

# Design Analysis and Algorithm, Lab Assignment 7

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## Question

**Assignment:** Imagine a person in on an island, you have to find the probability that a person is alive after taking 'n' steps on an island.

**Objective:** An island is in the form of a square ( $N \times N$ ) matrix, and a person is standing inside the matrix. A person on an island can take 'n' steps in one of the four directions: north, south, east or west. Therefore, the probability of moving in each direction is equal i.e., 25. Calculate the probability that the person is alive after walking n steps on the island, provided that the person dies on stepping outside the matrix.

Write a Python/JAVA/C/C++ program to create a dynamic programming solution to calculate the probability of survival, taking into account the island's boundaries and movement probabilities.

- The island is bounded and if the person steps out of bounds, they are considered "not alive".
- Implement a function and returns the probability that the person is still alive after taking 'n' steps starting from a specific location on the island.
- You have to find the time complexity of your solution for an  $N \times N$  matrix.

## Answer

Below is the Python code :

```
def probabilityOfSurvival(N, n, x, y, memo):
    if x < 0 or y < 0 or x >= N or y >= N:
        return 0.0

    if n == 0:
        return 1.0

    if memo[x][y][n] != -1:
        return memo[x][y][n]

    probability = 0.25 * (
        probabilityOfSurvival(N, n - 1, x - 1, y, memo) +
        probabilityOfSurvival(N, n - 1, x + 1, y, memo) +
        probabilityOfSurvival(N, n - 1, x, y - 1, memo) +
        probabilityOfSurvival(N, n - 1, x, y + 1, memo)
    )

    memo[x][y][n] = probability

    return probability

def calculateSurvivalProbability(N, n, x, y):
    memo = [[[-1 for _ in range(n + 1)] for _ in range(N)] for _ in range(N)]
```

```

    return probabilityOfSurvival(N, n, x, y, memo)

N = 5  # Size of the island (N*N matrix)
n = 10 # Number of steps
x = 2  # Starting X-coordinate
y = 2  # Starting Y-coordinate

probability = calculateSurvivalProbability(N, n, x, y)
print(f"Probability of survival: {probability:.4f}")

```

## Analysis

The provided Python code efficiently computes the probability of survival on an island using dynamic programming. Here's a brief analysis of the code:

- The code utilizes a recursive approach, considering the possible movements of the person (north, south, east, west) on the island.
- The 'probabilityOfSurvival' function checks boundary conditions, preventing the person from moving outside the N\*N matrix.
- Memoization is employed to store already computed results, ensuring that redundant calculations are avoided.
- The time complexity of the solution for an N\*N matrix is approximately  $O(N^2 * n)$ , where N is the size of the island and n is the number of steps.

This approach efficiently computes the probability of survival and ensures that the code handles boundary conditions appropriately, resulting in an optimal solution for the given problem.