**CS250: Archit Sharma 2101AI05**

**1. Observe and verify that better heuristics expands lesser states.**

Ans:

h1 = returns 0

h2 = returns number of tiles displaced from their destined position

h3 = sum of Manhattan distance of each tiles from the goal  
position (blank tile is not considered)

h4 = average of h3 and h4

According to the results given in data.xlsx, it is cleat that h1 explored the maximum number of states followed by h2, h4 and h3. This order also ranks the heuristics from worse to better.

**2. Observe and verify that all the states expanded by better heuristics should also be expanded by inferior heuristics.**

Ans:

The difference between better and inferior heuristic is that better heuristics are able to converge to solution while expanding lesser number of states. To verify this I compared the states expanded by h3 and h1, h3 being better always expanded lesser states as evidenced by data.xlsx. Also, h1 was a superset of h3 and this is evidenced by ‘h1 a superset?’ column in data.xlsx.

**3. Observe & verify monotone restrictions on the above provided heuristics.**

Ans:

As per the evidence provided in data.xlsx, we observe that the monotone restriction is obeyed by all the 4 heuristics.

**4. Observe unreachability.**

Ans:

Unreachability of the graph can be determined by each of the 4 heuristics listed. Each of them scans all the 9!/2 possible states and if the solution is not there, it prints appropriate message. As the solution can not be reached, it does not give the optimal path or optimal cost.

However the cost of determining the solution with the heuristics is computationaly intensive. So to get around this distance, I have implemented isSolvable() where the given 2d board is converted to a 2d string and total number of inversions are calculated which is equal to number of tiles that precedes another tile with lower number. If this is even, it can be solved and in the other case, it is unsolvable. This is also verified in data.xlsx for the 10 boards.

**5. Observe and verify whether monotone restriction is followed for the**

**following two Heuristics:**

**a. Monotone restriction: h(n) <= cost(n,m) + h(m)**

**b. a. h2(n) = number of tiles displaced from their destined position.**

**c. b. h3(n) = sum of Manhattan distance of each tiles from the goal**

**position.**

Ans:

h2 and h3 like the rest of the correct heuristics, follow the monotonic constraint. This constraint is paramount for the optimality of the solution. Refer to data.xlsx for the evidence.

**6. Observe and verify that if the cost of the empty tile is added (considering the empty tile as another tile) then monotonicity will be violated.**

Ans:

To verify this result, I have implemented another heuristic h5 which is similar to h3 but also counts the manhattan distance of the blank tile. The monotonicity of this heuristic is documented in ‘Monotonic h5’ column and it gives FALSE for 7 of 10 boards. This shows that it is not monotonic like others.