Assignment 1

Introduction

This assignment includes two parts, programming assignment and writing assignment. The deadline of this assignment is **17 Feb (11:59 PM), 2024**.

Part 1: Programming assignment

Download the code for this assignment here and then unzip the archive.

This assignment uses python 3. Do not use python 2.

You can work on the assignment using your favorite python editor. We recommend VSCode.

Post any questions or issues with this assignment to our discussion forum. Alternatively you may also contact your TA directly.

Problem 1: DFS-GSA (15 points)

In this part of the assignment you are going to implement

- a parser to read a search problem in the file `parse.py`, and
- Depth First Search (DFS) - Graph Search Algorithm (GSA) in the file `p1.py`

Both these python files have already been created for. Do not change anything that has already been implemented. Our autograder relies on the existing code. From the terminal you may run `python p1.py 1` to test if your code passes the first test case.

```
(base) AICourse@AICourse a1 % python p1.py 1
Grading Problem 1 :
----------> Test case 1 PASSED <----------
```

As you can see we have passed test case 1 here. This is because we have hardcoded the solution for you in this function.

```
def dfs_search(problem):
   #Your p1 code here
   solution = 'Ar D C\nAr C G'
   return solution
```

Note that this is exactly what the test case expects. To find out what the test case expects, you can open the file `test_cases/p1/1.sol`.

```
Ar D C
Ar C G
```

As you can see, the content of the file `test_cases/p1/1.sol` is identical to the return value of the function `dfs_search(problem)`.

Note that `test_cases/p1/1.sol` and other solution files consist of two lines of text that represent the following.

- Exploration order (i.e., the order in which states are added to the explored set)
- solution path (i.e., the first solution found)

You should return these two lines of text in the dfs_search() function above.

The exploration order is `Ar`, `D`, `C` and the solution path is `Ar`, `C`, `G`. The search problem definition can be found in the file `test_cases/p1/1.prob`, which we will introduce shortly.

Let's try another test case by changing the argument to the python program to `2`.

```
(base) AICourse@AICourse a1 % python p1.py 2
Grading Problem 1 :
----------> Test case 2 FAILED <----------
Your solution
Ar D C
Ar C G
Correct solution
A D
A D G
Delete "r" from position 1
Add " " to position 2
Add "D" to position 3
Add "
" to position 4
Add "A" to position 5
Delete "C" from position 9
Delete "
" from position 10
Delete "A" from position 11
Delete "r" from position 12
Delete " " from position 13
Delete "C" from position 14
Delete " " from position 15
```

We failed this test case. The correct solution can be found in `test_cases/p1/2.sol.`

```
A D
A D G
```

We will have to look at the `*.prob` files in the `test_case/p1/` folder to load the problem definition and then determine a corresponding solution. The `*.prob` files define weighted directed graphs with a single start state, a list of goal states, heuristics and arcs. For example,

consider the problem definition of the first test case defined in the file `test_cases/p1/1.prob`.

```
start_state: Ar
goal_states: G
Ar 0
B 0
C 0
D 0
G 0
Ar B 1.0
Ar C 2.0
Ar D 4.0
C G 8.0
```

The search problem is specified as follows.
line 1: start state
line 2: list of goal states separated by a space
line 3 … (n+2): (n = number of states) heuristic for each state

`<state> <heuristic>`

line (n+3) … end: state transitions of the form

`<start state> <end state> <cost>`

Note that we don't need the transition cost nor the heuristic for solving problem 1. However, you should implement the parsing for everything now so that you don't have to make modifications later.

You should decide on an appropriate data structure for the problem and return it from the following function in `parse.py`.

```
def read_graph_search_problem(file_path):
      #Your p1 code here
      problem = ''
      return problem
```

Once your implementation of both `read_graph_search_problem` and `dfs_search` is complete you can verify that you pass the first test case as follows.

```
(base) AICourse@AICourse a1 % python p1.py 1
Grading Problem 1 :
----------> Test case 1 PASSED <----------
```

You may check if you pass all 5 test cases as follows.

```
(base) AICourse@AICourse a1 % python p1.py -5
Grading Problem 1 :
----------> Test case 1 PASSED <----------
```

```
----------> Test case 2 PASSED <----------
----------> Test case 3 PASSED <----------
----------> Test case 4 PASSED <----------
----------> Test case 5 PASSED <----------
```

You may import anything from the Python Standard Library. Do not import packages that are not included in Python such as numpy.
Make sure that you pass all provided test cases before moving on to the next question. Note that we may use novel test cases for marking. You can also design your own new test cases for testing.

Problem 2: BFS-GSA (5 points)

In this part of the assignment you are going to implement Breadth First Search (BFS) - Graph Search Algorithm (GSA) in the file `p2.py`.

This should just involve copying over your DFS implementation from p1 and changing the `pop()` to `popleft()`.

Once you have done this, check if you pass all test cases as follows.

```
(base) AICourse@AICourse a1 % python p2.py -5
Grading Problem 2 :
----------> Test case 1 PASSED <----------
----------> Test case 2 PASSED <----------
----------> Test case 3 PASSED <----------
----------> Test case 4 PASSED <----------
----------> Test case 5 PASSED <----------
```

Problem 3: UCS-GSA (10 points)

In this part of the assignment you are going to implement Uniform Cost Search (UCS) - Graph Search Algorithm (GSA) in the file `p3.py`.

This should involve copying over your BFS implementation from p2 and changing the data structure to the priority queue.

Once you have done this, check if you pass test cases as follows.

```
(base) AICourse@AICourse a1 % python p3.py -6
Grading Problem 3 :
----------> Test case 1 PASSED <----------
----------> Test case 2 PASSED <----------
----------> Test case 3 PASSED <----------
----------> Test case 4 PASSED <----------
----------> Test case 5 PASSED <----------
```

```
----------> Test case 6 PASSED <----------
```

Note that there are 6 test cases this time.

Problem 4: Greedy (10 points)

In this part of the assignment you are going to implement Greedy Search - Graph Search Algorithm (GSA) in the file `p4.py`.

This should involve copying over your UCS implementation from p3 and making minor modifications.

Once you have done this, check if you pass test cases as follows.

```
(base) AICourse@AICourse a1 % python p4.py -6
Grading Problem 4 :
----------> Test case 1 PASSED <----------
----------> Test case 2 PASSED <----------
----------> Test case 3 PASSED <----------
----------> Test case 4 PASSED <----------
----------> Test case 5 PASSED <----------
----------> Test case 6 PASSED <----------
```

Problem 5: A* (10 points)

In this part of the assignment you are going to implement A* - Graph Search Algorithm (GSA) in the file `p5.py`.

This should involve copying over your Greedy implementation from p4 and adding the backward cost.

Once you have done this, check if you pass test cases as follows.

```
(base) AICourse@AICourse a1 % python p5.py -6
Grading Problem 5 :
----------> Test case 1 PASSED <----------
----------> Test case 2 PASSED <----------
----------> Test case 3 PASSED <----------
----------> Test case 4 PASSED <----------
----------> Test case 5 PASSED <----------
----------> Test case 6 PASSED <----------
```

Problem 6: 8 Queens Local Search - Number of Attacks (15 points)

The last two problems of this assignment use a different problem. Consider the content of the file `test_cases/p6/1.prob`.

```
. . . . . . . .
. . . . . . . .
. . . . . . . .
. . . q . . . .
q . . . q . . .
. q . . . q . q
. . q . . . q .
. . . . . . . .
```

It defines a state of the 8 Queens problem defined in class. In this problem you will load the problem in the following function of the file `parse.py`.

```
def read_8queens_search_problem(file_path):
     #Your p6 code here
     problem = ''
     return problem
```

Next, you will determine the attacks for each square in the following function of the file `p6.py`.

```
def number_of_attacks(problem):
     #Your p6 code here
```

The number of attacks for a particular square is defined as the number of direct and indirect attacks of other queens to that square, assuming the queen in the same column would move to that square.

For the first test case the correct number of attacks can be found in the file `test_cases/p6/1.sol` and is as follows.

```
18 12 14 13 13 12 14 14
14 16 13 15 12 14 12 16
14 12 18 13 15 12 14 14
15 14 14 17 13 16 13 16
17 14 17 15 17 14 16 16
17 17 16 18 15 17 15 17
18 14 17 15 15 14 17 16
14 14 13 17 12 14 12 18
```

Once you have implemented both functions correctly you should be able to pass all test cases.

```
(base) AICourse@AICourse a1 % python p6.py -4
Grading Problem 6 :
----------> Test case 1 PASSED <----------
----------> Test case 2 PASSED <----------
----------> Test case 3 PASSED <----------
```

```
----------> Test case 4 PASSED <----------
```

Problem 7: 8 Queens Local Search - Get a Better Board (10 points)

In this problem you will return a better board in the function `better_board` of the file `p7.py`. The better board moves one queen to the best position. Note that queens can only move to a position in the same column. If there are multiple best (i.e., lowest number of attacks) positions, you should select the first best position found if iterating row by row starting in the upper left.

Consider the first test case available in the file `test_cases/p7/1.prob`

```
. . . . . . . .
. . . . . . . .
. . . . . . . .
. . . q . . . .
q . . . q . . .
. q . . . q . q
. . q . . . q .
. . . . . . . .
```

and its corresponding solution available in the file `test_cases/p7/1.sol`.

```
. q . . . . . .
. . . . . . . .
. . . . . . . .
. . . q . . . .
q . . . q . . .
. . . . . q . q
. . q . . . q .
. . . . . . . .
```

Note that you may import existing code such as helper functions from your `p6.py` solution.

Once you are done, check for correctness as follows.

```
(base) AICourse@AICourse a1 % python p7.py -6
Grading Problem 7 :
----------> Test case 1 PASSED <----------
----------> Test case 2 PASSED <----------
----------> Test case 3 PASSED <----------
----------> Test case 4 PASSED <----------
----------> Test case 5 PASSED <----------
----------> Test case 6 PASSED <----------
```

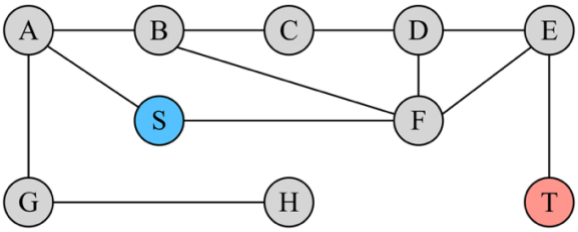
You may also use the following command to make sure you pass all test cases for this assignment.

```
(base) AICourse@AICourse a1 % python grader.py
```

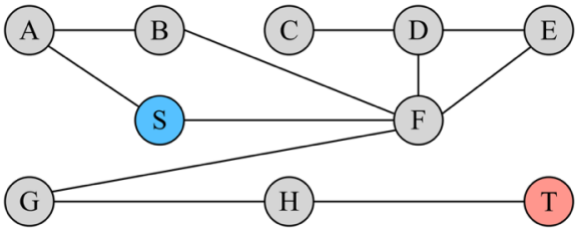
Part 2: Writing assignment

Answer the questions below and save your answers as "report.pdf".

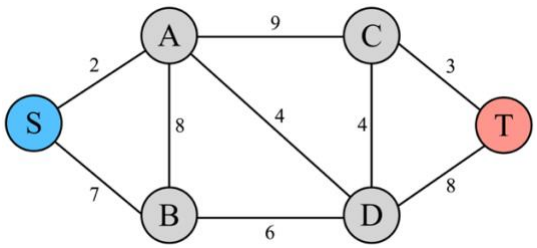
1. Apply the Breadth-First Search (BFS) algorithm to find a path from vertex S to vertex T in the given graph. In addition to the final path, you are also required to list the order in which nodes are expanded. (Assume lexicographic ordering when there are several choices) **(5 points)**



2. Apply the Depth-First Search (DFS) algorithm to find a path from vertex S to vertex T in the given graph. In addition to the final path, you are also required to list the order in which nodes are expanded. (Assume lexicographic ordering when there are several choices) **(5 points)**

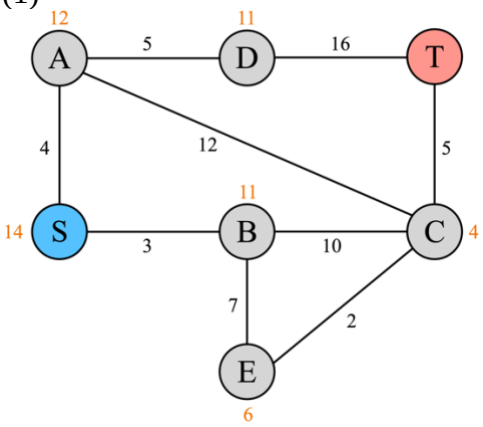


3. In the given graph, the number next to each edge is the cost of the performing the action corresponding to that edge. Apply the Uniform-Cost Search (UCS) algorithm to find a shortest path from vertex S to vertex T. In addition to the final path, you are also required to list the order in which nodes are expanded. (Assume lexicographic ordering when there are several choices) **(5 points)**

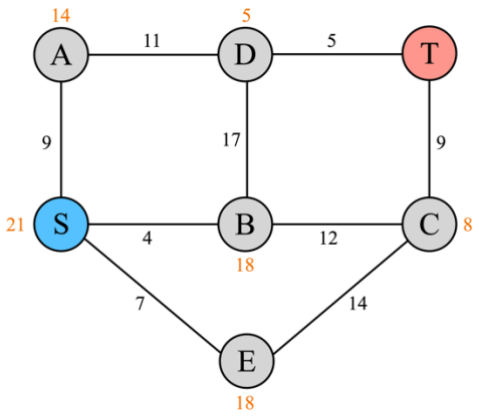


4. In the two given graphs, the number next to each edge is the cost of the performing the action corresponding to that edge. The number next to each vertex is the heuristic cost. Apply A* Search algorithm to find the shortest path from vertex S to vertex T. In addition to the final path, you are also required to 1) list the order in which nodes are expanded, 2) describe the concrete calculating and exploring steps (Assume lexicographic ordering when there are several choices) **(5 points + 5 points)**

(1)



(2)



Submission

To submit your assignment to Moodle, `*.zip` the following files ONLY:

- `p1.py`
- `p2.py`
- `p3.py`
- `p4.py`
- `p5.py`
- `p6.py`
- `p7.py`
- `parse.py`
- `report.pdf`

Do not zip any other files. Use the `*.zip` file format. Name the file UID.zip, where UID is your university number, like 3030661123.zip. Make sure that you have submitted the correct files and named all files correctly. We will deduct up to 5% for files with incorrectly file names.