**Assignment 2: Solving Puzzle Games Optimally**

**Alan Guo**

**831747**

**Experimentation:**

The following are the results of solving several puzzles using the IDA\* algorithm.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| ID | Initial Estimate () | Thresholds () | Solution | Generated Nodes | Expanded Nodes |
| 1 | 41 | 41 43 45 47 49 51 53 55 57 | 57 | 499,911,606 | 253,079,560 |
| 2 | 43 | 43 45 47 49 51 53 55 | 55 | 18,983,862 | 9,777,810 |
| 3 | 41 | 41 43 45 47 49 51 53 55 57 59 | 59 | 455,125,298 | 229,658,354 |
| 4 | 42 | 42 44 46 48 50 52 54 56 | 56 | 82,631,583 | 41,689,053 |
| 14 | 41 | 41 43 45 47 49 51 53 55 57 59 | 59 | 937,956,626 | 475,109,930 |
| 88 | 43 | 43 45 47 49 51 53 55 57 59 61 63 65 | 65 | 6,195,467,140 | 3,176,234,868 |

Table 1: Experimentation results for IDs 1, 2, 3, 4, 14, 88, including number of generated and expanded nodes

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | Manhattan Distance | | Manhattan Distance calculated incrementally | |
| ID | Total Search Time (sec) | Expanded Nodes/ Second | Total Search Time (secs) | Expanded Nodes/ Second |
| 1 | 27.20 | 9,302,731 | 8.63 | 29,319,825 |
| 2 | 1.06 | 9,208,381 | 0.33 | 29,997,882 |
| 3 | 25.24 | 9,100,367 | 7.82 | 29,353,774 |
| 4 | 4.52 | 9,230,771 | 1.43 | 29,239,428 |
| 14 | 52.99 | 8,965,193 | 16.26 | 29,218,606 |
| 88 | 341.93 | 9,289,138 | 107.93 | 29,429,858 |

Table 2: Search times for IDs 1, 2, 3, 4, 14, 88, calculating Manhattan distance directly vs. incrementally

**Improvements:**

Reduce expanded nodes:

Generated and expanded nodes were reduced by pruning duplicate nodes, by avoiding branching to the move which returns the search back to the parent node (avoiding the inverse move).

Speed up node generation:

Instead of calculating the Manhattan distance of each tile iteratively at each call, the heuristic function can be calculated incrementally. As each action/swap will change exactly one tile’s Manhattan distance by , this will require only one calculation. Using this, Table 2 shows a 3.2x increase in speed consistently.