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Q. A* algorithm for 8- Puzzle problem:

$f(n) = g(n) + h(n)$

Pseudocode & Algorithm:

To implement the A* algorithm for the 8-puzzle problem, we define two heuristics, h(n):

1. No. of Misplaced Tiles:
2. Manhattan Distance

The A* algorithm will use $f(n) = g(n) + h(n)$, where,
g(n) is the depth of the node.
h(n) is the heuristic, either misplaced tiles or Manhattan distance.

Algorithm:

1. Initialize:
→ Start with the initial state of the puzzle.
→ Use a priority queue to hold the nodes, ordered by $f(n) = g(n) + h(n)$.
→ Keep a set of visited nodes to avoid re-exploring nodes.

2. Expand Nodes:
→ While the priority queue is not empty.
→ Remove the node with the lowest f(n) from the queue.
→ If this node is the goal, return the solution.
→ Generate all possible child nodes (neighbouring states) by moving the blank tile.

For each child:

Calculate g(n) (increment depth by 1 from parent)
Calculate h(n) using the chosen heuristic.
If the child has not been visited or if it has a better f(n) than before, add it to the queue

3. Termination:

→ If the goal is found, return the path and total cost.

→ If no solution is found, return failure.

4. State space tree (misplaced tiles):

Final state:

$$\begin{matrix} 1 & 2 & 3 \\ 8 & 0 & 4 \\ 7 & 6 & 5 \end{matrix}$$

Initial state:

$$\begin{matrix} 2 & 8 & 3 \\ 1 & 6 & 4 \\ 7 & 0 & 5 \end{matrix}$$

$g=1$, $h=5$, $f=1+5=6$ $\begin{bmatrix} 2 & 8 & 3 \\ 1 & 6 & 4 \\ 0 & 7 & 5 \end{bmatrix}$

$\begin{bmatrix} 2 & 8 & 3 \\ 1 & 0 & 4 \\ 7 & 6 & 5 \end{bmatrix}$ $g=1$, $h=3$, $f=1+3=4$

$\begin{bmatrix} 2 & 8 & 3 \\ 1 & 6 & 4 \\ 7 & 5 & 0 \end{bmatrix}$ $g=1$, $h=5$, $f=6$

$g=2$, $h=3$, $f=5$ $\begin{bmatrix} 2 & 8 & 3 \\ 0 & 1 & 4 \\ 7 & 6 & 5 \end{bmatrix}$

$\begin{bmatrix} 2 & 0 & 3 \\ 1 & 8 & 4 \\ 7 & 6 & 5 \end{bmatrix}$ $g=2$, $h=3$, $f=5$

$\begin{bmatrix} 2 & 8 & 3 \\ 1 & 4 & 0 \\ 7 & 6 & 5 \end{bmatrix}$ $g=2$, $h=4$, $f=6$

$\begin{bmatrix} 0 & 8 & 3 \\ 2 & 1 & 4 \\ 7 & 6 & 5 \end{bmatrix}$ $g=3$, $h=3$, $f=6$

$g=3$, $h=4$, $f=7$ $\begin{bmatrix} 2 & 8 & 3 \\ 7 & 1 & 4 \\ 0 & 6 & 5 \end{bmatrix}$

$\begin{bmatrix} 0 & 2 & 3 \\ 1 & 8 & 4 \\ 7 & 6 & 5 \end{bmatrix}$ $g=3$, $h=2$, $f=5$

$\begin{bmatrix} 2 & 3 & 0 \\ 1 & 8 & 4 \\ 7 & 6 & 5 \end{bmatrix}$ $g=3$, $h=4$, $f=7$

$\begin{bmatrix} 1 & 2 & 3 \\ 0 & 8 & 4 \\ 7 & 6 & 5 \end{bmatrix}$ $g=4$, $h=1$, $f=5$

$$\begin{bmatrix} 1 & 2 & 3 \\ 0 & 8 & 4 \\ 7 & 6 & 5 \end{bmatrix} \quad g=4,\ h=1,\ f=5$$

$$\begin{bmatrix} 1 & 2 & 3 \\ 8 & 0 & 4 \\ 7 & 6 & 5 \end{bmatrix} \quad g=5,\ h=0,\ f=5$$

Final state.

$$\begin{bmatrix} 1 & 2 & 3 \\ 7 & 8 & 4 \\ 0 & 6 & 5 \end{bmatrix} \quad g=5,\ h=2,\ f=7$$

★. State space tree (Manhattan distance):

Initial state:

2 8 3
1 6 4
7 0 5

Final state:

1 2 3
8 0 4
7 6 5

$$g=0 \quad \begin{bmatrix} 2 & 8 & 3 \\ 1 & 6 & 4 \\ 7 & 0 & 5 \end{bmatrix} \quad h = 1+1+0+0+0+1+0+1 = \boxed{4}$$

$g=1$

Left:

$$\begin{bmatrix} 2 & 8 & 3 \\ 1 & 6 & 4 \\ 0 & 7 & 5 \end{bmatrix}$$

$h=4$

$\boxed{f=5}$

up:

$$\begin{bmatrix} 2 & 8 & 3 \\ 1 & 0 & 4 \\ 7 & 6 & 5 \end{bmatrix}$$

$\boxed{f = 3+1=4}$

Right:

$$\begin{bmatrix} 2 & 8 & 3 \\ 1 & 6 & 4 \\ 7 & 5 & 0 \end{bmatrix}$$

$h = 1+1+1+1=4$

$\boxed{f = 1+4=5}$

up, $g=2$:

$$\begin{bmatrix} 2 & 0 & 3 \\ 1 & 8 & 4 \\ 7 & 6 & 5 \end{bmatrix} \quad 1+1+2$$

$\boxed{f = 2+4=6}$

Right, $g=2$:

$$\begin{bmatrix} 2 & 8 & 3 \\ 1 & 4 & 0 \\ 7 & 6 & 5 \end{bmatrix} \quad 1+1+0+1+1+2 = 6$$

$f = 2+6=8.$

Left, $\boxed{g=3}$:

$$\begin{bmatrix} 0 & 2 & 3 \\ 1 & 8 & 4 \\ 7 & 6 & 5 \end{bmatrix}$$

$1+1 = f = 3+2 = 5$

down:

$$\begin{bmatrix} 2 & 8 & 3 \\ 1 & 0 & 4 \\ 7 & 6 & 5 \end{bmatrix}$$

$f = 3+3 = 6.$

Right:

$$\begin{bmatrix} 2 & 3 & 0 \\ 1 & 8 & 4 \\ 7 & 6 & 5 \end{bmatrix}$$

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$g = 4$

$$\begin{bmatrix} 0 & 2 & 3 \\ 1 & 8 & 4 \\ 7 & 6 & 5 \end{bmatrix} \quad \cancel{h = 1+1 = 2} \quad \cancel{f = 4+2 = 6} \ldots$$

$\boxed{g = 4}$

down

$$\begin{bmatrix} 1 & 2 & 3 \\ 0 & 8 & 4 \\ 7 & 6 & 5 \end{bmatrix} \quad h = 1 \quad f = 4+1 = 5$$

Right

$$\begin{bmatrix} 2 & 0 & 3 \\ 1 & 8 & 4 \\ 7 & 6 & 5 \end{bmatrix} \; X. \quad f = 4+4 = 8.$$

Right

$$\begin{bmatrix} 1 & 2 & 3 \\ 8 & 0 & 4 \\ 7 & 6 & 5 \end{bmatrix} \quad h = 0.$$

final state.

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