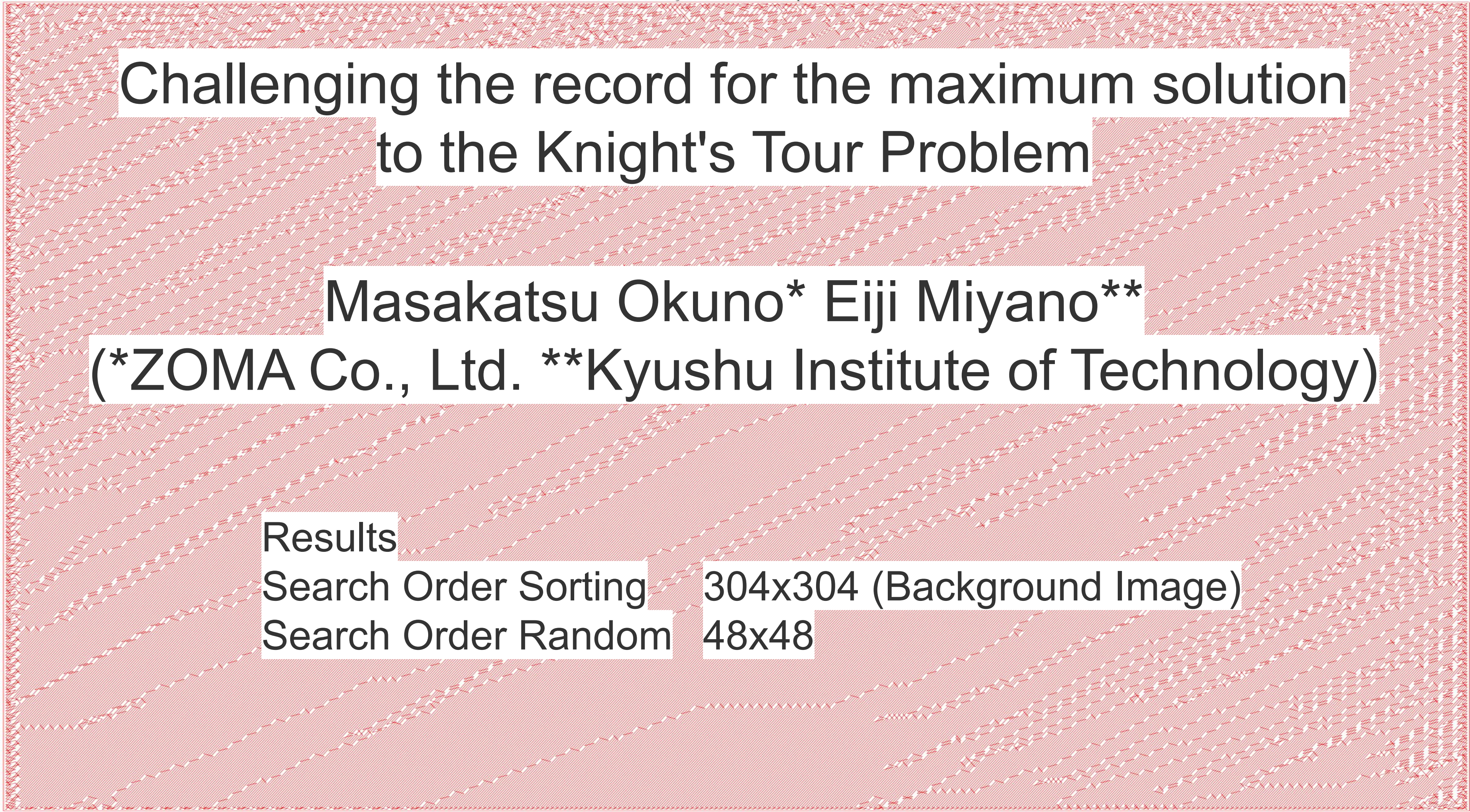
KnightTour 304x304 start=(0,0) end=(2,1)
seed=0 try=92471 solutions=1 step=92415



Challenging the record for the maximum solution to the Knight's Tour Problem

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Results

Search Order Sorting	304x304 (Background Image)
Search Order Random	48x48

The Knight's Tour Problem: Research Background and Objectives

Research Background

The Knight's Tour problem is a puzzle where a knight must traverse every square on a chessboard.
It is possible on boards of various sizes beyond 8x8.
A history of exploration predating computers.
No research has attempted larger sizes within practical time limits.

Research Goal

To determine the largest size solvable on a standard computer.

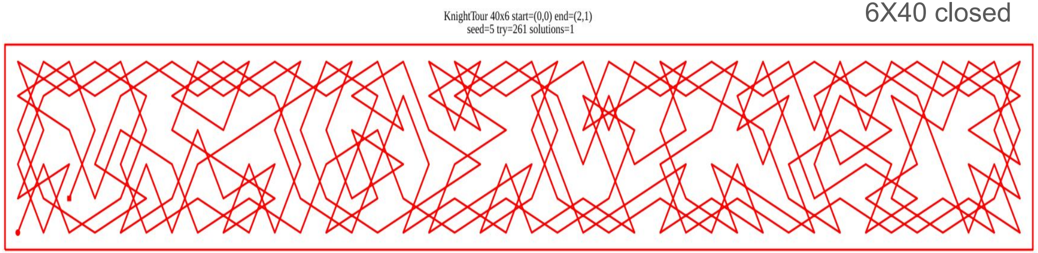
8X8 closed

8X8 open

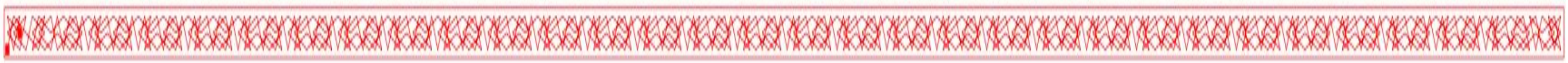
10X10 closed

20X20 closed

6X40 closed



3X90 closed



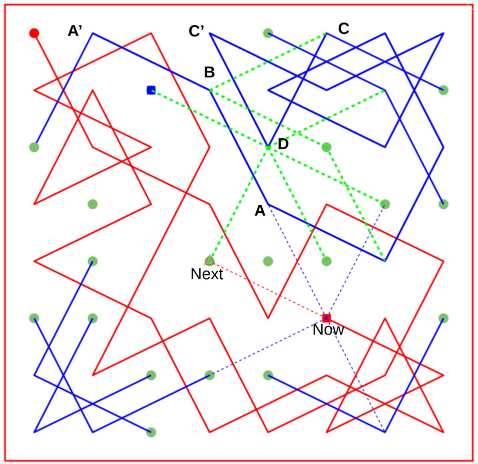
Algorithm Overview

Input: An undirected graph and the Start and End nodes contained within the graph
Strategy: Provide a Seed to shuffle the search order, examine whether moving from Now (the current node) to Next (the forward candidate) is valid, and explore the path using the Backtrack method

The following explains the algorithm and strategy by item.

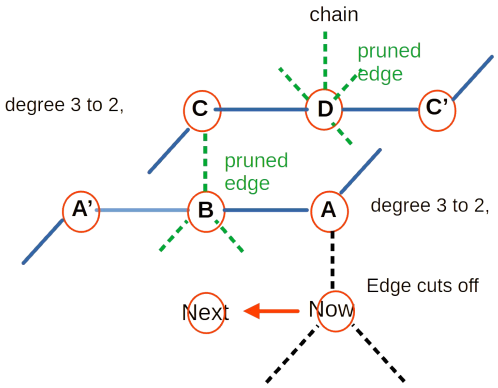
1. Edge pruning
Identify and prune unnecessary edges
2. Dead End Detection
Find dead ends and avoid them
3. Islands, Bridges, and Eulerian Paths
Decompose unvisited nodes into islands and bridges, then apply Eulerian path conditions
4. Parallel Processing (Threads)
Utilize parallel processing features provided by the programming language

1. Edge pruning



Example of pruning edges

1. When attempting to move from Now to Next, the edges (black dashed lines) connecting Now to other nodes are severed because the path is lost.
2. If the degree of A is 3, then the degree becomes 2, and B is contained in the single path of A and A'.
3. Since the only entrances and exits to B are A and A', the extra edges of B (green dashed lines) can be pruned.
4. As a result, C, which had a degree of 3, now has a degree of 2, and pruning becomes possible for D as well.



Pruning is chained, increasing the number of nodes contained within a single path (blue line).
The efficiency of exploration increases dramatically as the number of single paths increases.

2 Dead End Detection

- A dead end is a node that can no longer be traversed.
- As a result of pruning, Dead End is now identifiable.
- Dead End (Aota-maru) refers to the following three types:
- Figure 1: Nodes whose degree has become 1 or less due to pruning
- Figure 2: Nodes where no further candidate can be selected regardless of the direction from which they were approached
- Figure 3: Nodes that have formed a loop
- Upon detecting these, stop further searching.
- Pruning and dead-end detection are highly efficient.
- By avoiding the loop in Figure 3, Figure 4 confirms a direct path to End by the 44th move.

Figure 1

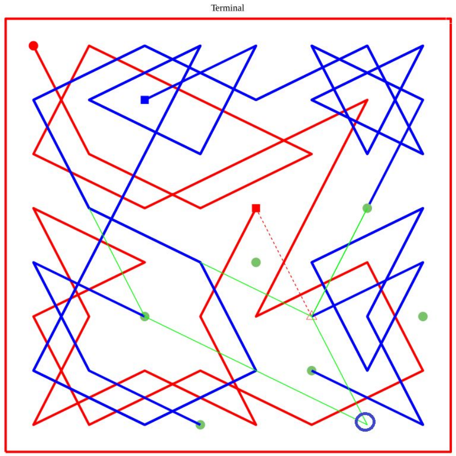


Figure 2

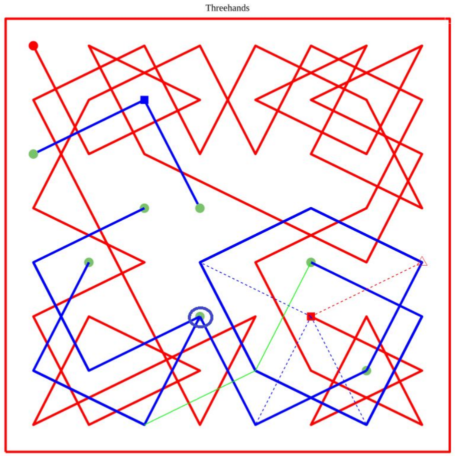


Figure 3

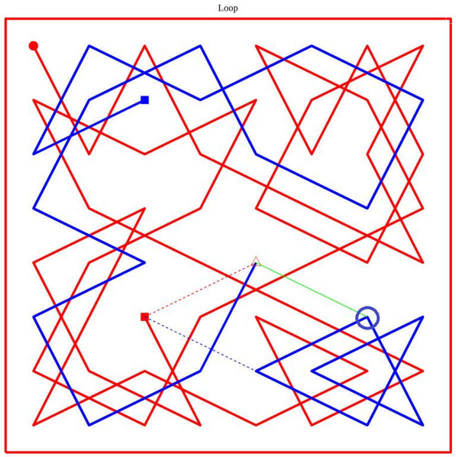
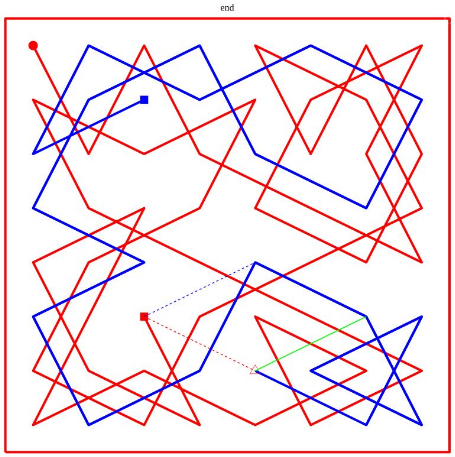


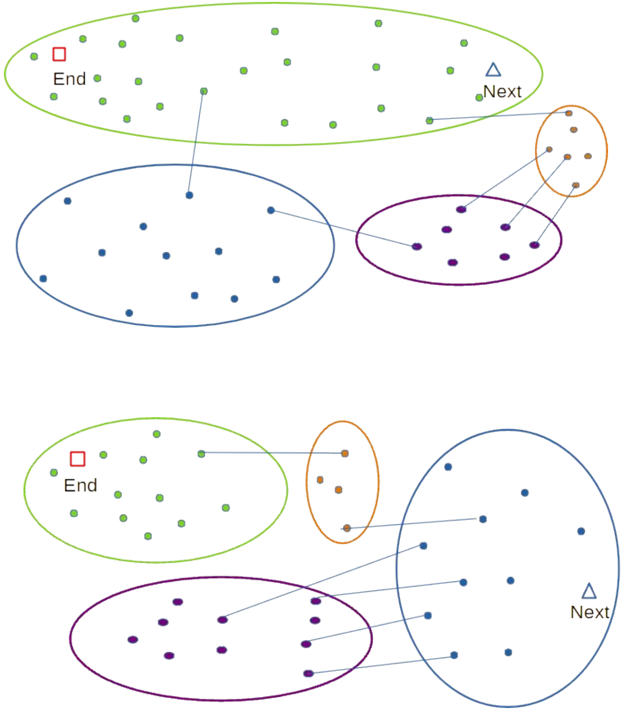
Figure 4

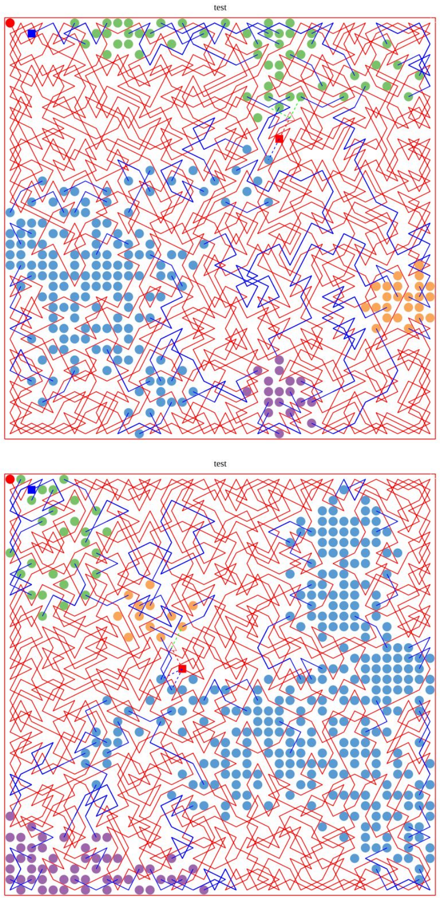


3 Islands and Bridges, Eulerian Paths

From Eulerian closed-loop property, the following holds:

1. If all bridges on the islands are in even numbers, Next and End must be on the same island.
2. If there are an odd number of islands connected by bridges, there can only be two such islands, and Next and End must be contained within separate islands with an odd number of bridges.
3. There must be no island without a bridge.



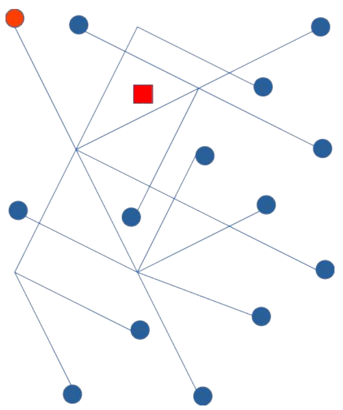


Colored circles indicate islands; blue lines indicate bridges. Red lines indicate areas already passed through.

- Global structural analysis yields clear results and is highly effective when dealing with large sizes.
- On the other hand, the computational cost is high.

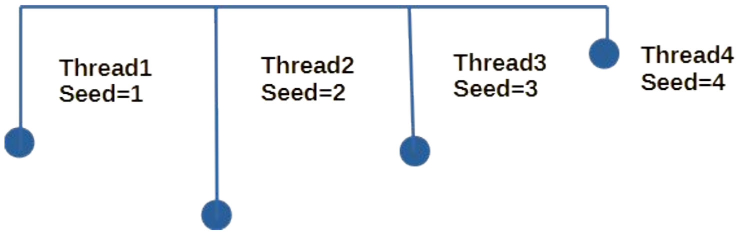
4 Parallel Processing (Threads)

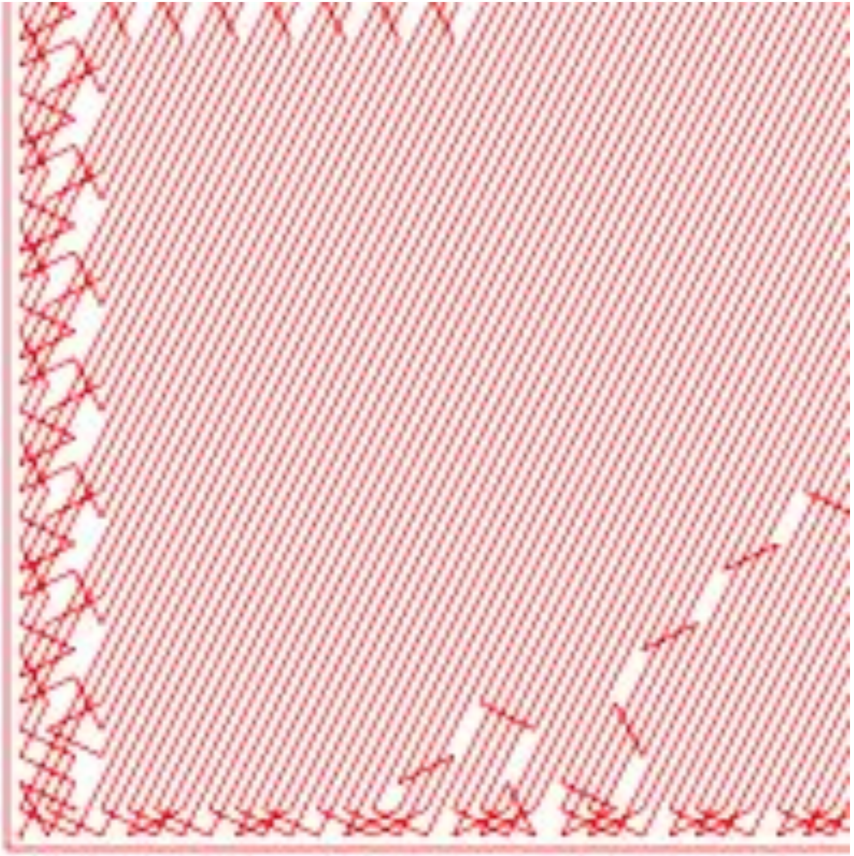
- When exploring a path from Start (red circle) to End (red square), decompose it into independent paths of a certain number of steps from Start (3 steps in the diagram).
- Launching multiple threads from a new Start (blue circle) to End achieves non-overlapping parallel execution.
- The more threads there are (the larger N is), the more efficient it becomes, but this comes at the cost of thread switching overhead.

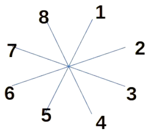


- Start and End are the same; launch multiple threads with different search orders.
- Depending on the combination of search order, it may be possible to reach the solution quickly with fewer attempts. Start and End are the same
- By pitting threads against each other in competition, solutions can be found in a shorter time. Start and End are identical; multiple threads are launched with different search orders.

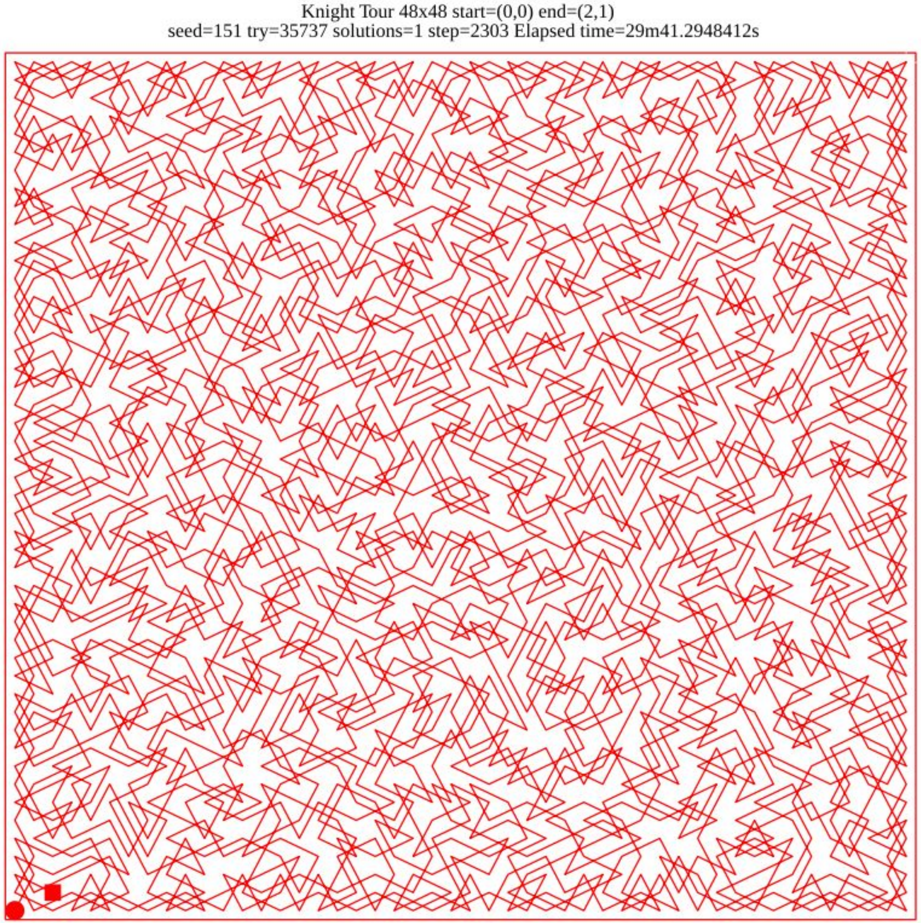
Threads enable finding large-scale solutions
Start and End are identical; multiple threa

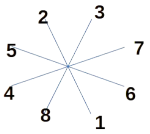






Search Order Sorting 304X304   Part





Search Order Random 48x48

Conclusion

- Search Order Sorting Type 304X304 and Search Order Random Type 48X48 are, as far as we know, the largest sizes found to date, excluding those composed of smaller boards.
- Therefore, it is reasonable to assert this result as the maximum record.
- Furthermore, algorithm improvements and record updates will continue in the future.

Halfway through the journey, In the helmet, infinite.

Thank you for your kind attention.