CS 4613 **Spring 2021**
Project 1: 15-Puzzle **E. K. Wong**

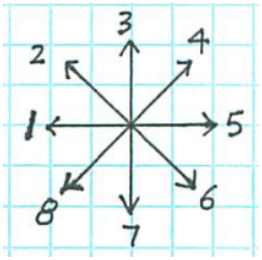
Total # points = 100. Figures 1 and 2 are on page 2.

Project Description: Implement the *A* Search Algorithm with Graph Search* for solving the 15-puzzle problem as described below. Use *sum of chessboard distances of tiles from their goal positions* as heuristic function, where chessboard distance is defined as the maximum of the horizontal and vertical distances. [Reminder: Graph Search does not allow repeated states.]

15-puzzle problem: On a 4 x 4 board 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*, *vertically* or *diagonally adjacent* to the blank position. Given a start board configuration and a goal board configuration, find a sequence of moves to reach the goal configuration from the start configuration. The goal is to find a solution with minimum number of moves.

To solve the puzzle problem, you can define eight virtual moves for the blank position:

1. Left
2. Up-left
3. Up
4. Up-right
5. Right
6. Down-right
7. Down
8. Down-left



You can work on the project alone or you can work in a team of two. 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 program and report.

Input and output file format: Your program will read in the initial and goal states from a text file that contains nine text lines as shown in Figure 1 below. Lines 1 to 4 contain the tile pattern for the initial state and lines 6 to 9 contain the tile pattern for the goal state. Line 5 is a blank line. *n* and *m* are integers that range from 0 to 15. Integer 0 represents a blank position and integers 1 to 15 represent tile numbers. Your program will produce an output text file that contains 14 lines as shown in Figure 2 below. Lines 1 to 4 and lines 6 to 9 contain the tile patterns for the initial and goal states as given in the input file. Lines 5 and 10 are blank lines. Line 11 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 12 is the total number of nodes *N* generated in your tree (including the root node.) Line 13 contains the solution that you have found. The solution is a sequence of actions (from root node to goal node) represented by the A's in line 13. Each A is a digit from 1 to 8 representing a virtual move of the blank position as illustrated above. Line 14 contains the $f(n)$ values of the nodes along the solution path, from root node to the goal node. There should be d number of A values in line 13 and $d+1$ number of f values in line 14.

Testing your program: Three input test files will be provided on NYU Classes for you to test your program.

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 NYU Classes by the due date. If you work in a team of two, only one partner needs to submit but put down both partners' names on the report.

1. A text file that contains the source code. 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 text files generated by your program for test input files 1 to 3.
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 the output text files 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 text files that you have to hand in as described in (1) and (2).

```
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.

```
**************************
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

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

Figure 2. Output file format. A is a digit from 1 to 8 representing a move direction as illustrated above.