National University of Singapore
School of Computing
IT5005 Artificial Intelligence

Uninformed and Informed Search

1. Consider the grid problem shown in Fig. 1. The grid extends to infinity in all directions. The agent can only move along the grid lines. Action *East*, *West*, *North*, and *South* takes the agent from state (r, c) to $(r, c+1)$, $(r, c-1)$, $(r+1, c)$, $(r-1, c)$, respectively. Each action costs one unit. The agent is initially assumed to be at state $(0, 0)$, and objective is to reach state $(2, 2)$. All action costs are same and equal to 1.

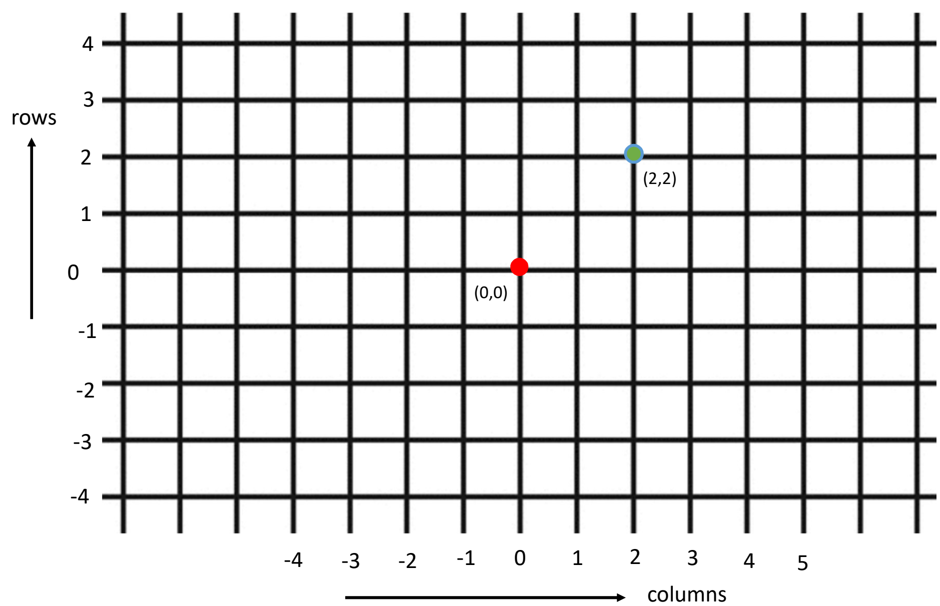

Figure 1: State is represented as (r, c), where r and c represent the row and column, respectively. The agent can move one step along the grid in *East*, *West*, *North*, and *South* directions; for example action *East* takes the agent from initial state $(0, 0)$ to $(0, 1)$; When choosing an action, ties are always broken in the order *East*, *West*, *North*, and *South*. For example, if you need to choose between *East* and *North*, first choose *East* and then *North*.

(a) Which algorithm would you recommend: tree search/graph search? Provide justification.

(b) Identify whether the following algorithms are complete and optimal. Provide the rationale for each answer.

i. Breadth-First Search

ii. Depth-Limited Search

iii. Iterative Deepening Search

2. An explicit state space graph is shown in Fig. 2. Several heuristics (i.e., estimated costs to reach the goal state from a node) are presented in Table 1. As an example, the column corresponding to h_5 can be interpreted as $h_5(A) = 5$, $h_5(B) = 7$, $h_5(C) = 2$, and $h_5(D) = 0$.

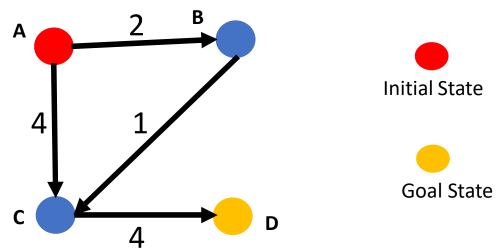

Figure 2: Explicit state space graph

Table 1: Heuristics for the state space graph shown in Fig. 2

Node	h_1	h_2	h_3	h_4	h_5
A	0	7	7	5	5
B	0	5	4	3	7
C	0	4	1	2	2
D	0	0	0	0	0

(a) Comment on admissibility and consistency of the heuristic functions h_i, $i = \{1, \ldots, 5\}$.

(b) Find the path from initial state to goal state using uniform-cost search, A* search, and greedy best first search algorithms. Use the heuristics in Table 1 when needed.

3. In informed search, we relax problem settings to enable the estimation of path-cost from a given state to a goal state. In an n-puzzle, assume that square B is blank; if square A is horizontally or vertically adjacent to square B, then a tile can move from square A to square B horizontally or vertically, respectively. Consider the following heuristic costs:

- Heuristic h_1: number of misplaced tiles compared to goal state

- Heuristic h_2: Manhattan distance of each tile to its position in goal state. It is defined as

$$h_2 = \sum_{i=1}^{n} |x_{i,a} - x_{i,t}| + |y_{i,a} - y_{i,t}| \tag{1}$$

where $(x_{i,a}, y_{i,a})$ is the actual position of a tile and $(x_{i,t}, y_{i,t})$ is its target position. The top left position is (1,1) and the bottom right position is (3,3).

(a) Show that both heuristics are admissible. Which heuristic can be a good estimate of the actual path-cost?

(b) Calculate the heuristic costs for the initial state of 8-puzzle shown in the Fig. 3.

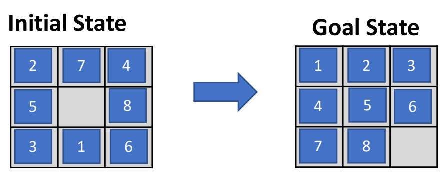

Figure 3: An 8-puzzle problem