Task (2) Knight's tour (Hamiltonian circuit)

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1. Problem description:

Is it possible for a chess knight to visit all the cells of an 8 × 8 chessboard exactly once, ending at a cell one knight's move away from the starting cell? (Such a tour is called closed or re-entrant. Note that a cell is considered visited only when the knight lands on it, not just passes over it on its move.)

In the problem, the knight is restricted to move according to its standard L-shaped move, which consists of moving two squares horizontally or vertically and then one square perpendicular to the previous direction, or vice versa. The knight must make a sequence of such moves to visit each square exactly once, ending at the starting square.

The closed-circuit aspect of the problem means that the knight's tour should form a closed loop, with the final move allowing the knight to return to its starting position. This adds an extra constraint to the problem, as not all open knight's tours (those that do not return to the starting square) can be extended to form a closed circuit.

The Knight's tour closed circuit problem is a classic example of a backtracking algorithm application, where the algorithm systematically explores all possible moves, backtracking when it reaches a dead end, until a solution is found or all possibilities are exhausted. Various heuristics, such as Warnsdorff's rule, can be applied to improve the efficiency of the search for a solution.

1	38	17	34	3	48	19	32
16	35	2	49	18	33	4	47
39	64	37	54	59	50	31	20
36	15	56	51	62	53	46	5
11	40	63	60	55	58	21	30
14	25	12	57	52	61	6	45
41	10	27	24	43	8	29	22
26	13	42	9	28	23	44	7

2. Detailed assumptions:

1) Standard 8x8 chessboard is assumed.
2) Knight moves according to its L-shaped pattern.
3) Each square on the chessboard must be visited exactly once.
4) The tour must form a closed loop, returning to the starting square.
5) Backtracking is typically employed in the solution algorithm.
6) Some algorithms may introduce randomness for efficiency.
7) Heuristics are commonly used to guide the search process.
8) An optimal or any valid closed-circuit solution may be sought.

3. Detailed solution including the pseudo-code and the description of your solution:

description of your solution

Warnsdorff's algorithm is a heuristic approach to solve the Knight's tour problem. It's based on the idea of always choosing the next move to be the one with the fewest onward moves (vertex with smallest degree). This heuristic helps to reduce the branching factor and improves the chances of finding a solution.

Pseudo-code:

1. Initialize an empty chessboard.
2. Start from a given square.
3. Mark the starting square as visited.
4. Find the next valid move using Warnsdorff's heuristic:
    - Consider all possible moves from the current square.
    - Choose the move with the fewest accessible squares.
5. Update the current position and mark it as visited.
6. Repeat steps 4-5 until all squares are visited or no further moves are possible.
7. Check if the tour is closed by verifying if the knight can move back to the starting square.
8. Print the solution if a closed tour is found.

```
procedure findClosedTour(startX, startY):
    create a chessboard grid
    initialize all squares with -1

    set currentX = startX
    set currentY = startY
    mark the starting square as visited

    repeat N * N - 1 times:
        find the next valid move based on Warnsdorff's heuristic
        if no valid move is found:
            return false
        update the current position and mark the square as visited

    if the tour does not end in a square adjacent to the starting
square:
        return false

    print the chessboard grid
    return true
```

4.Complexity analysis:

Time complexity: O(N^2)

Space Complexity: O(N^2)

5.Comparison with another algorithm:

Criteria	Brute Force Approach	Warnsdorff's Heuristic
Advantages	Guarantees to find a solution if it exists.	More efficient for larger chessboards.
	Conceptually simple and straightforward.	Often finds solutions faster.

		Lower space complexity.
Disadvantages	Exponential time complexity: O(8^(N^2)).	Not guaranteed to find solution always.
	Inefficient for large chessboards.	May fail for certain configurations.
		Possibility of not finding a solution.
Complexity	Time: O(8^(N^2)), Space: O(N^2).	Time: O(N^2), Space: O(N^2).

6.Conclusion:

In conclusion, solving the Knight's Tour problem can be approached in two main ways: brute force and using Warnsdorff's heuristic.

The brute force method checks every possible move until it finds a closed tour or exhausts all options. It's easy to understand but can be very slow, especially for larger chessboards.

On the other hand, Warnsdorff's heuristic method uses a simple rule to guide the knight's movements, making it faster and more efficient. While it may not always find the best solution, it strikes a good balance between speed and accuracy.

Overall, for practical purposes, Warnsdorff's heuristic approach is often the better choice due to its speed and reliability, even though it might not always find the absolute best solution.