CS 4613 **Fall 2022**

Project 1: 15-Puzzle Problem **E. K. Wong**

Total # points = 100.

Project Description: Implement the weighted *A** search algorithm with *graph search* for solving the 15-puzzle problem as described below. Use $h(n) =$ *Sum of Chessboard distances of the tiles from their goal positions* as heuristic function in the weighted *A** search and let *W* be an input parameter in your implementation. Your program will read in the initial and goal states, and the value for *W* from an input file and then generate an output file that contains the solution. [Reminder: *graph search* does not allow repeated states.]

15-puzzle problem: On a 4 x 4 board (as shown below) there are 15 tiles numbered from 1 to 15 and a blank position. A tile can slide into the blank position if it is horizontally or vertically adjacent to the blank position. Given a start board configuration and a goal board configuration, find a move sequence with a minimum number of moves to reach the goal configuration from the start configuration.

1	2	3	4
10	11		5
9	8	7	6
12	13	14	15

You can work on the project by yourself or form a team of two students to work on the project. You can discuss with your classmates on how to do the project but every team is expected to write their own code and submit their own project.

Input and output file formats: Your program will read in the value for *W*, the initial and goal states from a text file that contains 11 lines as shown in Figure 1 below. Line 1 contains the value for *W*. Line 2 is a blank line. Lines 3 to 6 contain the tile pattern for the initial state. Line 7 is a blank line. Lines 8 to 11 contain the tile pattern for the goal state. *W* is a floating point number. *n* and *m* are integers that range from 0 to 15, representing the blank position (0) and the tile numbers (1-15.)

Your program will produce an output file that contains 15 lines as shown in Figure 2 below. Lines 1 to 4 contain the tile pattern for the initial state. Line 5 is a blank line. Lines 6 to 9 contain the tile pattern for the goal state. You can just copy the initial and goal states from the input file to the output file. Line 10 is a blank line. Line 11 is the *W* value from the input file. Line 12 is the depth level *d* of the shallowest goal node as found by your search algorithm (assume the root node is at level 0.) Line 13 is the total number of nodes *N* generated in your tree (including the root node.) Line 14 contains the solution (a sequence of actions from root node to goal node) represented by A's. The A's are separated by blank spaces. Each A is a character from the set {L, R, U, D}, representing the left, right, up and down movements of the blank position. Line 15 contains the *f*(*n*) values of the nodes along the solution path from the root node to the goal node, separated by blank spaces. There should be *d* number of A values in line 14 and *d*+1 number of *f* values in line 15.

Testing your program: Input files will be provided on *Brightspace* for you to test your program. All input files are solvable; i.e., they have solutions.

Recommended languages: Python, C++/C and Java. If you would like to use a language other than these three, send me an email first.

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Submit on *Brightspace* by the due date:

1. Your source code file. Put comments in your source code to make it easier for someone else to read your program. Points will be taken off if you do not have comments in your source code.
2. The output files generated by your program for the input test files.
3. A PDF file that contains instructions on how to run your program. If your program requires compilation, instructions on how to compile your program should also be provided. Also, copy and paste your outputs and your source code onto the PDF file (to make it easier for us to grade your project.) This is in addition to the source code file and output files that you have to hand in separately, as described in (1) and (2) above.

If you work in a team of two, only one partner needs to submit but please write both partners' names on the source code and the PDF report.

```
W

n n n n
n n n n
n n n n
n n n n

m m m m
m m m m
m m m m
m m m m
```

Figure 1. Input file format (11 lines.)

```
***************************
n n n n
n n n n
n n n n
n n n n

m m m m
m m m m
m m m m
m m m m

W
d
N
A A A A A A A …………
f f f f f f f f ……………..
```

Figure 2. Output file format (15 lines.)