

Artificial Intelligence – 1st Assignment

One-agent Puzzle (Pancake Sorting) and Two-Agents Board Game (Congklak)

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Abstract—Pancake Sorting is the game to calculate how many times a pancake should be flipped, in order to have a balance shape. On the other hand, congklak is an ingenious board game from Indonesia, that is played by two player.

I. INTRODUCTION

THIS report was made to report how the game was made and worked. Along with this report, presented as well the screenshots and statistic of the algorithm to play these games.

II. DEFINITION

A. LITERATURE REVIEW

1. PANCAKE SORTING

Pancake sorting is the mathematical problem of sorting pancakes in order for a spatula to be inserted at any position in the stack and used to flip all pancakes above. The least amount of flips necessary to neatly arrange the pancakes is called the pancake number.

Watch the visualization in here :

<https://www.youtube.com/watch?v=kk-DDgoXfk>

<https://www.youtube.com/watch?v=ChMjvN1eAFI>

2. CONGKLAK

Congklak is Indonesian game which playing board is made from wood with either 5, 6, 7 or 9 holes in both sides (The varies number of hole is due to variations from island to island), plus 2 homebases (1 for each player). There are 2 players on this game, which compete to get as many shells as possible in their homebase. In order to win, the player either need to have the most shells in his/her homebase (*menang biji*) or to be the last person to run out of shells on your side of the board (*menang jalan*).

For further instruction on how to play the game, please refer to :

<https://www.expat.or.id/info/congklakinstructions.html>

Watch the visualization in here :

<https://www.youtube.com/watch?v=pxT4BbsdybY>

B. ALGORITHM¹

1. GREEDY SEARCH

Greedy best-first search algorithm always selects the path which appears best at that moment. It is the combination of depth-first search and breadth-first.

2. DEPTH-FIRST SEARCH

It is a recursive algorithm to search all the vertices of a tree data structure or a graph. The depth-first search (DFS) algorithm starts with the initial node of graph G and goes deeper until we find the goal node or the node with no children.

3. UNIFORM SEARCH

Uniform-cost search is an uninformed search algorithm that uses the lowest cumulative cost to find a path from the source to the destination. Nodes are expanded, starting from the root, according to the minimum cumulative cost. T

4. A* SEARCH

When, H a function that is an estimation $h(s)$ of the distance of the state to a solution, the resulting search algorithm is usually called BestFirst Search When

$$H(s) = c(s_0, s) + h(s)$$

the resulting search is the Branch&Bound algorithm which is known as A* in the AI community

5. MIN-MAX

Min-Max Search is used in AI to implement systems that can play zero-sum perfect-information games. Typically, this algorithm is implemented for two players board game.

It is an adaptation of hill climbing heuristic search alternating the choice of what state to choose next, according to the min or the max of the heuristic evaluation of the board position, depending which player turn is.

The idea is that while player A is trying to maximize the evaluation of the position, the

¹For the further usage how these algorithm was implemented, please refer to jupyter notebook and python code remarks

opponent is believed to be minimizing the same evaluation.

C. IMPLEMENTATION

The game will ask user whether it want to shown the representation of pancake or puzzle.

1. USER EXPERIENCE AND CODE LIMITATION

1.1. PANCAKE SORTING

User need to choose number 1 to start pancake puzzle.

The code uses by this program capables to :

- 1.1.1. randomly generate the position of starting puzzle or get the input from the user. The example below and statistic use randomly shuffles position for easier testing multiple times, but it can easily changed in main.py .
- 1.1.2. choose whether to call of the algorithm at once or just one of it. The example below and statistic calls all algorithm at once per sample, in order to compare the result.
- 1.1.3. The number of pancake to be play at least 4 pancakes, and the maximum is 9. But, I only ever test until 6 due to the performance limitation of the laptop

1.2. CONGKLAK

User need to choose number 2 to start congklak simulator.

The code uses by this program capable to :

- 1.2.1. User can change the level of how hard the game is.
- 1.2.2. The code is capable to accommodate human player vs min-max or random bot. However, this testing purpose only let min-max bot competes with random bot, or two min-max compete with each other, for easier and statistic purpose.
- 1.2.3. To give randomization to the pattern of the MinMax vs MinMax game, user can set the first three steps to be taken randomly.
- 1.2.4. The objective of this player is to compare how good min-max than randomly move agent without heuristic, and how the performance time of two min-max competes with each other.
- 1.2.5. So, the statistic will be counting how many times min-max win, lose, or tie when compete with random player or between two min-max.
- 1.2.6. The congklak game is 2-player game, can not be one-player or multi-player because it is the rule in the real world. So, the heuristic of this game regulate and limit the searching agent to be used by 2-player only for this game. But, on the highest level of abstraction, it is not limited.

2. CODE EXPLANATION

2.1. Main (Main.ipynb)

The starting page of this project. In this page, the user

can choose whether they want to simulate pancake puzzle or congklak game. The system will run the next steps according to the choice. (see C.1)

2.2. Searching Agent (AgentAlgorithm.py)

In this page, listed all the searching algorithm used by this program (min-max, DFS, Greedy, A* and Uniform Search).

For easier classification, the page is splitted into 2 different classes, searchingAlgorithm (finding path) and competingAlgorithm (playing game and finding winner).

This class have the highest abstraction of algorithm, so to accommodate heuristic and move of other game, an abstract heuristic functions were place in these classes.

2.3. Other Functionality (ReportingUtility.py)

This function was made to record the performance and study cases for statistical reason (see D.1 and D.2)

2.4. Pancake Puzzle

2.4.1. AgentPancake.py

This file is containing the playing agent for pancake puzzle.

In this file, the function can be called to make random study cases or accepting study cases from users.

For the random type, the system can be set to run each searching algorithm or just one of them.

2.4.2. PancakeFinal.py

This page is the representation 'board' of the pancake puzzle game.

2.4.3. PancakeQueue.py

This page is where the heuristic of pancake puzzle was placed.

2.4.4. Searching algorithm

Previous three pages will structurally call the searching agent (see C2.2)

2.5. Congklak Game

2.5.1. AgentCongklak.py

This page containing the playing agent for congklak game.

2.5.2. CongklakCMD.py

This file is containing further configuration for playing agent.

In this page, the system receive the configuration of the game (who is the player (bot/human), the difficulty, whether first three moves need to be randomize (only for minmax vs minmax), and whether the game will be recorded, and then play the simulation according to them.

2.5.3. CongklakBoard.py

This page is the representation 'board' of the congklak game.

2.5.4. CongklakMove.py

This page is the representation of how beads can

be rotated in the 'board' of congklak game.

2.5.5. CongklakRandomBot.py

This page is for searching agent. This playing agent separated from the abstract searching agent (see C.2.2), because this bot playing without any heuristic, only randomly moved and specialized for congklak only. This bot was made as the comparison for the game with heuristic-added minmax functionality.

2.5.6. Searching algorithm

Previous five pages will structurally call the searching agent (see C2.2)

D. RESULTS

1. PANCAKE SORTING

Will be shown on the result is the comparison of the result of each algorithm :

```
SUCCESSFULLY RANDOMED INPUT WITH DEEP FIRST SEARCH : d1324
Starting Stack: 1 3 2 4
Depth First Search Solution:
Final State: 4321 g=0, h=0
Time : 0.000496

SUCCESSFULLY RANDOMED INPUT WITH UNIFORMED SEARCH : u1324
Starting Stack: 1 3 2 4
Uniform Cost Search Solution:
Final State: 4321 g=0, h=0
Time : 0.026851

SUCCESSFULLY RANDOMED INPUT WITH GREEDY SEARCH : g1324
Starting Stack: 1 3 2 4
Greedy Search Solution:
Final State: 4321 g=0, h=0
Time : 0.003987

SUCCESSFULLY RANDOMED INPUT WITH ASTAR SEARCH : a1324
Starting Stack: 1 3 2 4
A* Search Solution:
Final State: 4321 g=0, h=0
Time : 0.021396
```

We can set the application to show the steps taken by the game :

```
SUCCESSFULLY RANDOMED INPUT WITH UNIFORMED SEARCH : u3241
Starting Stack: 3 2 4 1
Uniform Cost Search Solution:
32|41 g=0, h=4
|3214 g=2, h=4
4|123 g=6, h=3
Final State: 4321 g=9, h=0
Time : 0.007857
```

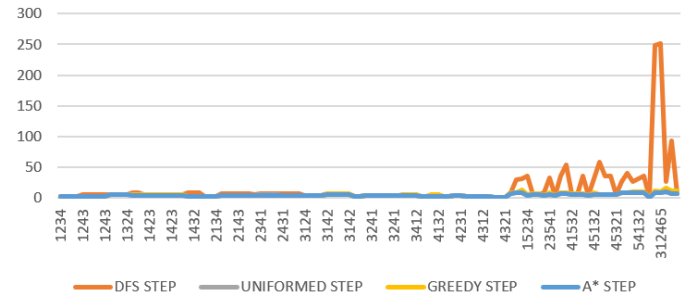
For the testing purpose, the system was automatically played various sample cases. The sample was consisted of 112 randomly generated cases, which each of algorithm (A*, Greedy, Uniform and DFS) played once. Therefore, for the testing purposes there were 448 times of playing pancake puzzle.

The sample consists of 81 cases of 4-pancakes-game, 26 cases of 5-pancakes-game, and 5 cases of 6-pancakes-game.

The average steps that needed by each algorithm to solve the puzzle

Cases	DFS	UNIFORM	GREEDY	ASTAR
4-Pancakes	4,75	3,57	3,89	3,52
5-Pancakes	24,12	6,04	7,23	7,23
6-Pancakes	125,60	8,20	11,80	8,20

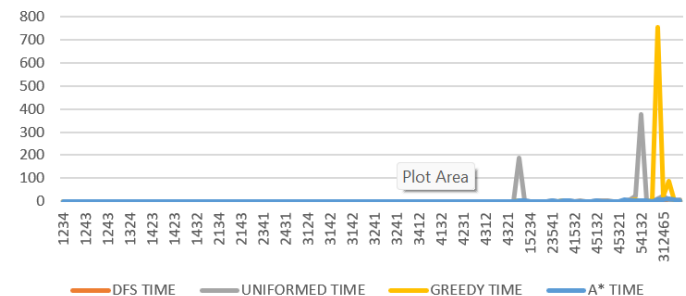
The comparison of steps taken by 4 algorithms to solve the puzzle



The average time that needed by each algorithm to solve the puzzle

Cases	DFS	UNIFORM	GREEDY	ASTAR
4-Pancakes	0,00	0,02	0,00	0,01
5-Pancakes	0,00	23,58	0,35	1,29
6-Pancakes	0,02	8,54	172,78	7,36

The comparison of processing time for 4 algorithms (in seconds)



Finally, from the tables and graphs, it is clear that in term of the number of steps, the highest number of steps needed was in average 51,49 steps by DFS. Followed by greedy, AStar, and Uniform Search.

But, in contrary DFS, was the fastest to solve the puzzle with only 0,0075 seconds. Followed by AStar. For Greedy Search, it was good for small number of pancakes, but after 5 pancakes, the time performance will be significantly slower. Uniform Search on the other hand, was in average took more time to calculate 5-pancakes than 6-pancakes.

2. CONGKLAK

2.1. Random Bot vs MinMax Bot

Will be shown are the simulation of the game play. In the picture it is clear to be simulated by random bot and minmax bot, how 2 player takes turn to spread

their beads. At the end of the game, there are summary of how long the game is taken and who is the winner.

```

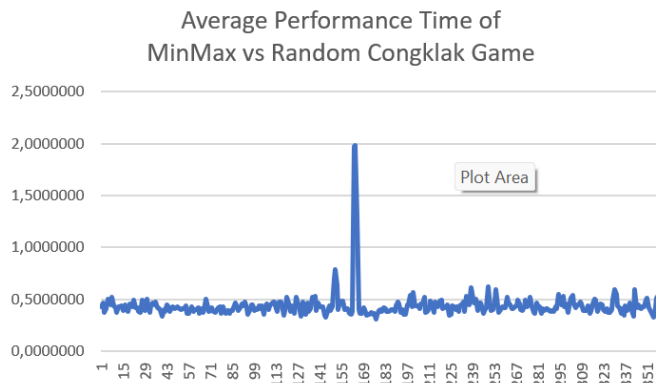
Bot Minimax Turn
2022-11-03 21:36:22.845467Player 2 move: 11
Bot Minimax Turn
2022-11-03 21:36:22.846051Player 2 move: 13
Bot Minimax Turn
2022-11-03 21:36:22.847224Player 1 move: 0
Bot Random Turn
2022-11-03 21:36:22.848038Player 1 move: 1
Bot Random Turn
2022-11-03 21:36:22.848662Player 1 move: 2
Bot Random Turn
2022-11-03 21:36:22.849830Player 1 move: 3
Bot Random Turn
2022-11-03 21:36:22.850432Player 1 move: 4
Bot Random Turn
2022-11-03 21:36:22.851287Player 1 move: 5
Bot Random Turn
2022-11-03 21:36:22.852225Player 1 move: 6
Bot Minimax Turn
Minimax Bot WINS IN : 0.398312 SECONDS

```

For the testing purpose, the system was automatically played 360 times consist of 60 games of each level (6 levels).

180 of the testing games started by Random Bot as first player, and 180 times started by MinMax Bot as first player.

Finally, all of 360 attempts was win by MinMax Algorithm.



2.2. MinMax Bot vs MinMaxBot

The picture below shows the simulation of 2 min-max bots compete with each other.

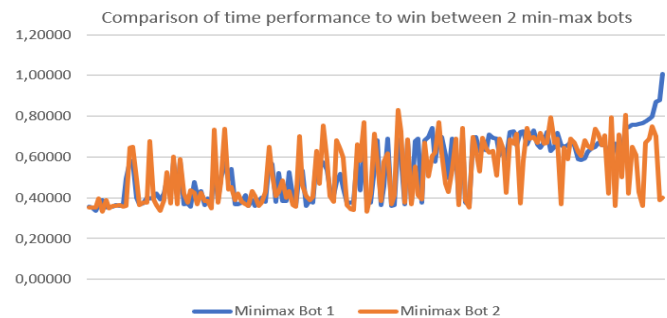
```

2022-11-21 20:55:05.241441Player 2 move: 12
Bot MinMax 2 Turn
2022-11-21 20:55:05.242442Player 2 move: 13
Bot MinMax 2 Turn
2022-11-21 20:55:05.243501Player 2 move: 8
Bot MinMax 2 Turn
2022-11-21 20:55:05.243501Player 2 move: 9
Bot MinMax 2 Turn
2022-11-21 20:55:05.244601Player 2 move: 10
Bot MinMax 2 Turn
2022-11-21 20:55:05.244601Player 2 move: 11
Bot MinMax 2 Turn
2022-11-21 20:55:05.245599Player 2 move: 12
Bot MinMax 2 Turn
2022-11-21 20:55:05.246600Player 2 move: 14
Bot MinMax 1 Turn
2022-11-21 20:55:05.246600Player 2 move: 13
Bot MinMax 2 Turn
2022-11-21 20:55:05.246600Player 2 move: 14
Bot MinMax 1 Turn
Minimax Bot 2 WINS IN : 0.346893 SECONDS

```

For the testing purpose, the system was automatically played 720 times consist of 120 games of each level (6 levels).

360 of the testing games started by MinMax Bot (Player1) as first player, and 360 times started by MinMax Bot (Player2) as first player.

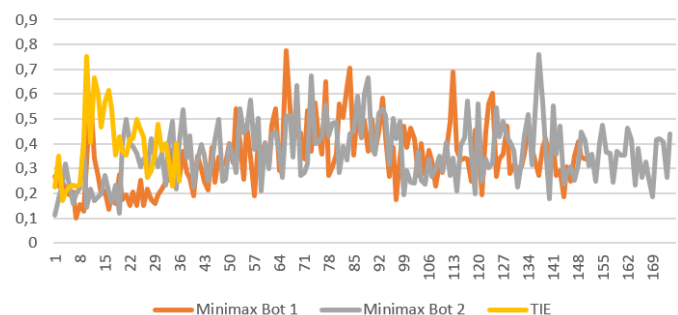


Half of the attempts done fully by minmax bots. Which was resulting in 180 wins by player 1 and 180 wins by player 2.

However, to give randomization of the game, the others half was set to do 3 random steps, before the rest was did by minmax bot.

Which was wined 150 times by player 1, 174 times by player 2, and the rest was tie.

Comparison of time performance to finish the game between 2 min-max bots with randomize start



III. CONCLUSION

From the testing attempts, author can conclude that in board game simulation heuristic-added min-max algorithm works significantly better than randomly moved. And if we play 2 min-max bots together, they can finish the game faster than min-max vs random.

For path searching algorithm, DFS has the better time performance for pancake games, but took the most steps. So, author will recommend to use AStar instead, due to its consistency. AStar was the second fastest, and second lowest number of steps—however the differences between AStar and the Greedy, the first, is only 0.2 steps in average.

IV. ACKNOWLEDGMENT

The authors gratefully acknowledge works of lukaskurnia and d-heck, as their previous works greatly inspired this project.

V. REFERENCES

- [1] Caianello P. and Stillo G., “Introduction of AI”, 2022
- [2] Caianello P. and Stillo G., “Heuristic Search”, 2022
- [3] Caianello P. and Stillo G., “Agent of Ontology”, 2022
- [4] Caianello P. and Stillo G., “Min-Max”, 2022

ANNEX A

THE TESTING RESULT OF PANCAKE SORTING PUZZLE (1-AGENT PUZZLE)

CASE STUDY	DFS STEP	DFS TIME	UNIFORMED STEP	UNIFORMED TIME	GREEDY STEP	GREEDY TIME	A* STEP	A* TIME
1234	2	0	2	0,0033	2	0,001	2	0
1234	2	0,001	2	0,00251	2	0,001	2	0
1234	2	0	2	0,00302	2	0,0005	2	0,00068
1234	2	0,00011	2	0,00178	2	0,0011	2	0
1243	6	0,0008	3	0,00745	3	0,001	3	0,001
1243	6	0,0019	3	0,01426	3	0,00648	3	0,00427
1243	6	0	3	0,00499	3	0,00095	3	0,00101
1243	6	0	3	0,00499	3	0,001	3	0,001
1243	6	0	3	0,004	3	0,00099	3	0,001
1324	5	0	5	0,02233	5	0,00303	5	0,01926
1324	5	0,00057	5	0,02382	5	0,00391	5	0,01928
1324	5	0,00108	5	0,03646	5	0,00443	5	0,02029
1324	5	0,00101	5	0,01635	5	0,00299	5	0,01358
1342	8	0,0006	4	0,03488	5	0,00508	4	0,03302
1342	8	0	4	0,02228	5	0,00299	4	0,02544
1423	5	0,001	4	0,02551	5	0,0049	4	0,00698
1423	5	0,001	4	0,02446	5	0,00431	4	0,00605
1423	5	0,00099	4	0,02564	5	0,00406	4	0,00754
1423	5	0,001	4	0,02781	5	0,00572	4	0,00798
1423	5	0,00066	4	0,03872	5	0,00698	4	0,00905
1423	5	0	4	0,0272	5	0,0089	4	0,00599
1423	5	0,00074	4	0,02516	5	0,00498	4	0,00798
1423	5	0,00137	4	0,02768	5	0,0074	4	0,01056
1432	8	0,00191	3	0,02141	3	0,001	3	0,00598
1432	8	0,00133	3	0,0163	3	0,00101	3	0,0029
1432	8	0	3	0,01602	3	0	3	0,0039
2134	3	0,00083	3	0,00726	3	0,00203	3	0,00104
2134	3	0,00038	3	0,0114	3	0,00379	3	0,00201
2134	3	0	3	0,004	3	0	3	0,00099
2143	7	0,0003	4	0,02978	4	0,0039	4	0,01162
2143	7	0,00169	4	0,02344	4	0,00401	4	0,01002
2143	7	0,00168	4	0,0273	4	0,00419	4	0,01024
2143	7	0,00147	4	0,02814	4	0,00394	4	0,01126
2143	7	0	4	0,01912	4	0,00325	4	0,00651
2143	7	0	4	0,01742	4	0,00296	4	0,00594
2314	6	0,0005	4	0,02984	4	0,0034	4	0,0167
2341	7	0,00226	5	0,027	4	0,00396	4	0,01852
2341	7	0,00785	5	0,03625	4	0,00519	4	0,02241
2341	7	0,001	5	0,01951	4	0,00297	4	0,01329
2341	7	0,0005	5	0,01902	4	0,00295	4	0,01333

2431	7	0,00147	4	0,0589	4	0,01057	4	0,01576
2431	7	0,00099	4	0,05932	4	0,00993	4	0,01716
2431	7	0,00138	4	0,06625	4	0,01098	4	0,0172
2431	7	0,00165	4	0,07254	4	0,01385	4	0,02866
3124	4	0,00123	4	0,03954	4	0,00094	4	0,01898
3124	4	0,00075	4	0,04448	4	0,00105	4	0,02003
3124	4	0,0005	4	0,05976	4	0,00197	4	0,02646
3124	4	0	4	0,02703	4	0,00093	4	0,01197
3142	5	0,00123	5	0,0645	7	0,01514	5	0,02292
3142	5	0,0005	5	0,05865	7	0,01343	5	0,02295
3142	5	0	5	0,03895	7	0,00915	5	0,01358
3142	5	0,00028	5	0,04284	7	0,01045	5	0,01666
3142	5	0	5	0,041	7	0,00997	5	0,01345
3214	3	0,00057	3	0,02166	3	0,00114	3	0,0055
3214	3	0,001	3	0,01127	3	0	3	0,00289
3241	4	0,0005	4	0,04632	4	0,00335	4	0,01216
3241	4	0,001	4	0,0475	4	0,00321	4	0,01327
3241	4	0	4	0,03076	4	0,00191	4	0,00629
3241	4	0,001	4	0,03082	4	0,00194	4	0,00759
3241	4	0,00101	4	0,03317	4	0,00234	4	0,00788
3241	4	0	4	0,02956	4	0,00192	4	0,00797
3241	4	0	4	0,03289	4	0,00271	4	0,00866
3412	6	0,00183	4	0,02865	6	0,00392	4	0,01104
3412	6	0,001	4	0,03061	6	0,00421	4	0,01173
3412	6	0	4	0,01983	6	0,002	4	0,00697
4123	2	0	2	0,00311	2	0,00099	2	0,00199
4123	2	0,0005	2	0,00099	2	0,00049	2	0,00165
4132	5	0,001	3	0,00524	5	0,00501	3	0,00507
4132	5	0	3	0,00352	5	0,00299	3	0,003
4213	3	0	3	0,00399	3	0,001	3	0,00498
4213	3	0	3	0,004	3	0	3	0,00498
4231	4	0,00008	4	0,00519	4	0,001	4	0,01313
4231	4	0,00058	4	0,0037	4	0,00095	4	0,01175
4312	2	0,0005	2	0,00101	2	0,001	2	0,001
4312	2	0	2	0	2	0,001	2	0
4312	2	0	2	0,00082	2	0,00096	2	0,00103
4312	2	0	2	0	2	0,00027	2	0,00103
4312	2	0	2	0,0007	2	0,00071	2	0,00054
4321	1	0	1	0	1	0,001	1	0
4321	1	0	1	0	1	0,001	1	0
4321	1	0	1	0	1	0	1	0
12453	8	0	7	0,38996	9	0,29248	7	0,20102
13542	30	0,00405	8	189,156	8	0,4627	8	3,66949
14253	31	0,002	8	1,37458	13	0,29499	8	1,20854
15234	36	0,00192	4	0,01504	6	0,01016	4	0,00498
21435	5	0,00092	5	0,10676	7	0,01669	5	0,04875

21435	5	0,00066	5	0,07349	7	0,00947	5	0,02831
23415	8	0,001	4	0,03782	4	0,00499	4	0,04173
23541	33	0,00499	6	1,49239	8	0,16873	6	0,76458
32541	4	0,001	4	0,02309	4	0,00399	4	0,01029
35142	35	0,00296	7	2,687	9	0,44452	7	1,75477
41352	53	0,00584	7	1,72808	9	0,18553	7	0,47834
41532	7	0	5	0,08626	7	0,01011	5	0,01771
42153	5	0,00108	5	0,51709	7	0,03803	5	0,15176
43251	35	0,00322	5	0,33626	7	0,0594	5	0,40648
43512	4	0,001	4	0,04324	4	0,00289	4	0,01228
45132	31	0,002	6	0,42015	8	0,11987	6	0,61
45213	58	0,003	6	0,59393	6	0,03664	6	0,41417
45231	36	0,0035	6	0,72466	6	0,0662	6	0,35545
45231	36	0,002	6	0,41429	6	0,04088	6	0,21118
45321	5	0,001	5	0,2093	5	0,00897	5	0,02492
52314	27	0,00553	8	4,05098	8	0,15636	8	5,51032
52431	40	0,00434	9	7,97106	9	0,5521	9	4,37155
53142	27	0,00187	9	24,29273	10	5,28789	9	4,44015
54132	31	0,00083	8	375,162	10	0,28889	8	4,36486
54231	36	0,00697	9	1,18646	10	0,59385	9	4,42373
54321	1	0	1	0	1	0	1	0,0005
132564	249	0,0238	9	9,27993	11	754,472	9	8,28175
312465	252	0,05718	8	21,37553	10	21,26317	8	7,71624
315624	27	0,00671	10	4,71435	16	85,17345	10	10,78292
354126	93	0,00899	7	2,88311	11	2,39562	7	6,42597
465321	7	0	7	4,46217	11	0,6176	7	3,5946

ANNEX B

THE TESTING RESULT OF CONGLAK (2-AGENTS BOARD GAME) – RANDOM BOT VS MINMAX BOT

ATTEMPTS NO	WINNER	TIME
1	Minimax Bot	0,42892
2	Minimax Bot	0,46878
3	Minimax Bot	0,376456
4	Minimax Bot	0,414588
5	Minimax Bot	0,498877
6	Minimax Bot	0,47801
7	Minimax Bot	0,450228
8	Minimax Bot	0,521221
9	Minimax Bot	0,436497
10	Minimax Bot	0,417003
11	Minimax Bot	0,375723
12	Minimax Bot	0,430727
13	Minimax Bot	0,430618
14	Minimax Bot	0,440937
15	Minimax Bot	0,396248
16	Minimax Bot	0,451319
17	Minimax Bot	0,398987
18	Minimax Bot	0,387358
19	Minimax Bot	0,452682
20	Minimax Bot	0,443157
21	Minimax Bot	0,430142
22	Minimax Bot	0,491115
23	Minimax Bot	0,424143
24	Minimax Bot	0,416903
25	Minimax Bot	0,38433
26	Minimax Bot	0,370481
27	Minimax Bot	0,494994
28	Minimax Bot	0,400183
29	Minimax Bot	0,394103
30	Minimax Bot	0,499302
31	Minimax Bot	0,460031
32	Minimax Bot	0,373642
33	Minimax Bot	0,442899
34	Minimax Bot	0,461882
35	Minimax Bot	0,447175
36	Minimax Bot	0,476019
37	Minimax Bot	0,417156
38	Minimax Bot	0,415184
39	Minimax Bot	0,396688
40	Minimax Bot	0,340116
41	Minimax Bot	0,401383

42	Minimax Bot	0,387535
43	Minimax Bot	0,447519
44	Minimax Bot	0,421755
45	Minimax Bot	0,386873
46	Minimax Bot	0,422423
47	Minimax Bot	0,425967
48	Minimax Bot	0,412164
49	Minimax Bot	0,420293
50	Minimax Bot	0,429619
51	Minimax Bot	0,412276
52	Minimax Bot	0,399925
53	Minimax Bot	0,40913
54	Minimax Bot	0,414607
55	Minimax Bot	0,441115
56	Minimax Bot	0,36344
57	Minimax Bot	0,361614
58	Minimax Bot	0,410697
59	Minimax Bot	0,428481
60	Minimax Bot	0,38703
61	Minimax Bot	0,398658
62	Minimax Bot	0,39986
63	Minimax Bot	0,417279
64	Minimax Bot	0,363444
65	Minimax Bot	0,413921
66	Minimax Bot	0,370998
67	Minimax Bot	0,397406
68	Minimax Bot	0,507705
69	Minimax Bot	0,426989
70	Minimax Bot	0,384118
71	Minimax Bot	0,390684
72	Minimax Bot	0,418044
73	Minimax Bot	0,379755
74	Minimax Bot	0,373307
75	Minimax Bot	0,395557
76	Minimax Bot	0,420812
77	Minimax Bot	0,432642
78	Minimax Bot	0,361743
79	Minimax Bot	0,427078
80	Minimax Bot	0,370451
81	Minimax Bot	0,369692
82	Minimax Bot	0,391924
83	Minimax Bot	0,364174
84	Minimax Bot	0,39025

85	Minimax Bot	0,390274
86	Minimax Bot	0,418303
87	Minimax Bot	0,463414
88	Minimax Bot	0,421897
89	Minimax Bot	0,38873
90	Minimax Bot	0,420006
91	Minimax Bot	0,453221
92	Minimax Bot	0,441893
93	Minimax Bot	0,472792
94	Minimax Bot	0,418284
95	Minimax Bot	0,352998
96	Minimax Bot	0,393173
97	Minimax Bot	0,444514
98	Minimax Bot	0,450591
99	Minimax Bot	0,390458
100	Minimax Bot	0,414916
101	Minimax Bot	0,404969
102	Minimax Bot	0,436645
103	Minimax Bot	0,413641
104	Minimax Bot	0,44023
105	Minimax Bot	0,360459
106	Minimax Bot	0,407794
107	Minimax Bot	0,461649
108	Minimax Bot	0,4033
109	Minimax Bot	0,434282
110	Minimax Bot	0,452795
111	Minimax Bot	0,474333
112	Minimax Bot	0,471454
113	Minimax Bot	0,409226
114	Minimax Bot	0,38118
115	Minimax Bot	0,477497
116	Minimax Bot	0,476893
117	Minimax Bot	0,44474
118	Minimax Bot	0,34487
119	Minimax Bot	0,428419
120	Minimax Bot	0,517308
121	Minimax Bot	0,467401
122	Minimax Bot	0,384688
123	Minimax Bot	0,441731
124	Minimax Bot	0,418425
125	Minimax Bot	0,367062
126	Minimax Bot	0,520403
127	Minimax Bot	0,459395
128	Minimax Bot	0,427889
129	Minimax Bot	0,338801
130	Minimax Bot	0,472384

131	Minimax Bot	0,368254
132	Minimax Bot	0,355821
133	Minimax Bot	0,463924
134	Minimax Bot	0,381158
135	Minimax Bot	0,408593
136	Minimax Bot	0,519777
137	Minimax Bot	0,510377
138	Minimax Bot	0,532305
139	Minimax Bot	0,393264
140	Minimax Bot	0,467155
141	Minimax Bot	0,431692
142	Minimax Bot	0,43092
143	Minimax Bot	0,427113
144	Minimax Bot	0,350353
145	Minimax Bot	0,332347
146	Minimax Bot	0,38389
147	Minimax Bot	0,436032
148	Minimax Bot	0,389986
149	Minimax Bot	0,425113
150	Minimax Bot	0,698067
151	Minimax Bot	0,79177
152	Minimax Bot	0,636595
153	Minimax Bot	0,404317
154	Minimax Bot	0,481055
155	Minimax Bot	0,462742
156	Minimax Bot	0,481914
157	Minimax Bot	0,403148
158	Minimax Bot	0,412585
159	Minimax Bot	0,413917
160	Minimax Bot	0,364847
161	Minimax Bot	0,359272
162	Minimax Bot	0,38391
163	Minimax Bot	1,970773
164	Minimax Bot	1,986587
165	Minimax Bot	1,306369
166	Minimax Bot	0,402935
167	Minimax Bot	0,364475
168	Minimax Bot	0,366342
169	Minimax Bot	0,419182
170	Minimax Bot	0,406339
171	Minimax Bot	0,344557
172	Minimax Bot	0,353967
173	Minimax Bot	0,352263
174	Minimax Bot	0,37638
175	Minimax Bot	0,352774
176	Minimax Bot	0,369619

177	Minimax Bot	0,309142
178	Minimax Bot	0,342583
179	Minimax Bot	0,393204
180	Minimax Bot	0,404032
181	Minimax Bot	0,384591
182	Minimax Bot	0,41968
183	Minimax Bot	0,409815
184	Minimax Bot	0,380231
185	Minimax Bot	0,383484
186	Minimax Bot	0,395717
187	Minimax Bot	0,399547
188	Minimax Bot	0,400189
189	Minimax Bot	0,385625
190	Minimax Bot	0,439458
191	Minimax Bot	0,477039
192	Minimax Bot	0,460663
193	Minimax Bot	0,370353
194	Minimax Bot	0,399741
195	Minimax Bot	0,358923
196	Minimax Bot	0,352997
197	Minimax Bot	0,444296
198	Minimax Bot	0,44684
199	Minimax Bot	0,542835
200	Minimax Bot	0,432754
201	Minimax Bot	0,567511
202	Minimax Bot	0,441211
203	Minimax Bot	0,441725
204	Minimax Bot	0,439513
205	Minimax Bot	0,409324
206	Minimax Bot	0,456504
207	Minimax Bot	0,454613
208	Minimax Bot	0,522639
209	Minimax Bot	0,370782
210	Minimax Bot	0,383541
211	Minimax Bot	0,422875
212	Minimax Bot	0,485465
213	Minimax Bot	0,435127
214	Minimax Bot	0,374496
215	Minimax Bot	0,478148
216	Minimax Bot	0,436273
217	Minimax Bot	0,427945
218	Minimax Bot	0,485752
219	Minimax Bot	0,491111
220	Minimax Bot	0,411027
221	Minimax Bot	0,426814
222	Minimax Bot	0,419968

223	Minimax Bot	0,446276
224	Minimax Bot	0,345234
225	Minimax Bot	0,358209
226	Minimax Bot	0,441134
227	Minimax Bot	0,426837
228	Minimax Bot	0,405405
229	Minimax Bot	0,431469
230	Minimax Bot	0,387136
231	Minimax Bot	0,436184
232	Minimax Bot	0,452212
233	Minimax Bot	0,476601
234	Minimax Bot	0,385627
235	Minimax Bot	0,532139
236	Minimax Bot	0,457958
237	Minimax Bot	0,445661
238	Minimax Bot	0,609727
239	Minimax Bot	0,509509
240	Minimax Bot	0,464074
241	Minimax Bot	0,500783
242	Minimax Bot	0,391652
243	Minimax Bot	0,470136
244	Minimax Bot	0,466787
245	Minimax Bot	0,440934
246	Minimax Bot	0,366365
247	Minimax Bot	0,413534
248	Minimax Bot	0,420746
249	Minimax Bot	0,620551
250	Minimax Bot	0,433754
251	Minimax Bot	0,391308
252	Minimax Bot	0,399252
253	Minimax Bot	0,493156
254	Minimax Bot	0,59837
255	Minimax Bot	0,437366
256	Minimax Bot	0,378467
257	Minimax Bot	0,405016
258	Minimax Bot	0,429287
259	Minimax Bot	0,419476
260	Minimax Bot	0,416238
261	Minimax Bot	0,522391
262	Minimax Bot	0,475774
263	Minimax Bot	0,447688
264	Minimax Bot	0,412084
265	Minimax Bot	0,413785
266	Minimax Bot	0,428008
267	Minimax Bot	0,437254
268	Minimax Bot	0,493376

269	Minimax Bot	0,454167
270	Minimax Bot	0,406474
271	Minimax Bot	0,394678
272	Minimax Bot	0,433089
273	Minimax Bot	0,489812
274	Minimax Bot	0,430233
275	Minimax Bot	0,471279
276	Minimax Bot	0,525893
277	Minimax Bot	0,433621
278	Minimax Bot	0,371451
279	Minimax Bot	0,362036
280	Minimax Bot	0,465416
281	Minimax Bot	0,417972
282	Minimax Bot	0,426728
283	Minimax Bot	0,369546
284	Minimax Bot	0,407091
285	Minimax Bot	0,393099
286	Minimax Bot	0,415324
287	Minimax Bot	0,412136
288	Minimax Bot	0,38985
289	Minimax Bot	0,386207
290	Minimax Bot	0,394891
291	Minimax Bot	0,386723
292	Minimax Bot	0,425881
293	Minimax Bot	0,412261
294	Minimax Bot	0,545128
295	Minimax Bot	0,4873
296	Minimax Bot	0,447916
297	Minimax Bot	0,534124
298	Minimax Bot	0,432803
299	Minimax Bot	0,453655
300	Minimax Bot	0,370148
301	Minimax Bot	0,430676
302	Minimax Bot	0,51217
303	Minimax Bot	0,543262
304	Minimax Bot	0,46017
305	Minimax Bot	0,41654
306	Minimax Bot	0,451507
307	Minimax Bot	0,451801
308	Minimax Bot	0,476279
309	Minimax Bot	0,452917
310	Minimax Bot	0,395848
311	Minimax Bot	0,392906
312	Minimax Bot	0,39032
313	Minimax Bot	0,437519
314	Minimax Bot	0,365829

315	Minimax Bot	0,382281
316	Minimax Bot	0,453311
317	Minimax Bot	0,499845
318	Minimax Bot	0,497469
319	Minimax Bot	0,380433
320	Minimax Bot	0,440394
321	Minimax Bot	0,459814
322	Minimax Bot	0,446587
323	Minimax Bot	0,398002
324	Minimax Bot	0,383069
325	Minimax Bot	0,407233
326	Minimax Bot	0,372328
327	Minimax Bot	0,377981
328	Minimax Bot	0,405658
329	Minimax Bot	0,494871
330	Minimax Bot	0,592807
331	Minimax Bot	0,546
332	Minimax Bot	0,441362
333	Minimax Bot	0,420803
334	Minimax Bot	0,366169
335	Minimax Bot	0,41112
336	Minimax Bot	0,347403
337	Minimax Bot	0,437557
338	Minimax Bot	0,394077
339	Minimax Bot	0,428677
340	Minimax Bot	0,467958
341	Minimax Bot	0,395111
342	Minimax Bot	0,334184
343	Minimax Bot	0,594806
344	Minimax Bot	0,420382
345	Minimax Bot	0,44805
346	Minimax Bot	0,418477
347	Minimax Bot	0,414626
348	Minimax Bot	0,427854
349	Minimax Bot	0,426917
350	Minimax Bot	0,496177
351	Minimax Bot	0,511641
352	Minimax Bot	0,42028
353	Minimax Bot	0,386568
354	Minimax Bot	0,366159
355	Minimax Bot	0,328445
356	Minimax Bot	0,424055
357	Minimax Bot	0,512858
358	Minimax Bot	0,541769
359	Minimax Bot	0,436041
360	Minimax Bot	0,398312

ANNEX C

THE TESTING RESULT OF CONGLAK (2-AGENTS BOARD GAME) – MINMAX BOT VS MINMAX BOT WITHOUT 3 RANDOM STEPS

ATTEMPT NUMBER	CASE/WINNER	TIME PERFORMANCE
1	Minimax Bot 2	0,343065
2	Minimax Bot 2	0,342115
3	Minimax Bot 2	0,414506
4	Minimax Bot 2	0,401599
5	Minimax Bot 2	0,374925
6	Minimax Bot 2	0,367309
7	Minimax Bot 1	0,37786
8	Minimax Bot 1	0,379335
9	Minimax Bot 1	0,364161
10	Minimax Bot 1	0,356958
11	Minimax Bot 1	0,390523
12	Minimax Bot 1	0,413134
13	Minimax Bot 2	0,408714
14	Minimax Bot 2	0,355706
15	Minimax Bot 2	0,364379
16	Minimax Bot 2	0,354037
17	Minimax Bot 2	0,359187
18	Minimax Bot 2	0,354247
19	Minimax Bot 1	0,359727
20	Minimax Bot 1	0,359723
21	Minimax Bot 1	0,359252
22	Minimax Bot 1	0,353984
23	Minimax Bot 1	0,357982
24	Minimax Bot 1	0,356927
25	Minimax Bot 2	0,353511
26	Minimax Bot 2	0,35625
27	Minimax Bot 2	0,354473
28	Minimax Bot 2	0,34985
29	Minimax Bot 2	0,357475
30	Minimax Bot 2	0,360189
31	Minimax Bot 1	0,35069
32	Minimax Bot 1	0,356
33	Minimax Bot 1	0,355649
34	Minimax Bot 1	0,371497
35	Minimax Bot 1	0,369639
36	Minimax Bot 1	0,365495
37	Minimax Bot 2	0,368817
38	Minimax Bot 2	0,375749
39	Minimax Bot 2	0,436134
40	Minimax Bot 2	0,39773

41	Minimax Bot 2	0,419469
42	Minimax Bot 2	0,402636
43	Minimax Bot 1	0,37751
44	Minimax Bot 1	0,373242
45	Minimax Bot 1	0,358511
46	Minimax Bot 1	0,36438
47	Minimax Bot 1	0,370654
48	Minimax Bot 1	0,385879
49	Minimax Bot 2	0,358816
50	Minimax Bot 2	0,372915
51	Minimax Bot 2	0,42072
52	Minimax Bot 2	0,669685
53	Minimax Bot 2	0,831461
54	Minimax Bot 2	0,712887
55	Minimax Bot 1	0,767875
56	Minimax Bot 1	0,72168
57	Minimax Bot 1	0,745824
58	Minimax Bot 1	0,680498
59	Minimax Bot 1	0,684361
60	Minimax Bot 1	0,658094
61	Minimax Bot 2	0,732564
62	Minimax Bot 2	0,660566
63	Minimax Bot 2	0,637845
64	Minimax Bot 2	0,716532
65	Minimax Bot 2	0,588057
66	Minimax Bot 2	0,646212
67	Minimax Bot 1	0,574259
68	Minimax Bot 1	0,602034
69	Minimax Bot 1	0,63731
70	Minimax Bot 1	0,644263
71	Minimax Bot 1	0,659318
72	Minimax Bot 1	0,576184
73	Minimax Bot 2	0,727756
74	Minimax Bot 2	0,683388
75	Minimax Bot 2	0,669839
76	Minimax Bot 2	0,604118
77	Minimax Bot 2	0,736714
78	Minimax Bot 2	0,689606
79	Minimax Bot 1	0,596478
80	Minimax Bot 1	0,594827
81	Minimax Bot 1	0,648301
82	Minimax Bot 1	0,743155

83	Minimax Bot 1	0,649932
84	Minimax Bot 1	0,786745
85	Minimax Bot 2	0,690807
86	Minimax Bot 2	0,582961
87	Minimax Bot 2	0,69636
88	Minimax Bot 2	0,698127
89	Minimax Bot 2	0,638455
90	Minimax Bot 2	0,741107
91	Minimax Bot 1	0,611731
92	Minimax Bot 1	0,682117
93	Minimax Bot 1	0,729332
94	Minimax Bot 1	0,69465
95	Minimax Bot 1	0,696563
96	Minimax Bot 1	0,661907
97	Minimax Bot 2	0,641738
98	Minimax Bot 2	0,671261
99	Minimax Bot 2	0,708193
100	Minimax Bot 2	0,79301
101	Minimax Bot 2	0,586767
102	Minimax Bot 2	0,623143
103	Minimax Bot 1	0,642577
104	Minimax Bot 1	0,663136
105	Minimax Bot 1	0,658965
106	Minimax Bot 1	0,628131
107	Minimax Bot 1	0,538773
108	Minimax Bot 1	0,578401
109	Minimax Bot 2	0,609492
110	Minimax Bot 2	0,693863
111	Minimax Bot 2	0,65066
112	Minimax Bot 2	0,688216
113	Minimax Bot 2	0,666868
114	Minimax Bot 2	0,691046
115	Minimax Bot 1	0,759782
116	Minimax Bot 1	0,639912
117	Minimax Bot 1	0,57795
118	Minimax Bot 1	0,692775
119	Minimax Bot 1	0,675039
120	Minimax Bot 1	0,674045
121	Minimax Bot 2	0,631334
122	Minimax Bot 2	0,618366
123	Minimax Bot 2	0,58116
124	Minimax Bot 2	0,669634
125	Minimax Bot 2	0,795994
126	Minimax Bot 2	0,756186
127	Minimax Bot 1	0,599234
128	Minimax Bot 1	0,688378
129	Minimax Bot 1	0,726104

130	Minimax Bot 1	0,722753
131	Minimax Bot 1	0,661146
132	Minimax Bot 1	0,573946
133	Minimax Bot 2	0,607221
134	Minimax Bot 2	0,710839
135	Minimax Bot 2	0,748703
136	Minimax Bot 2	0,665588
137	Minimax Bot 2	0,686946
138	Minimax Bot 2	0,621939
139	Minimax Bot 1	0,586938
140	Minimax Bot 1	0,589335
141	Minimax Bot 1	0,80049
142	Minimax Bot 1	0,727736
143	Minimax Bot 1	0,681124
144	Minimax Bot 1	0,709974
145	Minimax Bot 2	0,738528
146	Minimax Bot 2	0,772385
147	Minimax Bot 2	0,808546
148	Minimax Bot 2	0,616326
149	Minimax Bot 2	0,743174
150	Minimax Bot 2	0,689257
151	Minimax Bot 1	0,571552
152	Minimax Bot 1	0,705948
153	Minimax Bot 1	0,743901
154	Minimax Bot 1	0,699665
155	Minimax Bot 1	0,697477
156	Minimax Bot 1	0,717427
157	Minimax Bot 2	0,539375
158	Minimax Bot 2	0,670328
159	Minimax Bot 2	0,65931
160	Minimax Bot 2	0,715104
161	Minimax Bot 2	0,552016
162	Minimax Bot 2	0,637575
163	Minimax Bot 1	0,688818
164	Minimax Bot 1	0,659554
165	Minimax Bot 1	0,657137
166	Minimax Bot 1	0,544609
167	Minimax Bot 1	0,679323
168	Minimax Bot 1	0,519164
169	Minimax Bot 2	0,716174
170	Minimax Bot 2	0,645593
171	Minimax Bot 2	0,670073
172	Minimax Bot 2	0,702137
173	Minimax Bot 2	0,589831
174	Minimax Bot 2	0,650931
175	Minimax Bot 1	0,669986
176	Minimax Bot 1	0,651348

177	Minimax Bot 1	0,774901
178	Minimax Bot 1	0,53085
179	Minimax Bot 1	0,578654
180	Minimax Bot 1	0,757975
181	Minimax Bot 2	0,648294
182	Minimax Bot 2	0,688088
183	Minimax Bot 2	0,65472
184	Minimax Bot 2	0,604658
185	Minimax Bot 2	0,676791
186	Minimax Bot 2	0,601599
187	Minimax Bot 1	0,579738
188	Minimax Bot 1	0,724169
189	Minimax Bot 1	0,627533
190	Minimax Bot 1	0,356371
191	Minimax Bot 1	0,396678
192	Minimax Bot 1	0,33455
193	Minimax Bot 2	0,331313
194	Minimax Bot 2	0,341325
195	Minimax Bot 2	0,351822
196	Minimax Bot 2	0,348912
197	Minimax Bot 2	0,342551
198	Minimax Bot 2	0,350076
199	Minimax Bot 1	0,352867
200	Minimax Bot 1	0,342757
201	Minimax Bot 1	0,336729
202	Minimax Bot 1	0,341023
203	Minimax Bot 1	0,332616
204	Minimax Bot 1	0,356069
205	Minimax Bot 2	0,333648
206	Minimax Bot 2	0,337611
207	Minimax Bot 2	0,331865
208	Minimax Bot 2	0,35918
209	Minimax Bot 2	0,373348
210	Minimax Bot 2	0,359891
211	Minimax Bot 1	0,390706
212	Minimax Bot 1	0,394319
213	Minimax Bot 1	0,382137
214	Minimax Bot 1	0,382892
215	Minimax Bot 1	0,430277
216	Minimax Bot 1	0,493935
217	Minimax Bot 2	0,430426
218	Minimax Bot 2	0,352065
219	Minimax Bot 2	0,359582
220	Minimax Bot 2	0,423763
221	Minimax Bot 2	0,37637
222	Minimax Bot 2	0,381082
223	Minimax Bot 1	0,381485

224	Minimax Bot 1	0,362938
225	Minimax Bot 1	0,360498
226	Minimax Bot 1	0,433172
227	Minimax Bot 1	0,370166
228	Minimax Bot 1	0,377307
229	Minimax Bot 2	0,362967
230	Minimax Bot 2	0,370176
231	Minimax Bot 2	0,408149
232	Minimax Bot 2	0,491997
233	Minimax Bot 2	0,381857
234	Minimax Bot 2	0,433307
235	Minimax Bot 1	0,422538
236	Minimax Bot 1	0,411199
237	Minimax Bot 1	0,445711
238	Minimax Bot 1	0,399882
239	Minimax Bot 1	0,411614
240	Minimax Bot 1	0,3877
241	Minimax Bot 2	0,386392
242	Minimax Bot 2	0,486112
243	Minimax Bot 2	0,420883
244	Minimax Bot 2	0,388629
245	Minimax Bot 2	0,385403
246	Minimax Bot 2	0,388851
247	Minimax Bot 1	0,39547
248	Minimax Bot 1	0,382794
249	Minimax Bot 1	0,377643
250	Minimax Bot 1	0,352789
251	Minimax Bot 1	0,366502
252	Minimax Bot 1	0,376517
253	Minimax Bot 2	0,364615
254	Minimax Bot 2	0,362805
255	Minimax Bot 2	0,363148
256	Minimax Bot 2	0,364701
257	Minimax Bot 2	0,385838
258	Minimax Bot 2	0,38941
259	Minimax Bot 1	0,369388
260	Minimax Bot 1	0,381955
261	Minimax Bot 1	0,406057
262	Minimax Bot 1	0,374917
263	Minimax Bot 1	0,365688
264	Minimax Bot 1	0,366707
265	Minimax Bot 2	0,368536
266	Minimax Bot 2	0,375809
267	Minimax Bot 2	0,419034
268	Minimax Bot 2	0,404127
269	Minimax Bot 2	0,408071
270	Minimax Bot 2	0,42605

271	Minimax Bot 1	0,407315
272	Minimax Bot 1	0,374605
273	Minimax Bot 1	0,368428
274	Minimax Bot 1	0,378085
275	Minimax Bot 1	0,360568
276	Minimax Bot 1	0,476403
277	Minimax Bot 2	0,377862
278	Minimax Bot 2	0,407863
279	Minimax Bot 2	0,387757
280	Minimax Bot 2	0,389181
281	Minimax Bot 2	0,391001
282	Minimax Bot 2	0,393417
283	Minimax Bot 1	0,402308
284	Minimax Bot 1	0,379793
285	Minimax Bot 1	0,422858
286	Minimax Bot 1	0,387602
287	Minimax Bot 1	0,378067
288	Minimax Bot 1	0,401744
289	Minimax Bot 2	0,368541
290	Minimax Bot 2	0,377525
291	Minimax Bot 2	0,361188
292	Minimax Bot 2	0,387086
293	Minimax Bot 2	0,460226
294	Minimax Bot 2	0,370028
295	Minimax Bot 1	0,36168
296	Minimax Bot 1	0,401482
297	Minimax Bot 1	0,66545
298	Minimax Bot 1	0,87802
299	Minimax Bot 1	0,535076
300	Minimax Bot 1	0,657405
301	Minimax Bot 2	0,681624
302	Minimax Bot 2	0,430484
303	Minimax Bot 2	0,40121
304	Minimax Bot 2	0,413365
305	Minimax Bot 2	0,419405
306	Minimax Bot 2	0,5243
307	Minimax Bot 1	0,475309
308	Minimax Bot 1	0,760531
309	Minimax Bot 1	1.008.484
310	Minimax Bot 1	0,690603
311	Minimax Bot 1	0,618442
312	Minimax Bot 1	0,485919
313	Minimax Bot 2	0,500011
314	Minimax Bot 2	0,511223
315	Minimax Bot 2	0,530608

316	Minimax Bot 2	0,505111
317	Minimax Bot 2	0,69061
318	Minimax Bot 2	0,603263
319	Minimax Bot 1	0,623402
320	Minimax Bot 1	0,690687
321	Minimax Bot 1	0,630428
322	Minimax Bot 1	0,69968
323	Minimax Bot 1	0,629934
324	Minimax Bot 1	0,574088
325	Minimax Bot 2	0,703349
326	Minimax Bot 2	0,63069
327	Minimax Bot 2	0,641179
328	Minimax Bot 2	0,77054
329	Minimax Bot 2	0,583487
330	Minimax Bot 2	0,598663
331	Minimax Bot 1	0,869819
332	Minimax Bot 1	0,694325
333	Minimax Bot 1	0,633675
334	Minimax Bot 1	0,611488
335	Minimax Bot 1	0,437913
336	Minimax Bot 1	0,448447
337	Minimax Bot 2	0,433282
338	Minimax Bot 2	0,423231
339	Minimax Bot 2	0,430433
340	Minimax Bot 2	0,428646
341	Minimax Bot 2	0,476812
342	Minimax Bot 2	0,441681
343	Minimax Bot 1	0,523926
344	Minimax Bot 1	0,589624
345	Minimax Bot 1	0,521823
346	Minimax Bot 1	0,495372
347	Minimax Bot 1	0,496677
348	Minimax Bot 1	0,489863
349	Minimax Bot 2	0,469927
350	Minimax Bot 2	0,45385
351	Minimax Bot 2	0,467998
352	Minimax Bot 2	0,518771
353	Minimax Bot 2	0,625651
354	Minimax Bot 2	0,576034
355	Minimax Bot 1	0,61179
356	Minimax Bot 1	0,541041
357	Minimax Bot 1	0,582429
358	Minimax Bot 1	0,567111
359	Minimax Bot 1	0,591561
360	Minimax Bot 1	0,456954

ANNEX D

THE TESTING RESULT OF CONGKLAK (2-AGENTS BOARD GAME) – MINMAX BOT VS MINMAX BOT WITH 3 RANDOM STEPS

ATTEMPT NUMBER	CASE/WINNER	TIME PERFORMANCE
1	TIE	0,250664
2	Minimax Bot 2	0,111722
3	Minimax Bot 2	0,178452
4	TIE	0,226513
5	Minimax Bot 1	0,268449
6	Minimax Bot 2	0,245721
7	Minimax Bot 2	0,320129
8	Minimax Bot 2	0,233201
9	Minimax Bot 1	0,228348
10	Minimax Bot 1	0,246988
11	Minimax Bot 1	0,221248
12	Minimax Bot 1	0,194429
13	Minimax Bot 2	0,161332
14	Minimax Bot 2	0,198153
15	Minimax Bot 1	0,205234
16	Minimax Bot 2	0,220646
17	Minimax Bot 1	0,101007
18	Minimax Bot 1	0,155965
19	Minimax Bot 1	0,128286
20	Minimax Bot 1	0,326427
21	TIE	0,349611
22	Minimax Bot 2	0,394181
23	Minimax Bot 1	0,597004
24	Minimax Bot 1	0,341839
25	Minimax Bot 2	0,145284
26	Minimax Bot 1	0,267151
27	Minimax Bot 1	0,199535
28	Minimax Bot 2	0,217348
29	Minimax Bot 1	0,209306
30	Minimax Bot 2	0,17302
31	Minimax Bot 2	0,187924
32	Minimax Bot 1	0,13474
33	Minimax Bot 2	0,197631
34	TIE	0,170184
35	Minimax Bot 1	0,190564
36	Minimax Bot 1	0,161431
37	TIE	0,204744
38	Minimax Bot 2	0,271618
39	Minimax Bot 1	0,2769

40	Minimax Bot 2	0,207212
41	Minimax Bot 1	0,177132
42	Minimax Bot 2	0,162021
43	Minimax Bot 1	0,194002
44	Minimax Bot 1	0,15213
45	Minimax Bot 1	0,207496
46	Minimax Bot 1	0,150629
47	Minimax Bot 1	0,253024
48	Minimax Bot 1	0,150758
49	Minimax Bot 2	0,234357
50	Minimax Bot 1	0,218015
51	TIE	0,227693
52	Minimax Bot 2	0,122083
53	Minimax Bot 1	0,176816
54	TIE	0,232475
55	TIE	0,231141
56	TIE	0,23184
57	Minimax Bot 1	0,16093
58	Minimax Bot 1	0,192741
59	Minimax Bot 1	0,219816
60	Minimax Bot 1	0,24568
61	Minimax Bot 1	0,256548
62	Minimax Bot 2	0,397011
63	Minimax Bot 2	0,49773
64	Minimax Bot 2	0,400271
65	Minimax Bot 2	0,391345
66	Minimax Bot 2	0,360871
67	Minimax Bot 1	0,37665
68	Minimax Bot 1	0,299088
69	Minimax Bot 1	0,25782
70	Minimax Bot 2	0,308209
71	Minimax Bot 1	0,370807
72	Minimax Bot 1	0,286149
73	Minimax Bot 1	0,262149
74	Minimax Bot 1	0,192065
75	Minimax Bot 2	0,337062
76	Minimax Bot 2	0,308556
77	Minimax Bot 2	0,422372
78	Minimax Bot 2	0,343638
79	Minimax Bot 1	0,349656
80	Minimax Bot 1	0,301225
81	Minimax Bot 2	0,306389

82	Minimax Bot 1	0,247644
83	Minimax Bot 2	0,361442
84	Minimax Bot 2	0,231695
85	Minimax Bot 2	0,397096
86	Minimax Bot 1	0,212772
87	Minimax Bot 2	0,490081
88	Minimax Bot 2	0,216892
89	Minimax Bot 2	0,405814
90	Minimax Bot 2	0,537924
91	Minimax Bot 1	0,38565
92	Minimax Bot 1	0,244236
93	Minimax Bot 2	0,34216
94	Minimax Bot 2	0,433345
95	Minimax Bot 1	0,345896
96	Minimax Bot 1	0,320624
97	Minimax Bot 2	0,226581
98	Minimax Bot 1	0,319308
99	Minimax Bot 2	0,333268
100	Minimax Bot 2	0,397141
101	Minimax Bot 2	0,354054
102	Minimax Bot 1	0,402806
103	Minimax Bot 2	0,247771
104	TIE	0,410069
105	Minimax Bot 2	0,326421
106	Minimax Bot 1	0,321516
107	Minimax Bot 1	0,542562
108	Minimax Bot 2	0,416058
109	Minimax Bot 1	0,41032
110	Minimax Bot 1	0,256145
111	Minimax Bot 1	0,476675
112	Minimax Bot 1	0,345873
113	Minimax Bot 2	0,499226
114	Minimax Bot 2	0,248298
115	Minimax Bot 1	0,189181
116	Minimax Bot 1	0,403221
117	Minimax Bot 1	0,367649
118	Minimax Bot 1	0,396577
119	Minimax Bot 1	0,318422
120	Minimax Bot 1	0,474102
121	Minimax Bot 2	0,256682
122	Minimax Bot 2	0,396385
123	Minimax Bot 2	0,347547
124	Minimax Bot 2	0,284491
125	TIE	0,750193
126	Minimax Bot 2	0,542492
127	Minimax Bot 1	0,54284
128	Minimax Bot 1	0,292288
129	TIE	0,406556

130	Minimax Bot 1	0,366496
131	Minimax Bot 1	0,773901
132	Minimax Bot 1	0,540719
133	Minimax Bot 2	0,444415
134	Minimax Bot 2	0,458162
135	Minimax Bot 2	0,577671
136	Minimax Bot 1	0,410546
137	Minimax Bot 2	0,379506
138	Minimax Bot 1	0,443738
139	TIE	0,664484
140	Minimax Bot 2	0,502466
141	Minimax Bot 1	0,444964
142	Minimax Bot 2	0,209971
143	Minimax Bot 1	0,337041
144	Minimax Bot 2	0,406457
145	Minimax Bot 2	0,300477
146	Minimax Bot 2	0,439968
147	Minimax Bot 2	0,447116
148	Minimax Bot 2	0,365723
149	Minimax Bot 2	0,263116
150	Minimax Bot 1	0,535207
151	Minimax Bot 1	0,369675
152	Minimax Bot 1	0,565677
153	Minimax Bot 1	0,448804
154	Minimax Bot 1	0,357742
155	Minimax Bot 2	0,508464
156	TIE	0,598314
157	Minimax Bot 1	0,649953
158	Minimax Bot 2	0,512733
159	Minimax Bot 2	0,344782
160	Minimax Bot 2	0,635795
161	Minimax Bot 1	0,270749
162	TIE	0,468088
163	Minimax Bot 1	0,306728
164	Minimax Bot 1	0,35646
165	Minimax Bot 2	0,272314
166	Minimax Bot 2	0,284176
167	Minimax Bot 1	0,561264
168	Minimax Bot 2	0,31901
169	Minimax Bot 2	0,673205
170	TIE	0,567848
171	Minimax Bot 2	0,400741
172	Minimax Bot 2	0,40533
173	Minimax Bot 2	0,428756
174	Minimax Bot 2	0,555378
175	Minimax Bot 1	0,506886
176	TIE	0,617347
177	Minimax Bot 1	0,625585

178	Minimax Bot 1	0,705984
179	Minimax Bot 2	0,433343
180	Minimax Bot 2	0,481868
181	Minimax Bot 2	0,48789
182	Minimax Bot 2	0,284805
183	Minimax Bot 1	0,352808
184	Minimax Bot 2	0,389765
185	Minimax Bot 1	0,535785
186	Minimax Bot 2	0,333626
187	Minimax Bot 2	0,4411
188	Minimax Bot 1	0,425634
189	Minimax Bot 2	0,452032
190	TIE	0,538976
191	Minimax Bot 1	0,495821
192	Minimax Bot 1	0,370638
193	Minimax Bot 2	0,591383
194	Minimax Bot 2	0,429592
195	Minimax Bot 2	0,601335
196	Minimax Bot 2	0,666243
197	Minimax Bot 2	0,382142
198	Minimax Bot 2	0,358229
199	Minimax Bot 2	0,521946
200	Minimax Bot 1	0,498532
201	Minimax Bot 1	0,37192
202	TIE	0,355046
203	Minimax Bot 2	0,541296
204	Minimax Bot 1	0,447254
205	Minimax Bot 2	0,512674
206	Minimax Bot 1	0,585893
207	Minimax Bot 2	0,31655
208	Minimax Bot 2	0,502129
209	Minimax Bot 2	0,421886
210	Minimax Bot 2	0,490336
211	Minimax Bot 1	0,426589
212	Minimax Bot 2	0,19441
213	Minimax Bot 1	0,267518
214	Minimax Bot 1	0,385955
215	Minimax Bot 1	0,17491
216	Minimax Bot 2	0,293413
217	TIE	0,429542
218	Minimax Bot 1	0,344853
219	Minimax Bot 2	0,244536
220	Minimax Bot 2	0,240786
221	Minimax Bot 2	0,36911
222	Minimax Bot 1	0,471314
223	Minimax Bot 1	0,383768
224	Minimax Bot 2	0,252311
225	Minimax Bot 1	0,465015

226	Minimax Bot 2	0,235704
227	Minimax Bot 1	0,421159
228	Minimax Bot 1	0,27237
229	Minimax Bot 1	0,401774
230	Minimax Bot 2	0,340165
231	Minimax Bot 2	0,269953
232	Minimax Bot 2	0,301704
233	TIE	0,36832
234	Minimax Bot 2	0,348803
235	Minimax Bot 1	0,277771
236	Minimax Bot 1	0,372416
237	Minimax Bot 1	0,329414
238	Minimax Bot 1	0,228893
239	TIE	0,354044
240	Minimax Bot 2	0,289613
241	Minimax Bot 2	0,406327
242	Minimax Bot 2	0,273168
243	Minimax Bot 2	0,342248
244	Minimax Bot 1	0,321125
245	Minimax Bot 2	0,210585
246	Minimax Bot 1	0,284483
247	Minimax Bot 1	0,368165
248	Minimax Bot 2	0,392218
249	TIE	0,421187
250	Minimax Bot 2	0,423033
251	TIE	0,422414
252	Minimax Bot 1	0,486464
253	Minimax Bot 2	0,573991
254	Minimax Bot 1	0,687883
255	Minimax Bot 2	0,364812
256	TIE	0,499664
257	Minimax Bot 2	0,197273
258	Minimax Bot 2	0,561237
259	Minimax Bot 2	0,250264
260	Minimax Bot 1	0,372448
261	Minimax Bot 2	0,337505
262	Minimax Bot 2	0,302911
263	Minimax Bot 2	0,324
264	Minimax Bot 1	0,333144
265	Minimax Bot 1	0,341874
266	Minimax Bot 1	0,336947
267	Minimax Bot 2	0,546971
268	Minimax Bot 2	0,429078
269	Minimax Bot 2	0,489884
270	Minimax Bot 1	0,248207
271	Minimax Bot 1	0,454309
272	TIE	0,455866
273	Minimax Bot 2	0,422774

274	Minimax Bot 2	0,40822
275	Minimax Bot 2	0,373332
276	Minimax Bot 2	0,224492
277	Minimax Bot 2	0,324527
278	Minimax Bot 2	0,433449
279	Minimax Bot 2	0,516181
280	Minimax Bot 1	0,417999
281	Minimax Bot 2	0,316257
282	Minimax Bot 1	0,195849
283	Minimax Bot 1	0,449573
284	Minimax Bot 2	0,519388
285	Minimax Bot 2	0,76157
286	Minimax Bot 1	0,562568
287	Minimax Bot 1	0,604085
288	Minimax Bot 2	0,570484
289	Minimax Bot 2	0,382583
290	Minimax Bot 2	0,178998
291	Minimax Bot 2	0,55179
292	Minimax Bot 2	0,359863
293	Minimax Bot 2	0,472921
294	Minimax Bot 1	0,267476
295	Minimax Bot 2	0,236663
296	TIE	0,428828
297	Minimax Bot 1	0,338247
298	Minimax Bot 1	0,357416
299	Minimax Bot 1	0,471603
300	Minimax Bot 1	0,280004
301	Minimax Bot 2	0,285651
302	Minimax Bot 2	0,307333
303	TIE	0,263854
304	Minimax Bot 2	0,25304
305	Minimax Bot 2	0,318978
306	Minimax Bot 2	0,448966
307	Minimax Bot 1	0,315206
308	Minimax Bot 1	0,298103
309	TIE	0,290555
310	Minimax Bot 2	0,413845
311	TIE	0,364404
312	TIE	0,480802
313	Minimax Bot 2	0,309872
314	Minimax Bot 2	0,358162
315	Minimax Bot 1	0,306218
316	TIE	0,373097
317	Minimax Bot 1	0,357306

318	Minimax Bot 2	0,249434
319	TIE	0,400887
320	Minimax Bot 1	0,465115
321	Minimax Bot 1	0,376086
322	Minimax Bot 1	0,336866
323	Minimax Bot 1	0,271096
324	Minimax Bot 1	0,384084
325	Minimax Bot 2	0,403118
326	TIE	0,333277
327	Minimax Bot 1	0,419278
328	Minimax Bot 2	0,476619
329	Minimax Bot 2	0,364208
330	Minimax Bot 2	0,360955
331	Minimax Bot 1	0,350009
332	Minimax Bot 2	0,2444
333	Minimax Bot 1	0,396957
334	TIE	0,231376
335	Minimax Bot 1	0,27231
336	Minimax Bot 1	0,29298
337	Minimax Bot 2	0,370693
338	Minimax Bot 2	0,353905
339	Minimax Bot 2	0,356264
340	Minimax Bot 1	0,186516
341	Minimax Bot 2	0,461731
342	Minimax Bot 2	0,415669
343	Minimax Bot 2	0,232903
344	Minimax Bot 1	0,306442
345	Minimax Bot 2	0,383217
346	TIE	0,401012
347	Minimax Bot 1	0,250775
348	Minimax Bot 1	0,349313
349	Minimax Bot 2	0,266737
350	Minimax Bot 2	0,325438
351	Minimax Bot 2	0,259747
352	Minimax Bot 1	0,410812
353	Minimax Bot 2	0,187863
354	Minimax Bot 1	0,348545
355	Minimax Bot 2	0,416647
356	Minimax Bot 2	0,421742
357	Minimax Bot 1	0,338659
358	Minimax Bot 2	0,407387
359	Minimax Bot 2	0,264995
360	Minimax Bot 2	0,4386

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PANCAKE PUZZLE AND CONGKLAK GAME

Library used : re, copy, abc, random, time, datetime, importlib.abc, os, csv

Inspired by :

1. Congklak-MinMax by lukaskurnia
2. pancakeSearch by d-heck

What is pancake sorting puzzle?

Pancake sorting is the mathematical problem of sorting pancakes in order for a spatula to be inserted at any position in the stack and used to flip all pancakes above. The least amount of flips necessary to neatly arrange the pancakes is called the pancake number.

Watch the visualization in here :

- <https://www.youtube.com/watch?v=kk-DDgoXfk>
- <https://www.youtube.com/watch?v=ChMjvN1eAFI>

What is congklak?

Congklak is Indonesian game which playing board is made from wood with either 5, 6, 7 or 9 holes in both sides (The varies number of hole is due to variations from island to island), plus 2 homebases (1 for each player). There are 2 players on this game, which compete to get as many shells as possible in their homebase. In order to win, the player either need to have the most shells in his/her homebase (menang biji) or to be the last person to run out of shells on your side of the board (menang jalan).

For further instruction on how to play the game, please refer to :

- <https://www.expatriate.or.id/info/congklakinstructions.html>

Watch the visualization in here :

- <https://www.youtube.com/watch?v=pxT4BbsdybY>

The import use 2 non UDF library : copy and re

And then it calls 2 UDF AgentPancake and AgentCongklak to play the Pancake puzzle and Congklak game respectively

```
In [5]: import copy # Used for deep copy
import re # for checking input
from AgentPancake import PancakeCalling
from AgentCongklak import CongklakApp
```

The game will ask user whether it want to shown the representation of pancake or puzzle.

User need to choose number 1 to start pancake puzzle. The code uses by this program capables to :

1. randomly generate the position of starting puzzle or get the input from the user.

The example below and statistic use randomly shuffles position for easier testing multiple times, but it can easily changed in main.py .

2. choose whether to call of the algorithm at once or just one of it. The example below and statistic calls all algorithm at once per sample, in order to compare the result.
3. The number of pancake to be play at least 4 pancakes, and the maximum is 9.

But, I only ever test until 6 due to the performance limitation of the laptop

User can choose number 2 to play the 2-player congklak game :

1. User can change the level of how hard the game is.
2. The code is capable to accomodate human player vs min-max or random bot.

But, this testing purpose only let min-max bot competes with random bot or two min-max bot compete with each other, for easier and more statistically often.

3. The objective of this player is to compare how good min-max than randomly move agent without heuristic. The second objective in second turn-in is check the performance of min-max competes with each others.
4. So, the statistic will be counting how many times min-max win, lose, or tie when compete with random player. And the performance time, of min-max vs min-max
5. The congklak game is 2-player game, can not be one-player or multi-player because it is the rule in the real world.

So, the heuristic of this game regulate and limit the searching agent to be used by 2-player only for this game. But, on the highest level of abstraction, it is not limited.

To stop the game, user need to click on other keys than 1 or 2 in the questionnaire

```
In [ ]: playing = True
while (playing==True) :
    choose1 = input("\n\n\n\nHai.. What do you want to do? (1/2/Other_keys) \n1. 1 agent puzzl

    if (str(choose1) == "1") :
        pancakeCalling = PancakeCalling("RANDOM", 'm', 4, True, False, False)
        pancakeCalling = PancakeCalling("RANDOM", 'm', 5, True, False, False)
    elif (str(choose1) == "2") :
        choose2 = input("How hard do you want the game to be? 1(Hard)-6(Easy) : ")
        choose3 = (str)(input("What game do you want to play? (MvM) MinMax vs MinMax or (MvR) Min

        if ((choose3 == "MvR") or (choose3 == "MvM")):
            if (choose3 == "MvR"):
                choose4 = (int)(input("Who is the first player?\nPlayer with Random move (0) or I
            else :
                choose4 = 0
            app = CongklakApp(choose3, choose2, choose4, True, False) #mode, difficulty, player
        else:
            print("Incorrect input. Please retry...")
    else :
        playing = False
        print("Bye..Bye...")
```

SUCCESSFULLY RANDOMED INPUT WITH DEEP FIRST SEARCH : d4312

Starting Stack: 4 3 1 2

Depth First Search Solution:

43|12 g=0, h=2

Final State: 4321 g=2, h=0

Time : 0.0

SUCCESSFULLY RANDOMED INPUT WITH UNINFORMED SEARCH : u4312

Starting Stack: 4 3 1 2

Uniform Cost Search Solution:

43|12 g=0, h=2

Final State: 4321 g=2, h=0

Time : 0.0

SUCCESSFULLY RANDOMED INPUT WITH GREEDY SEARCH : g4312

Starting Stack: 4 3 1 2

Greedy Search Solution:

43|12 g=0, h=2

Final State: 4321 g=2, h=0

Time : 0.0

SUCCESSFULLY RANDOMED INPUT WITH ASTAR SEARCH : a4312

Starting Stack: 4 3 1 2

A* Search Solution:

43|12 g=0, h=2

Final State: 4321 g=2, h=0

Time : 0.0

SUCCESSFULLY RANDOMED INPUT WITH DEEP FIRST SEARCH : d24351

Starting Stack: 2 4 3 5 1

Depth First Search Solution:

24|351 g=0, h=5

|24153 g=3, h=5

35|142 g=8, h=5

3|5241 g=11, h=5

|31425 g=15, h=5

5|2413 g=20, h=4

53|142 g=24, h=4

5|3241 g=27, h=4

51|423 g=31, h=4

5|1324 g=34, h=4

54|231 g=38, h=3

5|4132 g=41, h=3

|52314 g=45, h=4

4|1325 g=50, h=5

45|231 g=54, h=5

4|5132 g=57, h=5

42|315 g=61, h=5

4|2513 g=64, h=5

43|152 g=68, h=5

4|3251 g=71, h=5

|41523 g=75, h=5

3|2514 g=80, h=5

34|152 g=84, h=5

34251 g=87, h=5

|34251 g=87, h=5

15|243 g=92, h=5

1|5342 g=95, h=5

|12435 g=99, h=5

53|421 g=104, h=4

5|3124 g=107, h=4

54|213 g=111, h=3

5|4312 g=114, h=2
52|134 g=118, h=4
5|2431 g=121, h=4
51|342 g=125, h=4
|51243 g=128, h=4
3|4215 g=133, h=5
|35124 g=137, h=5
4|2153 g=142, h=5
43|512 g=146, h=5
|43215 g=149, h=5
5|1234 g=154, h=4
Final State: 54321 g=158, h=0
Time : 0.001193

SUCCESSFULLY RANDOMED INPUT WITH UNINFORMED SEARCH : u24351

Starting Stack: 2 4 3 5 1
Uniform Cost Search Solution:
2|4351 g=0, h=5
|21534 g=4, h=5
43|512 g=9, h=5
|43215 g=12, h=5
5|1234 g=17, h=4
Final State: 54321 g=21, h=0
Time : 0.08738

SUCCESSFULLY RANDOMED INPUT WITH GREEDY SEARCH : g24351

Starting Stack: 2 4 3 5 1
Greedy Search Solution:
24|351 g=0, h=5
2|4153 g=3, h=5
|23514 g=7, h=5
41|532 g=12, h=5
|41235 g=15, h=5
5|3214 g=20, h=4
54|123 g=24, h=3
Final State: 54321 g=27, h=0
Time : 0.014636

SUCCESSFULLY RANDOMED INPUT WITH ASTAR SEARCH : a24351

Starting Stack: 2 4 3 5 1
A* Search Solution:
2|4351 g=0, h=5
|21534 g=4, h=5
43|512 g=9, h=5
|43215 g=12, h=5
5|1234 g=17, h=4
Final State: 54321 g=21, h=0
Time : 0.025314

Bot MinMax 2 Turn
MvM 0
2022-11-21 20:45:12.244699Player 1 move: 6
Bot MinMax 1 Turn
2022-11-21 20:45:12.244699Player 2 move: 14
Bot MinMax 2 Turn
2022-11-21 20:45:12.244699Player 1 move: 2
Bot MinMax 1 Turn
2022-11-21 20:45:12.244699Player 2 move: 12
Bot MinMax 2 Turn
2022-11-21 20:45:12.245715Player 1 move: 6
Bot MinMax 2 Turn
2022-11-21 20:45:12.245715Player 1 move: 4
Bot MinMax 1 Turn
2022-11-21 20:45:12.245715Player 2 move: 12
Bot MinMax 2 Turn
2022-11-21 20:45:12.246778Player 1 move: 2
Bot MinMax 2 Turn
2022-11-21 20:45:12.247754Player 1 move: 4
Bot MinMax 2 Turn
2022-11-21 20:45:12.249758Player 1 move: 5
Bot MinMax 2 Turn
2022-11-21 20:45:12.249758Player 1 move: 3
Bot MinMax 2 Turn
2022-11-21 20:45:12.250678Player 1 move: 0
Bot MinMax 2 Turn
2022-11-21 20:45:12.251662Player 1 move: 5
Bot MinMax 2 Turn
2022-11-21 20:45:12.251662Player 1 move: 3
Bot MinMax 2 Turn
2022-11-21 20:45:12.252662Player 1 move: 6
Bot MinMax 2 Turn
2022-11-21 20:45:12.253662Player 1 move: 2
Bot MinMax 2 Turn
2022-11-21 20:45:12.253662Player 1 move: 6
Bot MinMax 2 Turn
2022-11-21 20:45:12.254663Player 1 move: 1
Bot MinMax 2 Turn
2022-11-21 20:45:12.254663Player 1 move: 6
Bot MinMax 1 Turn
2022-11-21 20:45:12.254663Player 2 move: 12
Bot MinMax 2 Turn
2022-11-21 20:45:12.256322Player 1 move: 5
Bot MinMax 1 Turn
2022-11-21 20:45:12.256322Player 2 move: 13
Bot MinMax 2 Turn
2022-11-21 20:45:12.256322Player 1 move: 6
Bot MinMax 2 Turn
2022-11-21 20:45:12.256322Player 1 move: 2
Bot MinMax 2 Turn
2022-11-21 20:45:12.257742Player 1 move: 1
Bot MinMax 1 Turn
2022-11-21 20:45:12.257742Player 2 move: 14
Bot MinMax 1 Turn
2022-11-21 20:45:12.257742Player 2 move: 11
Bot MinMax 2 Turn
2022-11-21 20:45:12.258742Player 1 move: 0
Bot MinMax 1 Turn
2022-11-21 20:45:12.258742Player 2 move: 14
Bot MinMax 1 Turn
2022-11-21 20:45:12.258742Player 2 move: 12
Bot MinMax 1 Turn

2022-11-21 20:45:12.259741Player 2 move: 14
Bot MinMax 1 Turn
2022-11-21 20:45:12.259741Player 2 move: 9
Bot MinMax 2 Turn
2022-11-21 20:45:12.259741Player 1 move: 6
Bot MinMax 2 Turn
2022-11-21 20:45:12.260741Player 1 move: 1
Bot MinMax 2 Turn
2022-11-21 20:45:12.260741Player 1 move: 6
Bot MinMax 2 Turn
2022-11-21 20:45:12.260741Player 1 move: 5
Bot MinMax 2 Turn
2022-11-21 20:45:12.260741Player 1 move: 3
Bot MinMax 1 Turn
2022-11-21 20:45:12.260741Player 2 move: 12
Bot MinMax 1 Turn
2022-11-21 20:45:12.261741Player 2 move: 14
Bot MinMax 1 Turn
2022-11-21 20:45:12.261741Player 2 move: 9
Bot MinMax 2 Turn
2022-11-21 20:45:12.261741Player 1 move: 6
Bot MinMax 1 Turn
2022-11-21 20:45:12.261741Player 2 move: 12
Bot MinMax 1 Turn
2022-11-21 20:45:12.262741Player 2 move: 14
Bot MinMax 1 Turn
2022-11-21 20:45:12.262741Player 2 move: 10
Bot MinMax 1 Turn
2022-11-21 20:45:12.262741Player 2 move: 14
Bot MinMax 1 Turn
2022-11-21 20:45:12.262741Player 2 move: 12
Bot MinMax 1 Turn
2022-11-21 20:45:12.262741Player 2 move: 14
Bot MinMax 1 Turn
2022-11-21 20:45:12.262741Player 2 move: 9
Bot MinMax 2 Turn
2022-11-21 20:45:12.262741Player 1 move: 4
Bot MinMax 2 Turn
2022-11-21 20:45:12.262741Player 1 move: 6
Bot MinMax 2 Turn
2022-11-21 20:45:12.262741Player 2 move: 10
Bot MinMax 2 Turn
2022-11-21 20:45:12.262741Player 2 move: 11
Bot MinMax 2 Turn
2022-11-21 20:45:12.262741Player 2 move: 12
Bot MinMax 2 Turn
2022-11-21 20:45:12.262741Player 2 move: 13
Bot MinMax 2 Turn
2022-11-21 20:45:12.262741Player 2 move: 14
Bot MinMax 1 Turn
Minimax Bot 2 WINS IN : 0.018042 SECONDS

Bot Minimax Turn
MvR 0
2022-11-21 20:45:20.400434Player 1 move: 0
Bot Minimax Turn
2022-11-21 20:45:20.401434Player 1 move: 1
Bot Minimax Turn
2022-11-21 20:45:20.403340Player 1 move: 6
Bot Minimax Turn
2022-11-21 20:45:20.404338Player 1 move: 6
Bot Minimax Turn
2022-11-21 20:45:20.405346Player 1 move: 0
Bot Minimax Turn
2022-11-21 20:45:20.405346Player 1 move: 2
Bot Minimax Turn
2022-11-21 20:45:20.406342Player 1 move: 0
Bot Minimax Turn
2022-11-21 20:45:20.407334Player 1 move: 2
Bot Minimax Turn
2022-11-21 20:45:20.408334Player 1 move: 0
Bot Minimax Turn
2022-11-21 20:45:20.409353Player 1 move: 4
Bot Minimax Turn
2022-11-21 20:45:20.410335Player 1 move: 1
Bot Minimax Turn
2022-11-21 20:45:20.411352Player 1 move: 4
Bot Minimax Turn
2022-11-21 20:45:20.412351Player 1 move: 6
Bot Minimax Turn
2022-11-21 20:45:20.413369Player 1 move: 3
Bot Minimax Turn
2022-11-21 20:45:20.413369Player 1 move: 6
Bot Minimax Turn
2022-11-21 20:45:20.415369Player 1 move: 2
Bot Minimax Turn
2022-11-21 20:45:20.415369Player 1 move: 6
Bot Minimax Turn
2022-11-21 20:45:20.416353Player 1 move: 4
Bot Minimax Turn
2022-11-21 20:45:20.416353Player 1 move: 3
Bot Random Turn
2022-11-21 20:45:20.416353Player 2 move: 14
Bot Minimax Turn
2022-11-21 20:45:20.416353Player 1 move: 6
Bot Minimax Turn
2022-11-21 20:45:20.417335Player 1 move: 4
Bot Minimax Turn
2022-11-21 20:45:20.417335Player 1 move: 0
Bot Random Turn
2022-11-21 20:45:20.417335Player 2 move: 9
Bot Minimax Turn
2022-11-21 20:45:20.417335Player 1 move: 5
Bot Random Turn
2022-11-21 20:45:20.417335Player 2 move: 8
Bot Random Turn
2022-11-21 20:45:20.417335Player 2 move: 9
Bot Minimax Turn
2022-11-21 20:45:20.418334Player 1 move: 6
Bot Minimax Turn
2022-11-21 20:45:20.418334Player 1 move: 0
Bot Minimax Turn
2022-11-21 20:45:20.419334Player 1 move: 6
Bot Minimax Turn

2022-11-21 20:45:20.419334Player 1 move: 3
Bot Random Turn
2022-11-21 20:45:20.419334Player 2 move: 9
Bot Minimax Turn
2022-11-21 20:45:20.420334Player 1 move: 1
Bot Minimax Turn
2022-11-21 20:45:20.420334Player 1 move: 3
Bot Minimax Turn
2022-11-21 20:45:20.421334Player 1 move: 6
Bot Minimax Turn
2022-11-21 20:45:20.421334Player 1 move: 2
Bot Minimax Turn
2022-11-21 20:45:20.421334Player 1 move: 6
Bot Minimax Turn
2022-11-21 20:45:20.421334Player 1 move: 3
Bot Minimax Turn
2022-11-21 20:45:20.421334Player 1 move: 6
Bot Minimax Turn
2022-11-21 20:45:20.422334Player 1 move: 5
Bot Minimax Turn
2022-11-21 20:45:20.422334Player 1 move: 0
Bot Random Turn
2022-11-21 20:45:20.422334Player 2 move: 9
Bot Minimax Turn
2022-11-21 20:45:20.422334Player 1 move: 3
Bot Random Turn
2022-11-21 20:45:20.422334Player 2 move: 12
Bot Minimax Turn
2022-11-21 20:45:20.422334Player 1 move: 4
Bot Random Turn
2022-11-21 20:45:20.422334Player 2 move: 11
Bot Minimax Turn
2022-11-21 20:45:20.422334Player 1 move: 2
Bot Random Turn
2022-11-21 20:45:20.422334Player 2 move: 8
Bot Minimax Turn
2022-11-21 20:45:20.423334Player 1 move: 3
Bot Random Turn
2022-11-21 20:45:20.423334Player 2 move: 12
Bot Minimax Turn
2022-11-21 20:45:20.423334Player 1 move: 6
Bot Minimax Turn
2022-11-21 20:45:20.423334Player 1 move: 4
Bot Minimax Turn
2022-11-21 20:45:20.423334Player 1 move: 0
Bot Random Turn
2022-11-21 20:45:20.423334Player 2 move: 12
Bot Minimax Turn
2022-11-21 20:45:20.423334Player 1 move: 1
Bot Random Turn
2022-11-21 20:45:20.423334Player 2 move: 9
Bot Minimax Turn
2022-11-21 20:45:20.424334Player 1 move: 2
Bot Random Turn
2022-11-21 20:45:20.424334Player 2 move: 11
Bot Minimax Turn
2022-11-21 20:45:20.424334Player 1 move: 3
Bot Random Turn
2022-11-21 20:45:20.424334Player 2 move: 10
Bot Minimax Turn
2022-11-21 20:45:20.424334Player 1 move: 4
Bot Random Turn

2022-11-21 20:45:20.424334Player 2 move: 11
Bot Minimax Turn
2022-11-21 20:45:20.424334Player 1 move: 5
Bot Random Turn
2022-11-21 20:45:20.424334Player 2 move: 12
Bot Minimax Turn
2022-11-21 20:45:20.424334Player 1 move: 1
Bot Random Turn
2022-11-21 20:45:20.424334Player 2 move: 8
Bot Minimax Turn
2022-11-21 20:45:20.424334Player 1 move: 2
Bot Random Turn
2022-11-21 20:45:20.424334Player 2 move: 12
Bot Minimax Turn
2022-11-21 20:45:20.424334Player 1 move: 3
Bot Random Turn
2022-11-21 20:45:20.424334Player 2 move: 13
Bot Random Turn
2022-11-21 20:45:20.424334Player 2 move: 10
Bot Minimax Turn
2022-11-21 20:45:20.425334Player 1 move: 4
Bot Random Turn
2022-11-21 20:45:20.425334Player 2 move: 8
Bot Minimax Turn
2022-11-21 20:45:20.425334Player 1 move: 5
Bot Random Turn
2022-11-21 20:45:20.425334Player 2 move: 11
Bot Minimax Turn
2022-11-21 20:45:20.425334Player 1 move: 0
Bot Random Turn
2022-11-21 20:45:20.425334Player 2 move: 12
Bot Minimax Turn
2022-11-21 20:45:20.425334Player 1 move: 2
Bot Random Turn
2022-11-21 20:45:20.425334Player 2 move: 10
Bot Minimax Turn
2022-11-21 20:45:20.425334Player 1 move: 3
Bot Random Turn
2022-11-21 20:45:20.425334Player 2 move: 11
Bot Minimax Turn
2022-11-21 20:45:20.425334Player 1 move: 4
Bot Random Turn
2022-11-21 20:45:20.425334Player 2 move: 12
Bot Minimax Turn
2022-11-21 20:45:20.425334Player 1 move: 1
Bot Random Turn
2022-11-21 20:45:20.425334Player 2 move: 13
Bot Minimax Turn
2022-11-21 20:45:20.425334Player 1 move: 2
Bot Random Turn
2022-11-21 20:45:20.425334Player 2 move: 11
Bot Minimax Turn
2022-11-21 20:45:20.426334Player 1 move: 3
Bot Random Turn
2022-11-21 20:45:20.426334Player 2 move: 10
Bot Minimax Turn
2022-11-21 20:45:20.426334Player 1 move: 6
Bot Minimax Turn
2022-11-21 20:45:20.426334Player 1 move: 4
Bot Minimax Turn
2022-11-21 20:45:20.426334Player 1 move: 6
Bot Minimax Turn

2022-11-21 20:45:20.426334Player 2 move: 12
Bot Random Turn
2022-11-21 20:45:20.426334Player 2 move: 14
Bot Minimax Turn
2022-11-21 20:45:20.426334Player 2 move: 11
Bot Minimax Turn
2022-11-21 20:45:20.426334Player 2 move: 14
Bot Minimax Turn
2022-11-21 20:45:20.426334Player 2 move: 13
Bot Minimax Turn
2022-11-21 20:45:20.426334Player 2 move: 9
Bot Minimax Turn
2022-11-21 20:45:20.426334Player 2 move: 11
Bot Minimax Turn
2022-11-21 20:45:20.426334Player 2 move: 14
Bot Minimax Turn
2022-11-21 20:45:20.426334Player 2 move: 14
Bot Minimax Turn
2022-11-21 20:45:20.426334Player 2 move: 12
Bot Minimax Turn
2022-11-21 20:45:20.426334Player 2 move: 10
Bot Minimax Turn
2022-11-21 20:45:20.426334Player 2 move: 11
Bot Minimax Turn
2022-11-21 20:45:20.426334Player 2 move: 10
Bot Minimax Turn
2022-11-21 20:45:20.426334Player 2 move: 9
Bot Minimax Turn
2022-11-21 20:45:20.426334Player 2 move: 11
Bot Minimax Turn
2022-11-21 20:45:20.426334Player 2 move: 10
Bot Minimax Turn
2022-11-21 20:45:20.426334Player 2 move: 9
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2022-11-21 20:45:20.426334Player 2 move: 9
Bot Minimax Turn
2022-11-21 20:45:20.426334Player 2 move: 9
Bot Minimax Turn
2022-11-21 20:45:20.426334Player 2 move: 13
Bot Minimax Turn
2022-11-21 20:45:20.426334Player 2 move: 13
Bot Minimax Turn
2022-11-21 20:45:20.426334Player 2 move: 9
Bot Minimax Turn
2022-11-21 20:45:20.426334Player 2 move: 12
Bot Minimax Turn
2022-11-21 20:45:20.426334Player 2 move: 8
Bot Minimax Turn
2022-11-21 20:45:20.426334Player 2 move: 8
Bot Minimax Turn
2022-11-21 20:45:20.426334Player 2 move: 9
Bot Minimax Turn
2022-11-21 20:45:20.426334Player 2 move: 8
Bot Minimax Turn
2022-11-21 20:45:20.426334Player 2 move: 14
Bot Minimax Turn
2022-11-21 20:45:20.426334Player 2 move: 9
Bot Minimax Turn
2022-11-21 20:45:20.426334Player 2 move: 12
Bot Minimax Turn
2022-11-21 20:45:20.426334Player 2 move: 13
Bot Minimax Turn

2022-11-21 20:45:20.427334Player 2 move: 13
Bot Minimax Turn
2022-11-21 20:45:20.427334Player 2 move: 8
Bot Minimax Turn
2022-11-21 20:45:20.427334Player 2 move: 11
Bot Minimax Turn
2022-11-21 20:45:20.427334Player 2 move: 12
Bot Minimax Turn
2022-11-21 20:45:20.427334Player 2 move: 12
Bot Minimax Turn
2022-11-21 20:45:20.427334Player 2 move: 10
Bot Minimax Turn
2022-11-21 20:45:20.427334Player 2 move: 12
Bot Minimax Turn
2022-11-21 20:45:20.427334Player 2 move: 12
Bot Minimax Turn
2022-11-21 20:45:20.427334Player 2 move: 9
Bot Minimax Turn
2022-11-21 20:45:20.427334Player 2 move: 11
Bot Minimax Turn
2022-11-21 20:45:20.427334Player 2 move: 11
Bot Minimax Turn
2022-11-21 20:45:20.427334Player 2 move: 8
Bot Minimax Turn
2022-11-21 20:45:20.427334Player 2 move: 8
Bot Minimax Turn
2022-11-21 20:45:20.427334Player 2 move: 11
Bot Minimax Turn
2022-11-21 20:45:20.427334Player 2 move: 12
Bot Minimax Turn
2022-11-21 20:45:20.427334Player 2 move: 8
Bot Minimax Turn
2022-11-21 20:45:20.427334Player 2 move: 9
Bot Minimax Turn
2022-11-21 20:45:20.427334Player 2 move: 11
Bot Minimax Turn
2022-11-21 20:45:20.427334Player 2 move: 8
Bot Minimax Turn
2022-11-21 20:45:20.427334Player 2 move: 14
Bot Random Turn
Minimax Bot WINS IN : 0.028133 SECONDS

Bot Random Turn
MvR 1
2022-11-21 20:45:28.548689Player 2 move: 8
Bot Random Turn
2022-11-21 20:45:28.548689Player 2 move: 14
Bot Random Turn
2022-11-21 20:45:28.548689Player 2 move: 9
Bot Minimax Turn
2022-11-21 20:45:28.550746Player 1 move: 1
Bot Minimax Turn
2022-11-21 20:45:28.551730Player 1 move: 5
Bot Random Turn
2022-11-21 20:45:28.551730Player 2 move: 11
Bot Minimax Turn
2022-11-21 20:45:28.552767Player 1 move: 3
Bot Minimax Turn
2022-11-21 20:45:28.553654Player 1 move: 4
Bot Minimax Turn
2022-11-21 20:45:28.554654Player 1 move: 0
Bot Minimax Turn
2022-11-21 20:45:28.555660Player 1 move: 2
Bot Minimax Turn
2022-11-21 20:45:28.555660Player 1 move: 4
Bot Minimax Turn
2022-11-21 20:45:28.556881Player 1 move: 1
Bot Minimax Turn
2022-11-21 20:45:28.557939Player 1 move: 0
Bot Minimax Turn
2022-11-21 20:45:28.557939Player 1 move: 4
Bot Random Turn
2022-11-21 20:45:28.557939Player 2 move: 13
Bot Minimax Turn
2022-11-21 20:45:28.559007Player 1 move: 3
Bot Minimax Turn
2022-11-21 20:45:28.559007Player 1 move: 0
Bot Random Turn
2022-11-21 20:45:28.559007Player 2 move: 11
Bot Minimax Turn
2022-11-21 20:45:28.560007Player 1 move: 5
Bot Minimax Turn
2022-11-21 20:45:28.560007Player 1 move: 4
Bot Random Turn
2022-11-21 20:45:28.560007Player 2 move: 10
Bot Minimax Turn
2022-11-21 20:45:28.560007Player 1 move: 2
Bot Minimax Turn
2022-11-21 20:45:28.561007Player 1 move: 0
Bot Minimax Turn
2022-11-21 20:45:28.561007Player 1 move: 4
Bot Minimax Turn
2022-11-21 20:45:28.562007Player 1 move: 6
Bot Minimax Turn
2022-11-21 20:45:28.562007Player 1 move: 2
Bot Random Turn
2022-11-21 20:45:28.562007Player 2 move: 12
Bot Minimax Turn
2022-11-21 20:45:28.562007Player 1 move: 6
Bot Minimax Turn
2022-11-21 20:45:28.563088Player 1 move: 3
Bot Minimax Turn
2022-11-21 20:45:28.563088Player 1 move: 6
Bot Minimax Turn

2022-11-21 20:45:28.563088Player 1 move: 5
Bot Minimax Turn
2022-11-21 20:45:28.563088Player 1 move: 2
Bot Random Turn
2022-11-21 20:45:28.563088Player 2 move: 11
Bot Minimax Turn
2022-11-21 20:45:28.564089Player 1 move: 3
Bot Random Turn
2022-11-21 20:45:28.564089Player 2 move: 9
Bot Minimax Turn
2022-11-21 20:45:28.564089Player 1 move: 3
Bot Random Turn
2022-11-21 20:45:28.564089Player 2 move: 8
Bot Minimax Turn
2022-11-21 20:45:28.564089Player 1 move: 4
Bot Random Turn
2022-11-21 20:45:28.564089Player 2 move: 12
Bot Random Turn
2022-11-21 20:45:28.564089Player 2 move: 14
Bot Random Turn
2022-11-21 20:45:28.564089Player 2 move: 13
Bot Minimax Turn
2022-11-21 20:45:28.564089Player 1 move: 5
Bot Random Turn
2022-11-21 20:45:28.564089Player 2 move: 11
Bot Minimax Turn
2022-11-21 20:45:28.565040Player 1 move: 2
Bot Random Turn
2022-11-21 20:45:28.565040Player 2 move: 13
Bot Minimax Turn
2022-11-21 20:45:28.565040Player 1 move: 3
Bot Random Turn
2022-11-21 20:45:28.565040Player 2 move: 12
Bot Minimax Turn
2022-11-21 20:45:28.565040Player 1 move: 4
Bot Random Turn
2022-11-21 20:45:28.565040Player 2 move: 12
Bot Minimax Turn
2022-11-21 20:45:28.565040Player 1 move: 1
Bot Random Turn
2022-11-21 20:45:28.565040Player 2 move: 14
Bot Minimax Turn
2022-11-21 20:45:28.565040Player 1 move: 6
Bot Minimax Turn
2022-11-21 20:45:28.565040Player 1 move: 2
Bot Minimax Turn
2022-11-21 20:45:28.565040Player 1 move: 4
Bot Random Turn
2022-11-21 20:45:28.565040Player 2 move: 13
Bot Minimax Turn
2022-11-21 20:45:28.566091Player 1 move: 5
Bot Random Turn
2022-11-21 20:45:28.566091Player 2 move: 8
Bot Minimax Turn
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2022-11-21 20:45:28.566091Player 1 move: 0
Bot Random Turn
2022-11-21 20:45:28.566091Player 2 move: 12
Bot Minimax Turn
2022-11-21 20:45:28.566091Player 1 move: 1
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2022-11-21 20:45:28.566091Player 2 move: 11
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Bot Minimax Turn
2022-11-21 20:45:28.568100Player 2 move: 14
Bot Random Turn
Minimax Bot WINS IN : 0.019411 SECONDS