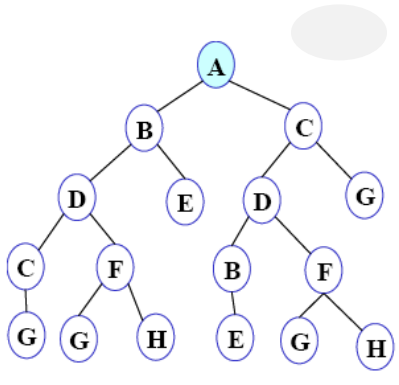
Introduction to Artificial Intelligence

Unit # 3

Recap: BFS, DFS, IDS

- Start Node: A
- Goal Node: G
- Identify the path taken by each scheme
- Identify the number of nodes explored by each scheme



BFS and DFS Algorithms

BFS

- Let L be a list containing the initial state
- Loop
  - If L is empty return failure
  - Node ← remove-first(L)
  - If Node is a goal
    - Return the path from initial state of Node
  - Else
    - Generate all successors of Node
    - Add generated nodes to the ***back*** of L
- End Loop

DFS

- Let L be a list containing the initial state
- Loop
  - If L is empty return failure
  - Node ← remove-first(L)
  - If Node is a goal
    - Return the path from initial state of Node
  - Else
    - Generate all successors of Node
    - Add generated nodes to the ***front*** of L
- End Loop

Search Methods

- Uninformed (Blind) Search
  - Breadth-first
  - Depth-first
  - Depth-limited
  - Iterative deepening depth-first
- Informed (or heuristic) Search
  - Best-first
  - A*
- Adversarial
  - Minimax
  - Alpha-beta Pruning

Problem Solving by Search

- Define search space
  - Initial, goal, and intermediate states
- Define operators for expanding a given state into its possible successor states
- Apply search algorithm to find path from initial to goal state, while avoiding a repeating state during the search.

The 8-puzzle

- The puzzle consists of a 3 x 3 grid, with the numbers 1 through 8 on tiles within the grid and one blank square.
- Tiles can be slid about within the grid, but a tile can only be moved into the empty square if it is adjacent to the empty square.
- The start state of the puzzle is a random configuration, and the goal state is as shown in the picture below.

7	6	
4	3	1
2	5	8

1	2	3
8		4
7	6	5

Goal State

Heuristic

- Depth-first and breadth-first search are described as brute-force search methods.
- They do not employ any special knowledge of the search trees they are examining but simply examine every node in order until they happen upon the goal.
- A heuristic is a rule of thumb that may help solve a given problem. Heuristics take problem knowledge into consideration to help guide the search within the domain.

Heuristic Function

- A **heuristic evaluation function** is a function that when applied to a node gives a value that represents a good estimate of the distance of the node from the goal.
- For two nodes *m* and *n*, and a heuristic function *f*, if $f(m) < f(n)$, then it should be the case that *m* is more likely to be on an **optimal path** to the goal node than *n*.

Basic Idea Behind a Heuristic Search

- We assume that we have a heuristic (evaluation) function, f, to help decide which node is the best one to expand next. This function is based on information specific to the problem domain.
- Expand next that node, n, having the smallest value of f(n). Resolve ties arbitrarily.
- Terminate when the node to be expanded next is a goal node.

Heuristic # 1

- The first heuristic we consider is to count how many tiles are in the wrong place. We will call this heuristic, *h*1(node).
- In the case of the first state shown in Figure 4.5, *h*1 (node) = 8 because all the tiles are in the wrong place.
- However, this is misleading because we could imagine a state with a heuristic value of 8 but where each tile could be moved to its correct place in one move.

7	6	
4	3	1
2	5	8

1	2	3
8		4
7	6	5

Heuristic # 2

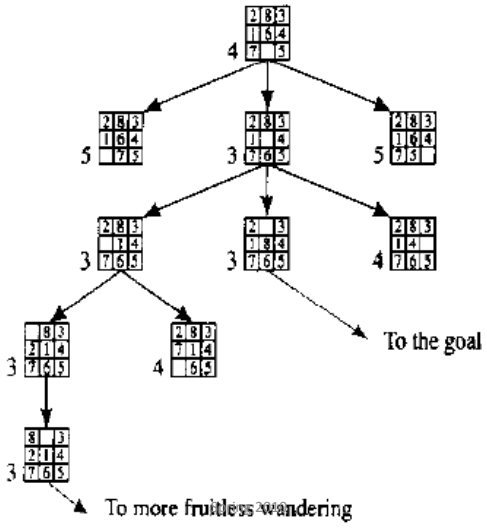
- An improved heuristic, *h*2, takes into account how far each tile had to move to get to its correct state.
- This is achieved by summing the **Manhattan distances** of each tile from its correct position.
- Manhattan distance is the sum of the horizontal and vertical moves that need to be made to get from one position to another, named after the grid system of roads used in Manhattan.
- *h*2 (node) = 2 + 2 + 2 + 2 + 3 + 3 + 1 + 3 = 18
- It is worth noting that *h*2 (node) ≥ *h*1 (node) for any node. This means that *h*2 **dominates** *h*1, implying that a search method using heuristic *h*2 will always perform more efficiently than the same search method using *h*1.

Best-first search

- Best-first search expands the node that appears to be closest to goal
- Evaluation function *f(n) = h(n)* (heuristic)

  = estimate of cost from *n* to *goal*

Best-first Search (Using Heuristic # 1)



1	2	3
8		4
7	6	5

Goal State

Best-first Search (Using Heuristic # 2)

2	8	3
1	6	4
7		5

1	2	3
8		4
7	6	5

Goal State

- Expand the tree