MOHAMED BIN ZAYED
UNIVERSITY OF
ARTIFICIAL INTELLIGENCE

MOHAMED BIN ZAYED
UNIVERSITY OF
ARTIFICIAL INTELLIGENCE

# Lab 5: Solving Problems by Searching-Part II

**Dr. Maryam Sultana**

**Research Associate @MBZUAI,**
**United Arab Emirates**

Maryam.Sultana@mbzuai.ac.ae

**Research Interest: Computer Vision, machine learning, artificial intelligence, , deep learning, Background/Foreground Separation**

MOHAMED BIN ZAYED UNIVERSITY OF ARTIFICIAL INTELLIGENCE

MOHAMED BIN ZAYED UNIVERSITY OF ARTIFICIAL INTELLIGENCE

# Main Contents

Eight Digit Problem

Part A: A* Search Algorithm

MOHAMED BIN ZAYED UNIVERSITY OF ARTIFICIAL INTELLIGENCE

# Main Contents

- ❑Eight-digit Problem
- ❑Initial Game shown in Figure 1
- ❑Target State shown in Figure 1

**General Instructions**

All written answers must be in order and clearly.

You should modify the code in the code cells of the jupyter platform between

*# BEGIN_YOUR_CODE*

and

*# END_YOUR_CODE*

but you can add other helper functions outside this block if you want.

**Eight - digit problem**

Problem background: There are eight numbers 1, 2, 3, 4, 5, 6, 7, and 8 placed on a 3×3 checkerboard. Each number occupies a grid and there is a space.

Moving rules: These numbers can be moved on the board. The moving rule is: the numbers adjacent to the space can be moved into the space.

Solution goal: The problem is: the specified initial game and target game are given in Fig.1. You need to use the search algorithm to make the initial game state transition to the target game state, and give the sequence of movement of the numbers.

| | | |
|---|---|---|
| 2 | 8 | 3 |
| 1 | | 4 |
| 7 | 6 | 5 |

Initial Game

| | | |
|---|---|---|
| 8 | 1 | 3 |
| 2 | | 4 |
| 7 | 6 | 5 |

Target Game

Figure 1: The initial state and target state of the eight-digit problem

MOHAMED BIN ZAYED
UNIVERSITY OF
ARTIFICIAL INTELLIGENCE

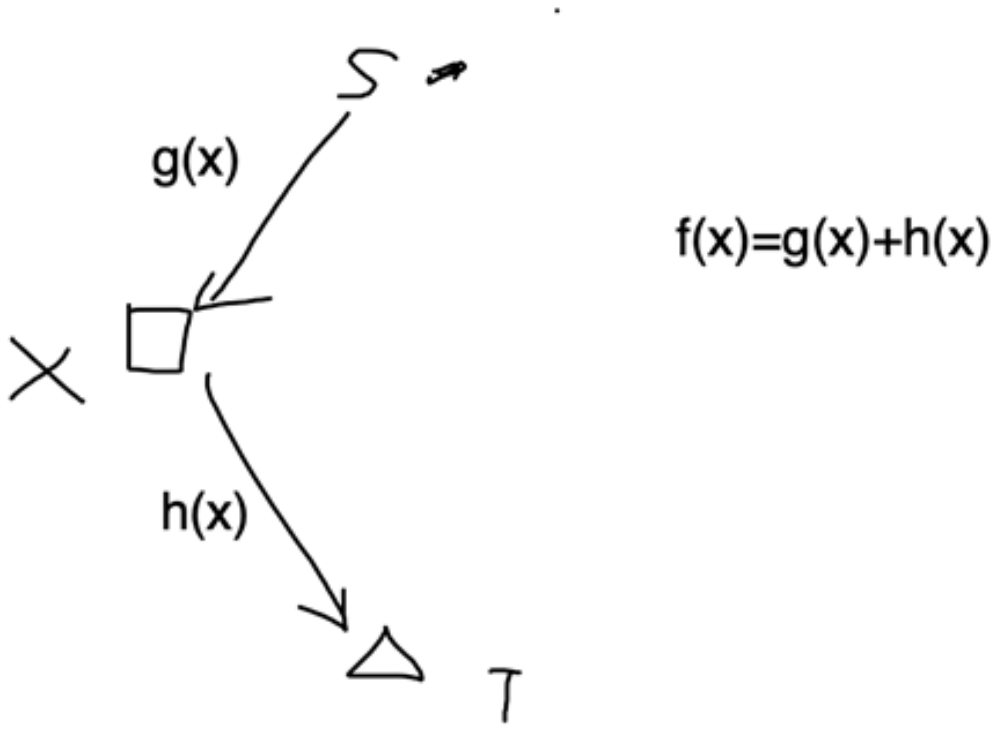
# Heuristic search

- Disadvantages of uninformed search: in the large space problem, it often leads to the problem of **"combination explosion".**
- To solve this problem, we introduce a heuristic search strategy (also called informed search).
- Heuristic information: the information that helps to find a path to the target state as soon as possible.

MOHAMED BIN ZAYED
UNIVERSITY OF
ARTIFICIAL INTELLIGENCE

# A* search algorithm

- Heuristic information:
- **f(x) = g(x) + h(x)**
- f(x): the estimated cost from the initial state to the target state through state x;
- g(x): the actual cost from the initial state to the state x;
- h(x): the estimated cost of the best path from state x to the target state.



MOHAMED BIN ZAYED
UNIVERSITY OF
ARTIFICIAL INTELLIGENCE

# The idea estimation

- $K(n_i, n_j)$: the actual cost of the **best path** between nodes n_i and n_j
- $g*(n) = K(s, n)$: the actual cost of the **best path** from the starting node s to node n
- $h*(n)=K(n, T)$: The actual cost of the **best path** from n to the target node T
- $f*(n) = g*(n) + h*(n)$: The actual cost of the **best path** from the starting node s to the target node through node n

MOHAMED BIN ZAYED
UNIVERSITY OF
ARTIFICIAL INTELLIGENCE

# Idea

- $f*(n)$ cannot be known in advance. Use the evaluation function f(n) to approximate it

- **Use evaluation function: f(n)=g(n)+h(n)**

  - g(n) is an estimate of $g*(n)$, Obviously, $g(n) \geq g*(n)$

  - h(n) is an estimate of $h*(n)$. In the $A*$ algorithm, for each node: $h(n) \leq h*(n)$

- **In eight – digit problem:**
  - g(n): the number of moved steps for the node n.
  - h(n): the number of grids for node n which have different digits compared to the target state

MOHAMED BIN ZAYED UNIVERSITY OF ARTIFICIAL INTELLIGENCE

# Heuristic Function

- h(n): the number of grids for node n which have different digits compared to the target state

- h1 = number of misplaced tiles

| | | |
|---|---|---|
| 2 | 8 | 3 |
| 1 | | 4 |
| 7 | 6 | 5 |

Initial Game

| | | |
|---|---|---|
| 8 | 1 | 3 |
| 2 | | 4 |
| 7 | 6 | 5 |

Target Game

- In the above figure, 3 tiles are out of position, hence for this state, h1 = 3

MOHAMED BIN ZAYED
UNIVERSITY OF
ARTIFICIAL INTELLIGENCE

# *A** algorithm process:

- **Step 1:** Create *OPEN* table and *CLOSED* table;
- **Step 2:** Put the initial node s with f(s) into the *OPEN* table;
- **Step 3:** Create an expanded node table CLOSED, the table is empty at the beginning;
- **Step 4:** Loop: If the *OPEN* table is empty, the search fails and exits.
- **Step 5:** Remove the first node *N* from the *OPEN* table and put it into the *CLOSED* table, and label it with the sequence number *n*;
- **Step 6:** If the target node T=N , the search is successful and ends.
- **Step 7:** Extend node n, for each successor node m:
- **Step 8:** Rearrange the OPEN table according to the value of f(x) from small to large;
- **Step 9:** Turn to LOOP.

MOHAMED BIN ZAYED UNIVERSITY OF ARTIFICIAL INTELLIGENCE

# Tasks

- In Part A, you need to use the A search algorithm to solve the eight-digit problem

- And you need to conduct more in-depth research on the heuristic search algorithm and the A algorithm as required.

1. Consider how to choose a suitable heuristic function for various problems. We have given the choice of heuristic function for the eight-digit problem. Please understand the benefits of this design.
2. The difference between A search algorithm and A* search algorithm is the range of $h(x)$. Please think about the impact of their differences on search efficiency.
3. Complete the code according to your understanding on the jupyter platform, so that it can solve the eight-digit problem.
4. Read the concept of the admissibility of the algorithm, and consider how to prove the admissibility of the A* search algorithm in conjunction with the hints.
5. Understand the heuristic ability of $h(x)$ and think about how to prove the *conclusion 1*.
6. Please answer the reasons for extending the heuristic function to the evaluation function, and understand the role of $g(x)$ in the evaluation function.
7. Understand the monotonic restriction of the heuristic function $h(x)$ and prove the *conclusion 2*.

MOHAMED BIN ZAYED
UNIVERSITY OF
ARTIFICIAL INTELLIGENCE

# Q&A

- If you have any questions, you can ask me during lab sessions or contact at following email:

- ID: Maryam.Sultana@mbzuai.ac.ae