

Approach

- A* algorithm was implemented to solve the 15 puzzle problem.
- The heuristic used was sum of manhattan distance of the misplaced tiles + 2* total linear conflicts.
- Manhattan distance is the sum of horizontal and vertical distance of the tile from its current position to the goal state position.
- Linear conflict is a configuration when goal position of one tile is blocked by other tile which is in the same row/column as the first tile and both the tiles have their goal position in the same row/column where they are currently.

Optimality of Approach

- A* is optimal if the heuristic used is consistent.
- Sum of manhattan distances of misplaced tiles on its own is a consistent heuristic as it calculates number of moves required to solve relaxed n-puzzle problem where tiles can be stacked on each other.
- Each linear conflict configuration requires at least two additional moves to solve it. Since manhattan distance does not take into account configuration of other tiles wrt tile for which manhattan distance is being calculated, these moves are not accounted for by it and can be added to it.
- So sum of manhattan distances + $2 \times (\text{total linear conflicts})$ is a consistent heuristic and the solution is optimal.

Comparison of Different Implementations

Inputs	A* with manhattan distance+linear conflict heuristic	IDA* with manhattan distance+linear conflict heuristic	A* with manhattan distance heuristic
initial_state1	Time- 0.001s Nodes generated- 31	Time- 0.001s Nodes generated- 19	Time- 0.001s Nodes generated- 110
initial_state2	Time- 1s Nodes generated- 28194	Time- 2s Nodes generated- 50686	Time- 20s Nodes generated- 564487
initial_state3	Time- 5.7s Nodes generated- 161427	Time- 11s Nodes generated-416451	Time- 248s Nodes generated- 6676354
initial_state4	Time- 16s Nodes generated-394856	Time- 18s Nodes generated- 437084	Time- 90s Nodes generated- 3183377

IDA * performed worse than A* on average but was lighter on memory. Manhattan distance + linear conflict was a huge improvement over just manhattan distance heuristic.