**TEST REPORT**

The following test results were deduced on a computer with a clock speed of 2.00 GHz.

The following parameters were tested:

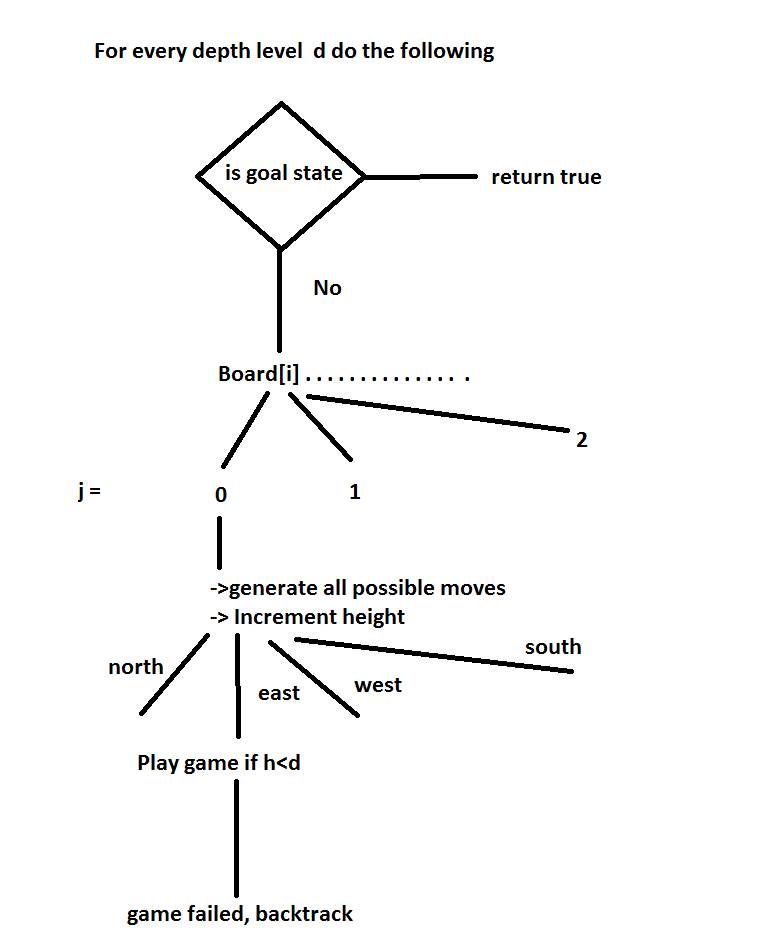
* Execution Time
* Number of nodes expanded
* Number of moves made
* Memory Usage

The above parameters were tested against:

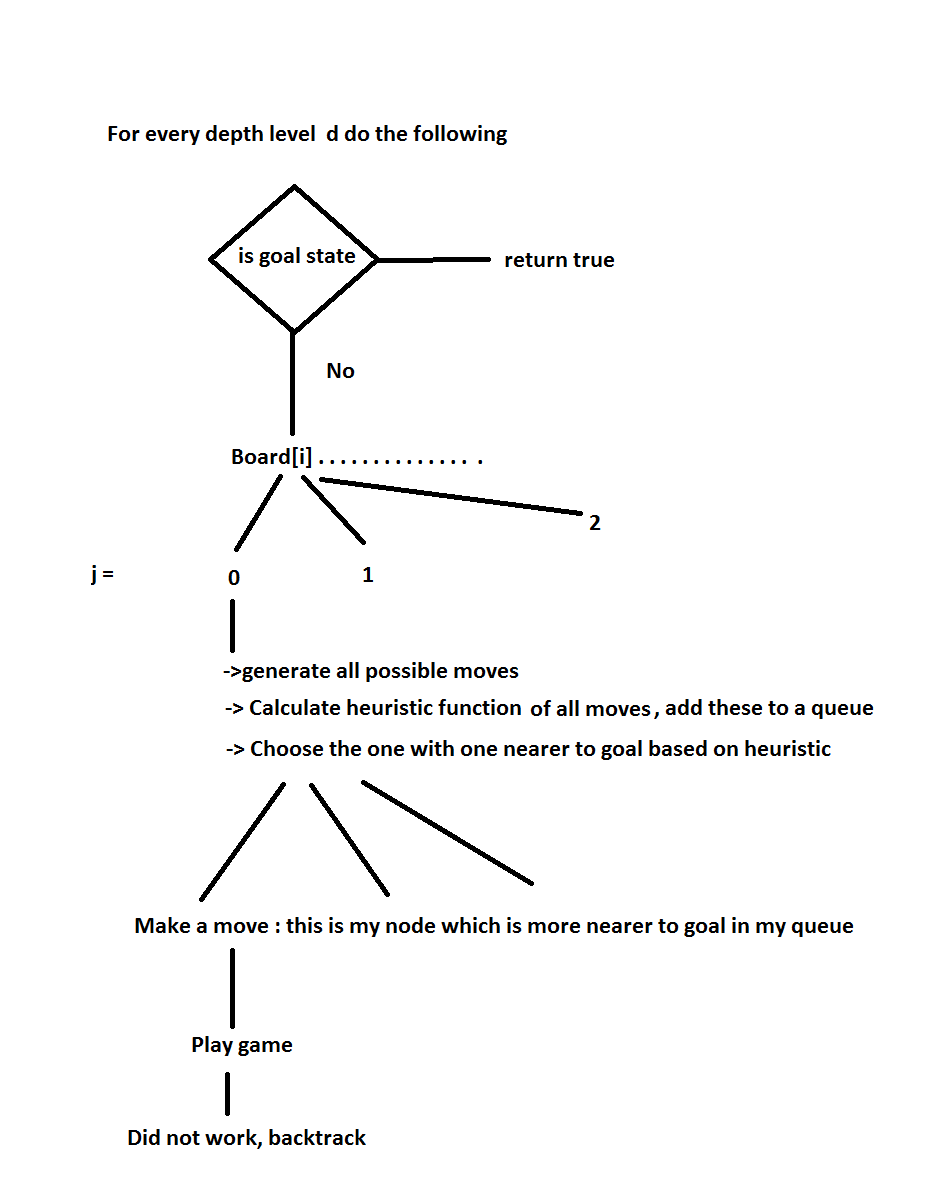
* Iterative Deepening search
* A\* search with Manhattan distance heuristic
* A\* search with a heuristic which is a variant of pagoda function
* A\* search with a random heuristic

A brief description of the algorithms as applied to this game:

Iterative Deepening:

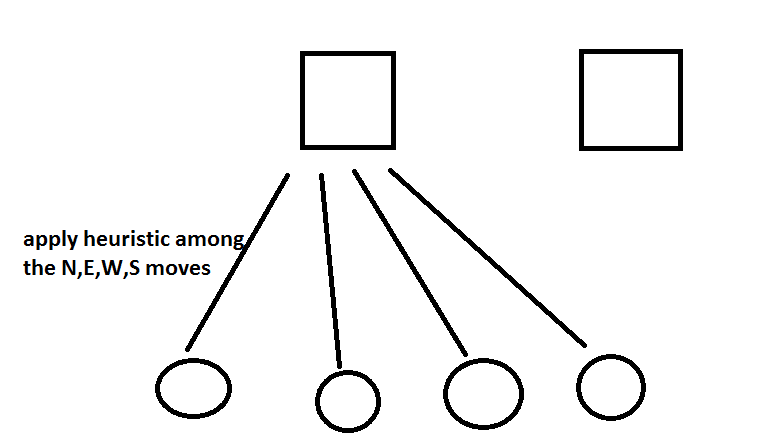


* A\* search heuristic

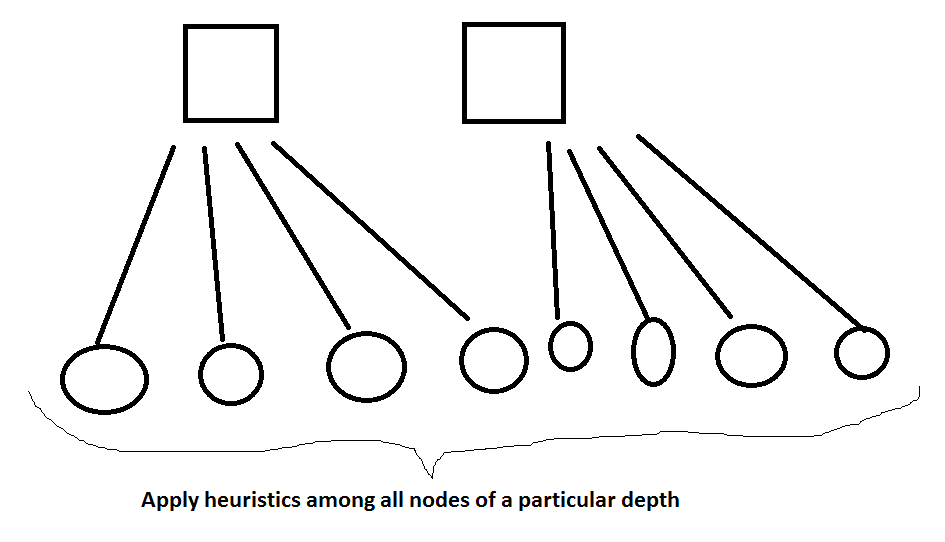


Three heuristics were considered:

* Sum of the distances of each peg from the centre.
* Assigning a value to all board positions, to determine if a particular board is favorable [[1]](#footnote-1)or not. ( this is not my own idea. I picked this up by learning about pagoda functions and other papers)
* Assigning a random value to moves in proportion to number of moves. Though this heuristic is not consistent or admissible, it always performs better than DFS.
* The order of applying the heuristics also is tested :
* The DFS way:



* The BFS way:



* Minimal pruning has been performed. The failed state nodes are transposed and added to a hashmap. If we encounter a similar node, we discard it.
* Memory is maintained minimal, by backtracking on the same board.[[2]](#footnote-2)

The following test cases were considered[[3]](#footnote-3):

|  |  |  |
| --- | --- | --- |
| BOARD | Number of Pegs |  |
| Config1 | 4 | <--000--,--0X0--,0X00000,00X0000,00X0000,--000--,--000--> |
| Config2 | 8 | <--000--,--000--,XXXX000,XXX0000,X000000,--000--,--000--> |
| Cross | 6 | <--000--,--0X0--,00XXX00,000X000,000X000,--000--,--000--> |
| Plus | 8 | <--000--,--0X0--,000X000,0XXXXX0,000X000,--0X0--,--000--> |
| Pyramid | 16 | <--000--,--0X0--,00XXX00,0XXXXX0,XXXXXXX,--000--,--000--> |
| Fireplace | 11 | <--XXX--,--XXX--,00XXX00,00X0X00,0000000,--000--,--000--> |
| complete | 32 | <--XXX--,--XXX--,XXXXXXX,XXX0XXX,XXXXXXX,--XXX--,--XXX--> |
| NoSolution | 22 | <--XXX--,--000--,XXXXXXX,X00000X,XXXXXXX,--000--,--XXX--> |
| No Solution | 33 | <--XXX--,--XXX--,XXXXXXX,XXXXXXX,XXXXXXX,--XXX--,--XXX--> |

**Observations of the tests performed:**

* **The heuristics applied perform better for more number of pegs**
* **BFS way of applying the heuristic performs better than DFS way of applying the heuristic**
* **Random heuristic sometimes performs better than no heuristics**
* **The pagoda variant performs better than the Manhattan distance heuristic.**
* **The direction of the moves made ( north, east, west, south) also matter. The goal positions are likely to be hit earlier.**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Board Config | Execution Time( in seconds) | | | | | | |
|  | Iterative Deepening | A\* Heuristic (Manhattan distance) | | A\* (pagoda variant) | | A\*( a random heuristic) | |
|  |  | DFS | BFS | DFS | BFS | DFS | BFS |
| Config1 | 0.0019 | 0.01 | 0.001 | 0.01 | 0.001 | 0.01 | 0 |
| Config2 | 0.03 | 0.03 | 0.03 | 0.03 | 0.003 | 0.018 | 0.016 |
| Cross | 0.04 | 0.0019 | 0.002 | 0.002 | 0.002 | 0.001 | 0.02 |
| Plus | 0.66 | 0.012 | 0.005 | 0.008 | 0.003 | 0.005 | 0.03 |
| Pyramid | >1 hour | 0.053 | 9.3 | 0.837 | 0.41 | 0.002 | 0.04 |
| Fireplace | 1.87 seconds | 0.67 | 1.08 | 0.631 | 0.11 | 0.36 | 0.038 |
| complete | >1 hour | >1hour | >1hour | 18 min | 15 min | 1.44 | >1 hour |
| No Solution | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| No Solution | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
|  | Number Of Nodes Expanded | | | | | | |
|  | Iterative Deepening | A\* Heuristic (Manhattan distance) | | A\* (pagoda variant) | | A\*( a random heuristic) | |
|  |  | DFS | BFS | DFS | BFS | DFS | BFS |
| Config1 | 10 | 4 | 3 | 4 | 4 | 4 | 6 |
| Config2 | 963 | 242 | 229 | 242 | 13 | 242 | 221 |
| Cross | 83 | 9 | 6 | 9 | 6 | 9 | 17 |
| Plus | 1761 | 53 | 22 | 53 | 9 | 56 | 24 |
| Pyramid |  | 5771 | 64858 | 5771 | 2500 | 23 | 464 |
| Fireplace | 51913 | 4341 | 7927 | 4341 | 766 | 4991 | 457 |
| complete | --a lot-- |  | 8,97,345 | 7022154 | 5,34,564 | 18629 | -- |
| No Solution | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| No Solution | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Number of Moves Made | | | | | | |
| Iterative Deepening | A\* Heuristic (Manhattan distance) | | A\* (pagoda variant) | | A\*( a random heuristic) | |
|  | DFS | BFS | DFS | BFS | DFS | BFS |
| 17 | 5 | 3 | 5 | 5 | 5 | 9 |
| 1919 | 477 | 451 | 477 | 19 | 477 | 435 |
| 161 | 13 | 7 | 13 | 7 | 13 | 29 |
| 3514 | 98 | 36 | 98 | 10 | 104 | 40 |
|  | 11527 | 129701 | 11527 | 4985 | 31 | 913 |
| 103816 | 8672 | 14584 | 8672 | 1522 | 9972 | 907 |
| --- |  | 16342982 | 14044277 | 10453232 | 37227 |  |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 |

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Board Config | Memory consumed in Bytes | | | | | | |
|  | Iterative Deepening | A\* Heuristic (Manhattan distance) | | A\* (pagoda variant) | | A\*( a random heuristic) | |
|  |  | DFS | BFS | DFS | BFS | DFS | BFS |
| Config1 | 568 | 184 | 184 | 184 | 184 | 184 | 184 |
| Config2 | 1080 | 184 | 184 | 184 | 184 | 184 | 184 |
| Cross | 824 | 184 | 184 | 184 | 184 | 184 | 184 |
| Plus | 1208 | 184 | 184 | 184 | 184 | 184 | 184 |
| Pyramid |  | 184 | 184 | 184 | 184 | 184 | 184 |
| Fireplace | 1464 | 184 | 184 | 184 | 184 | 184 | 184 |
| complete |  | 184 | 184 | 184 | 184 | 184 | 184 |
| No Solution | 2944 | 128 | 128 | 128 | 128 | 128 | 128 |
| No Solution | 4352 | 128 | 128 | 128 | 128 | 128 | 128 |

References :

\* http://www.jaapsch.net/puzzles/pegsolit.htm

\* <http://www.delphiforfun.org/programs/PegSolitaire.htm>

\* The following books and research papers ideas were used while formulating the solution of this project.





1. Refer to “winning ways in mathematical plays” [↑](#footnote-ref-1)
2. Refer to DFS solves Peg Solitaire [↑](#footnote-ref-2)
3. Few test cases were picked from <http://www.delphiforfun.org/programs/PegSolitaire.htm> [↑](#footnote-ref-3)