 - y_2|$ where $|y_1 - y_2|$ represents absolute difference between y_1 and y_2. As an example of coordinates, tile 8 in start state below can be considered at coordinates (1,2) while tile 8 in goal state below can be considered at coordinates (2,3).

Start state:

1	2	0
8	5	3
7	4	6

Goal state:

1	2	3
4	5	6
7	8	0

[6 marks]

2.b

The distance matrix below provides the distance between each pair of objects W, X, Y, and Z. Using hierarchical agglomerative clustering with single link and complete link respectively, write the cluster formation process, including (i) each merge of objects and/or clusters, (ii) the height after each merge, and (iii) the final dendrogram. [8 marks]

	W	X	Y	Z
W		1	4	5
X	1		2	6
Y	4	2		3
Z	5	6	3	

2.c

In the following 2D datasets, two clusters of data points can be visually observed in each dataset. For each dataset, briefly explain your analysis of whether k-means clustering algorithm will give the same clustering as the visual observation of clusters (observable by naked eye). Justify your reasoning.

[6 marks]