

# **CS561 - ARTIFICIAL INTELLIGENCE LAB**

## **ASSIGNMENT-1: A\* Search, BFS**

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**Date : 25/08/2021**

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### **Observations**

$h_1$  = number of tiles displaced,  $h_2$  = manhattan distance,  $b$  = branching factor,  $m$  = depth of solution

**BFS** : we are not able to say for sure which heuristic is better, there were test cases when  $h_2$  outperformed  $h_1$  and vice versa. BFS can stuck in loops if in queue it keeps on finding state with same heuristic value as it does not consider backward cost to reach current state, therefore it is not complete algorithm

- Time:  $O(b^m)$  (in worst case but a good heuristic can improve execution time)
- Space:  $O(b^m)$  (stores all nodes in memory)
- Optimal: No (does not guarantee lowest cost solution).
- Complete : No (does not guarantee a solution, can get stuck in loops).

**A\*** :  $h_2$  was better(search time & lesser no of explored states) than using  $h_1$ , and it always finds a solution (this verifies the fact that  $h_2$  dominates  $h_1$ )

- Time:  $O(b^m)$  (in worst case but a good heuristic can improve execution time)
- Space:  $O(b^m)$  (stores all nodes in memory)
- Optimal: Yes (provided heuristic used is admissible (i.e. does not overestimate))
- Complete : Yes (guaranteed to get a solution if it exists).

**Conclusion** : BFS is not able to find shortest path to goal always since it focuses on the lowest heuristic without considering backward cost where as A\* focuses on heuristics and the cost of getting to that state which leads to better results

## # Test1

StartState  
T8 T3 T5  
T4 T1 T6  
T2 T7 B

GoalState  
T1 T2 T3  
T8 B T4  
T7 T6 T5

Algorithm Name	BFS
Heuristic Function	Displace Cost Heuristics
Total number of states explored	521
Total number of states to optimal path	71
Optimal Path Cost	70
Time Taken For Execution	0.04990649223327637 seconds
Optimal Path	T8 T3 T5 T4 T1 T6 T2 T7 B ..... ..... ..... T1 T3 T5 T8 B T4 T2 T7 T6 ..... ..... ..... T1 T2 T3 T8 B T4 T7 T6 T5

Algorithm Name	Astar
Heuristic Function	Displace Cost Heuristics
Total number of states explored	166
Total number of states to optimal path	15
Optimal Path Cost	14
Time Taken For Execution	0.015999794006347656 seconds
Optimal Path	T8 T3 T5 T4 T1 T6 T2 T7 B ..... ..... ..... T8 T1 T3 T2 T4 T5 T7 T6 B ..... ..... ..... T1 T2 T3 T8 B T4 T7 T6 T5

Algorithm Name	BFS
Heuristic Function	Manhattan Cost Heuristics
Total number of states explored	16
Total number of states to optimal path	15
Optimal Path Cost	14
Time Taken For Execution	0.001996755599975586 seconds
Optimal Path	T8 T3 T5 T4 T1 T6 T2 T7 B ..... ..... ..... T8 T1 T3 T2 T4 B T7 T6 T5 ..... ..... ..... T1 T2 T3 T8 B T4 T7 T6 T5

Algorithm Name	Astar
Heuristic Function	Manhattan Cost Heuristics
Total number of states explored	16
Total number of states to optimal path	15
Optimal Path Cost	14
Time Taken For Execution	0.003999233245849609 seconds
Optimal Path	T8 T3 T5 T4 T1 T6 T2 T7 B ..... ..... ..... T8 T1 T3 T2 T4 T5 T7 T6 B ..... ..... ..... T1 T2 T3 T8 B T4 T7 T6 T5

## # Test2

Start State :  
T8 T6 T7  
T2 T5 T4  
T3 B T1

Goal State :  
T1 T2 T3  
T4 T5 T6  
T7 T8 B

Algorithm Name	BFS
Heuristic Function	Displace Cost Heuristics
Total number of states explored	1316
Total number of states to optimal path	130
Optimal Path Cost	129
Time Taken For Execution	0.12466645240783691 seconds
Optimal Path	T8 T6 T7 T2 T5 T4 T3 B T1 ..... ..... ..... T4 T1 T2 B T3 T6 T7 T8 T5 ..... ..... ..... T1 T2 T3 T4 T5 T6 T7 T8 B

Algorithm Name	Astar
Heuristic Function	Displace Cost Heuristics
Total number of states explored	143848
Total number of states to optimal path	32
Optimal Path Cost	31
Time Taken For Execution	15.512041330337524 seconds
Optimal Path	T8 T6 T7 T2 T5 T4 T3 B T1 ..... ..... ..... B T5 T2 T1 T7 T6 T8 T3 T4 ..... ..... ..... T1 T2 T3 T4 T5 T6 T7 T8 B

Algorithm Name	BFS
Heuristic Function	Manhattan Cost Heuristics
Total number of states explored	72
Total number of states to optimal path	48
Optimal Path Cost	47
Time Taken For Execution	0.008975982666015625 seconds
Optimal Path	T8 T6 T7 T2 T5 T4 T3 B T1 ..... ..... ..... T3 T2 B T1 T5 T8 T4 T7 T6 ..... ..... ..... T1 T2 T3 T4 T5 T6 T7 T8 B

Algorithm Name	Astar
Heuristic Function	Manhattan Cost Heuristics
Total number of states explored	21197
Number of states to optimal path	32
Optimal Path Cost	31
Time Taken For Execution	3.3079609870910645 seconds
Optimal Path	T8 T6 T7 T2 T5 T4 T3 B T1 ..... ..... ..... T3 T8 T5 B T2 T6 T1 T4 T7 ..... ..... ..... T1 T2 T3 T4 T5 T6 T7 T8 B