Thomas Pollard
CS – 441 Artificial intelligence, Winter 2021
Programming 1 Report

AI – Programming Assignment 1

Overview

Programming1.py is my implementation of greedy best first search as well as A* search for solving the 8-puzzle problem and the 15-puzzle problem. The 8 and 15 problems are implemented as classes that contain a goal test, heuristic, and transition model functions (actions). There are three heuristics to evaluate the "correctness" of each state.

1. Heuristic 1 (h1 in the program) is the number of tiles misplaced.
2. Heuristic 2 (h2) is the total Manhattan distance of each tile from its goal location
3. Heuristic 3 (h3) is the average of h1 and h2

I used the same starting state for each heuristic on both the best first and A* search to give the comparisons meaning. I am going to discuss the results before showing the solutions because the solutions take up 12 pages. For the best first search, H1, H2, and H3 found solutions with average path length of 77, 73, and 66.2 respectively. For A* search, all heuristics found the optimal solution with an average path length of 24.2. There were some variations in performance though. H1 consistently took the greatest number of steps to find the solution in A* searches, followed by H3, where H2 was the fastest. For the best first search, which heuristic performed best was greatly determined by the starting state.

I also implemented the 15-puzzle solver which usually found solution with the best first search. H1, H2, and H3 found solutions with an average of 538.2, 258.6, and 246.2 steps respectively.

The A* solution for the 15-puzzle problem would occasionally find a solution, but only with H2. Most of the time, however, it would not find a solution within the generous 4 million iteration limit I specified. When it did find a solution, it was an average of 53 steps long.

8-Puzzle Best First Search Results

Start state	H1	Path	H2	Path	H3	Path
[['8' '2' '6'] ['7' '5' '1'] ['b' '4' '3']]	94	[8, 2, 6, 7, 5, 1, 'b', 4, 3] [8, 2, 6, 'b', 5, 1, 7, 4, 3] [8, 2, 6, 5, 'b', 1, 7, 4, 3] [8, 2, 6, 5, 1, 'b', 7, 4, 3] [8, 2, 'b', 5, 1, 6, 7, 4, 3] [8, 'b', 2, 5, 1, 6, 7, 4, 3] [8, 1, 2, 5, 'b', 6, 7, 4, 3] [8, 1, 2, 'b', 5, 6, 7, 4, 3] ['b', 1, 2, 8, 5, 6, 7, 4, 3] [1, 'b', 2, 8, 5, 6, 7, 4, 3] [1, 2, 'b', 8, 5, 6, 7, 4, 3] [1, 2, 6, 8, 5, 'b', 7, 4, 3] [1, 2, 6, 8, 5, 3, 7, 4, 'b'] [1, 2, 6, 8, 5, 3, 7, 'b', 4] [1, 2, 6, 8, 'b', 3, 7, 5, 4]	54	[8, 2, 6, 7, 5, 1, 'b', 4, 3] [8, 2, 6, 7, 5, 1, 4, 'b', 3] [8, 2, 6, 7, 'b', 1, 4, 5, 3] [8, 2, 6, 7, 1, 'b', 4, 5, 3] [8, 2, 'b', 7, 1, 6, 4, 5, 3] [8, 'b', 2, 7, 1, 6, 4, 5, 3] [8, 1, 2, 7, 'b', 6, 4, 5, 3] [8, 1, 2, 7, 5, 6, 4, 'b', 3] [8, 1, 2, 7, 5, 6, 'b', 4, 3] [8, 1, 2, 'b', 5, 6, 7, 4, 3] ['b', 1, 2, 8, 5, 6, 7, 4, 3] [1, 'b', 2, 8, 5, 6, 7, 4, 3] [1, 5, 2, 8, 'b', 6, 7, 4, 3] [1, 5, 2, 'b', 8, 6, 7, 4, 3] [1, 5, 2, 7, 8, 6, 'b', 4, 3] [1, 5, 2, 7, 8, 6, 4, 'b', 3] [1, 5, 2, 7, 'b', 6, 4, 8, 3]	46	[8, 2, 6, 7, 5, 1, 'b', 4, 3] [8, 2, 6, 'b', 5, 1, 7, 4, 3] [8, 2, 6, 5, 'b', 1, 7, 4, 3] [8, 2, 6, 5, 1, 'b', 7, 4, 3] [8, 2, 'b', 5, 1, 6, 7, 4, 3] [8, 'b', 2, 5, 1, 6, 7, 4, 3] [8, 1, 2, 5, 'b', 6, 7, 4, 3] [8, 1, 2, 'b', 5, 6, 7, 4, 3] ['b', 1, 2, 8, 5, 6, 7, 4, 3] [1, 'b', 2, 8, 5, 6, 7, 4, 3] [1, 5, 2, 8, 'b', 6, 7, 4, 3] [1, 5, 2, 'b', 8, 6, 7, 4, 3] [1, 5, 2, 7, 8, 6, 'b', 4, 3] [1, 5, 2, 7, 8, 6, 4, 'b', 3] [1, 5, 2, 7, 'b', 6, 4, 8, 3]

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		[1, 2, 6, 8, 3, 'b', 7, 5, 4] [1, 2, 'b', 8, 3, 6, 7, 5, 4] [1, 'b', 2, 8, 3, 6, 7, 5, 4] [1, 3, 2, 8, 'b', 6, 7, 5, 4] [1, 3, 2, 8, 5, 6, 7, 'b', 4] [1, 3, 2, 8, 5, 6, 7, 4, 'b'] [1, 3, 2, 8, 5, 'b', 7, 4, 6] [1, 3, 'b', 8, 5, 2, 7, 4, 6] [1, 'b', 3, 8, 5, 2, 7, 4, 6] [1, 5, 3, 8, 'b', 2, 7, 4, 6] [1, 5, 3, 8, 2, 'b', 7, 4, 6] [1, 5, 3, 8, 2, 6, 7, 4, 'b'] [1, 5, 3, 8, 2, 6, 7, 'b', 4] [1, 5, 3, 8, 2, 6, 'b', 7, 4] [1, 5, 3, 'b', 2, 6, 8, 7, 4] [1, 5, 3, 2, 'b', 6, 8, 7, 4] [1, 'b', 3, 2, 5, 6, 8, 7, 4] ['b', 1, 3, 2, 5, 6, 8, 7, 4] [2, 1, 3, 'b', 5, 6, 8, 7, 4] [2, 1, 3, 8, 5, 6, 'b', 7, 4] [2, 1, 3, 8, 5, 6, 7, 'b', 4] [2, 1, 3, 8, 'b', 6, 7, 5, 4] [2, 1, 3, 'b', 8, 6, 7, 5, 4] ['b', 1, 3, 2, 8, 6, 7, 5, 4] [1, 'b', 3, 2, 8, 6, 7, 5, 4] [1, 8, 3, 2, 'b', 6, 7, 5, 4] [1, 8, 3, 2, 5, 6, 7, 'b', 4] [1, 8, 3, 2, 5, 6, 'b', 7, 4] [1, 8, 3, 'b', 5, 6, 2, 7, 4] [1, 8, 3, 5, 'b', 6, 2, 7, 4] [1, 'b', 3, 5, 8, 6, 2, 7, 4] ['b', 1, 3, 5, 8, 6, 2, 7, 4] [5, 1, 3, 'b', 8, 6, 2, 7, 4] [5, 1, 3, 2, 8, 6, 'b', 7, 4] [5, 1, 3, 2, 8, 6, 7, 'b', 4] [5, 1, 3, 2, 'b', 6, 7, 8, 4] [5, 1, 3, 'b', 2, 6, 7, 8, 4] ['b', 1, 3, 5, 2, 6, 7, 8, 4] [1, 'b', 3, 5, 2, 6, 7, 8, 4] [1, 2, 3, 5, 'b', 6, 7, 8, 4] [1, 2, 3, 5, 6, 'b', 7, 8, 4] [1, 2, 3, 5, 6, 4, 7, 8, 'b'] [1, 2, 3, 5, 6, 4, 7, 'b', 8] [1, 2, 3, 5, 'b', 4, 7, 6, 8] [1, 2, 3, 'b', 5, 4, 7, 6, 8] [1, 2, 3, 7, 5, 4, 'b', 6, 8] [1, 2, 3, 7, 5, 4, 6, 'b', 8]		[1, 5, 2, 7, 8, 6, 4, 'b', 3] [1, 5, 2, 7, 'b', 6, 4, 8, 3] [1, 'b', 2, 7, 5, 6, 4, 8, 3] [1, 2, 'b', 7, 5, 6, 4, 8, 3] [1, 2, 6, 7, 5, 'b', 4, 8, 3] [1, 2, 6, 7, 5, 3, 4, 8, 'b'] [1, 2, 6, 7, 5, 3, 4, 'b', 8] [1, 2, 6, 7, 'b', 3, 4, 5, 8] [1, 2, 6, 7, 3, 'b', 4, 5, 8] [1, 2, 'b', 7, 3, 6, 4, 5, 8] [1, 'b', 2, 7, 3, 6, 4, 5, 8] [1, 3, 2, 7, 'b', 6, 4, 5, 8] [1, 3, 2, 7, 5, 6, 4, 'b', 8] [1, 3, 2, 7, 5, 6, 4, 8, 'b'] [1, 3, 2, 7, 5, 'b', 4, 8, 6] [1, 3, 'b', 7, 5, 2, 4, 8, 6] [1, 'b', 3, 7, 5, 2, 4, 8, 6] [1, 5, 3, 7, 'b', 2, 4, 8, 6] [1, 5, 3, 7, 2, 'b', 4, 8, 6] [1, 5, 3, 7, 2, 6, 4, 8, 'b'] [1, 5, 3, 7, 2, 6, 4, 'b', 8] [1, 5, 3, 7, 2, 6, 'b', 4, 8] [1, 5, 3, 'b', 2, 6, 7, 4, 8] [1, 5, 3, 2, 'b', 6, 7, 4, 8] [1, 5, 3, 2, 4, 6, 7, 'b', 8] [1, 5, 3, 2, 4, 6, 'b', 7, 8] [1, 5, 3, 'b', 4, 6, 2, 7, 8] [1, 5, 3, 4, 'b', 6, 2, 7, 8] [1, 'b', 3, 4, 5, 6, 2, 7, 8] ['b', 1, 3, 4, 5, 6, 2, 7, 8] [4, 1, 3, 'b', 5, 6, 2, 7, 8] [4, 1, 3, 2, 5, 6, 'b', 7, 8] [4, 1, 3, 2, 5, 6, 7, 'b', 8] [4, 1, 3, 2, 'b', 6, 7, 5, 8] [4, 1, 3, 'b', 2, 6, 7, 5, 8] ['b', 1, 3, 4, 2, 6, 7, 5, 8] [1, 'b', 3, 4, 2, 6, 7, 5, 8] [1, 2, 3, 4, 'b', 6, 7, 5, 8] [1, 2, 3, 4, 5, 6, 7, 'b', 8] [1, 2, 3, 4, 5, 6, 7, 8, 'b']		[1, 'b', 2, 7, 5, 6, 4, 8, 3] [1, 2, 'b', 7, 5, 6, 4, 8, 3] [1, 2, 6, 7, 5, 'b', 4, 8, 3] [1, 2, 6, 7, 5, 3, 4, 8, 'b'] [1, 2, 6, 7, 5, 3, 4, 'b', 8] [1, 2, 6, 7, 5, 3, 'b', 4, 8] [1, 2, 6, 'b', 5, 3, 7, 4, 8] [1, 2, 6, 5, 'b', 3, 7, 4, 8] [1, 2, 6, 5, 3, 'b', 7, 4, 8] [1, 2, 'b', 5, 3, 6, 7, 4, 8] [1, 'b', 2, 5, 3, 6, 7, 4, 8] [1, 3, 2, 5, 'b', 6, 7, 4, 8] [1, 3, 2, 5, 4, 6, 7, 'b', 8] [1, 3, 2, 5, 4, 6, 7, 8, 'b'] [1, 3, 2, 5, 4, 'b', 7, 8, 6] [1, 3, 2, 5, 'b', 4, 7, 8, 6] [1, 'b', 2, 5, 3, 4, 7, 8, 6] [1, 2, 'b', 5, 3, 4, 7, 8, 6] [1, 2, 4, 5, 3, 'b', 7, 8, 6] [1, 2, 4, 5, 'b', 3, 7, 8, 6] [1, 2, 4, 'b', 5, 3, 7, 8, 6] ['b', 2, 4, 1, 5, 3, 7, 8, 6] [2, 'b', 4, 1, 5, 3, 7, 8, 6] [2, 4, 'b', 1, 5, 3, 7, 8, 6] [2, 4, 3, 1, 5, 'b', 7, 8, 6] [2, 4, 3, 1, 'b', 5, 7, 8, 6] [2, 'b', 3, 1, 4, 5, 7, 8, 6] ['b', 2, 3, 1, 4, 5, 7, 8, 6] [1, 2, 3, 'b', 4, 5, 7, 8, 6] [1, 2, 3, 4, 'b', 5, 7, 8, 6] [1, 2, 3, 4, 5, 'b', 7, 8, 6] [1, 2, 3, 4, 5, 6, 7, 8, 'b']

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[['8' '4' '6'] ['7' '3' '5'] ['b' '1' '2']]	106	Omitted because of length > 100	80	[8, 4, 6, 7, 3, 5, 'b', 1, 2] [8, 4, 6, 'b', 3, 5, 7, 1, 2] ['b', 4, 6, 8, 3, 5, 7, 1, 2] [4, 'b', 6, 8, 3, 5, 7, 1, 2] [4, 3, 6, 8, 'b', 5, 7, 1, 2] [4, 3, 6, 8, 5, 'b', 7, 1, 2] [4, 3, 'b', 8, 5, 6, 7, 1, 2] [4, 'b', 3, 8, 5, 6, 7, 1, 2] [4, 5, 3, 8, 'b', 6, 7, 1, 2] [4, 5, 3, 'b', 8, 6, 7, 1, 2] [4, 5, 3, 7, 8, 6, 'b', 1, 2] [4, 5, 3, 7, 8, 6, 1, 'b', 2] [4, 5, 3, 7, 'b', 6, 1, 8, 2] [4, 5, 3, 'b', 7, 6, 1, 8, 2]	62	[8, 4, 6, 7, 3, 5, 'b', 1, 2] [8, 4, 6, 'b', 3, 5, 7, 1, 2] ['b', 4, 6, 8, 3, 5, 7, 1, 2] [4, 'b', 6, 8, 3, 5, 7, 1, 2] [4, 3, 6, 8, 'b', 5, 7, 1, 2] [4, 3, 6, 8, 5, 'b', 7, 1, 2] [4, 3, 'b', 8, 5, 6, 7, 1, 2] [4, 'b', 3, 8, 5, 6, 7, 1, 2] [4, 5, 3, 8, 'b', 6, 7, 1, 2] [4, 5, 3, 8, 1, 6, 7, 'b', 2] [4, 5, 3, 8, 1, 6, 'b', 7, 2] [4, 5, 3, 'b', 1, 6, 8, 7, 2] [4, 5, 3, 1, 'b', 6, 8, 7, 2] [4, 'b', 3, 1, 5, 6, 8, 7, 2]

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				[2, 1, 3, 'b', 5, 6, 4, 8, 7]		[1, 3, 2, 4, 5, 'b', 7, 6, 8]
				['b', 1, 3, 2, 5, 6, 4, 8, 7]		[1, 3, 2, 4, 'b', 5, 7, 6, 8]
				[1, 'b', 3, 2, 5, 6, 4, 8, 7]		[1, 3, 2, 4, 6, 5, 7, 'b', 8]
				[1, 5, 3, 2, 'b', 6, 4, 8, 7]		[1, 3, 2, 4, 6, 5, 7, 8, 'b']
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				[1, 5, 3, 4, 2, 6, 'b', 8, 7]		[1, 3, 2, 4, 'b', 6, 7, 8, 5]
				[1, 5, 3, 4, 2, 6, 8, 'b', 7]		[1, 'b', 2, 4, 3, 6, 7, 8, 5]
				[1, 5, 3, 4, 2, 6, 8, 7, 'b']		[1, 2, 'b', 4, 3, 6, 7, 8, 5]
				[1, 5, 3, 4, 2, 'b', 8, 7, 6]		[1, 2, 6, 4, 3, 'b', 7, 8, 5]
				[1, 5, 3, 4, 'b', 2, 8, 7, 6]		[1, 2, 6, 4, 3, 5, 7, 8, 'b']
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[['2' '8' '5'] ['6' '7' '4'] ['b' '1' '3']]	46	[2, 8, 5, 6, 7, 4, 'b', 1, 3] [2, 8, 5, 'b', 7, 4, 6, 1, 3] [2, 8, 5, 7, 'b', 4, 6, 1, 3] [2, 8, 5, 7, 1, 4, 6, 'b', 3] [2, 8, 5, 7, 1, 4, 'b', 6, 3] [2, 8, 5, 'b', 1, 4, 7, 6, 3] [2, 8, 5, 1, 'b', 4, 7, 6, 3] [2, 'b', 5, 1, 8, 4, 7, 6, 3] ['b', 2, 5, 1, 8, 4, 7, 6, 3] [1, 2, 5, 'b', 8, 4, 7, 6, 3] [1, 2, 5, 8, 'b', 4, 7, 6, 3] [1, 2, 5, 8, 4, 'b', 7, 6, 3] [1, 2, 5, 8, 4, 3, 7, 6, 'b'] [1, 2, 5, 8, 4, 3, 7, 'b', 6] [1, 2, 5, 8, 'b', 3, 7, 4, 6] [1, 'b', 5, 8, 2, 3, 7, 4, 6] [1, 5, 'b', 8, 2, 3, 7, 4, 6] [1, 5, 3, 8, 2, 'b', 7, 4, 6] [1, 5, 3, 8, 'b', 2, 7, 4, 6] [1, 5, 3, 'b', 8, 2, 7, 4, 6] [1, 5, 3, 7, 8, 2, 'b', 4, 6] [1, 5, 3, 7, 8, 2, 4, 'b', 6] [1, 5, 3, 7, 'b', 2, 4, 8, 6] [1, 5, 3, 7, 2, 'b', 4, 8, 6] [1, 5, 3, 7, 2, 6, 4, 8, 'b'] [1, 5, 3, 7, 2, 6, 4, 'b', 8] [1, 5, 3, 7, 2, 6, 'b', 4, 8]	30	[2, 8, 5, 6, 7, 4, 'b', 1, 3] [2, 8, 5, 6, 7, 4, 1, 'b', 3] [2, 8, 5, 6, 'b', 4, 1, 7, 3] [2, 8, 5, 'b', 6, 4, 1, 7, 3] [2, 8, 5, 1, 6, 4, 'b', 7, 3] [2, 8, 5, 1, 6, 4, 7, 'b', 3] [2, 8, 5, 1, 'b', 4, 7, 6, 3] [2, 8, 5, 1, 4, 'b', 7, 6, 3] [2, 8, 5, 1, 4, 3, 7, 6, 'b'] [2, 8, 5, 1, 4, 3, 7, 'b', 6] [2, 8, 5, 1, 'b', 3, 7, 4, 6] [2, 'b', 5, 1, 8, 3, 7, 4, 6] [2, 5, 'b', 1, 8, 3, 7, 4, 6] [2, 5, 3, 1, 8, 'b', 7, 4, 6] [2, 5, 3, 1, 8, 6, 7, 4, 'b'] [2, 5, 3, 1, 8, 6, 7, 'b', 4] [2, 5, 3, 1, 'b', 6, 7, 8, 4] [2, 'b', 3, 1, 5, 6, 7, 8, 4] ['b', 2, 3, 1, 5, 6, 7, 8, 4] [1, 2, 3, 'b', 5, 6, 7, 8, 4] [1, 2, 3, 7, 5, 6, 'b', 8, 4] [1, 2, 3, 7, 5, 6, 8, 'b', 4] [1, 2, 3, 7, 5, 6, 8, 4, 'b'] [1, 2, 3, 7, 5, 'b', 8, 4, 6] [1, 2, 3, 7, 'b', 5, 8, 4, 6] [1, 2, 3, 7, 4, 5, 8, 'b', 6] [1, 2, 3, 7, 4, 5, 'b', 8, 6]	82	[2, 8, 5, 6, 7, 4, 'b', 1, 3] [2, 8, 5, 6, 7, 4, 1, 'b', 3] [2, 8, 5, 6, 'b', 4, 1, 7, 3] [2, 8, 5, 'b', 6, 4, 1, 7, 3] [2, 8, 5, 1, 6, 4, 'b', 7, 3] [2, 8, 5, 1, 6, 4, 7, 'b', 3] [2, 8, 5, 1, 'b', 4, 7, 6, 3] [2, 8, 5, 1, 4, 'b', 7, 6, 3] [2, 8, 5, 1, 4, 3, 7, 6, 'b'] [2, 8, 5, 1, 4, 3, 7, 'b', 6] [2, 8, 5, 1, 'b', 3, 7, 4, 6] [2, 'b', 5, 1, 8, 3, 7, 4, 6] ['b', 2, 5, 1, 8, 3, 7, 4, 6] [1, 2, 5, 'b', 8, 3, 7, 4, 6] [1, 2, 5, 7, 8, 3, 'b', 4, 6] [1, 2, 5, 7, 8, 3, 4, 'b', 6] [1, 2, 5, 7, 'b', 3, 4, 8, 6] [1, 2, 5, 'b', 7, 3, 4, 8, 6] [1, 2, 5, 4, 7, 3, 'b', 8, 6] [1, 2, 5, 4, 7, 3, 8, 'b', 6] [1, 2, 5, 4, 'b', 3, 8, 7, 6] [1, 'b', 5, 4, 2, 3, 8, 7, 6] [1, 5, 'b', 4, 2, 3, 8, 7, 6] [1, 5, 3, 4, 2, 'b', 8, 7, 6] [1, 5, 3, 4, 'b', 2, 8, 7, 6] [1, 'b', 3, 4, 5, 2, 8, 7, 6] [1, 3, 'b', 4, 5, 2, 8, 7, 6]

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[['1' 'b' '8'] ['5' '2' '4'] ['3' '6' '7']]	75	[1, 'b', 8, 5, 2, 4, 3, 6, 7] [1, 2, 8, 5, 'b', 4, 3, 6, 7] [1, 2, 8, 'b', 5, 4, 3, 6, 7] [1, 2, 8, 3, 5, 4, 'b', 6, 7] [1, 2, 8, 3, 5, 4, 6, 'b', 7] [1, 2, 8, 3, 5, 4, 6, 7, 'b'] [1, 2, 8, 3, 5, 'b', 6, 7, 4] [1, 2, 8, 3, 'b', 5, 6, 7, 4] [1, 2, 8, 3, 7, 5, 6, 'b', 4] [1, 2, 8, 3, 7, 5, 'b', 6, 4] [1, 2, 8, 'b', 7, 5, 3, 6, 4] [1, 2, 8, 7, 'b', 5, 3, 6, 4] [1, 2, 8, 7, 5, 'b', 3, 6, 4] [1, 2, 8, 7, 5, 4, 3, 6, 'b'] [1, 2, 8, 7, 5, 4, 3, 'b', 6] [1, 2, 8, 7, 5, 4, 'b', 3, 6] [1, 2, 8, 'b', 5, 4, 7, 3, 6] [1, 2, 8, 5, 'b', 4, 7, 3, 6] [1, 2, 8, 5, 4, 'b', 7, 3, 6] [1, 2, 8, 5, 4, 6, 7, 3, 'b'] [1, 2, 8, 5, 4, 6, 7, 'b', 3] [1, 2, 8, 5, 4, 6, 'b', 7, 3] [1, 2, 8, 'b', 4, 6, 5, 7, 3] [1, 2, 8, 4, 'b', 6, 5, 7, 3] [1, 2, 8, 4, 6, 'b', 5, 7, 3] [1, 2, 8, 4, 6, 3, 5, 7, 'b'] [1, 2, 8, 4, 6, 3, 5, 'b', 7] [1, 2, 8, 4, 'b', 3, 5, 6, 7] [1, 'b', 8, 4, 2, 3, 5, 6, 7] [1, 8, 'b', 4, 2, 3, 5, 6, 7] [1, 8, 3, 4, 2, 'b', 5, 6, 7] [1, 8, 3, 4, 'b', 2, 5, 6, 7] [1, 8, 3, 4, 6, 2, 5, 'b', 7] [1, 8, 3, 4, 6, 2, 5, 7, 'b'] [1, 8, 3, 4, 6, 'b', 5, 7, 2] [1, 8, 3, 4, 'b', 6, 5, 7, 2] [1, 8, 3, 4, 7, 6, 5, 'b', 2] [1, 8, 3, 4, 7, 6, 'b', 5, 2]	103	Omitted because of solution > 100	51	[1, 'b', 8, 5, 2, 4, 3, 6, 7] [1, 2, 8, 5, 'b', 4, 3, 6, 7] [1, 2, 8, 5, 6, 4, 3, 'b', 7] [1, 2, 8, 5, 6, 4, 3, 7, 'b'] [1, 2, 8, 5, 6, 'b', 3, 7, 4] [1, 2, 8, 5, 'b', 6, 3, 7, 4] [1, 2, 8, 'b', 5, 6, 3, 7, 4] [1, 2, 8, 3, 5, 6, 'b', 7, 4] [1, 2, 8, 3, 5, 6, 7, 'b', 4] [1, 2, 8, 3, 5, 6, 7, 4, 'b'] [1, 2, 8, 3, 5, 'b', 7, 4, 6] [1, 2, 8, 3, 'b', 5, 7, 4, 6] [1, 2, 8, 'b', 3, 5, 7, 4, 6] [1, 2, 8, 7, 3, 5, 'b', 4, 6] [1, 2, 8, 7, 3, 5, 4, 'b', 6] [1, 2, 8, 7, 'b', 5, 4, 3, 6] [1, 2, 8, 7, 5, 'b', 4, 3, 6] [1, 2, 8, 7, 5, 6, 4, 3, 'b'] [1, 2, 8, 7, 5, 6, 4, 'b', 3] [1, 2, 8, 7, 'b', 6, 4, 5, 3] [1, 2, 8, 'b', 7, 6, 4, 5, 3] [1, 2, 8, 4, 7, 6, 'b', 5, 3] [1, 2, 8, 4, 7, 6, 5, 'b', 3] [1, 2, 8, 4, 'b', 6, 5, 7, 3] [1, 2, 8, 4, 6, 'b', 5, 7, 3] [1, 2, 'b', 4, 6, 8, 5, 7, 3] [1, 'b', 2, 4, 6, 8, 5, 7, 3] [1, 6, 2, 4, 'b', 8, 5, 7, 3] [1, 6, 2, 4, 8, 'b', 5, 7, 3] [1, 6, 2, 4, 8, 3, 5, 7, 'b'] [1, 6, 2, 4, 8, 3, 5, 'b', 7] [1, 6, 2, 4, 'b', 3, 5, 8, 7] [1, 'b', 2, 4, 6, 3, 5, 8, 7] [1, 2, 'b', 4, 6, 3, 5, 8, 7] [1, 2, 3, 4, 6, 'b', 5, 8, 7] [1, 2, 3, 4, 'b', 6, 5, 8, 7] [1, 2, 3, 'b', 4, 6, 5, 8, 7] [1, 2, 3, 5, 4, 6, 'b', 8, 7]

		[1, 8, 3, 'b', 7, 6, 4, 5, 2] [1, 8, 3, 7, 'b', 6, 4, 5, 2] [1, 8, 3, 7, 5, 6, 4, 'b', 2] [1, 8, 3, 7, 5, 6, 'b', 4, 2] [1, 8, 3, 'b', 5, 6, 7, 4, 2] [1, 8, 3, 5, 'b', 6, 7, 4, 2] [1, 8, 3, 5, 4, 6, 7, 'b', 2] [1, 8, 3, 5, 4, 6, 7, 2, 'b'] [1, 8, 3, 5, 4, 'b', 7, 2, 6] [1, 8, 3, 5, 'b', 4, 7, 2, 6] [1, 8, 3, 5, 2, 4, 7, 'b', 6] [1, 8, 3, 5, 2, 4, 7, 6, 'b'] [1, 8, 3, 5, 2, 'b', 7, 6, 4] [1, 8, 3, 5, 'b', 2, 7, 6, 4] [1, 'b', 3, 5, 8, 2, 7, 6, 4] [1, 3, 'b', 5, 8, 2, 7, 6, 4] [1, 3, 2, 5, 8, 'b', 7, 6, 4] [1, 3, 2, 5, 8, 4, 7, 6, 'b'] [1, 3, 2, 5, 8, 4, 7, 'b', 6] [1, 3, 2, 5, 'b', 4, 7, 8, 6] [1, 'b', 2, 5, 3, 4, 7, 8, 6] [1, 2, 'b', 5, 3, 4, 7, 8, 6] [1, 2, 4, 5, 3, 'b', 7, 8, 6] [1, 2, 4, 5, 'b', 3, 7, 8, 6] [1, 2, 4, 'b', 5, 3, 7, 8, 6] ['b', 2, 4, 1, 5, 3, 7, 8, 6] [2, 'b', 4, 1, 5, 3, 7, 8, 6] [2, 4, 'b', 1, 5, 3, 7, 8, 6] [2, 4, 3, 1, 5, 'b', 7, 8, 6] [2, 4, 3, 1, 5, 6, 7, 8, 'b'] [2, 4, 3, 1, 5, 6, 7, 'b', 8] [2, 4, 3, 1, 'b', 6, 7, 5, 8] [2, 'b', 3, 1, 4, 6, 7, 5, 8] ['b', 2, 3, 1, 4, 6, 7, 5, 8] [1, 2, 3, 'b', 4, 6, 7, 5, 8] [1, 2, 3, 4, 'b', 6, 7, 5, 8] [1, 2, 3, 4, 5, 6, 7, 'b', 8] [1, 2, 3, 4, 5, 6, 7, 8, 'b']				[1, 2, 3, 5, 4, 6, 8, 'b', 7] [1, 2, 3, 5, 'b', 6, 8, 4, 7] [1, 2, 3, 'b', 5, 6, 8, 4, 7] [1, 2, 3, 8, 5, 6, 'b', 4, 7] [1, 2, 3, 8, 5, 6, 4, 'b', 7] [1, 2, 3, 8, 5, 6, 4, 7, 'b'] [1, 2, 3, 8, 5, 'b', 4, 7, 6] [1, 2, 3, 8, 'b', 5, 4, 7, 6] [1, 2, 3, 'b', 8, 5, 4, 7, 6] [1, 2, 3, 4, 8, 5, 'b', 7, 6] [1, 2, 3, 4, 8, 5, 7, 'b', 6] [1, 2, 3, 4, 'b', 5, 7, 8, 6] [1, 2, 3, 4, 5, 'b', 7, 8, 6] [1, 2, 3, 4, 5, 6, 7, 8, 'b']
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Thomas Pollard
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		[2, 8, 3, 'b', 5, 6, 4, 7, 1]		[8, 'b', 3, 7, 2, 6, 4, 5, 1]		[8, 'b', 3, 7, 2, 6, 4, 5, 1]
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		[2, 8, 3, 4, 6, 'b', 7, 5, 1]		[8, 2, 3, 'b', 5, 6, 7, 4, 1]		[8, 2, 3, 7, 5, 'b', 4, 1, 6]
		[2, 8, 3, 4, 6, 1, 7, 5, 'b']		[8, 2, 3, 5, 'b', 6, 7, 4, 1]		[8, 2, 3, 7, 'b', 5, 4, 1, 6]
		[2, 8, 3, 4, 6, 1, 7, 'b', 5]		[8, 2, 3, 5, 4, 6, 7, 'b', 1]		[8, 2, 3, 7, 1, 5, 4, 'b', 6]
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		['b', 2, 3, 4, 8, 1, 7, 6, 5]		[8, 2, 3, 5, 'b', 4, 7, 1, 6]		[8, 2, 3, 1, 'b', 5, 7, 4, 6]
		[4, 2, 3, 'b', 8, 1, 7, 6, 5]		[8, 2, 3, 'b', 5, 4, 7, 1, 6]		[8, 2, 3, 1, 5, 'b', 7, 4, 6]
		[4, 2, 3, 7, 8, 1, 'b', 6, 5]		['b', 2, 3, 8, 5, 4, 7, 1, 6]		[8, 2, 3, 1, 5, 6, 7, 4, 'b']
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		[4, 2, 3, 7, 'b', 1, 6, 8, 5]		[2, 5, 3, 8, 'b', 4, 7, 1, 6]		[8, 2, 3, 1, 'b', 6, 7, 5, 4]
		[4, 2, 3, 7, 1, 'b', 6, 8, 5]		[2, 5, 3, 8, 4, 'b', 7, 1, 6]		[8, 'b', 3, 1, 2, 6, 7, 5, 4]
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		[4, 2, 3, 'b', 1, 5, 7, 6, 8]		[2, 5, 3, 'b', 4, 6, 8, 7, 1]		[1, 'b', 3, 2, 8, 6, 7, 5, 4]
		[4, 2, 3, 1, 'b', 5, 7, 6, 8]		[2, 5, 3, 4, 'b', 6, 8, 7, 1]		['b', 1, 3, 2, 8, 6, 7, 5, 4]
		[4, 2, 3, 1, 6, 5, 7, 'b', 8]		[2, 'b', 3, 4, 5, 6, 8, 7, 1]		[2, 1, 3, 'b', 8, 6, 7, 5, 4]
		[4, 2, 3, 1, 6, 5, 7, 8, 'b']		['b', 2, 3, 4, 5, 6, 8, 7, 1]		[2, 1, 3, 8, 'b', 6, 7, 5, 4]
		[4, 2, 3, 1, 6, 'b', 7, 8, 5]		[4, 2, 3, 'b', 5, 6, 8, 7, 1]		[2, 1, 3, 8, 5, 6, 7, 'b', 4]
		[4, 2, 3, 1, 'b', 6, 7, 8, 5]		[4, 2, 3, 8, 5, 6, 'b', 7, 1]		[2, 1, 3, 8, 5, 6, 'b', 7, 4]
		[4, 2, 3, 'b', 1, 6, 7, 8, 5]		[4, 2, 3, 8, 5, 6, 7, 'b', 1]		[2, 1, 3, 'b', 5, 6, 8, 7, 4]
		[4, 2, 3, 7, 1, 6, 'b', 8, 5]		[4, 2, 3, 8, 5, 6, 7, 1, 'b']		['b', 1, 3, 2, 5, 6, 8, 7, 4]
		[4, 2, 3, 7, 1, 6, 8, 'b', 5]		[4, 2, 3, 8, 5, 'b', 7, 1, 6]		[1, 'b', 3, 2, 5, 6, 8, 7, 4]
		[4, 2, 3, 7, 'b', 6, 8, 1, 5]		[4, 2, 3, 8, 'b', 5, 7, 1, 6]		[1, 5, 3, 2, 'b', 6, 8, 7, 4]
		[4, 2, 3, 'b', 7, 6, 8, 1, 5]		[4, 2, 3, 'b', 8, 5, 7, 1, 6]		[1, 5, 3, 'b', 2, 6, 8, 7, 4]
		['b', 2, 3, 4, 7, 6, 8, 1, 5]		[4, 2, 3, 7, 8, 5, 'b', 1, 6]		[1, 5, 3, 8, 2, 6, 'b', 7, 4]
		[2, 'b', 3, 4, 7, 6, 8, 1, 5]		[4, 2, 3, 7, 8, 5, 1, 'b', 6]		[1, 5, 3, 8, 2, 6, 7, 'b', 4]
		[2, 7, 3, 4, 'b', 6, 8, 1, 5]		[4, 2, 3, 7, 'b', 5, 1, 8, 6]		[1, 5, 3, 8, 2, 6, 7, 4, 'b']
		[2, 7, 3, 4, 1, 6, 8, 'b', 5]		[4, 2, 3, 'b', 7, 5, 1, 8, 6]		[1, 5, 3, 8, 2, 'b', 7, 4, 6]
		[2, 7, 3, 4, 1, 6, 'b', 8, 5]		[4, 2, 3, 1, 7, 5, 'b', 8, 6]		[1, 5, 3, 8, 'b', 2, 7, 4, 6]
		[2, 7, 3, 'b', 1, 6, 4, 8, 5]		[4, 2, 3, 1, 7, 5, 8, 'b', 6]		[1, 'b', 3, 8, 5, 2, 7, 4, 6]
		[2, 7, 3, 1, 'b', 6, 4, 8, 5]		[4, 2, 3, 1, 'b', 5, 8, 7, 6]		[1, 3, 'b', 8, 5, 2, 7, 4, 6]
		[2, 'b', 3, 1, 7, 6, 4, 8, 5]		[4, 2, 3, 1, 5, 'b', 8, 7, 6]		[1, 3, 2, 8, 5, 'b', 7, 4, 6]
		['b', 2, 3, 1, 7, 6, 4, 8, 5]		[4, 2, 3, 1, 5, 6, 8, 7, 'b']		[1, 3, 2, 8, 5, 6, 7, 4, 'b']
		[1, 2, 3, 'b', 7, 6, 4, 8, 5]		[4, 2, 3, 1, 5, 6, 8, 'b', 7]		[1, 3, 2, 8, 5, 6, 7, 'b', 4]
		[1, 2, 3, 4, 7, 6, 'b', 8, 5]		[4, 2, 3, 1, 'b', 6, 8, 5, 7]		[1, 3, 2, 8, 'b', 6, 7, 5, 4]
		[1, 2, 3, 4, 7, 6, 8, 'b', 5]		[4, 2, 3, 'b', 1, 6, 8, 5, 7]		[1, 'b', 2, 8, 3, 6, 7, 5, 4]
		[1, 2, 3, 4, 7, 6, 8, 5, 'b']		['b', 2, 3, 4, 1, 6, 8, 5, 7]		[1, 2, 'b', 8, 3, 6, 7, 5, 4]
		[1, 2, 3, 4, 7, 'b', 8, 5, 6]		[2, 'b', 3, 4, 1, 6, 8, 5, 7]		[1, 2, 6, 8, 3, 'b', 7, 5, 4]
		[1, 2, 3, 4, 'b', 7, 8, 5, 6]		[2, 1, 3, 4, 'b', 6, 8, 5, 7]		[1, 2, 6, 8, 'b', 3, 7, 5, 4]
		[1, 2, 3, 4, 5, 7, 8, 'b', 6]		[2, 1, 3, 4, 5, 6, 8, 'b', 7]		[1, 2, 6, 8, 5, 3, 7, 'b', 4]
		[1, 2, 3, 4, 5, 7, 'b', 8, 6]		[2, 1, 3, 4, 5, 6, 'b', 8, 7]		[1, 2, 6, 8, 5, 3, 7, 4, 'b']
		[1, 2, 3, 'b', 5, 7, 4, 8, 6]		[2, 1, 3, 'b', 5, 6, 4, 8, 7]		[1, 2, 6, 8, 5, 'b', 7, 4, 3]

		[1, 2, 3, 5, 'b', 7, 4, 8, 6] [1, 2, 3, 5, 7, 'b', 4, 8, 6] [1, 2, 3, 5, 7, 6, 4, 8, 'b'] [1, 2, 3, 5, 7, 6, 4, 'b', 8] [1, 2, 3, 5, 'b', 6, 4, 7, 8] [1, 2, 3, 'b', 5, 6, 4, 7, 8] [1, 2, 3, 4, 5, 6, 'b', 7, 8] [1, 2, 3, 4, 5, 6, 7, 'b', 8] [1, 2, 3, 4, 5, 6, 7, 8, 'b']		['b', 1, 3, 2, 5, 6, 4, 8, 7] [1, 'b', 3, 2, 5, 6, 4, 8, 7] [1, 5, 3, 2, 'b', 6, 4, 8, 7] [1, 5, 3, 'b', 2, 6, 4, 8, 7] [1, 5, 3, 4, 2, 6, 'b', 8, 7] [1, 5, 3, 4, 2, 6, 8, 'b', 7] [1, 5, 3, 4, 2, 6, 8, 7, 'b'] [1, 5, 3, 4, 2, 'b', 8, 7, 6] [1, 5, 3, 4, 'b', 2, 8, 7, 6] [1, 'b', 3, 4, 5, 2, 8, 7, 6] [1, 3, 'b', 4, 5, 2, 8, 7, 6] [1, 3, 2, 4, 5, 'b', 8, 7, 6] [1, 3, 2, 4, 'b', 5, 8, 7, 6] [1, 3, 2, 4, 7, 5, 8, 'b', 6] [1, 3, 2, 4, 7, 5, 'b', 8, 6] [1, 3, 2, 'b', 7, 5, 4, 8, 6] [1, 3, 2, 7, 'b', 5, 4, 8, 6] [1, 3, 2, 7, 5, 'b', 4, 8, 6] [1, 3, 2, 7, 5, 6, 4, 8, 'b'] [1, 3, 2, 7, 5, 6, 4, 'b', 8] [1, 3, 2, 7, 5, 6, 'b', 4, 8] [1, 3, 2, 'b', 5, 6, 7, 4, 8] [1, 3, 2, 5, 'b', 6, 7, 4, 8] [1, 3, 2, 5, 4, 6, 7, 'b', 8] [1, 3, 2, 5, 4, 6, 7, 8, 'b'] [1, 3, 2, 5, 4, 'b', 7, 8, 6] [1, 3, 2, 5, 'b', 4, 7, 8, 6] [1, 'b', 2, 5, 3, 4, 7, 8, 6] [1, 2, 'b', 5, 3, 4, 7, 8, 6] [1, 2, 4, 5, 3, 'b', 7, 8, 6] [1, 2, 4, 5, 'b', 3, 7, 8, 6] [1, 2, 4, 'b', 5, 3, 7, 8, 6] ['b', 2, 4, 1, 5, 3, 7, 8, 6] [2, 'b', 4, 1, 5, 3, 7, 8, 6] [2, 4, 'b', 1, 5, 3, 7, 8, 6] [2, 4, 3, 1, 5, 'b', 7, 8, 6] [2, 4, 3, 1, 'b', 5, 7, 8, 6] [2, 'b', 3, 1, 4, 5, 7, 8, 6] ['b', 2, 3, 1, 4, 5, 7, 8, 6] [1, 2, 3, 'b', 4, 5, 7, 8, 6] [1, 2, 3, 4, 'b', 5, 7, 8, 6] [1, 2, 3, 4, 5, 'b', 7, 8, 6] [1, 2, 3, 4, 5, 6, 7, 8, 'b']		[1, 2, 6, 8, 'b', 5, 7, 4, 3] [1, 2, 6, 'b', 8, 5, 7, 4, 3] [1, 2, 6, 7, 8, 5, 'b', 4, 3] [1, 2, 6, 7, 8, 5, 4, 'b', 3] [1, 2, 6, 7, 'b', 5, 4, 8, 3] [1, 2, 6, 7, 5, 'b', 4, 8, 3] [1, 2, 6, 7, 5, 3, 4, 8, 'b'] [1, 2, 6, 7, 5, 3, 4, 'b', 8] [1, 2, 6, 7, 5, 3, 'b', 4, 8] [1, 2, 6, 'b', 5, 3, 7, 4, 8] [1, 2, 6, 5, 'b', 3, 7, 4, 8] [1, 2, 6, 5, 3, 'b', 7, 4, 8] [1, 2, 'b', 5, 3, 6, 7, 4, 8] [1, 'b', 2, 5, 3, 6, 7, 4, 8] [1, 3, 2, 5, 'b', 6, 7, 4, 8] [1, 3, 2, 5, 4, 6, 7, 'b', 8] [1, 3, 2, 5, 4, 6, 7, 8, 'b'] [1, 3, 2, 5, 4, 'b', 7, 8, 6] [1, 3, 2, 5, 'b', 4, 7, 8, 6] [1, 'b', 2, 5, 3, 4, 7, 8, 6] [1, 2, 'b', 5, 3, 4, 7, 8, 6] [1, 2, 4, 5, 3, 'b', 7, 8, 6] [1, 2, 4, 5, 'b', 3, 7, 8, 6] [1, 2, 4, 'b', 5, 3, 7, 8, 6] ['b', 2, 4, 1, 5, 3, 7, 8, 6] [2, 'b', 4, 1, 5, 3, 7, 8, 6] [2, 4, 'b', 1, 5, 3, 7, 8, 6] [2, 4, 3, 1, 5, 'b', 7, 8, 6] [2, 4, 3, 1, 'b', 5, 7, 8, 6] [2, 'b', 3, 1, 4, 5, 7, 8, 6] ['b', 2, 3, 1, 4, 5, 7, 8, 6] [1, 2, 3, 'b', 4, 5, 7, 8, 6] [1, 2, 3, 4, 'b', 5, 7, 8, 6] [1, 2, 3, 4, 5, 'b', 7, 8, 6] [1, 2, 3, 4, 5, 6, 7, 8, 'b']
Average	77		73		66.2	

Thomas Pollard
CS – 441 Artificial intelligence, Winter 2021
Programming 1 Report

8-Puzzle A* Search Results

Start state	H1	Path	H2	Path	H3	Path
[['8' '2' '6'] ['7' '5' '1'] ['b' '4' '3']]	24	[8, 2, 6, 7, 5, 1, 'b', 4, 3] [8, 2, 6, 7, 5, 1, 4, 'b', 3] [8, 2, 6, 7, 'b', 1, 4, 5, 3] [8, 2, 6, 7, 1, 'b', 4, 5, 3] [8, 2, 'b', 7, 1, 6, 4, 5, 3] [8, 'b', 2, 7, 1, 6, 4, 5, 3] [8, 1, 2, 7, 'b', 6, 4, 5, 3] [8, 1, 2, 7, 6, 'b', 4, 5, 3] [8, 1, 2, 7, 6, 3, 4, 5, 'b'] [8, 1, 2, 7, 6, 3, 4, 'b', 5] [8, 1, 2, 7, 'b', 3, 4, 6, 5] [8, 1, 2, 'b', 7, 3, 4, 6, 5] ['b', 1, 2, 8, 7, 3, 4, 6, 5] [1, 'b', 2, 8, 7, 3, 4, 6, 5] [1, 2, 'b', 8, 7, 3, 4, 6, 5] [1, 2, 3, 8, 7, 'b', 4, 6, 5] [1, 2, 3, 8, 7, 5, 4, 6, 'b'] [1, 2, 3, 8, 7, 5, 4, 'b', 6] [1, 2, 3, 8, 'b', 5, 4, 7, 6] [1, 2, 3, 'b', 8, 5, 4, 7, 6] [1, 2, 3, 4, 8, 5, 'b', 7, 6] [1, 2, 3, 4, 8, 5, 7, 'b', 6] [1, 2, 3, 4, 'b', 5, 7, 8, 6] [1, 2, 3, 4, 5, 'b', 7, 8, 6] [1, 2, 3, 4, 5, 6, 7, 8, 'b']	24	[8, 2, 6, 7, 5, 1, 'b', 4, 3] [8, 2, 6, 7, 5, 1, 4, 'b', 3] [8, 2, 6, 7, 'b', 1, 4, 5, 3] [8, 2, 6, 7, 1, 'b', 4, 5, 3] [8, 2, 'b', 7, 1, 6, 4, 5, 3] [8, 'b', 2, 7, 1, 6, 4, 5, 3] [8, 1, 2, 7, 'b', 6, 4, 5, 3] [8, 1, 2, 7, 6, 'b', 4, 5, 3] [8, 1, 2, 7, 6, 3, 4, 5, 'b'] [8, 1, 2, 7, 6, 3, 4, 'b', 5] [8, 1, 2, 7, 'b', 3, 4, 6, 5] [8, 1, 2, 'b', 7, 3, 4, 6, 5] ['b', 1, 2, 8, 7, 3, 4, 6, 5] [1, 'b', 2, 8, 7, 3, 4, 6, 5] [1, 2, 'b', 8, 7, 3, 4, 6, 5] [1, 2, 3, 8, 7, 'b', 4, 6, 5] [1, 2, 3, 8, 7, 5, 4, 6, 'b'] [1, 2, 3, 8, 7, 5, 4, 'b', 6] [1, 2, 3, 8, 'b', 5, 4, 7, 6] [1, 2, 3, 'b', 8, 5, 4, 7, 6] [1, 2, 3, 4, 8, 5, 'b', 7, 6] [1, 2, 3, 4, 8, 5, 7, 'b', 6] [1, 2, 3, 4, 'b', 5, 7, 8, 6] [1, 2, 3, 4, 5, 'b', 7, 8, 6] [1, 2, 3, 4, 5, 6, 7, 8, 'b']	24	[8, 2, 6, 7, 5, 1, 'b', 4, 3] [8, 2, 6, 7, 5, 1, 4, 'b', 3] [8, 2, 6, 7, 'b', 1, 4, 5, 3] [8, 2, 6, 7, 1, 'b', 4, 5, 3] [8, 2, 'b', 7, 1, 6, 4, 5, 3] [8, 'b', 2, 7, 1, 6, 4, 5, 3] [8, 1, 2, 7, 'b', 6, 4, 5, 3] [8, 1, 2, 7, 6, 'b', 4, 5, 3] [8, 1, 2, 7, 6, 3, 4, 5, 'b'] [8, 1, 2, 7, 6, 3, 4, 'b', 5] [8, 1, 2, 7, 'b', 3, 4, 6, 5] [8, 1, 2, 'b', 7, 3, 4, 6, 5] ['b', 1, 2, 8, 7, 3, 4, 6, 5] [1, 'b', 2, 8, 7, 3, 4, 6, 5] [1, 2, 'b', 8, 7, 3, 4, 6, 5] [1, 2, 3, 8, 7, 'b', 4, 6, 5] [1, 2, 3, 8, 7, 5, 4, 6, 'b'] [1, 2, 3, 8, 7, 5, 4, 'b', 6] [1, 2, 3, 8, 'b', 5, 4, 7, 6] [1, 2, 3, 'b', 8, 5, 4, 7, 6] [1, 2, 3, 4, 8, 5, 'b', 7, 6] [1, 2, 3, 4, 8, 5, 7, 'b', 6] [1, 2, 3, 4, 'b', 5, 7, 8, 6] [1, 2, 3, 4, 5, 'b', 7, 8, 6] [1, 2, 3, 4, 5, 6, 7, 8, 'b']
[['8' '4' '6'] ['7' '3' '5'] ['b' '1' '2']]	24	[8, 4, 6, 7, 3, 5, 'b', 1, 2] [8, 4, 6, 'b', 3, 5, 7, 1, 2] ['b', 4, 6, 8, 3, 5, 7, 1, 2] [4, 'b', 6, 8, 3, 5, 7, 1, 2] [4, 3, 6, 8, 'b', 5, 7, 1, 2] [4, 3, 6, 8, 1, 5, 7, 'b', 2] [4, 3, 6, 8, 1, 5, 7, 2, 'b'] [4, 3, 6, 8, 1, 'b', 7, 2, 5] [4, 3, 'b', 8, 1, 6, 7, 2, 5] [4, 'b', 3, 8, 1, 6, 7, 2, 5] [4, 1, 3, 8, 'b', 6, 7, 2, 5] [4, 1, 3, 'b', 8, 6, 7, 2, 5] ['b', 1, 3, 4, 8, 6, 7, 2, 5] [1, 'b', 3, 4, 8, 6, 7, 2, 5] [1, 3, 'b', 4, 8, 6, 7, 2, 5] [1, 3, 6, 4, 8, 'b', 7, 2, 5] [1, 3, 6, 4, 'b', 8, 7, 2, 5] [1, 3, 6, 4, 2, 8, 7, 'b', 5] [1, 3, 6, 4, 2, 8, 7, 5, 'b'] [1, 3, 6, 4, 2, 'b', 7, 5, 8]	24	[8, 4, 6, 7, 3, 5, 'b', 1, 2] [8, 4, 6, 'b', 3, 5, 7, 1, 2] ['b', 4, 6, 8, 3, 5, 7, 1, 2] [4, 'b', 6, 8, 3, 5, 7, 1, 2] [4, 3, 6, 8, 'b', 5, 7, 1, 2] [4, 3, 6, 8, 1, 5, 7, 'b', 2] [4, 3, 6, 8, 1, 5, 7, 2, 'b'] [4, 3, 6, 8, 1, 'b', 7, 2, 5] [4, 3, 'b', 8, 1, 6, 7, 2, 5] [4, 'b', 3, 8, 1, 6, 7, 2, 5] [4, 1, 3, 8, 'b', 6, 7, 2, 5] [4, 1, 3, 'b', 8, 6, 7, 2, 5] ['b', 1, 3, 4, 8, 6, 7, 2, 5] [1, 'b', 3, 4, 8, 6, 7, 2, 5] [1, 3, 'b', 4, 8, 6, 7, 2, 5] [1, 3, 6, 4, 8, 'b', 7, 2, 5] [1, 3, 6, 4, 'b', 8, 7, 2, 5] [1, 3, 6, 4, 2, 8, 7, 'b', 5] [1, 3, 6, 4, 2, 8, 7, 5, 'b'] [1, 3, 6, 4, 2, 'b', 7, 5, 8]	24	[8, 4, 6, 7, 3, 5, 'b', 1, 2] [8, 4, 6, 'b', 3, 5, 7, 1, 2] ['b', 4, 6, 8, 3, 5, 7, 1, 2] [4, 'b', 6, 8, 3, 5, 7, 1, 2] [4, 3, 6, 8, 'b', 5, 7, 1, 2] [4, 3, 6, 8, 1, 5, 7, 'b', 2] [4, 3, 6, 8, 1, 5, 7, 2, 'b'] [4, 3, 6, 8, 1, 'b', 7, 2, 5] [4, 3, 'b', 8, 1, 6, 7, 2, 5] [4, 'b', 3, 8, 1, 6, 7, 2, 5] [4, 1, 3, 8, 'b', 6, 7, 2, 5] [4, 1, 3, 'b', 8, 6, 7, 2, 5] ['b', 1, 3, 4, 8, 6, 7, 2, 5] [1, 'b', 3, 4, 8, 6, 7, 2, 5] [1, 3, 'b', 4, 8, 6, 7, 2, 5] [1, 3, 6, 4, 8, 'b', 7, 2, 5] [1, 3, 6, 4, 'b', 8, 7, 2, 5] [1, 3, 6, 4, 2, 8, 7, 'b', 5] [1, 3, 6, 4, 2, 8, 7, 5, 'b'] [1, 3, 6, 4, 2, 'b', 7, 5, 8]

		[1, 3, 'b', 4, 2, 6, 7, 5, 8] [1, 'b', 3, 4, 2, 6, 7, 5, 8] [1, 2, 3, 4, 'b', 6, 7, 5, 8] [1, 2, 3, 4, 5, 6, 7, 'b', 8] [1, 2, 3, 4, 5, 6, 7, 8, 'b']		[1, 3, 'b', 4, 2, 6, 7, 5, 8] [1, 'b', 3, 4, 2, 6, 7, 5, 8] [1, 2, 3, 4, 'b', 6, 7, 5, 8] [1, 2, 3, 4, 5, 6, 7, 'b', 8] [1, 2, 3, 4, 5, 6, 7, 8, 'b']		[1, 3, 'b', 4, 2, 6, 7, 5, 8] [1, 'b', 3, 4, 2, 6, 7, 5, 8] [1, 2, 3, 4, 'b', 6, 7, 5, 8] [1, 2, 3, 4, 5, 6, 7, 'b', 8] [1, 2, 3, 4, 5, 6, 7, 8, 'b']
[['2' '8' '5'] ['6' '7' '4'] ['b' '1' '3']]	22	[2, 8, 5, 6, 7, 4, 'b', 1, 3] [2, 8, 5, 6, 7, 4, 1, 'b', 3] [2, 8, 5, 6, 'b', 4, 1, 7, 3] [2, 8, 5, 6, 4, 'b', 1, 7, 3] [2, 8, 5, 6, 4, 3, 1, 7, 'b'] [2, 8, 5, 6, 4, 3, 1, 'b', 7] [2, 8, 5, 6, 'b', 3, 1, 4, 7] [2, 'b', 5, 6, 8, 3, 1, 4, 7] [2, 5, 'b', 6, 8, 3, 1, 4, 7] [2, 5, 3, 6, 8, 'b', 1, 4, 7] [2, 5, 3, 6, 'b', 8, 1, 4, 7] [2, 5, 3, 'b', 6, 8, 1, 4, 7] [2, 5, 3, 1, 6, 8, 'b', 4, 7] [2, 5, 3, 1, 6, 8, 4, 'b', 7] [2, 5, 3, 1, 6, 8, 4, 7, 'b'] [2, 5, 3, 1, 6, 'b', 4, 7, 8] [2, 5, 3, 1, 'b', 6, 4, 7, 8] [2, 'b', 3, 1, 5, 6, 4, 7, 8] ['b', 2, 3, 1, 5, 6, 4, 7, 8] [1, 2, 3, 'b', 5, 6, 4, 7, 8] [1, 2, 3, 4, 5, 6, 'b', 7, 8] [1, 2, 3, 4, 5, 6, 7, 'b', 8] [1, 2, 3, 4, 5, 6, 7, 8, 'b']	22	[2, 8, 5, 6, 7, 4, 'b', 1, 3] [2, 8, 5, 6, 7, 4, 1, 'b', 3] [2, 8, 5, 6, 'b', 4, 1, 7, 3] [2, 8, 5, 6, 4, 'b', 1, 7, 3] [2, 8, 5, 6, 4, 3, 1, 7, 'b'] [2, 8, 5, 6, 4, 3, 1, 'b', 7] [2, 8, 5, 6, 'b', 3, 1, 4, 7] [2, 'b', 5, 6, 8, 3, 1, 4, 7] [2, 5, 'b', 6, 8, 3, 1, 4, 7] [2, 5, 3, 6, 8, 'b', 1, 4, 7] [2, 5, 3, 6, 'b', 8, 1, 4, 7] [2, 5, 3, 'b', 6, 8, 1, 4, 7] [2, 5, 3, 1, 6, 8, 'b', 4, 7] [2, 5, 3, 1, 6, 8, 4, 'b', 7] [2, 5, 3, 1, 6, 8, 4, 7, 'b'] [2, 5, 3, 1, 6, 'b', 4, 7, 8] [2, 5, 3, 1, 'b', 6, 4, 7, 8] [2, 'b', 3, 1, 5, 6, 4, 7, 8] ['b', 2, 3, 1, 5, 6, 4, 7, 8] [1, 2, 3, 'b', 5, 6, 4, 7, 8] [1, 2, 3, 4, 5, 6, 'b', 7, 8] [1, 2, 3, 4, 5, 6, 7, 'b', 8] [1, 2, 3, 4, 5, 6, 7, 8, 'b']	22	[2, 8, 5, 6, 7, 4, 'b', 1, 3] [2, 8, 5, 6, 7, 4, 1, 'b', 3] [2, 8, 5, 6, 'b', 4, 1, 7, 3] [2, 8, 5, 6, 4, 'b', 1, 7, 3] [2, 8, 5, 6, 4, 3, 1, 7, 'b'] [2, 8, 5, 6, 4, 3, 1, 'b', 7] [2, 8, 5, 6, 'b', 3, 1, 4, 7] [2, 'b', 5, 6, 8, 3, 1, 4, 7] [2, 5, 'b', 6, 8, 3, 1, 4, 7] [2, 5, 3, 6, 8, 'b', 1, 4, 7] [2, 5, 3, 6, 'b', 8, 1, 4, 7] [2, 5, 3, 'b', 6, 8, 1, 4, 7] [2, 5, 3, 1, 6, 8, 'b', 4, 7] [2, 5, 3, 1, 6, 8, 4, 'b', 7] [2, 5, 3, 1, 6, 8, 4, 7, 'b'] [2, 5, 3, 1, 6, 'b', 4, 7, 8] [2, 5, 3, 1, 'b', 6, 4, 7, 8] [2, 'b', 3, 1, 5, 6, 4, 7, 8] ['b', 2, 3, 1, 5, 6, 4, 7, 8] [1, 2, 3, 'b', 5, 6, 4, 7, 8] [1, 2, 3, 4, 5, 6, 'b', 7, 8] [1, 2, 3, 4, 5, 6, 7, 'b', 8] [1, 2, 3, 4, 5, 6, 7, 8, 'b']
[['1' 'b' '8'] ['5' '2' '4'] ['3' '6' '7']]	25	[1, 'b', 8, 5, 2, 4, 3, 6, 7] [1, 2, 8, 5, 'b', 4, 3, 6, 7] [1, 2, 8, 5, 6, 4, 3, 'b', 7] [1, 2, 8, 5, 6, 4, 3, 7, 'b'] [1, 2, 8, 5, 6, 'b', 3, 7, 4] [1, 2, 'b', 5, 6, 8, 3, 7, 4] [1, 'b', 2, 5, 6, 8, 3, 7, 4] [1, 6, 2, 5, 'b', 8, 3, 7, 4] [1, 6, 2, 5, 7, 8, 3, 'b', 4] [1, 6, 2, 5, 7, 8, 'b', 3, 4] [1, 6, 2, 'b', 7, 8, 5, 3, 4] [1, 6, 2, 7, 'b', 8, 5, 3, 4] [1, 6, 2, 7, 3, 8, 5, 'b', 4] [1, 6, 2, 7, 3, 8, 5, 4, 'b'] [1, 6, 2, 7, 3, 'b', 5, 4, 8] [1, 6, 2, 7, 'b', 3, 5, 4, 8] [1, 6, 2, 7, 4, 3, 5, 'b', 8] [1, 6, 2, 7, 4, 3, 'b', 5, 8] [1, 6, 2, 'b', 4, 3, 7, 5, 8]	25	[1, 'b', 8, 5, 2, 4, 3, 6, 7] [1, 2, 8, 5, 'b', 4, 3, 6, 7] [1, 2, 8, 5, 6, 4, 3, 'b', 7] [1, 2, 8, 5, 6, 4, 3, 7, 'b'] [1, 2, 8, 5, 6, 'b', 3, 7, 4] [1, 2, 'b', 5, 6, 8, 3, 7, 4] [1, 'b', 2, 5, 6, 8, 3, 7, 4] [1, 6, 2, 5, 'b', 8, 3, 7, 4] [1, 6, 2, 5, 7, 8, 3, 'b', 4] [1, 6, 2, 5, 7, 8, 'b', 3, 4] [1, 6, 2, 'b', 7, 8, 5, 3, 4] [1, 6, 2, 7, 'b', 8, 5, 3, 4] [1, 6, 2, 7, 3, 8, 5, 'b', 4] [1, 6, 2, 7, 3, 8, 5, 4, 'b'] [1, 6, 2, 7, 3, 'b', 5, 4, 8] [1, 6, 2, 7, 'b', 3, 5, 4, 8] [1, 6, 2, 7, 4, 3, 5, 'b', 8] [1, 6, 2, 7, 4, 3, 'b', 5, 8] [1, 6, 2, 'b', 4, 3, 7, 5, 8]	25	[1, 'b', 8, 5, 2, 4, 3, 6, 7] [1, 2, 8, 5, 'b', 4, 3, 6, 7] [1, 2, 8, 5, 6, 4, 3, 'b', 7] [1, 2, 8, 5, 6, 4, 3, 7, 'b'] [1, 2, 8, 5, 6, 'b', 3, 7, 4] [1, 2, 'b', 5, 6, 8, 3, 7, 4] [1, 'b', 2, 5, 6, 8, 3, 7, 4] [1, 6, 2, 5, 'b', 8, 3, 7, 4] [1, 6, 2, 5, 7, 8, 3, 'b', 4] [1, 6, 2, 5, 7, 8, 'b', 3, 4] [1, 6, 2, 'b', 7, 8, 5, 3, 4] [1, 6, 2, 7, 'b', 8, 5, 3, 4] [1, 6, 2, 7, 3, 8, 5, 'b', 4] [1, 6, 2, 7, 3, 8, 5, 4, 'b'] [1, 6, 2, 7, 3, 'b', 5, 4, 8] [1, 6, 2, 7, 'b', 3, 5, 4, 8] [1, 6, 2, 7, 4, 3, 5, 'b', 8] [1, 6, 2, 7, 4, 3, 'b', 5, 8] [1, 6, 2, 'b', 4, 3, 7, 5, 8]

		[1, 6, 2, 4, 'b', 3, 7, 5, 8] [1, 'b', 2, 4, 6, 3, 7, 5, 8] [1, 2, 'b', 4, 6, 3, 7, 5, 8] [1, 2, 3, 4, 6, 'b', 7, 5, 8] [1, 2, 3, 4, 'b', 6, 7, 5, 8] [1, 2, 3, 4, 5, 6, 7, 'b', 8] [1, 2, 3, 4, 5, 6, 7, 8, 'b']		[1, 6, 2, 4, 'b', 3, 7, 5, 8] [1, 'b', 2, 4, 6, 3, 7, 5, 8] [1, 2, 'b', 4, 6, 3, 7, 5, 8] [1, 2, 3, 4, 6, 'b', 7, 5, 8] [1, 2, 3, 4, 'b', 6, 7, 5, 8] [1, 2, 3, 4, 5, 6, 7, 'b', 8] [1, 2, 3, 4, 5, 6, 7, 8, 'b']		[1, 6, 2, 4, 'b', 3, 7, 5, 8] [1, 'b', 2, 4, 6, 3, 7, 5, 8] [1, 2, 'b', 4, 6, 3, 7, 5, 8] [1, 2, 3, 4, 6, 'b', 7, 5, 8] [1, 2, 3, 4, 'b', 6, 7, 5, 8] [1, 2, 3, 4, 5, 6, 7, 'b', 8] [1, 2, 3, 4, 5, 6, 7, 8, 'b']
[['8' '3' 'b'] ['7' '5' '6'] ['2' '4' '1']]	26	[8, 3, 'b', 7, 5, 6, 2, 4, 1] [8, 'b', 3, 7, 5, 6, 2, 4, 1] ['b', 8, 3, 7, 5, 6, 2, 4, 1] [7, 8, 3, 'b', 5, 6, 2, 4, 1] [7, 8, 3, 2, 5, 6, 'b', 4, 1] [7, 8, 3, 2, 5, 6, 4, 'b', 1] [7, 8, 3, 2, 5, 6, 4, 1, 'b'] [7, 8, 3, 2, 5, 'b', 4, 1, 6] [7, 8, 3, 2, 'b', 5, 4, 1, 6] [7, 'b', 3, 2, 8, 5, 4, 1, 6] ['b', 7, 3, 2, 8, 5, 4, 1, 6] [2, 7, 3, 'b', 8, 5, 4, 1, 6] [2, 7, 3, 8, 'b', 5, 4, 1, 6] [2, 7, 3, 8, 1, 5, 4, 'b', 6] [2, 7, 3, 8, 1, 5, 'b', 4, 6] [2, 7, 3, 'b', 1, 5, 8, 4, 6] [2, 7, 3, 1, 'b', 5, 8, 4, 6] [2, 'b', 3, 1, 7, 5, 8, 4, 6] ['b', 2, 3, 1, 7, 5, 8, 4, 6] [1, 2, 3, 'b', 7, 5, 8, 4, 6] [1, 2, 3, 7, 'b', 5, 8, 4, 6] [1, 2, 3, 7, 4, 5, 8, 'b', 6] [1, 2, 3, 7, 4, 5, 'b', 8, 6] [1, 2, 3, 'b', 4, 5, 7, 8, 6] [1, 2, 3, 4, 'b', 5, 7, 8, 6] [1, 2, 3, 4, 5, 'b', 7, 8, 6] [1, 2, 3, 4, 5, 6, 7, 8, 'b']	26	[8, 3, 'b', 7, 5, 6, 2, 4, 1] [8, 'b', 3, 7, 5, 6, 2, 4, 1] ['b', 8, 3, 7, 5, 6, 2, 4, 1] [7, 8, 3, 'b', 5, 6, 2, 4, 1] [7, 8, 3, 2, 5, 6, 'b', 4, 1] [7, 8, 3, 2, 5, 6, 4, 'b', 1] [7, 8, 3, 2, 5, 6, 4, 1, 'b'] [7, 8, 3, 2, 5, 'b', 4, 1, 6] [7, 8, 3, 2, 'b', 5, 4, 1, 6] [7, 'b', 3, 2, 8, 5, 4, 1, 6] ['b', 7, 3, 2, 8, 5, 4, 1, 6] [2, 7, 3, 'b', 8, 5, 4, 1, 6] [2, 7, 3, 8, 'b', 5, 4, 1, 6] [2, 7, 3, 8, 1, 5, 4, 'b', 6] [2, 7, 3, 8, 1, 5, 'b', 4, 6] [2, 7, 3, 'b', 1, 5, 8, 4, 6] [2, 7, 3, 1, 'b', 5, 8, 4, 6] [2, 'b', 3, 1, 7, 5, 8, 4, 6] ['b', 2, 3, 1, 7, 5, 8, 4, 6] [1, 2, 3, 'b', 7, 5, 8, 4, 6] [1, 2, 3, 7, 'b', 5, 8, 4, 6] [1, 2, 3, 7, 4, 5, 8, 'b', 6] [1, 2, 3, 7, 4, 5, 'b', 8, 6] [1, 2, 3, 'b', 4, 5, 7, 8, 6] [1, 2, 3, 4, 'b', 5, 7, 8, 6] [1, 2, 3, 4, 5, 'b', 7, 8, 6] [1, 2, 3, 4, 5, 6, 7, 8, 'b']	26	[8, 3, 'b', 7, 5, 6, 2, 4, 1] [8, 'b', 3, 7, 5, 6, 2, 4, 1] ['b', 8, 3, 7, 5, 6, 2, 4, 1] [7, 8, 3, 'b', 5, 6, 2, 4, 1] [7, 8, 3, 2, 5, 6, 'b', 4, 1] [7, 8, 3, 2, 5, 6, 4, 'b', 1] [7, 8, 3, 2, 5, 6, 4, 1, 'b'] [7, 8, 3, 2, 5, 'b', 4, 1, 6] [7, 8, 3, 2, 'b', 5, 4, 1, 6] [7, 'b', 3, 2, 8, 5, 4, 1, 6] ['b', 7, 3, 2, 8, 5, 4, 1, 6] [2, 7, 3, 'b', 8, 5, 4, 1, 6] [2, 7, 3, 8, 'b', 5, 4, 1, 6] [2, 7, 3, 8, 1, 5, 4, 'b', 6] [2, 7, 3, 8, 1, 5, 'b', 4, 6] [2, 7, 3, 'b', 1, 5, 8, 4, 6] [2, 7, 3, 1, 'b', 5, 8, 4, 6] [2, 'b', 3, 1, 7, 5, 8, 4, 6] ['b', 2, 3, 1, 7, 5, 8, 4, 6] [1, 2, 3, 'b', 7, 5, 8, 4, 6] [1, 2, 3, 7, 'b', 5, 8, 4, 6] [1, 2, 3, 7, 4, 5, 8, 'b', 6] [1, 2, 3, 7, 4, 5, 'b', 8, 6] [1, 2, 3, 'b', 4, 5, 7, 8, 6] [1, 2, 3, 4, 'b', 5, 7, 8, 6] [1, 2, 3, 4, 5, 'b', 7, 8, 6] [1, 2, 3, 4, 5, 6, 7, 8, 'b']
Average	24.2		24.2		24.2	

Thomas Pollard
CS – 441 Artificial intelligence, Winter 2021
Programming 1 Report

15 Puzzle Best First Search

Start State	H1	H2	H3
[['9' '12' '4' '10'] ['14' '3' '1' 'b'] ['7' '11' '6' '13'] ['8' '2' '15' '5']]	422	314	238
[['10' '7' 'b' '2'] ['1' '13' '3' '15'] ['4' '14' '11' '9'] ['5' '6' '8' '12']]	386	336	270
[['b' '9' '10' '11'] ['4' '1' '15' '5'] ['8' '3' '12' '14'] ['6' '7' '13' '2']]	550	212	204
[['10' '6' '5' '13'] ['12' '15' '1' '11'] ['9' '8' '4' '2'] ['3' 'b' '14' '7']]	892	254	232
[['4' 'b' '9' '10'] ['11' '13' '7' '3'] ['15' '2' '5' '8'] ['12' '1' '14' '6']]	441	177	287
Average	538.2	258.6	246.2

Thomas Pollard
CS – 441 Artificial intelligence, Winter 2021
Programming 1 Report

15 Puzzle A* Search Results

Start State	H1	H2	H3
[['9' '12' '4' '10'] ['14' '3' '1' 'b'] ['7' '11' '6' '13'] ['8' '2' '15' '5']]	Did not find solution in within iteration limit	54	Did not find solution in within iteration limit
[['10' '7' 'b' '2'] ['1' '13' '3' '15'] ['4' '14' '11' '9'] ['5' '6' '8' '12']]	Did not find solution in within iteration limit	Did not find solution in within iteration limit	Did not find solution in within iteration limit
[['b' '9' '10' '11'] ['4' '1' '15' '5'] ['8' '3' '12' '14'] ['6' '7' '13' '2']]	Did not find solution in within iteration limit	52	Did not find solution in within iteration limit
[['10' '6' '5' '13'] ['12' '15' '1' '11'] ['9' '8' '4' '2'] ['3' 'b' '14' '7']]	Did not find solution in within iteration limit	Did not find solution in within iteration limit	Did not find solution in within iteration limit
[['4' 'b' '9' '10'] ['11' '13' '7' '3'] ['15' '2' '5' '8'] ['12' '1' '14' '6']]	Did not find solution in within iteration limit	53	Did not find solution in within iteration limit
Average		53	