PROJECT 2

Solving N-queens problem using Hill-Climbing and its variants

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1. **Problem**

   Solve the N-Queen problem using Hill Climbing algorithm

2. **Aim**

   To solve the N Queen problem by using hill-climbing search and its variants, we must place N chess queens on an N×N chessboard so that no two queens attack each other. n-queens problem.

   Here we can implement any of the following method to solve the problem:

- Steepest- ascent hill climbing
- Hill-climbing with sideways move
- Random-restart hill-climbing with sideways move
- Random-restart hill-climbing without sideways move

3. **Language**

   The code is developed in python 3.7

4. **Abstract**

The N-queens problem is the problem of placing 'n' chess queens on an n×n chessboard so that no two queens threaten each other. This means that no two queens can be in same row, column or diagonal. Here the problem is solved using a complete-state formulation, which means we start with all 8 queens on the board and move them around to reach the goal state. We represent the n*n chess board as a matrix.

4.1. Introduction

- **Steepest- ascent hill climbing**

  The Steepest-ascent hill climbing continually moves in the direction of increasing value. It terminates when it reaches a peak i.e., where there are no neighbors who has a higher value.

- **Hill-climbing with sideways move**

  Hill-climbing allow sideways moves in hope that algorithm can escape. In this method we must place a limit on the possible number of sideways moves to avoid infinite loops.

  In this project we considered sideways moves with a limit of 300. This increases percentage of problem instances solved from **14 to 94%**

- **Random-restart hill-climbing with and without sideways move**
  This is a local search algorithm. It is an iterative algorithm that starts with an arbitrary solution to a problem, then attempts to find a better solution by incrementally changing a single element of the solution. If the change produces a better solution, an incremental change is made to the new solution, repeating until no further improvements can be found.

  The hill-climbing algorithms often fail to find a goal when one exists because they can get stuck on local maxima. Random-restart can be used to solve the problem of local maxima, as it conducts a series of hill-climbing searches from randomly generated initial states, until a goal is found.

  This can be implemented with and without sideways moves.

5. Experimental Analysis

- **Input**

  The program accepts size of the puzzle i.e., 4 – queen or 8-queen from the user. User also provides the number of iterations to be made. The program is designed in such a way that it takes user input to choose any one of the four hill-climbing methods.

- **Output**

  The application places all the queens in the correct position in such a way that no two queens threaten each other i.e., no two queens can be in same row, column or diagonal. If in any of the iteration the algorithm could not find the solution it prints that "no solution is found" and records the fail percentage. As a final result it prints the total success and failure percentage, total number of steps taken in success and failure results.

5.1. Global Variables

Iterations	This variable stores the number of iterations to be made given by user
is_it_possible	This variable stores the Boolean value true or false, to tell whether the puzzle can be solved. Intially it is "True"
randomRestarts	To print the number of random restarts happened.
restart_Strategy_steps	Stores the values of the steps taken to restart. It increments each time the intial state is again generated.
Passedboard	This is initially given as none.

5.2. Classes defined in the program

5.2.1. *Board Class*

- This class initializes the method which will generate a random initial state.

Methods

def __init__	This method places the "Q" in the random positions and print in the form of matrix
if __name__ == "__main__"	It has the main display logic to solve the N-queen program. It contains the code to take the input from the user and to generate and display the output results.

5.2.2. *Nqueen Class*

- This class contains all the methods to solve the N-queen problem using any one of the above mentioned hill climbing methods, methods to print the results.

Methods

def __init__	Initialize method which calls the hill-climbing methods based on the search_type variable taken from the user
print_configuration	Printing the configuration of the N-Queen Puzzle
hill_Climbing	Definition for the Steepest hill climbing Algorithm
sideways_Move	Definition for the Sideways hill climbing Algorithm
random_Restart_without_sidemove	Definition for the Random Restart without sideways allowing hill climbing Algorithm
random_Restart_with_sidemove	Definition for the Random Restart with sideways allow hill climbing Algorithm
print_results	Print Definition exclusive to each type of Hill climbing algorithm
calculate_attack_pairs	Definition for calculating the number of attack pairs based on the straight attacks and diagonal attacks
calc_leastcost	This function tries moving every queen to every spot, with only one move and returns the move that has the least number of attacks pairs
calc_hueristic	This function tries moving every queen to every spot, with only one move and returns the move that has the least number of attacks pairs or if not then it will atleast try to send the state with same heuristic

6. Results

Note : Mentioning here output obtained in the 300th iteration

a. Steepest- ascent hill climbing:

**********Welcome to N Queen Solver*********

Please select the size of the Puzzle to be solved:
Choose
"1" if you wish to solve default 8-queens puzzle, or
"2" to assign your desired puzzle.

1

Please select number of Iterations to be made:
Choose
"1" Select if you want to solve the puzzle for 300 runs, or
"2" Select if you want to assign your desired number of run interations.

1

Select any one of the Search Strategy:
Choose
"1" Steepest Ascent Hill Climbing, or
"2" Hill Climbing with Sideways Move, or
"3" Random-Restart Hill Climbing without Sidemove,or
"4" Random-Restart Hill Climbing with Sidemove

1

==========
OUTPUT FOR RUN: 1
==========

Initial State:
. . . . Q . . .
Q . . Q . . . .
. Q . . . . . .
. . . . . Q .
. . . . . Q . .
. . . . . Q
. . Q . . . . .
. . . . . .

Total number of attack pairs: 3
. . . . Q . . .
. . . Q . . . .
. Q . . . . . .
. . . . . Q .

. . . . . Q . .
. . . . . Q
. . Q . . . . .
Q . . . . . .

Total number of attack pairs: 2
. . . . Q . . .
. . . . . .
. Q . . . . . .
. . . Q . . Q .
. . . . . Q . .
. . . . . Q
. . Q . . . . .
Q . . . . . .

Total number of attack pairs: 1
. . . . Q . . .
. . . . . Q .
. Q . . . . . .
. . . Q . . . .
. . . . . Q . .
. . . . . Q
. . Q . . . . .
Q . . . . . .

*****NO SOLUTION FOUND*****

==========
OUTPUT FOR RUN: 2
==========

Initial State:
. . . . . .
. . Q . . . . .
. Q . . . . . .
. . . . . Q
Q . . . Q . Q .
. . . . . .
. . . . . Q . .
. . . Q . . . .

Total number of attack pairs: 5
. . . . . Q .

. . Q . . . . .
. Q . . . . . .
. . . . Q
Q . . . Q . . .
. . . .
. . . . . Q . .
. . . Q . . . .

Total number of attack pairs: 3
. . . . . . Q .
. . Q . . . . .
. Q . . . . . .
. . . . Q
. . . . Q . . .
Q . . . . . .
. . . . . Q . .
. . . Q . . . .

Total number of attack pairs: 2
. . . . . . Q .
. . Q . . . . .
. . . .
. Q . . . . . Q
. . . . Q . . .
Q . . . . . .
. . . . . Q . .
. . . Q . . . .

Total number of attack pairs: 0
. . . . . . Q .
. . Q . . . . .
. . . . Q
. Q . . . . . .
. . . . Q . . .
Q . . . . . .
. . . . . Q . .
. . . Q . . . .

*****SOLUTION FOUND*****

==========
OUTPUT FOR RUN: 74
==========

Initial State:
. . Q . . . . .
. . . . . Q . .
. . . . Q
. Q . Q . . Q .
. . . . . .
. . . . . .
Q . . . . . .
. . . . Q . . .

Total number of attack pairs: 3
. . Q . . . . .
. . . . . Q . .
. . . . Q
. Q . . . . Q .
. . . Q . . . .
. . . . . .
Q . . . . . .
. . . . Q . . .

Total number of attack pairs: 2
. . Q . . . . .
. . . . . Q . .
. . . . Q
. Q . . . . Q .
. . . Q . . . .
Q . . . . . .
. . . . . .
. . . . Q . . .

Total number of attack pairs: 0
. . Q . . . . .
. . . . . Q . .
. . . . Q
. Q . . . . . .
. . . Q . . . .
Q . . . . . .
. . . . . Q .
. . . . Q . . .

*****SOLUTION FOUND*****

==========
OUTPUT FOR RUN: 75
==========

Initial State:
. . . Q . Q . .
. . . .
. . Q . . . . .
Q Q . . . . . .
. . . .
. . . . Q . . .
. . . .
. . . . . . Q Q

Total number of attack pairs: 5
. . . Q . Q . .
. . . .
. . Q . . . . .
. Q . . . . . .
. . . .
. . . . Q . . .
Q . . . .
. . . . . . Q Q

Total number of attack pairs: 3
. . . Q . Q . .
. . . .
. . Q . . . . .
. Q . . . . . .
. . . . . . Q .
. . . . Q . . .
Q . . . . . .
. . . . Q

Total number of attack pairs: 2
. . . Q . Q . .
. . Q . . . . .
. . . .
. Q . . . . . .
. . . . . . Q .
. . . . Q . . .
Q . . . . . .
. . . . Q

*****NO SOLUTION FOUND*****

Total Runs: 300
Total Success: 39
Success Percentage: 13.0 %
Total Fail: 261
Fail Percentage: 87.0 %
Average number of steps in success: 3.8974358974358974
Total Steps for Success: 152
Total Steps for Fail: 792
Average number of steps in fail: 3.0344827586206895

b. Hill-climbing with sideways move

==========
OUTPUT FOR RUN: 296
==========

Initial State:
Q . . . Q Q . .
. . . . . .
. . . . . .
. Q . . . . . .
. . . . . .
. . Q . . . Q .
. . . Q . . . Q
. . . . . .

Total number of attack pairs: 5
Q . . . . Q . .
. . . . . .
. . . . Q . . .
. Q . . . . . .
. . . . . .
. . Q . . . Q .
. . . Q . . . Q
. . . . . .

Total number of attack pairs: 3
Q . . . . Q . .
. . . . . .
. . . . Q . . .

. Q . . . . . .
. . . . . .
. . Q . . . Q .
. . . . . Q
. . . Q . . . .

Total number of attack pairs: 2
. . . . . Q . .
Q . . . . . .
. . . . Q . . .
. Q . . . . . .
. . . . . .
. . Q . . . Q .
. . . . . Q
. . . Q . . . .

Total number of attack pairs: 1
. . . . . Q . .
Q . . . . . .
. . . . Q . Q .
. Q . . . . . .
. . . . . .
. . Q . . . . .
. . . . . Q
. . . Q . . . .
Successors with hueristic same as that of the current state: 4
Random index to choose one of the same heuristic ssuccessor: 3

Total number of attack pairs: 1
. . . . . Q . .
Q . . . . . .
. . . . Q . Q .
. Q . . . . . .
. . . . . Q
. . Q . . . . .
. . . . . .
. . . Q . . . .

Total number of attack pairs: 0
. . . . . Q . .
Q . . . . . .
. . . . Q . . .
. Q . . . . . .

. . . . . Q
. . Q . . . . .
. . . . . Q .
. . . Q . . . .

*****SOLUTION FOUND*****

==========
OUTPUT FOR RUN: 297
==========

Initial State:
. . . . . .
. . . . . .
. . . . . Q . .
. . Q . . . Q .
Q . . . Q . . .
. Q . . . . . .
. . . . . .
. . . Q . . . Q

Total number of attack pairs: 6
. . . . . .
Q . . . . . .
. . . . . Q . .
. . Q . . . Q .
. . . . Q . . .
. Q . . . . . .
. . . . . .
. . . Q . . . Q

Total number of attack pairs: 4
. . Q . . . . .
Q . . . . . .
. . . . . Q . .
. . . . . Q .
. . . . Q . . .
. Q . . . . . .
. . . . . .
. . . Q . . . Q

Total number of attack pairs: 2
. . Q . . . . .

Q . . . . . .
. . . . . Q . .
. . . . . Q .
. . . . Q . . .
. Q . . . . . .
. . . . . Q
. . . Q . . . .
Successors with hueristic same as that of the current state: 4
Random index to choose one of the same heuristic ssuccessor: 0

Total number of attack pairs: 2
. . Q . . . . .
Q . . . . . .
. . . . . Q . .
. Q . . . . Q .
. . . . Q . . .
. . . . . .
. . . . . Q
. . . Q . . . .

Total number of attack pairs: 1
. . Q . . . Q .
Q . . . . . .
. . . . . Q . .
. Q . . . . . .
. . . . Q . . .
. . . . . .
. . . . . Q
. . . Q . . . .
Successors with hueristic same as that of the current state: 4
Random index to choose one of the same heuristic ssuccessor: 1

Total number of attack pairs: 1
. . . . . Q .
Q . . . . . .
. . . . . Q . .
. Q . . . . . .
. . . . Q . . .
. . Q . . . . .
. . . . . Q
. . . Q . . . .
Successors with hueristic same as that of the current state: 3
Random index to choose one of the same heuristic ssuccessor: 1

Total number of attack pairs: 1
. . . . . Q .
Q . . . . . .
. . . . . Q . .
. Q . . . . . .
. . . . Q . . .
. . . . . .
. . . . . Q
. . Q Q . . . .
Successors with hueristic same as that of the current state: 3
Random index to choose one of the same heuristic ssuccessor: 1

Total number of attack pairs: 1
. . . . . Q .
Q . . . . . .
. . . . . Q . .
. Q . . . . . .
. . . . Q . . .
. . Q . . . . .
. . . . . Q
. . . Q . . . .
Successors with hueristic same as that of the current state: 3
Random index to choose one of the same heuristic ssuccessor: 2

Total number of attack pairs: 1
. . . . . Q Q .
Q . . . . . .
. . . . . .
. Q . . . . . .
. . . . Q . . .
. . Q . . . . .
. . . . . Q
. . . Q . . . .
Successors with hueristic same as that of the current state: 3
Random index to choose one of the same heuristic ssuccessor: 2

Total number of attack pairs: 1
. . . . . Q . .
Q . . . . . .
. . . . . .
. Q . . . Q .
. . . . Q . . .

. . Q . . . . .
. . . . Q
. . . Q . . . .
Successors with hueristic same as that of the current state: 4
Random index to choose one of the same heuristic ssuccessor: 0

Total number of attack pairs: 1
. . . . . Q . .
Q . . . . . .
. Q . . . . . .
. . . . . Q .
. . . . Q . . .
. . Q . . . . .
. . . . Q
. . . Q . . . .
Successors with hueristic same as that of the current state: 3
Random index to choose one of the same heuristic ssuccessor: 0

Total number of attack pairs: 1
. . . . . Q . .
. . . . . .
Q Q . . . . . .
. . . . . Q .
. . . . Q . . .
. . Q . . . . .
. . . . Q
. . . Q . . . .
Successors with hueristic same as that of the current state: 4
Random index to choose one of the same heuristic ssuccessor: 0

Total number of attack pairs: 1
. . . . . Q . .
Q . . . . . .
. Q . . . . . .
. . . . . Q .
. . . . Q . . .
. . Q . . . . .
. . . . Q
. . . Q . . . .
Successors with hueristic same as that of the current state: 3
Random index to choose one of the same heuristic ssuccessor: 0

Total number of attack pairs: 1

. . . . . Q . .
. . . . . .
Q Q . . . . . .
. . . . . Q .
. . . . Q . . .
. . Q . . . . .
. . . . . Q
. . . Q . . . .
Successors with hueristic same as that of the current state: 4
Random index to choose one of the same heuristic ssuccessor: 2

Total number of attack pairs: 1
. . . . . Q . .
. . . Q . . . .
Q Q . . . . . .
. . . . . Q .
. . . . Q . . .
. . Q . . . . .
. . . . . Q
. . . . . .
Successors with hueristic same as that of the current state: 5
Random index to choose one of the same heuristic ssuccessor: 1

Total number of attack pairs: 1
. . . . . Q . .
. . . Q . . . .
. Q . . . . . .
. . . . . Q .
. . . . Q . . .
. . Q . . . . .
. . . . . Q
Q . . . . . .
Successors with hueristic same as that of the current state: 3
Random index to choose one of the same heuristic ssuccessor: 0

Total number of attack pairs: 1
. . . . . Q . .
. . . Q . . . .
Q Q . . . . . .
. . . . . Q .
. . . . Q . . .
. . Q . . . . .
. . . . . Q

. . . . . .
Successors with hueristic same as that of the current state: 5
Random index to choose one of the same heuristic ssuccessor: 1

Total number of attack pairs: 1
. . . . . Q . .
. . . Q . . . .
. Q . . . . . .
. . . . . Q .
. . . . Q . . .
. . Q . . . . .
. . . . . Q
Q . . . . . .
Successors with hueristic same as that of the current state: 3
Random index to choose one of the same heuristic ssuccessor: 2

Total number of attack pairs: 1
. . . . . Q . .
. . . Q . . . .
. Q . . . . . .
. . . . . Q .
. . Q . Q . . .
. . . . . .
. . . . . Q
Q . . . . . .
Successors with hueristic same as that of the current state: 2
Random index to choose one of the same heuristic ssuccessor: 1

Total number of attack pairs: 1
. . . . . Q . .
. . . Q . . . .
. Q . . . . . .
. . . . . Q .
. . Q . . . . .
. . . . . .
. . . . . Q
Q . . . Q . . .
Successors with hueristic same as that of the current state: 4
Random index to choose one of the same heuristic ssuccessor: 2

Total number of attack pairs: 1
. . . . . Q . .
. . . Q . . . .

. Q . . . . . .
. . . . . Q .
. . Q . Q . . .
. . . . . .
. . . . . Q
Q . . . . . .
Successors with hueristic same as that of the current state: 2
Random index to choose one of the same heuristic ssuccessor: 0

Total number of attack pairs: 1
. . . . . Q . .
. . . Q . . . .
. Q . . . . . .
. . . . . Q .
. . . . Q . . .
. . Q . . . . .
. . . . . Q
Q . . . . . .
Successors with hueristic same as that of the current state: 3
Random index to choose one of the same heuristic ssuccessor: 1

Total number of attack pairs: 1
. . . . . Q . .
. . . Q . . . .
. Q . . . . . .
. . . . . Q .
. . . . Q . . .
. . Q . . . . .
Q . . . . . Q
. . . . . .
Successors with hueristic same as that of the current state: 6
Random index to choose one of the same heuristic ssuccessor: 4

Total number of attack pairs: 1
. . . . . Q . .
. . . Q . . . .
. Q . . . . . .
. . . . . Q Q
. . . . Q . . .
. . Q . . . . .
Q . . . . . .
. . . . . .
Successors with hueristic same as that of the current state: 5

Random index to choose one of the same heuristic ssuccessor: 2

Total number of attack pairs: 1
. . . . . Q . .
. . . Q . . . .
. Q . . . . . .
. . . . Q
. . . . Q . . .
. . Q . . . . .
Q . . . . . .
. . . . . Q .
Successors with hueristic same as that of the current state: 3
Random index to choose one of the same heuristic ssuccessor: 2

Total number of attack pairs: 1
. . . . . Q . .
. . . Q . . . .
. Q . . . . . .
. . . . Q
. . . . Q . . .
. . Q . . . Q .
Q . . . . . .
. . . . . .

Total number of attack pairs: 0
. . . . . Q . .
. . . Q . . . .
. Q . . . . . .
. . . . Q
. . . . Q . . .
. . . . . Q .
Q . . . . . .
. . Q . . . . .

*****SOLUTION FOUND*****

==========
OUTPUT FOR RUN: 298
==========

Initial State:
. Q . Q . . . .
. . . . . .

. . Q . . Q . .
. . . . . .
Q . . . . . .
. . . . Q . . Q
. . . . . Q .
. . . . . .

Total number of attack pairs: 5
. Q . Q . . . .
. . . . . .
. . . . . Q . .
. . Q . . . . .
Q . . . . . .
. . . . Q . . Q
. . . . . Q .
. . . . . .

Total number of attack pairs: 3
. Q . Q . . . .
. . . . . .
. . . . . Q . .
. . Q . . . . .
Q . . . . . .
. . . . . Q
. . . . . Q .
. . . . Q . . .

Total number of attack pairs: 2
. Q . . . . . .
. . . . . .
. . . . . Q . .
. . Q . . . . .
Q . . . . . .
. . . Q . . . Q
. . . . . Q .
. . . . Q . . .

Total number of attack pairs: 1
. Q . . . . . .
. . . . . Q
. . . . . Q . .
. . Q . . . . .
Q . . . . . .

. . . Q . . . .
. . . . . Q .
. . . . Q . . .
Successors with hueristic same as that of the current state: 2
Random index to choose one of the same heuristic ssuccessor: 1

Total number of attack pairs: 1
. Q . . . . . .
. . . . . .
. . . . . Q . .
. . Q . . . . Q
Q . . . . . .
. . . Q . . . .
. . . . . Q .
. . . . Q . . .
Successors with hueristic same as that of the current state: 5
Random index to choose one of the same heuristic ssuccessor: 0

Total number of attack pairs: 1
. Q Q . . . . .
. . . . . .
. . . . . Q . .
. . . . . Q
Q . . . . . .
. . . Q . . . .
. . . . . Q .
. . . . Q . . .
Successors with hueristic same as that of the current state: 4
Random index to choose one of the same heuristic ssuccessor: 1

Total number of attack pairs: 1
. Q . . . . . .
. . Q . . . . .
. . . . . Q . .
. . . . . Q
Q . . . . . .
. . . Q . . . .
. . . . . Q .
. . . . Q . . .
Successors with hueristic same as that of the current state: 3
Random index to choose one of the same heuristic ssuccessor: 0

Total number of attack pairs: 1

. Q Q . . . . .
. . . . . .
. . . . . Q . .
. . . . . Q
Q . . . . . .
. . . Q . . . .
. . . . . Q .
. . . . Q . . .
Successors with hueristic same as that of the current state: 4
Random index to choose one of the same heuristic ssuccessor: 1

Total number of attack pairs: 1
. Q . . . . .
. . Q . . . . .
. . . . . Q . .
. . . . . Q
Q . . . . . .
. . . Q . . . .
. . . . . Q .
. . . . Q . . .
Successors with hueristic same as that of the current state: 3
Random index to choose one of the same heuristic ssuccessor: 0

Total number of attack pairs: 1
. Q Q . . . . .
. . . . . .
. . . . . Q . .
. . . . . Q
Q . . . . . .
. . . Q . . . .
. . . . . Q .
. . . . Q . . .
Successors with hueristic same as that of the current state: 4
Random index to choose one of the same heuristic ssuccessor: 3

Total number of attack pairs: 1
. Q . . . . .
. . . . . .
. . . . . Q . .
. . . . . Q
Q . . . . . .
. . . Q . . . .
. . . . . Q .

. . Q . Q . . .
Successors with hueristic same as that of the current state: 5
Random index to choose one of the same heuristic ssuccessor: 3

Total number of attack pairs: 1
. Q . . . . . .
. . . . Q . . .
. . . . . Q . .
. . . . Q
Q . . . . . .
. . . Q . . . .
. . . . . Q .
. . Q . . . . .
Successors with hueristic same as that of the current state: 3
Random index to choose one of the same heuristic ssuccessor: 1

Total number of attack pairs: 1
. Q . . . . . .
. . . . . .
. . . . . Q . .
. . . . Q
Q . . . . . .
. . . Q . . . .
. . . . . Q .
. . Q . Q . . .
Successors with hueristic same as that of the current state: 5
Random index to choose one of the same heuristic ssuccessor: 2

Total number of attack pairs: 1
. Q . . . . . .
. . . . . .
. . . . . Q . .
. . Q . . . . Q
Q . . . . . .
. . . Q . . . .
. . . . . Q .
. . . . Q . . .
Successors with hueristic same as that of the current state: 5
Random index to choose one of the same heuristic ssuccessor: 2

Total number of attack pairs: 1
. Q . . . . . .
. . . . . .

. . . . . Q . .
. . . . . Q
Q . . . . . .
. . . Q . . . .
. . . . . Q .
. . Q . Q . . .
Successors with hueristic same as that of the current state: 5
Random index to choose one of the same heuristic ssuccessor: 2

Total number of attack pairs: 1
. Q . . . . . .
. . . . . .
. . . . . Q . .
. . Q . . . . Q
Q . . . . . .
. . . Q . . . .
. . . . . Q .
. . . . Q . . .
Successors with hueristic same as that of the current state: 5
Random index to choose one of the same heuristic ssuccessor: 1

Total number of attack pairs: 1
. Q . . . . . .
. . Q . . . . .
. . . . . Q . .
. . . . . Q
Q . . . . . .
. . . Q . . . .
. . . . . Q .
. . . . Q . . .
Successors with hueristic same as that of the current state: 3
Random index to choose one of the same heuristic ssuccessor: 0

Total number of attack pairs: 1
. Q Q . . . . .
. . . . . .
. . . . . Q . .
. . . . . Q
Q . . . . . .
. . . Q . . . .
. . . . . Q .
. . . . Q . . .
Successors with hueristic same as that of the current state: 4

Random index to choose one of the same heuristic ssuccessor: 0

Total number of attack pairs: 1
. . Q . . . . .
. . . . . .
. Q . . . Q . .
. . . . . Q
Q . . . . . .
. . . Q . . . .
. . . . . Q .
. . . . Q . . .
Successors with hueristic same as that of the current state: 4
Random index to choose one of the same heuristic ssuccessor: 3

Total number of attack pairs: 1
. . Q . . . . .
. . . . . .
. Q . . . . . .
. . . . . Q
Q . . . . Q . .
. . . Q . . . .
. . . . . Q .
. . . . Q . . .
Successors with hueristic same as that of the current state: 9
Random index to choose one of the same heuristic ssuccessor: 5

Total number of attack pairs: 1
. . Q . . Q . .
. . . . . .
. Q . . . . . .
. . . . . Q
Q . . . . . .
. . . Q . . . .
. . . . . Q .
. . . . Q . . .
Successors with hueristic same as that of the current state: 5
Random index to choose one of the same heuristic ssuccessor: 3

Total number of attack pairs: 1
. . Q . . . . .
. . . . . .
. Q . . . Q . .
. . . . . Q

Q . . . . . .
. . . Q . . . .
. . . . . Q .
. . . . Q . . .
Successors with hueristic same as that of the current state: 4
Random index to choose one of the same heuristic ssuccessor: 1

Total number of attack pairs: 1
. . Q . . Q . .
. . . . . .
. Q . . . . . .
. . . . . Q
Q . . . . . .
. . . Q . . . .
. . . . . Q .
. . . . Q . . .
Successors with hueristic same as that of the current state: 5
Random index to choose one of the same heuristic ssuccessor: 1

Total number of attack pairs: 1
. . . . . Q . .
. . . . . .
. Q . . . . . .
. . . . . Q
Q . . . . . .
. . . Q . . . .
. . . . . Q .
. . Q . Q . . .
Successors with hueristic same as that of the current state: 5
Random index to choose one of the same heuristic ssuccessor: 2

Total number of attack pairs: 1
. . . . . Q . .
. . . . Q . . .
. Q . . . . . .
. . . . . Q
Q . . . . . .
. . . Q . . . .
. . . . . Q .
. . Q . . . . .
Successors with hueristic same as that of the current state: 3
Random index to choose one of the same heuristic ssuccessor: 1

Total number of attack pairs: 1
. . . . . Q . .
. . . . . .
. Q . . . . . .
. . . . Q . . Q
Q . . . . . .
. . . Q . . . .
. . . . . Q .
. . Q . . . . .
Successors with hueristic same as that of the current state: 5
Random index to choose one of the same heuristic ssuccessor: 0

Total number of attack pairs: 1
. . . . . Q . .
. . . . Q . . .
. Q . . . . . .
. . . . . Q
Q . . . . . .
. . . Q . . . .
. . . . . Q .
. . Q . . . . .
Successors with hueristic same as that of the current state: 3
Random index to choose one of the same heuristic ssuccessor: 0

Total number of attack pairs: 1
. . . . . Q . .
. . . . . .
. Q . . Q . . .
. . . . . Q
Q . . . . . .
. . . Q . . . .
. . . . . Q .
. . Q . . . . .
Successors with hueristic same as that of the current state: 5
Random index to choose one of the same heuristic ssuccessor: 2

Total number of attack pairs: 1
. . . . . Q . .
. . . . Q . . .
. Q . . . . . .
. . . . . Q
Q . . . . . .
. . . Q . . . .

. . . . . Q .
. . Q . . . . .
Successors with hueristic same as that of the current state: 3
Random index to choose one of the same heuristic ssuccessor: 1

Total number of attack pairs: 1
. . . . . Q . .
. . . . . .
. Q . . . . . .
. . . . Q . . Q
Q . . . . . .
. . . Q . . . .
. . . . . Q .
. . Q . . . . .
Successors with hueristic same as that of the current state: 5
Random index to choose one of the same heuristic ssuccessor: 3

Total number of attack pairs: 1
. . . . . Q . .
. . . . . Q
. Q . . . . . .
. . . . Q . . .
Q . . . . . .
. . . Q . . . .
. . . . . Q .
. . Q . . . . .
Successors with hueristic same as that of the current state: 2
Random index to choose one of the same heuristic ssuccessor: 1

Total number of attack pairs: 1
. . . . . Q . .
. . . . . .
. Q . . . . . .
. . . . Q . . .
Q . . . . . Q
. . . Q . . . .
. . . . . Q .
. . Q . . . . .
Successors with hueristic same as that of the current state: 5
Random index to choose one of the same heuristic ssuccessor: 2

Total number of attack pairs: 1
. . . . . .

. . . . . Q . .
. Q . . . . . .
. . . . Q . . .
Q . . . . . Q
. . . Q . . . .
. . . . . Q .
. . Q . . . . .
Successors with hueristic same as that of the current state: 4
Random index to choose one of the same heuristic ssuccessor: 3

Total number of attack pairs: 1
. . . . . Q
. . . . . Q . .
. Q . . . . . .
. . . . Q . . .
Q . . . . . .
. . . Q . . . .
. . . . . Q .
. . Q . . . . .
Successors with hueristic same as that of the current state: 3
Random index to choose one of the same heuristic ssuccessor: 2

Total number of attack pairs: 1
. . . . . .
. . . . . Q . .
. Q . . . . . .
. . . . Q . . .
Q . . . . . Q
. . . Q . . . .
. . . . . Q .
. . Q . . . . .
Successors with hueristic same as that of the current state: 4
Random index to choose one of the same heuristic ssuccessor: 2

Total number of attack pairs: 1
. . . . . Q . .
. . . . . .
. Q . . . . . .
. . . . Q . . .
Q . . . . . Q
. . . Q . . . .
. . . . . Q .
. . Q . . . . .

Successors with hueristic same as that of the current state: 5
Random index to choose one of the same heuristic ssuccessor: 0

Total number of attack pairs: 1
. . . . . Q . .
Q . . . . . .
. Q . . . . . .
. . . . Q . . .
. . . . Q
. . . Q . . . .
. . . . . Q .
. . Q . . . . .
Successors with hueristic same as that of the current state: 3
Random index to choose one of the same heuristic ssuccessor: 2

Total number of attack pairs: 1
. . . . . Q . .
Q . . . . . .
. . . . . .
. . . . Q . . .
. . . . Q
. Q . Q . . . .
. . . . . Q .
. . Q . . . . .
Successors with hueristic same as that of the current state: 2
Random index to choose one of the same heuristic ssuccessor: 1

Total number of attack pairs: 1
. . . . . Q . .
Q . . Q . . . .
. . . . . .
. . . . Q . . .
. . . . Q
. Q . . . . . .
. . . . . Q .
. . Q . . . . .

Total number of attack pairs: 0
. . . . . Q . .
. . . Q . . . .
Q . . . . . .
. . . . Q . . .
. . . . Q

. Q . . . . . .
. . . . . Q .
. . Q . . . . .

*****SOLUTION FOUND*****

==========
OUTPUT FOR RUN: 299
==========

Initial State:
. Q . Q . . . .
. . . . . .
. . . . . .
. . Q . . . . .
Q . . . Q . . .
. . . . . Q Q
. . . . . .
. . . . . Q . .

Total number of attack pairs: 3
. . . Q . . . .
. . . . . .
. . . . . .
. . Q . . . . .
Q . . . Q . . .
. . . . . Q Q
. Q . . . . . .
. . . . . Q . .

Total number of attack pairs: 1
. . . Q . . . .
. . . . . .
. . . . . Q
. . Q . . . . .
Q . . . Q . . .
. . . . . Q .
. Q . . . . . .
. . . . . Q . .
Successors with hueristic same as that of the current state: 4
Random index to choose one of the same heuristic ssuccessor: 1

Total number of attack pairs: 1

. . . Q . . . .
. . . . . .
. . . . . Q
. . Q . . . . .
. . . . Q . . .
. . . . . Q .
Q Q . . . . . .
. . . . . Q . .
Successors with hueristic same as that of the current state: 4
Random index to choose one of the same heuristic ssuccessor: 2

Total number of attack pairs: 1
. . . Q . . . .
. Q . . . . . .
. . . . . Q
. . Q . . . . .
. . . . Q . . .
. . . . . Q .
Q . . . . . .
. . . . . Q . .
Successors with hueristic same as that of the current state: 2
Random index to choose one of the same heuristic ssuccessor: 1

Total number of attack pairs: 1
. . . Q Q . . .
. Q . . . . . .
. . . . . Q
. . Q . . . . .
. . . . . .
. . . . . Q .
Q . . . . . .
. . . . . Q . .
Successors with hueristic same as that of the current state: 4
Random index to choose one of the same heuristic ssuccessor: 2

Total number of attack pairs: 1
. . . Q . . . .
. Q . . . . . .
. . . . . Q
. . Q . . . . .
. . . . Q . . .
. . . . . Q .
Q . . . . . .

. . . . . Q . .
Successors with hueristic same as that of the current state: 2
Random index to choose one of the same heuristic ssuccessor: 0

Total number of attack pairs: 1
. . . Q . . . .
. . . . . .
. . . . . Q
. . Q . . . . .
. . . . Q . . .
. . . . . Q .
Q Q . . . . . .
. . . . . Q . .
Successors with hueristic same as that of the current state: 4
Random index to choose one of the same heuristic ssuccessor: 0

Total number of attack pairs: 1
. . . Q . . . .
Q . . . . . .
. . . . . Q
. . Q . . . . .
. . . . Q . . .
. . . . . Q .
. Q . . . . . .
. . . . . Q . .
Successors with hueristic same as that of the current state: 3
Random index to choose one of the same heuristic ssuccessor: 1

Total number of attack pairs: 1
. . . Q . . . .
. . . . . .
. . . . . Q
. . Q . . . . .
. . . . Q . . .
. . . . . Q .
Q Q . . . . . .
. . . . . Q . .
Successors with hueristic same as that of the current state: 4
Random index to choose one of the same heuristic ssuccessor: 2

Total number of attack pairs: 1
. . . Q . . . .
. Q . . . . . .

. . . . . Q
. . Q . . . . .
. . . . Q . . .
. . . . . Q .
Q . . . . . .
. . . . . Q . .
Successors with hueristic same as that of the current state: 2
Random index to choose one of the same heuristic ssuccessor: 0

Total number of attack pairs: 1
. . . Q . . . .
. . . . . .
. . . . . Q
. . Q . . . . .
. . . . Q . . .
. . . . . Q .
Q Q . . . . . .
. . . . . Q . .
Successors with hueristic same as that of the current state: 4
Random index to choose one of the same heuristic ssuccessor: 0

Total number of attack pairs: 1
. . . Q . . . .
Q . . . . . .
. . . . . Q
. . Q . . . . .
. . . . Q . . .
. . . . . Q .
. Q . . . . . .
. . . . . Q . .
Successors with hueristic same as that of the current state: 3
Random index to choose one of the same heuristic ssuccessor: 1

Total number of attack pairs: 1
. . . Q . . . .
. . . . . .
. . . . . Q
. . Q . . . . .
. . . . Q . . .
. . . . . Q .
Q Q . . . . . .
. . . . . Q . .
Successors with hueristic same as that of the current state: 4

Random index to choose one of the same heuristic ssuccessor: 3

Total number of attack pairs: 1
. . . . . .
. . . Q . . . .
. . . . . Q
. . Q . . . . .
. . . . Q . . .
. . . . . Q .
Q Q . . . . . .
. . . . . Q . .
Successors with hueristic same as that of the current state: 4
Random index to choose one of the same heuristic ssuccessor: 3

Total number of attack pairs: 1
. . . Q . . . .
. . . . . .
. . . . . Q
. . Q . . . . .
. . . . Q . . .
. . . . . Q .
Q Q . . . . . .
. . . . . Q . .
Successors with hueristic same as that of the current state: 4
Random index to choose one of the same heuristic ssuccessor: 0

Total number of attack pairs: 1
. . . Q . . . .
Q . . . . . .
. . . . . Q
. . Q . . . . .
. . . . Q . . .
. . . . . Q .
. Q . . . . . .
. . . . . Q . .
Successors with hueristic same as that of the current state: 3
Random index to choose one of the same heuristic ssuccessor: 1

Total number of attack pairs: 1
. . . Q . . . .
. . . . . .
. . . . . Q
. . Q . . . . .

. . . . Q . . .
. . . . . Q .
Q Q . . . . . .
. . . . . Q . .
Successors with hueristic same as that of the current state: 4
Random index to choose one of the same heuristic ssuccessor: 3

Total number of attack pairs: 1
. . . . . .
. . . Q . . . .
. . . . . Q
. . Q . . . . .
. . . . Q . . .
. . . . . Q .
Q Q . . . . . .
. . . . . Q . .
Successors with hueristic same as that of the current state: 4
Random index to choose one of the same heuristic ssuccessor: 0

Total number of attack pairs: 1
Q . . . . . .
. . . Q . . . .
. . . . . Q
. . Q . . . . .
. . . . Q . . .
. . . . . Q .
. Q . . . . . .
. . . . . Q . .
Successors with hueristic same as that of the current state: 2
Random index to choose one of the same heuristic ssuccessor: 0

Total number of attack pairs: 1
. . . . . .
. . . Q . . . .
. . . . . Q
Q . Q . . . . .
. . . . Q . . .
. . . . . Q .
. Q . . . . . .
. . . . . Q . .
Successors with hueristic same as that of the current state: 4
Random index to choose one of the same heuristic ssuccessor: 1

Total number of attack pairs: 1
. . . . . .
. . . Q . . . .
. . . . . Q
. . Q . . . . .
. . . . Q . . .
. . . . . Q .
Q Q . . . . . .
. . . . . Q . .
Successors with hueristic same as that of the current state: 4
Random index to choose one of the same heuristic ssuccessor: 3

Total number of attack pairs: 1
. . . Q . . . .
. . . . . .
. . . . . Q
. . Q . . . . .
. . . . Q . . .
. . . . . Q .
Q Q . . . . . .
. . . . . Q . .
Successors with hueristic same as that of the current state: 4
Random index to choose one of the same heuristic ssuccessor: 1

Total number of attack pairs: 1
. . . Q . . . .
. . . . . .
. . . . . Q
. . Q . . . . .
Q . . . Q . . .
. . . . . Q .
. Q . . . . . .
. . . . . Q . .
Successors with hueristic same as that of the current state: 4
Random index to choose one of the same heuristic ssuccessor: 2

Total number of attack pairs: 1
. . . Q . . . .
. . . . . .
. . . . Q . . Q
. . Q . . . . .
Q . . . . . .
. . . . . Q .

. Q . . . . . .
. . . . . Q . .

Total number of attack pairs: 0
. . . Q . . . .
. . . . Q
. . . . Q . . .
. . Q . . . . .
Q . . . . . .
. . . . . Q .
. Q . . . . . .
. . . . . Q . .

*****SOLUTION FOUND*****

==========
OUTPUT FOR RUN: 300
==========

Initial State:
. . . . . Q Q
. Q . . Q Q . .
Q . . . . . .
. . Q Q . . . .
. . . . . .
. . . . . .
. . . . . .
. . . . . .

Total number of attack pairs: 7
. . . . . Q Q
. . . . Q Q . .
Q . . . . . .
. . Q Q . . . .
. . . . . .
. . . . . .
. . . . . .
. Q . . . . . .

Total number of attack pairs: 4
. . . . . Q Q
. . . . Q Q . .
Q . . . . . .

. . Q . . . . .
. . . . . .
. . . . . .
. . . Q . . . .
. Q . . . . . .

Total number of attack pairs: 2
. . . . . Q Q
. . . . Q . . .
Q . . . . . .
. . Q . . . . .
. . . . . .
. . . . . Q . .
. . . Q . . . .
. Q . . . . . .
Successors with hueristic same as that of the current state: 7
Random index to choose one of the same heuristic ssuccessor: 5

Total number of attack pairs: 2
. . . . . Q .
. . . . Q . . .
Q . . . . . .
. . Q . . . . .
. . . . . .
. . . . . Q . Q
. . . Q . . . .
. Q . . . . . .
Successors with hueristic same as that of the current state: 8
Random index to choose one of the same heuristic ssuccessor: 0

Total number of attack pairs: 2
. . . . . Q .
. . . . Q . . .
. . . . . .
. . Q . . . . .
Q . . . . . .
. . . . . Q . Q
. . . Q . . . .
. Q . . . . . .
Successors with hueristic same as that of the current state: 7
Random index to choose one of the same heuristic ssuccessor: 5

Total number of attack pairs: 2

. . . . . Q .
. . . . Q . . .
. . . . . Q
. . Q . . . . .
Q . . . . . .
. . . . . Q . .
. . . Q . . . .
. Q . . . . . .
Successors with hueristic same as that of the current state: 6
Random index to choose one of the same heuristic ssuccessor: 3

Total number of attack pairs: 2
. . . . . Q Q
. . . . Q . . .
. . . . . .
. . Q . . . . .
Q . . . . . .
. . . . . Q . .
. . . Q . . . .
. Q . . . . . .
Successors with hueristic same as that of the current state: 8
Random index to choose one of the same heuristic ssuccessor: 1

Total number of attack pairs: 2
. . . . . Q Q
. . Q . Q . . .
. . . . . .
. . . . . .
Q . . . . . .
. . . . . Q . .
. . . Q . . . .
. Q . . . . . .
Successors with hueristic same as that of the current state: 8
Random index to choose one of the same heuristic ssuccessor: 3

Total number of attack pairs: 2
. . . . . Q
. . Q . Q . . .
. . . . . Q .
. . . . . .
Q . . . . . .
. . . . . Q . .
. . . Q . . . .

. Q . . . . . .
Successors with hueristic same as that of the current state: 7
Random index to choose one of the same heuristic ssuccessor: 6

Total number of attack pairs: 2
. . . . Q
. . Q . Q . . .
. . . .
. . . .
Q . . . . . .
. . . . . Q . .
. . . Q . . . .
. Q . . . . Q .

Total number of attack pairs: 1
. . . . Q
. . Q . . . . .
. . . . Q . . .
. . . .
Q . . . . . .
. . . . . Q . .
. . . Q . . . .
. Q . . . . Q .
Successors with hueristic same as that of the current state: 2
Random index to choose one of the same heuristic ssuccessor: 1

Total number of attack pairs: 1
. . . . Q
. . Q . . . . .
. . . . Q . . .
. . . . . . Q .
Q . . . . . .
. . . . . Q . .
. . . Q . . . .
. Q . . . . . .
Successors with hueristic same as that of the current state: 1

Total number of attack pairs: 1
. . . . Q
. . Q . . . . .
. . . . Q . . .
. . . .
Q . . . . . .

. . . . . Q . .
. . . Q . . . .
. Q . . . . Q .
Successors with hueristic same as that of the current state: 2
Random index to choose one of the same heuristic ssuccessor: 0

Total number of attack pairs: 1
. . . . . Q
. . Q . . . . .
. . . . Q . . .
. Q . . . . . .
Q . . . . . .
. . . . . Q . .
. . . Q . . . .
. . . . . Q .
Successors with hueristic same as that of the current state: 2
Random index to choose one of the same heuristic ssuccessor: 0

Total number of attack pairs: 1
. . . . . Q
. . Q . . . . .
. . . . Q . . .
. Q . . . . . .
. . . . . .
Q . . . Q . .
. . . Q . . . .
. . . . . Q .
Successors with hueristic same as that of the current state: 2
Random index to choose one of the same heuristic ssuccessor: 0

Total number of attack pairs: 1
. . . . . Q
. . Q . . . . .
. . . . Q . . .
. Q . . . . . .
Q . . . . . .
. . . . . Q . .
. . . Q . . . .
. . . . . Q .
Successors with hueristic same as that of the current state: 2
Random index to choose one of the same heuristic ssuccessor: 1

Total number of attack pairs: 1

. . . . . Q
. . Q . . . . .
. . . . Q . . .
. . . . . .
Q . . . . . .
. . . . . Q . .
. . . Q . . . .
. Q . . . . Q .
Successors with hueristic same as that of the current state: 2
Random index to choose one of the same heuristic ssuccessor: 1

Total number of attack pairs: 1
. . . . . Q
. . Q . . . . .
. . . . Q . . .
. . . . . Q .
Q . . . . . .
. . . . . Q . .
. . . Q . . . .
. Q . . . . . .
Successors with hueristic same as that of the current state: 1

Total number of attack pairs: 1
. . . . . Q
. . Q . . . . .
. . . . Q . . .
. . . . . .
Q . . . . . .
. . . . . Q . .
. . . Q . . . .
. Q . . . . Q .
Successors with hueristic same as that of the current state: 2
Random index to choose one of the same heuristic ssuccessor: 0

Total number of attack pairs: 1
. . . . . Q
. . Q . . . . .
. . . . Q . . .
. Q . . . . . .
Q . . . . . .
. . . . . Q . .
. . . Q . . . .
. . . . . Q .

Successors with hueristic same as that of the current state: 2
Random index to choose one of the same heuristic ssuccessor: 0

Total number of attack pairs: 1
. . . . Q
. . Q . . . . .
. . . . Q . . .
. Q . . . . . .
. . . .
Q . . . . Q . .
. . . Q . . . .
. . . . . . Q .
Successors with hueristic same as that of the current state: 2
Random index to choose one of the same heuristic ssuccessor: 1

Total number of attack pairs: 1
. . . .
. . Q . . . . .
. . . . Q . . .
. Q . . . . . .
. . . . Q
Q . . . . Q . .
. . . Q . . . .
. . . . . . Q .
Successors with hueristic same as that of the current state: 4
Random index to choose one of the same heuristic ssuccessor: 3

Total number of attack pairs: 1
. . . . Q
. . Q . . . . .
. . . . Q . . .
. Q . . . . . .
. . . .
Q . . . . Q . .
. . . Q . . . .
. . . . . . Q .
Successors with hueristic same as that of the current state: 2
Random index to choose one of the same heuristic ssuccessor: 1

Total number of attack pairs: 1
. . . .
. . Q . . . . .
. . . . Q . . .

. Q . . . . . .
. . . . Q
Q . . . . Q . .
. . . Q . . . .
. . . . . Q .
Successors with hueristic same as that of the current state: 4
Random index to choose one of the same heuristic ssuccessor: 3

Total number of attack pairs: 1
. . . . Q
. . Q . . . . .
. . . . Q . . .
. Q . . . . . .
. . . .
Q . . . . Q . .
. . . Q . . . .
. . . . . Q .
Successors with hueristic same as that of the current state: 2
Random index to choose one of the same heuristic ssuccessor: 1

Total number of attack pairs: 1
. . . .
. . Q . . . . .
. . . . Q . . .
. Q . . . . . .
. . . . Q
Q . . . . Q . .
. . . Q . . . .
. . . . . Q .
Successors with hueristic same as that of the current state: 4
Random index to choose one of the same heuristic ssuccessor: 2

Total number of attack pairs: 1
. . . . . Q . .
. . Q . . . . .
. . . . Q . . .
. Q . . . . . .
. . . . Q
Q . . . . . .
. . . Q . . . .
. . . . . Q .
Successors with hueristic same as that of the current state: 3
Random index to choose one of the same heuristic ssuccessor: 2

Total number of attack pairs: 1
. . . . . .
. . Q . . . . .
. . . . Q . . .
. Q . . . . . .
. . . . Q
Q . . . . Q . .
. . . Q . . . .
. . . . . Q .
Successors with hueristic same as that of the current state: 4
Random index to choose one of the same heuristic ssuccessor: 1

Total number of attack pairs: 1
. . . . . .
. . Q . . . . .
. . . . Q . . .
. Q . . . . . .
. . . . Q
. . . . . Q . .
. . . Q . . . .
Q . . . . . Q .
Successors with hueristic same as that of the current state: 5
Random index to choose one of the same heuristic ssuccessor: 2

Total number of attack pairs: 1
. . . . . Q . .
. . Q . . . . .
. . . . Q . . .
. Q . . . . . .
. . . . Q
. . . . . .
. . . Q . . . .
Q . . . . . Q .
Successors with hueristic same as that of the current state: 5
Random index to choose one of the same heuristic ssuccessor: 1

Total number of attack pairs: 1
. . . . . Q . .
. . Q . . . . .
. . . . Q . . .
. Q . . . . . .
. . . . Q

Q . . . . . .
. . . Q . . . .
. . . . . Q .
Successors with hueristic same as that of the current state: 3
Random index to choose one of the same heuristic ssuccessor: 0

Total number of attack pairs: 1
Q . . . . Q . .
. . Q . . . . .
. . . . Q . . .
. Q . . . . . .
. . . . . Q
. . . . . .
. . . Q . . . .
. . . . . Q .
Successors with hueristic same as that of the current state: 3
Random index to choose one of the same heuristic ssuccessor: 2

Total number of attack pairs: 1
Q . . . . . .
. . Q . . . . .
. . . . Q . . .
. Q . . . . . .
. . . . . Q
. . . . . Q . .
. . . Q . . . .
. . . . . Q .
Successors with hueristic same as that of the current state: 3
Random index to choose one of the same heuristic ssuccessor: 1

Total number of attack pairs: 1
. . . . . .
. . Q . . . . .
. . . . Q . . .
. Q . . . . . .
. . . . . Q
. . . . . Q . .
. . . Q . . . .
Q . . . . Q .
Successors with hueristic same as that of the current state: 5
Random index to choose one of the same heuristic ssuccessor: 1

Total number of attack pairs: 1

. . . . . .
. . Q . . . . .
. . . . Q . . .
. Q . . . . . .
. . . . Q
Q . . . . Q . .
. . . Q . . . .
. . . . . Q .
Successors with hueristic same as that of the current state: 4
Random index to choose one of the same heuristic ssuccessor: 0

Total number of attack pairs: 1
Q . . . . . .
. . Q . . . . .
. . . . Q . . .
. Q . . . . . .
. . . . Q
. . . . . Q . .
. . . Q . . . .
. . . . . Q .
Successors with hueristic same as that of the current state: 3
Random index to choose one of the same heuristic ssuccessor: 0

Total number of attack pairs: 1
. . . . . .
. . Q . . . . .
. . . . Q . . .
. Q . . . . . .
. . . . Q
Q . . . . Q . .
. . . Q . . . .
. . . . . Q .
Successors with hueristic same as that of the current state: 4
Random index to choose one of the same heuristic ssuccessor: 3

Total number of attack pairs: 1
. . . . . Q
. . Q . . . . .
. . . . Q . . .
. Q . . . . . .
. . . . . .
Q . . . . Q . .
. . . Q . . . .

. . . . . Q .
Successors with hueristic same as that of the current state: 2
Random index to choose one of the same heuristic ssuccessor: 1

Total number of attack pairs: 1
. . . . . .
. . Q . . . . .
. . . . Q . . .
. Q . . . . . .
. . . . . Q
Q . . . . Q . .
. . . Q . . . .
. . . . . Q .
Successors with hueristic same as that of the current state: 4
Random index to choose one of the same heuristic ssuccessor: 3

Total number of attack pairs: 1
. . . . . Q
. . Q . . . . .
. . . . Q . . .
. Q . . . . . .
. . . . . .
Q . . . . Q . .
. . . Q . . . .
. . . . . Q .
Successors with hueristic same as that of the current state: 2
Random index to choose one of the same heuristic ssuccessor: 1

Total number of attack pairs: 1
. . . . . .
. . Q . . . . .
. . . . Q . . .
. Q . . . . . .
. . . . . Q
Q . . . . Q . .
. . . Q . . . .
. . . . . Q .
Successors with hueristic same as that of the current state: 4
Random index to choose one of the same heuristic ssuccessor: 0

Total number of attack pairs: 1
Q . . . . . .
. . Q . . . . .

. . . . Q . . .
. Q . . . . . .
. . . . Q
. . . . . Q . .
. . . Q . . . .
. . . . . Q .
Successors with hueristic same as that of the current state: 3
Random index to choose one of the same heuristic ssuccessor: 0

Total number of attack pairs: 1
. . . . . .
. . Q . . . . .
. . . . Q . . .
. Q . . . . . .
. . . . Q
Q . . . . Q . .
. . . Q . . . .
. . . . . Q .
Successors with hueristic same as that of the current state: 4
Random index to choose one of the same heuristic ssuccessor: 1

Total number of attack pairs: 1
. . . . . .
. . Q . . . . .
. . . . Q . . .
. Q . . . . . .
. . . . Q
. . . . . Q . .
. . . Q . . . .
Q . . . . . Q .
Successors with hueristic same as that of the current state: 5
Random index to choose one of the same heuristic ssuccessor: 1

Total number of attack pairs: 1
. . . . . .
. . Q . . . . .
. . . . Q . . .
. Q . . . . . .
. . . . Q
Q . . . . Q . .
. . . Q . . . .
. . . . . Q .
Successors with hueristic same as that of the current state: 4

Random index to choose one of the same heuristic ssuccessor: 0

Total number of attack pairs: 1
Q . . . . . .
. . Q . . . . .
. . . . Q . . .
. Q . . . . . .
. . . . Q
. . . . . Q . .
. . . Q . . . .
. . . . . Q .
Successors with hueristic same as that of the current state: 3
Random index to choose one of the same heuristic ssuccessor: 2

Total number of attack pairs: 1
Q . . . . Q . .
. . Q . . . . .
. . . . Q . . .
. Q . . . . . .
. . . . Q
. . . . . .
. . . Q . . . .
. . . . . Q .
Successors with hueristic same as that of the current state: 3
Random index to choose one of the same heuristic ssuccessor: 0

Total number of attack pairs: 1
. . . . . Q . .
. . Q . . . . .
. . . . Q . . .
. Q . . . . . .
. . . . Q
Q . . . . . .
. . . Q . . . .
. . . . . Q .
Successors with hueristic same as that of the current state: 3
Random index to choose one of the same heuristic ssuccessor: 0

Total number of attack pairs: 1
Q . . . . Q . .
. . Q . . . . .
. . . . Q . . .
. Q . . . . . .

. . . . . Q
. . . . . .
. . . Q . . . .
. . . . . Q .
Successors with hueristic same as that of the current state: 3
Random index to choose one of the same heuristic ssuccessor: 0

Total number of attack pairs: 1
. . . . . Q . .
. . Q . . . . .
. . . . Q . . .
. Q . . . . . .
. . . . . Q
Q . . . . . .
. . . Q . . . .
. . . . . Q .
Successors with hueristic same as that of the current state: 3
Random index to choose one of the same heuristic ssuccessor: 0

Total number of attack pairs: 1
Q . . . . Q . .
. . Q . . . . .
. . . . Q . . .
. Q . . . . . .
. . . . . Q
. . . . . .
. . . Q . . . .
. . . . . Q .
Successors with hueristic same as that of the current state: 3
Random index to choose one of the same heuristic ssuccessor: 2

Total number of attack pairs: 1
Q . . . . . .
. . Q . . . . .
. . . . Q . . .
. Q . . . . . .
. . . . . Q
. . . . . Q . .
. . . Q . . . .
. . . . . Q .
Successors with hueristic same as that of the current state: 3
Random index to choose one of the same heuristic ssuccessor: 1

Total number of attack pairs: 1
. . . . . .
. . Q . . . . .
. . . . Q . . .
. Q . . . . . .
. . . . Q
. . . . . Q . .
. . . Q . . . .
Q . . . . . Q .
Successors with hueristic same as that of the current state: 5
Random index to choose one of the same heuristic ssuccessor: 4

Total number of attack pairs: 1
. . . . . .
. . Q . . . . .
. . . . Q . Q .
. Q . . . . . .
. . . . Q
. . . . . Q . .
. . . Q . . . .
Q . . . . . .
Successors with hueristic same as that of the current state: 3
Random index to choose one of the same heuristic ssuccessor: 0

Total number of attack pairs: 1
. . . . . Q . .
. . Q . . . . .
. . . . Q . Q .
. Q . . . . . .
. . . . Q
. . . . . .
. . . Q . . . .
Q . . . . . .
Successors with hueristic same as that of the current state: 4
Random index to choose one of the same heuristic ssuccessor: 3

Total number of attack pairs: 1
. . . . . Q . .
. . Q . . . . .
. . . . Q . . .
. Q . . . . . .
. . . . Q
. . . . . .

. . . Q . . . .
Q . . . . . Q .
Successors with hueristic same as that of the current state: 5
Random index to choose one of the same heuristic ssuccessor: 3

Total number of attack pairs: 1
. . . . . Q . .
. . Q . . . . .
. . . . Q . Q .
. Q . . . . . .
. . . . Q
. . . . . .
. . . Q . . . .
Q . . . . . .
Successors with hueristic same as that of the current state: 4
Random index to choose one of the same heuristic ssuccessor: 2

Total number of attack pairs: 1
. . . . . Q . .
. . Q . . . . .
. . . . Q . . .
. Q . . . . . .
. . . . Q
. . . . . .
. . . Q . . Q .
Q . . . . . .
Successors with hueristic same as that of the current state: 4
Random index to choose one of the same heuristic ssuccessor: 3

Total number of attack pairs: 1
. . . . . Q . .
. . Q . . . . .
. . . . Q . . .
. Q . . . . . .
. . . . Q
. . . . . .
. . . Q . . . .
Q . . . . . Q .
Successors with hueristic same as that of the current state: 5
Random index to choose one of the same heuristic ssuccessor: 1

Total number of attack pairs: 1
. . . . . Q . .

. . Q . . . . .
. . . . Q . . .
. Q . . . . . .
. . . . Q
Q . . . . . .
. . . Q . . . .
. . . . . Q .
Successors with hueristic same as that of the current state: 3
Random index to choose one of the same heuristic ssuccessor: 1

Total number of attack pairs: 1
. . . . . Q . .
. . Q . . . . .
. . . . Q . . .
. Q . . . . . .
. . . . Q
. . . . . .
. . . Q . . . .
Q . . . . . Q .
Successors with hueristic same as that of the current state: 5
Random index to choose one of the same heuristic ssuccessor: 1

Total number of attack pairs: 1
. . . . . Q . .
. . Q . . . . .
. . . . Q . . .
. Q . . . . . .
. . . . Q
Q . . . . . .
. . . Q . . . .
. . . . . Q .
Successors with hueristic same as that of the current state: 3
Random index to choose one of the same heuristic ssuccessor: 1

Total number of attack pairs: 1
. . . . . Q . .
. . Q . . . . .
. . . . Q . . .
. Q . . . . . .
. . . . Q
. . . . . .
. . . Q . . . .
Q . . . . . Q .

Successors with hueristic same as that of the current state: 5
Random index to choose one of the same heuristic ssuccessor: 3

Total number of attack pairs: 1
. . . . . Q . .
. . Q . . . . .
. . . . Q . Q .
. Q . . . . . .
. . . . Q
. . . . . .
. . . Q . . . .
Q . . . . . .
Successors with hueristic same as that of the current state: 4
Random index to choose one of the same heuristic ssuccessor: 2

Total number of attack pairs: 1
. . . . . Q . .
. . Q . . . . .
. . . . Q . . .
. Q . . . . . .
. . . . Q
. . . . . .
. . . Q . . Q .
Q . . . . . .
Successors with hueristic same as that of the current state: 4
Random index to choose one of the same heuristic ssuccessor: 1

Total number of attack pairs: 1
. . . . . Q . .
. . Q . . . . .
. . . . Q . . .
. Q . . . . . .
. . . . Q
. . . . . .
. . . . . Q .
Q . . Q . . . .
Successors with hueristic same as that of the current state: 5
Random index to choose one of the same heuristic ssuccessor: 0

Total number of attack pairs: 1
. . . . . Q . .
Q . Q . . . . .
. . . . Q . . .

. Q . . . . . .
. . . . Q
. . . .
. . . . . Q .
. . . Q . . . .

Total number of attack pairs: 0
. . . . . Q . .
Q . . . . . .
. . . . Q . . .
. Q . . . . . .
. . . . Q
. . Q . . . . .
. . . . . Q .
. . . Q . . . .

*****SOLUTION FOUND*****

Total Runs: 300
Total Success: 277
Success Percentage: 92.33333333333333 %
Total Fail: 23
Fail Percentage: 7.666666666666666 %
Average number of steps in success: 18.588447653429604
Total Steps for Success: 5149
Total Steps for Fail: 1380
Average number of steps in fail: 60.0

c. Random-restart hill-climbing with sideways move

==========
OUTPUT FOR RUN: 300
==========

Initial State:
. . . . . .
Q . . . Q . .
. . . . . .
. Q . . . . .
. . Q Q Q . . Q
. . . . . .
. . . . . .

. . . . . Q .

Total Number of attack pairs: 7
. . Q . . . . .
Q . . . . Q . .
. . . . . .
. Q . . . . . .
. . . Q Q . . Q
. . . . . .
. . . . . .
. . . . . Q .

Total Number of attack pairs: 3
. . Q . . . . .
Q . . . . Q . .
. . . Q . . . .
. Q . . . . . .
. . . . Q . . Q
. . . . . .
. . . . . .
. . . . . Q .

Total Number of attack pairs: 2
. . Q . . . . .
. . . . . Q . .
. . . Q . . . .
Q Q . . . . . .
. . . . Q . . Q
. . . . . .
. . . . . .
. . . . . Q .

Total Number of attack pairs: 1
. . Q . . . . .
. . . . . Q . .
. . . Q . . . .
Q . . . . . .
. . . . Q . . Q
. . . . . .
. Q . . . . . .
. . . . . Q .

Initial State:

. . . . . .
. . . . . Q . .
. . . . Q . . .
. Q . . . . . Q
. . . . . Q .
. . . . . .
Q . Q . . . . .
. . . Q . . . .

Total Number of attack pairs: 7
. . . . . Q
. . . . . Q . .
. . . . Q . . .
. Q . . . . . .
. . . . . Q .
. . . . . .
Q . Q . . . . .
. . . Q . . . .

Total Number of attack pairs: 4
. . . . . Q
. . . . . Q . .
. . . . Q . . .
. Q . . . . . .
. . . . . Q .
Q . . . . . .
. . Q . . . . .
. . . Q . . . .

Total Number of attack pairs: 3
. . . Q . . . Q
. . . . . Q . .
. . . . Q . . .
. Q . . . . . .
. . . . . Q .
Q . . . . . .
. . Q . . . . .
. . . . . .

Total Number of attack pairs: 1
. . . Q . . . Q
. . . . . Q . .
. . . . . .

. Q . . . . . .
. . . . . Q .
Q . . . . . .
. . Q . . . . .
. . . . Q . . .

Total Number of attack pairs: 0
. . . Q . . . .
. . . . . Q . .
. . . . . Q
. Q . . . . . .
. . . . . Q .
Q . . . . . .
. . Q . . . . .
. . . . Q . . .

*****SOLUTION FOUND*****

Total Runs: 300
Total Success: 300
Success Percentage: 100.0 %
Number of random restarts: 1734
Average number of random restarts: 5.78
Average number of steps: 27.956666666666667

d. Random-restart hill-climbing without sideways move

Total Runs: 300
Total Success: 300
Success Percentage: 100.0 %
Number of random restarts: 14
Average number of random restarts: 0.04666666666666667
Average number of steps: 22.623333333333335