Project 1 Analysis

From the random runs I conducted it appears that A* is much more efficient than BFS in the number of nodes explored. I found that A* with heuristic H1 seems to explore fewer nodes by a factor of about 10. I also found that A* with heuristic H2 seemed to explore fewer nodes than heuristic H1 by about a factor of 10.

The average number of children explored by each square in BFS is the average of the total number of branches from all nodes: 4*1 + 3*4 + 2*4 = 24, divided by number of squares. So 24/9 = 8/3. However this doesn't account for nodes of states that have already been discovered. Because of this the effective branching factor for BFS is about 1.6 +/- ~0.02 depending on the starting state. This measurement was calculated by the following formula: n^(1/m), n being the number of nodes explored and m being the number of moves required to solve the puzzle.

The same calculations can be made for A* H1 and H2. For H1 the effective branching factor is about 1.46 +/- ~0.02. For H2 the effective branching factor is about 1.35 +/- ~0.02.

These results are pretty consistent with what one would expect. By the nature of BFS it can't pursue more favorable states so it is likely to explore a significant portion of the reachable state space (9!/2) before finding the solution. On the other hand, A* can explore nodes with more optimal states first giving it an obvious advantage. Comparing the A* heuristics, H1 provides the number of binary (true or false) out of place nodes while H2 provides the sum of the manhattan distance to the correct position of each square. Again, H2 being more efficient than H1 makes sense since H2 provides the algorithm with more information in a more accurate heuristic.

For an example of why H2 works better, consider a state where one or more out of place squares are only one space away from their goal position. H2 would be able to correctly distinguish this state as more optimal than one where the out of place squares are more than one space from their goal positions. H1 on the other hand would treat them the same as long as they have the same number of out of place squares.