Problem Statement

I. Hill Climbing using Steepest Ascent Hill Climbing

In Hill-Climbing technique, starting at the base of a hill, we walk upwards until we reach the top of the hill. In other words, we start with initial state and we keep improving the solution until its optimal.

It's a variation of a generate-and-test algorithm which discards all states which do not look promising or seem unlikely to lead us to the goal state. To take such decisions, it uses heuristics (an evaluation function) which indicates how close the current state is to the goal state.

In simple words, Hill-Climbing = generate-and-test + heuristics

II. Hill Climbing Search with Sideways Move

The hill climbing search algorithms halts if it reaches plateau where the best successor has same value as the current state.

Then we allow algorithm to move sideways in the hope that the plateau is actually is a shoulder.

The algorithm will go in an infinite loop if the algorithm reaches to a flat local maximum and that is not a shoulder.

The only solution of it is to put limit on the number of consecutive sideways move allowed.

III. Random Restart Hill Climbing without Sideways Move

Random restart hill climbing conducts series of hill climbing searches from randomly generated initial states, until a goal state is found.

The probability of this technique approaches 1, because sometimes it will eventually generate goal state as the initial state.

If each hill-climbing search has a probability p of success, then the expected number of restarts required is 1/p.

For 8-queens instances with no sideways moves allowed, $p \approx 0.14$, so we need roughly 7 iterations to find a goal (6 failures and 1 success). Roughly 22 steps in all.

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For 8-queens instances, When we allow sideways moves, $1/0.94 \approx 1.06$ iterations are needed on average and $(1 \times 21) + (0.06/0.94) \times 64 \approx 25$ steps.

Program Structure

- Global Variables
    1. n
    2. success_steps
    3. failure_steps
    4. success_count
    5. failure_count

- Functions
    1. printState()
        - It prints the current state of the N*N board

    2. calculateHeuristics()
        - This functions counts the number of attacks on the other queens and finds the heuristic values for each of the square board.

    3. calculateMinBoard()
        - This function moves the queen to the position in same column where the heuristic value of the function is less.

    4. hill_climbing()
        - This function takes board as an input and returns solution using steepest ascent hill climbing.

5. hill_climbing_random_restart()
    - The function randomly restarts from any state. It calls the other two function calculateHeuristics() and calculateMinBoard() recursively for 100 iterations of time. It returns the total number of count and the success and the failure steps.

6. random_restart_hill_climbing_with_sideways()
    - The function randomly restarts from any state. It calls the other two function calculateHeuristics() and calculateMinBoard() recursively it searches for the global minimum. But if it get stucks at local minima than it will iterate for 100 moves and will try to find the optimum solution.

Implementation of 4 Queen Problem

Enter the value of n: 4

Steepest-ascent Hill Climbing

Executing...

The search sequence for random configuration: 1

Q000
0000
00Q0
0Q0Q

Q000
00Q0
0000
0Q0Q

Q000
00Q0
000Q
0Q00

Failure
Number of Steps: 2

The search sequence for random configuration: 2
0Q0Q
0000

Q0Q0
0000

0Q0Q
0000
Q000
00Q0

0Q00
000Q
Q000
00Q0

Success
Number of Steps: 2

The search sequence for random configuration: 3
0000
0Q00
Q00Q
00Q0

000Q
0Q00
Q000
00Q0

Failure
Number of Steps: 1

The search sequence for random configuration: 4

0000
000Q
QQ00
00Q0

0Q00
000Q
Q000
00Q0

Success
Number of Steps: 1

Success rate is: 37.8 % and Failure rate is: 62.2 %

The average number of steps when the algorithm succeeds: 1.9

The average number of steps when the algorithm fails: 2.3

Hill-climbing search with sideways move

Executing...

The search sequence for random configuration: 1
000Q
0QQ0
Q000
0000

000Q
0Q00
Q000

00Q0

0Q0Q
0000
Q000
00Q0

0Q00
000Q
Q000
00Q0

Success
Number of Steps: 3

The search sequence for random configuration: 2
0Q00
0000
Q0Q0
000Q

0Q00
0000
Q000
00QQ

0Q00
000Q
Q000
00Q0

Success

Number of Steps: 2

The search sequence for random configuration: 3
0000
0Q0Q
Q000
00Q0

0Q00
000Q
Q000
00Q0

Success
Number of Steps: 1

The search sequence for random configuration: 4
00Q0
0000
Q000
0Q0Q

00Q0
Q000
0000
0Q0Q

00Q0
Q000
000Q
0Q00

Success
Number of Steps: 2

Success rate is: 100.0 % and Failure rate is: 0.0 %

The average number of steps when the algorithm succeeds: 2.85

Random-restart hill-climbing search without sideways move

Executing...

The average number of random restarts required without sideways move

1.44 The average number of steps required without sideways move 5.03

Random-restart hill-climbing search with sideways move

Executing…

The average number of random restarts required with sideways move

0.0 The average number of steps required with sideways move 2.74

Performance Measure

Hill Climbing Search	Success rate	Failure Rate	Average number of steps when it succeeds	Average number of steps when it fails
	37.8	62.2	1.9	2.3

Hill Climbing Search with sideways move	Success rate	Failure Rate	Average number of steps when it succeeds	Average number of steps when it fails
	100	0	2.85	0

Random Restart hill climbing search	Average number of random restarts required without sideways move	Average number of steps required without sideways move	Average number of random restarts required with sideways move	Average number of steps required with sideways move
	1.44	5.03	0.0	2.04