Problem Description

In this problem, you are given a chessboard of size $n \times n$, where n represents both the height and width of the board. The chessboard is represented by an integer matrix grid, with each integer being unique and ranging from 0 to n * n - 1. The grid shows the order in which a knight has visited each cell on the chessboard, starting from the top-left cell (which should be 0). The knight is supposed to visit every cell exactly once.

The task is to verify if the given grid represents a valid knight's tour. In a knight's tour, the knight starts at the top-left corner and makes moves in an "L" shape pattern: either moving two squares vertically and one square horizontally, or two squares horizontally and one square vertically. Every cell must be visited exactly once in the tour. The problem asks you to return true if the grid is a valid tour, or false if it is not.

To approach this solution, you can simulate the knight's path using the given grid and check if each move is valid. Begin by ensuring

Intuition

invalid immediately. Next, create an array pos that will store the coordinates (x, y) for each step the knight takes. It is necessary because the grid is a 2D array representing the tour sequence, and you need to derive the actual coordinates visited at each step.

that the knight starts at the top-left corner, which would be the 0th position in the tour—any other starting position makes the grid

Once you have the coordinates for the entire path the knight took, go through them in pairs and check if the difference between two adjacent coordinates corresponds to a legal knight move. A legal knight move is only valid if the change in x (dx) and change in y

(dy) match either (1, 2) or (2, 1). If at any point you find that the move does not match these conditions, the tour is invalid, and

you return false. If all the moves are legal, once you complete the traversal of the path, you return true indicating the grid represents a valid knight's tour.

Solution Approach The solution begins by creating a list pos that will record the coordinates (i, j) corresponding to each step of the knight's tour, with

i being the row index and j being the column index in the grid. The grid holds integers that represent the move sequences, and the

pos list will be used to store the actual (x, y) positions for these moves.

Next, a for loop iterates over each cell (i, j) of the grid to fill out the pos list where pos[grid[i][j]] will be the tuple (i, j), effectively mapping the move sequence to coordinates. If the knight did not start at the top-left corner (grid[0][0] should be 0), then the grid is immediately deemed invalid.

positions (x1, y1) and (x2, y2), we calculate the absolute differences dx as abs(x1 - x2) and dy as abs(y1 - y2). These differences correspond to the movements made by the knight. We check if the move is a legal knight's move—a move that results in dx being 1 and dy being 2 or vice versa. The ok variable holds a

Boolean representing whether the move is valid (dx == 1 and dy == 2) or (dx == 2 and dy == 1).

After the post list is populated, another for loop iterates through post in pairs using the pairwise function. For each pair of adjacent

If at any point, a pair of positions does not form a legal knight's move, the function returns false because this would indicate an invalid knight's tour. Finally, if all adjacent pairs fulfill the criteria of a knight's valid move, the loop completes without finding any invalid moves, and the

This approach relies on the idea of transforming the problem into a simpler data structure (pos list) that can be more easily traversed and verified. The pairwise iterator is a pattern that helps in checking the adjacent elements without manually handling index

function returns true, which signifies that the provided grid corresponds to a valid configuration of the knight's tour.

Example Walkthrough Let's consider a 5×5 chessboard and a sequence that we need to verify. Let's assume the given grid is as follows: 1 0 10 17 6 23

According to our solution approach, we need to first map each move sequence number to its coordinates on the grid.

legal knight's move.

16 3 20 12

13 22 19 2

24 1 14 21 7

• ...

 grid[0][0] is 0, so pos[0] becomes (0, 0). grid[0][1] is 10, so pos[10] becomes (0, 1).

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Our pos list now represents the sequence in which the knight moves on the chessboard.
 2. Next, we iterate through the pos list to verify if each move is valid.
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• grid[4][4] is 2, so pos[2] becomes (4, 4).

1. To create the pos list, we iterate through the grid:

increments, making the code more readable and less error-prone.

The pairwise iteration helps us quickly check the moves one after the other: Current Position = (0, 0), Next Position = (2, 1), Move = Legal Current Position = (2, 1), Next Position = (4, 4), Move = Illegal, returns false.

• We then look at pos[1] to pos[2]: moving from (2, 1) to (4, 4). The differences dx = 2 and dy = 3 do not match the legal

• For the start: pos[0] is (0, 0) and pos[1] is (2, 1). The move from (0, 0) to (2, 1) has differences dx = 2 and dy = 1, which is a

We immediately know that the sequence is not a valid knight's tour since the second move is not legal for a knight, so we don't need to check the entire grid. This example walkthrough effectively illustrates how our algorithm works to verify a knight's tour on the chessboard. By converting

move sequences into coordinates and verifying each move one by one, we can efficiently determine the validity of the tour.

Python Solution

def check_valid_grid(self, grid: List[List[int]]) -> bool:

int[] previousPosition = positions[i - 1];

// Calculate the distance between the current number and the previous number

// Check if the distance satisfies the condition for a knight's move in chess

int dx = Math.abs(previousPosition[0] - currentPosition[0]);

int dy = Math.abs(previousPosition[1] - currentPosition[1]);

// If the move is not valid, the grid is not valid

boolean is ValidMove = $(dx == 1 \&\& dy == 2) \mid \mid (dx == 2 \&\& dy == 1);$

int[] currentPosition = positions[i];

// If all moves are valid, the grid is valid

if (!isValidMove) {

return false;

moves of a knight. Thus, according to our algorithm, we return false.

from typing import List

Get the size of the grid

size = len(grid)

from itertools import pairwise # Python 3.10 introduced pairwise function in itertools class Solution:

""" Check if the numbers in the grid follow a knight's move pattern

A boolean value indicating whether the grid is valid under the condition

that each consecutive number must be a knight's move away from the previous.

8 Args: grid: A 2D list representing a square grid 9 10 11 Returns:

Ensure the first element is 0 as required by the problem's conditions 16 if grid[0][0] != 0: 17 18 return False 19

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 23
             # Initialize a list to hold the positions of the numbers in the grid
 24
             positions = [None] * (size * size)
 25
 26
             # Populate the positions list with coordinates of numbers from the grid
             for row_index in range(size):
 27
 28
                 for col_index in range(size):
 29
                     # Note that the numbers have to be decreased by 1 to become 0-indexed positions
 30
                     positions[grid[row_index][col_index] - 1] = (row_index, col_index)
 31
 32
             # Use pairwise from itertools to iterate over consecutive pairs of number positions
 33
             for (row1, col1), (row2, col2) in pairwise(positions):
 34
                 # Calculate the absolute deltas between the positions
 35
                 delta_row, delta_col = abs(row1 - row2), abs(col1 - col2)
 36
 37
                 # Check for valid knight's move: either 1 by 2 steps or 2 by 1 step
 38
                 is_valid_knight_move = (delta_row == 1 and delta_col == 2) or (delta_row == 2 and delta_col == 1)
 39
                 if not is_valid_knight_move:
 40
                     # If any pair of numbers is not separated by a knight's move, the grid is invalid
 41
                     return False
 42
 43
             # If all pairs of numbers are separated by a knight's move, the grid is valid
 44
             return True
 45
Java Solution
   class Solution {
         // Function to check if a given grid represents a valid grid for the given conditions
         public boolean checkValidGrid(int[][] grid) {
             // Check if the first element is 0 as required
             if (grid[0][0] != 0) {
  5
                 return false;
  6
  8
             // Calculate the size of the grid
  9
 10
             int gridSize = grid.length;
 11
             // Create a position array to store positions of each number in the grid
 12
 13
             int[][] positions = new int[gridSize * gridSize][2];
             for (int row = 0; row < gridSize; ++row) {</pre>
 14
 15
                 for (int col = 0; col < gridSize; ++col) {</pre>
 16
                     // Storing the current number's position
 17
                     positions[grid[row][col]] = new int[] {row, col};
 18
 19
 20
 21
             // Loop to check the validity of the grid based on the position of consecutive numbers
 22
             for (int i = 1; i < gridSize * gridSize; ++i) {</pre>
 23
                 // Get the positions of the current and previous numbers
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40 return true; 41 42 } 43

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C++ Solution
    #include <vector>
    #include <cmath> // Include <cmath> for abs function
    // The Solution class containing a method to check if a grid is valid
  5 class Solution {
     public:
         // Method to check if the moves in the grid represent a valid knight's tour
         bool checkValidGrid(std::vector<std::vector<int>>& grid) {
             // The start position must be 0, if not return false
  9
             if (grid[0][0] != 0) {
 10
                 return false;
 11
 12
 13
 14
             // Size of the grid
 15
             int gridSize = grid.size();
 16
 17
             // Vector to hold the positions of the numbers in the grid
 18
             std::vector<std::pair<int, int>> numberPositions(gridSize * gridSize);
 19
 20
             // Populate numberPositions with coordinates of each number in the grid
 21
             for (int row = 0; row < gridSize; ++row) {</pre>
 22
                 for (int col = 0; col < gridSize; ++col) {</pre>
 23
                     numberPositions[grid[row][col]] = {row, col};
 24
 25
 26
 27
             // Iterate over the numbers in the grid and check if each move is a valid knight move
 28
             for (int number = 1; number < gridSize * gridSize; ++number) {</pre>
 29
                 // Get the current and previous positions
                 auto [previousX, previousY] = numberPositions[number - 1];
 30
 31
                 auto [currentX, currentY] = numberPositions[number];
 32
                 // Calculate the differences in x and y coordinates
 33
 34
                 int deltaX = std::abs(previousX - currentX);
 35
                 int deltaY = std::abs(previousY - currentY);
 36
 37
                 // Check if the move is a valid knight's move (L shape move)
 38
                 bool isValidKnightMove = (deltaX == 1 && deltaY == 2) || (deltaX == 2 && deltaY == 1);
 39
 40
                 // If the move isn't valid, return false
                 if (!isValidKnightMove) {
 41
 42
                     return false;
 43
 44
 45
 46
             // If all moves are valid, the grid represents a valid knight's tour
 47
             return true;
```

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49 };
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Typescript Solution
    function checkValidGrid(grid: number[][]): boolean {
        // Ensure the first element is 0 as expected
        if (grid[0][0] !== 0) {
             return false;
  4
  5
  6
        // Find the size of the grid
        const gridSize = grid.length;
  8
        // Initialize an array to track the positions of the numbers in the grid
         const positions = Array.from({ length: gridSize * gridSize }, () => new Array(2).fill(0));
12
13
        // Populate positions array with the coordinates of each number in the grid
14
         for (let row = 0; row < gridSize; ++row) {</pre>
15
             for (let col = 0; col < gridSize; ++col) {</pre>
16
                 positions[grid[row][col]] = [row, col];
17
18
19
        // Validate the positions of all numbers from 1 to n*n - 1
 20
21
         for (let i = 1; i < gridSize * gridSize; ++i) {</pre>
            // Get the position of the current and previous number
22
 23
             const previousPos = positions[i - 1];
             const currentPos = positions[i];
 24
 25
 26
             // Calculate the absolute differences in x and y directions
 27
             const deltaX = Math.abs(previousPos[0] - currentPos[0]);
             const deltaY = Math.abs(previousPos[1] - currentPos[1]);
28
 29
 30
             // Check for knight-like move (L-shape): 2 by 1 or 1 by 2 steps
 31
             const isValidMove = (deltaX === 1 && deltaY === 2) || (deltaX === 2 && deltaY === 1);
 32
 33
            // If the move is not valid, return false
 34
            if (!isValidMove) {
 35
                 return false;
 36
 37
 38
        // If all positions are valid, return true
 40
         return true;
 41 }
 42
```

Time and Space Complexity The time complexity of the code is $0(n^2)$. This is because the main computations are in the nested for-loops, which iterate over every cell in the given grid. Since the grid is n by n, the iterations run for n^2 times.

The space complexity of the code is $0(n^2)$ as well. This stems from creating a list called pos of size n * n, which is used to store the positions of the integers from the grid in a 1D array. Since the grid stores n^2 elements, and we're converting it to a 1D array, the space taken by pos will also be n^2.