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## CS170 Project 1 Report

### Design

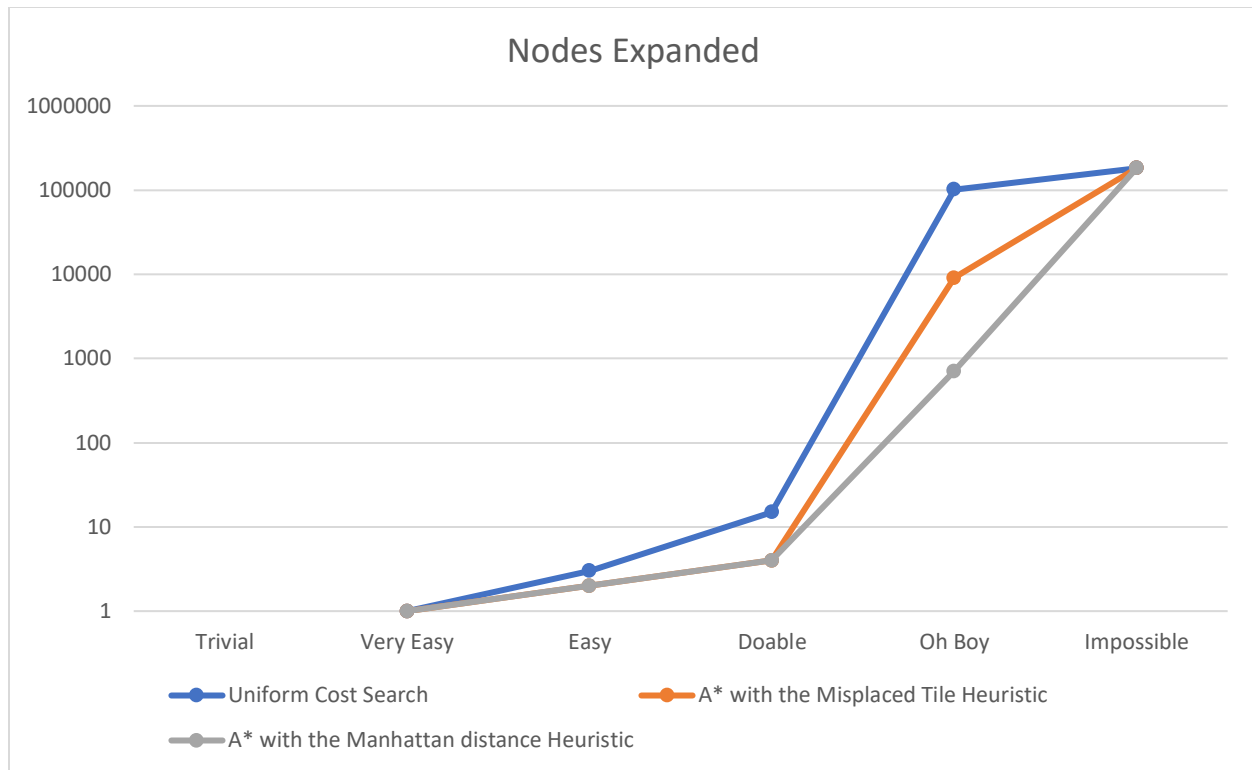
- Objects
  - o puzz8 object
    - g, weight from distance from initial
    - h, weight from distance from goal, measured by heuristic
    - array of length 9, with puzzle
- Helper Functions
  - o Expand
    - Adds nodes to frontier if not explored yet (max of 4 added possible)
  - o Choose
    - Loops through frontier chooses lowest cost node
  - o Switch
    - Creates a new puzzle with two spots switch
    - Allows for easy node generation
  - o Find
    - Finds a value in an array, and returns an index
    - Allows switch problem to know which indexes to switch
- I implemented a graph search, and compared three heuristics
  - o No heuristic
    - Uniform Cost Search
  - o Misplaced Tiles
  - o Manhattan Distance
- I used an Explored set, and a List for the frontier

### Findings

- As the problems grow more difficult, the more important the heuristic becomes
- For Trivial or Easy problems the heuristic barely improves performance
- A good heuristic can be far better than an alright heuristic, and an alright heuristic is far better than no heuristic

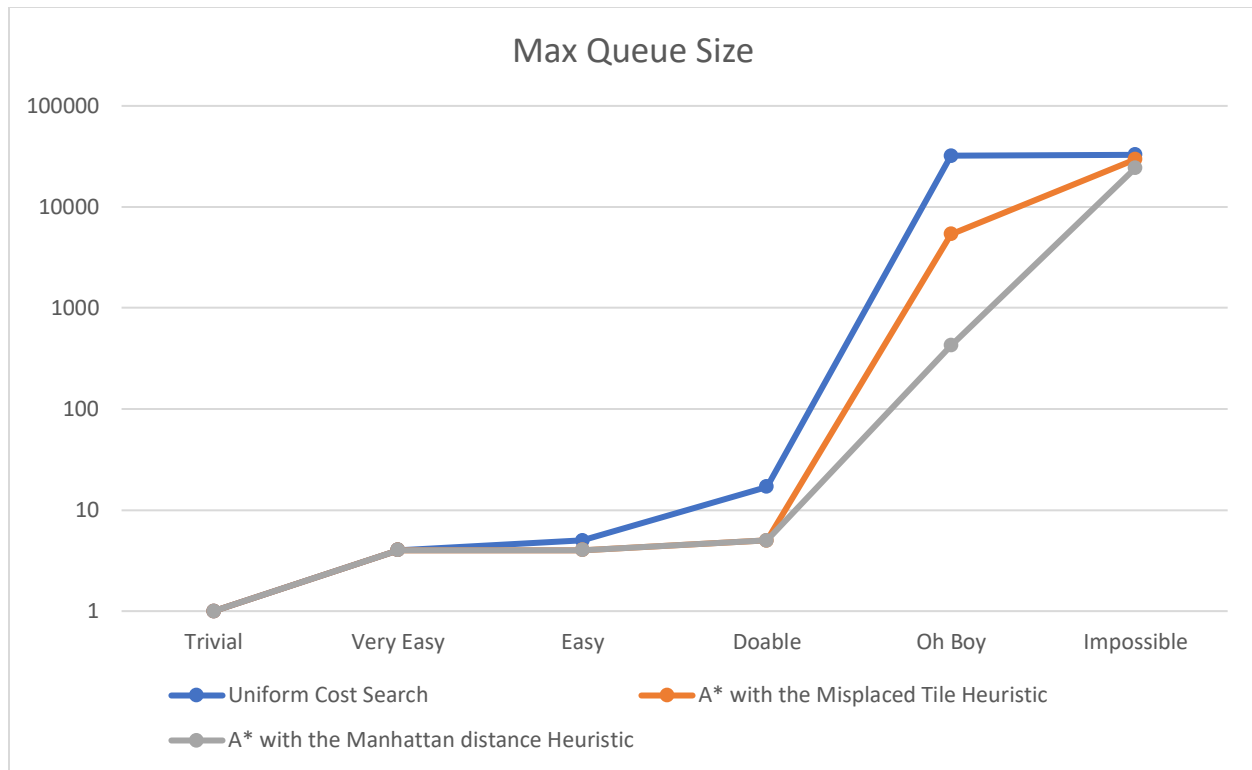
### Test Cases

Trivial	Very Easy	East	Doable	Oh Boy	Impossible
1 2 3	1 2 3	1 2 0	0 1 2	8 7 1	1 2 3
4 5 6	4 5 6	4 5 3	4 5 3	6 0 2	4 5 6
7 8 0	7 0 8	7 8 6	7 8 6	5 4 3	8 7 0
Solved in 0 Moves	Solved in 1 Moves	Solved in 2 Moves	Solved in 4 Moves	Solved in 22 Moves	Unsolvable



	Trivial	Very Easy	Easy	Doable	Oh Boy	Impossible
Uniform Cost Search	0	1	3	15	102070	181440
A* with the Misplaced Tile Heuristic	0	1	2	4	9120	181440
A* with the Manhattan distance Heuristic	0	1	2	4	709	181440

- For the simpler puzzles, trivial, very easy, and easy, all three searches expanded similar amounts of nodes
- For the Doable puzzle, the A\* searches began to outstrip the Uniform Cost Search
- The Manhattan Distance and Misplaced Tile Heuristics Performed exactly the same from the Doable puzzle, but showed extreme differences for the Oh Boy puzzle, with the Manhattan distance Heuristic beating the Misplaced Tile Heuristic by more than a factor of 10
- All three algorithms expanded the maximum of 181,440, or  $(9!/2)$ , nodes for the impossible puzzle before failing.



Max Queue Size						
	Trivial	Very Easy	Easy	Doable	Oh Boy	Impossible
Uniform Cost Search	1	4	5	17	32156	32780
A* with the Misplaced Tile Heuristic	1	4	4	5	5395	29571
A* with the Manhattan distance Heuristic	1	4	4	5	425	24295

- Space wise the three algorithms performed similarly for the Trivial, Very Easy, and Easy Puzzles.
- For the Doable Puzzle the Uniform Cost Search Used a bit more than 3x the space as the two A\* searches.
- For the Oh Boy, the Manhattan Distance Heuristic shines as it performs almost 100x better than the Uniform Cost Search and 10x better than the Misplaced Tile Heuristic.
- For the Impossible Puzzle, all three Algorithms used up similar amounts of space.
- It is important to note that the Uniform cost search performed just as poorly on the Oh Boy puzzle and the Impossible puzzle, suggesting that after a certain point all puzzles are the same space wise, and that point comes very early for the Uniform Cost Search