## **PROJECT 2**

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

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### **Table of contents**

1	Problem
2	Aim
3	Language
4	Abstract
4.1	Introduction
5	Experiment Analysis
5.1	Global Variables
5.2	Classes defined in the program
5.2.1	Board class
5.2.2	Nqueen class
6	Results

#### 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 it	erations to be made
	given by	user
is_it_possible	This variable stores the Boolean value	e true or false, to tell
	whether the puzzle can be solved. Inti-	ally it is "True"
randomRestarts	To print the number of random restar	ts happened.
restart_Strategy_steps	Stores the values of the steps taken to	restart. It increments
	each time the intial state is again gene	rated.
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

definit	This method places the "Q" in the random positions and print in the
	form of matrix
ifname ==	It has the main display logic to solve the N-queen program. It
"main"	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

Initialize method which calls the hill-climbing methods
based on the search_type variable taken from the user
based on the search_type variable taken from the user
Printing the configuration of the N-Queen Puzzle
Definition for the Steepest hill climbing Algorithm
Definition for the Sideways hill climbing Algorithm
Definition for the Random Restart without sideways
allowing hill climbing Algorithm
Definition for the Random Restart with sideways allow
hill climbing Algorithm
<u> </u>
Print Definition exclusive to each type of Hill climbing
algorithm
Definition for calculating the number of attack pairs
based on the straight attacks and diagonal attacks
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
·
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 300<sup>th</sup> 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
QQ .Q
Q.
Q
Q Q
••••••
Total number of attack pairs: 3
Q
Q .Q
Q.

Q Q Q
Total number of attack pairs: 2QQQQQQ QQQQ
Total number of attack pairs: 1QQQQQQQQQQ
*****NO SOLUTION FOUND*****
OUTPUT FOR RUN: 2
Initial State:QQ QQQQQQQQ.
Total number of attack pairs: 5 Q .

Q .QQ Q Q
Total number of attack pairs: 3QQQQQQQQ
Total number of attack pairs: 2QQQQQQQQQQQQQQQQQQ
Total number of attack pairs: 0QQQQ Q Q Q Q Q
*****SOLUTION FOUND****
OUTPUT FOR RUN: 74

Initial State:QQQQQQQQQ
Total number of attack pairs: 3QQQQ QQQ QQ QQ
Total number of attack pairs: 2QQQ QQ QQ QQ
Total number of attack pairs: 0QQQQ Q Q Q QQ
*****SOLUTION FOUND****

OUTPUT FOR RUN: 75
Initial State:Q.QQ QQQQ
Total number of attack pairs: 5Q.QQQQQQQ
Total number of attack pairs: 3Q.QQQQQ QQ QQ
Total number of attack pairs: 2Q.QQQQQQQQ

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## **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...QQ.. . . . . . . . . . . . . . . . . .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...

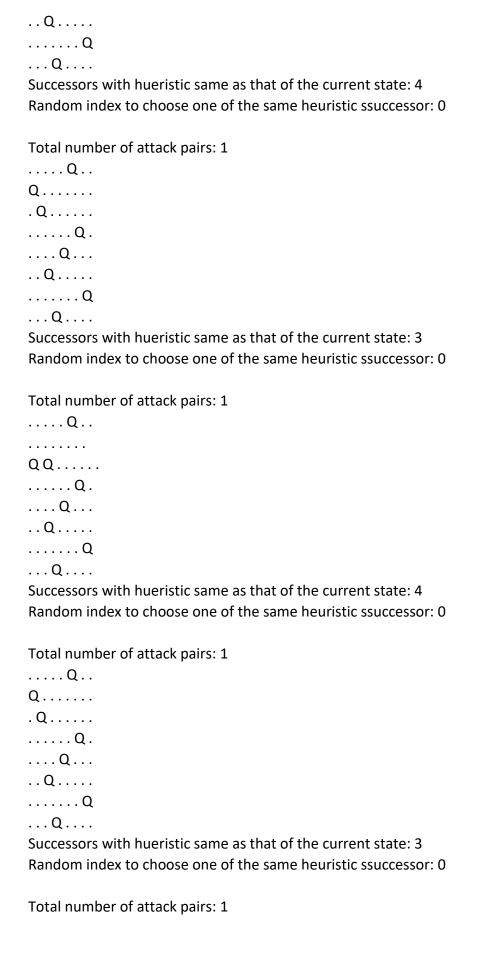
\*\*\*\*\*NO SOLUTION FOUND\*\*\*\*\*

.Q QQ. QQ Q
Total number of attack pairs: 2Q QQQQQQQQQQ
Total number of attack pairs: 1Q QQ QQQ.QQQ.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: 1Q QQ.QQQ
Total number of attack pairs: 0Q QQQ

Q Q Q.
*****SOLUTION FOUND****
OUTPUT FOR RUN: 297
Initial State:
Total number of attack pairs: 6 QQQQQQ
Total number of attack pairs: 4Q Q QQQQQQ
Total number of attack pairs: 2 Q

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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
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Total number of attack pairs: 1
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QQ 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: 1Q QQQ



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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
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Successors with hueristic same as that of the current state: 5
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Successors with hueristic same as that of the current state: 5

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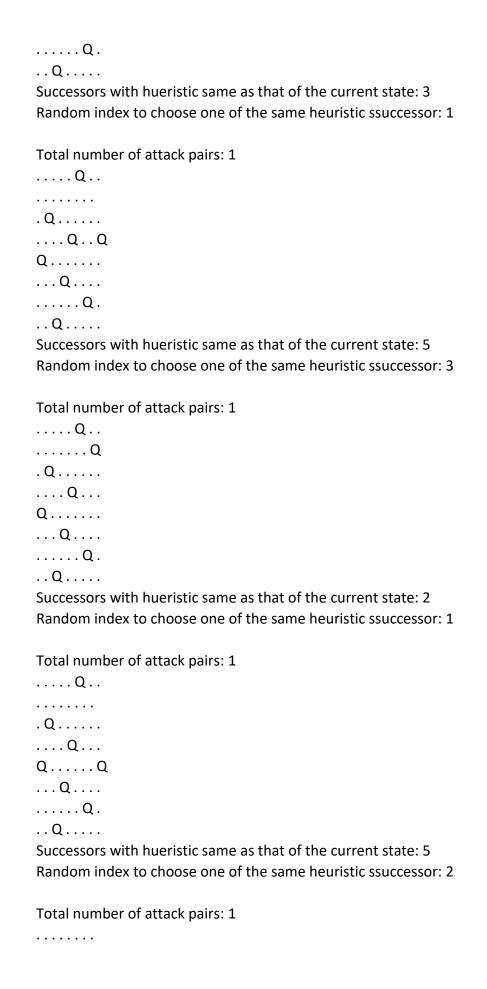
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Total number of attack pairs: 1
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Successors with hueristic same as that of the current state: 3
Random index to choose one of the same heuristic ssuccessor: 2
Total number of attack pairs: 1
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Successors with hueristic same as that of the current state: 2
Random index to choose one of the same heuristic ssuccessor: 1
Transfer mack to encose one of the same nearistic souccessor.
Total number of attack pairs: 1
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QQ
Q
Q
.Q
Q.
Q
Total number of attack pairs: 0
Q
Q
Q
Q
Q

. <b>Q</b>
Q.
Q
*****SOLUTION FOUND****
=======================================
OUTPUT FOR RUN: 299
=======================================
Initial State:
.Q.Q
Q
QQ
QQ
Q
Total number of attack pairs: 3
•
Q
•••••
Q
QQ
QQ
. Q
Q
Total number of attack pairs: 1
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QQ
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Successors with hueristic same as that of the current state: 4
Random index to choose one of the same heuristic ssuccessor: 1
namasin mack to choose one of the same neuristic soutlesson. I

Total number of attack pairs: 1

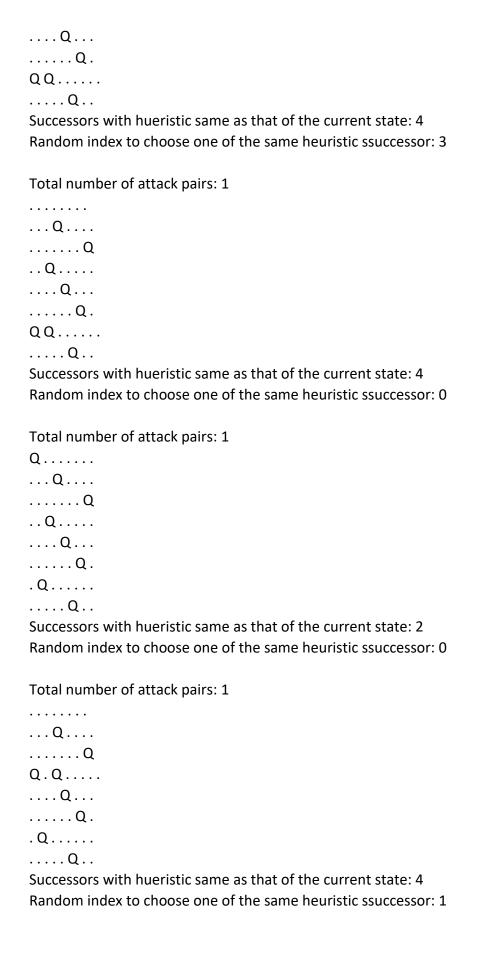
QQQQQQQ Successors with hueristic same as that of the current state: 4 Random index to choose one of the same heuristic ssuccessor: 2
Total number of attack pairs: 1QQQQQQQQQ Successors with hueristic same as that of the current state: 2 Random index to choose one of the same heuristic ssuccessor: 1
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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
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QQ
Q
Successors with hueristic same as that of the current state: 4
Random index to choose one of the same heuristic ssuccessor: 0
Tatal assessing of attack assessing 4
Total number of attack pairs: 1
Q
QQ
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
Name of the same nearestic spacessor.
Total number of attack pairs: 1
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QQ
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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.... 3

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Q Q
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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
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Q
Q
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QQ
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: 1Q QQQ
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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
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Total number of attack pairs: 1
QQQQQQQ Successors with hueristic same as that of the current state: 4 Random index to choose one of the same heuristic ssuccessor: 3
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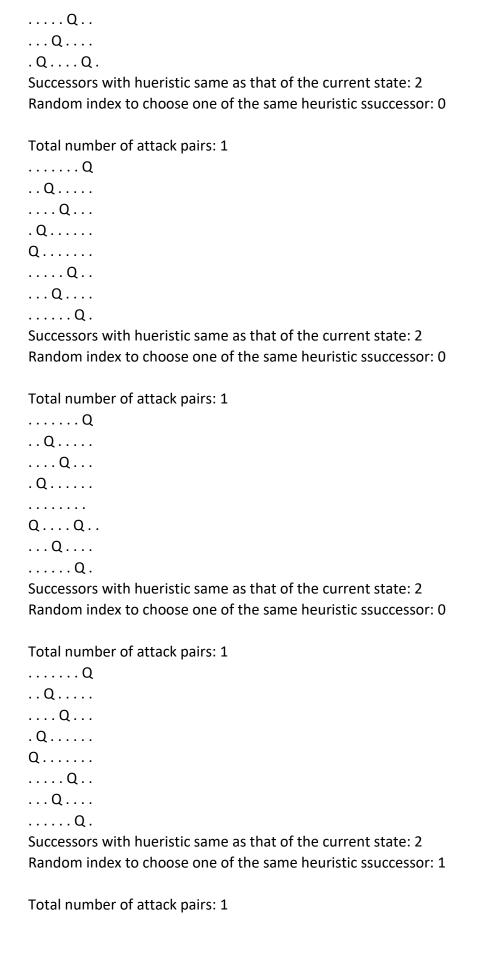
. Q
Total number of attack pairs: 0QQQQQ Q QQQ
*****SOLUTION FOUND*****
OUTPUT FOR RUN: 300
Initial State:QQ .QQQ QQQ
Total number of attack pairs: 7QQQQ QQQQQ
Total number of attack pairs: 4QQQQ

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

QQ QQ QQ QQ 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: 2QQQQ QQ QQ 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: 2QQQ.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: 2QQ.QQQ

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Total number of attack pairs: 2
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Total number of attack pairs: 1
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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
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Successors with hueristic same as that of the current state: 1
Total number of attack pairs: 1
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<b>U</b>



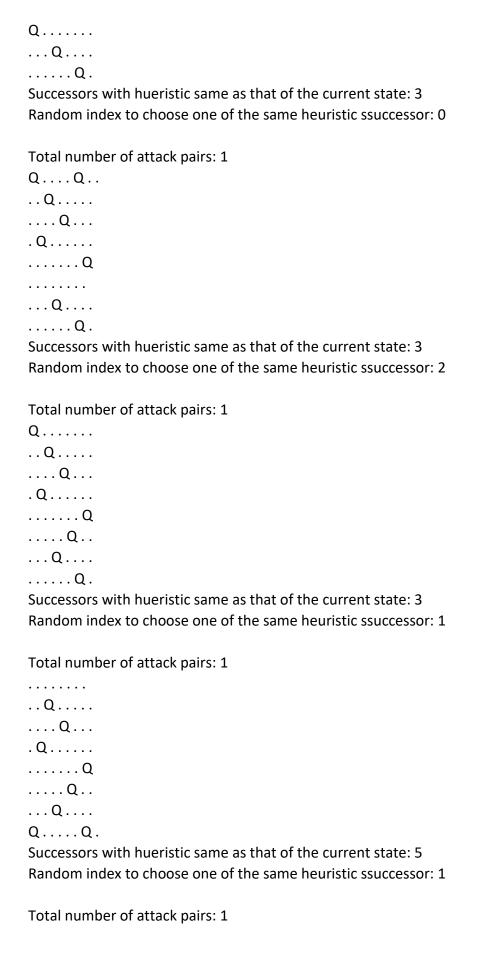
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Successors with hueristic same as that of the current state: 2
Random index to choose one of the same heuristic ssuccessor: 1
Total number of attack pairs: 1
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Successors with hueristic same as that of the current state: 1
Total number of attack pairs: 1
Total number of attack pairs: 1 Q
Total number of attack pairs: 1QQ
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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
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Successors with hueristic same as that of the current state: 2
Random index to choose one of the same heuristic ssuccessor: 1
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Total number of attack pairs: 1
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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
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Successors with hueristic same as that of the current state: 2
Random index to choose one of the same heuristic ssuccessor: 1
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Total number of attack pairs: 1
Total Hamber of attack pairs. 1
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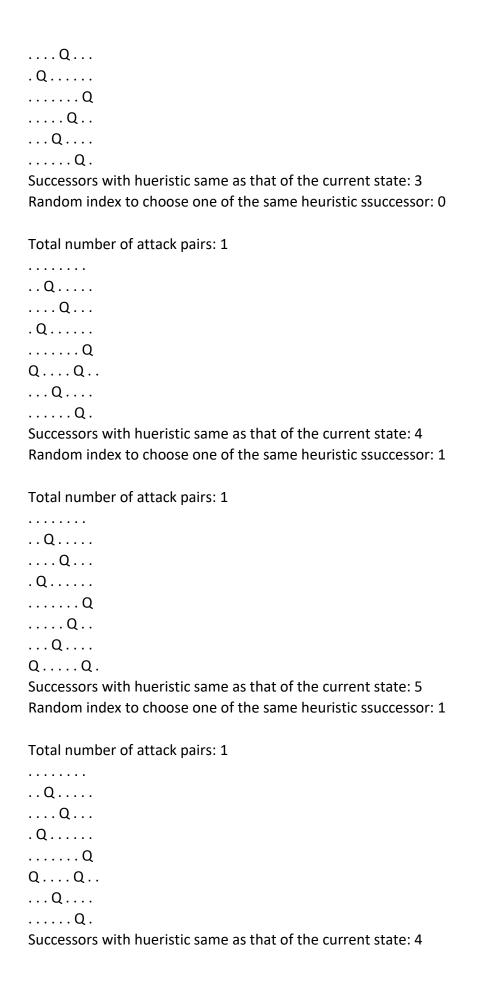
. Q
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Successors with hueristic same as that of the current state: 4
Random index to choose one of the same heuristic ssuccessor: 3
Total number of attack pairs: 1
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Successors with hueristic same as that of the current state: 2
Random index to choose one of the same heuristic ssuccessor: 1
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Total number of attack pairs: 1
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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
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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
Total number of attack pairs: 1QQQ
QQ QQ. 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: 1QQQQQQ
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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
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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
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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
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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
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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
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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
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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
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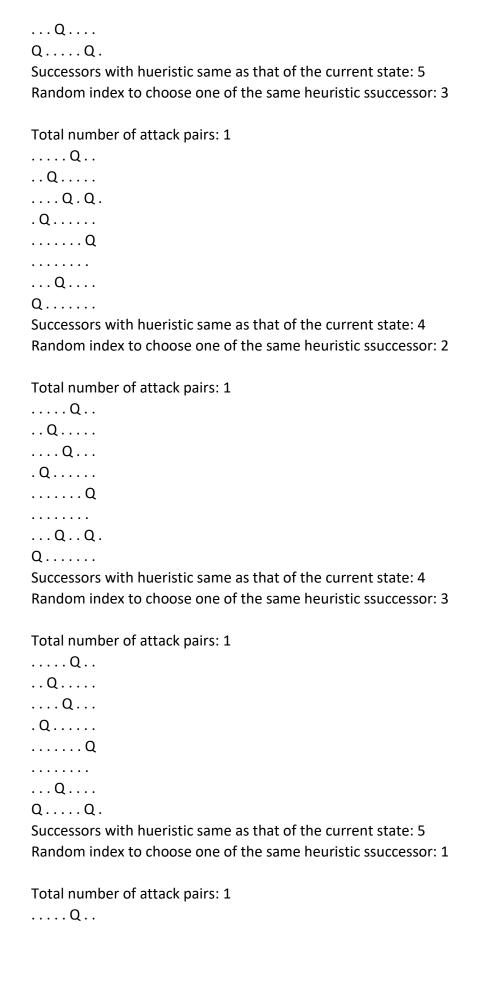


Random index to choose one of the same heuristic ssuccessor: 0

Total number of attack pairs: 1
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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
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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
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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
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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
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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
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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
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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
Total number of attack pairs: 1
Total number of attack pairs: 1
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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: 1QQQQQQ



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Successors with hueristic same as that of the current state: 3
Random index to choose one of the same heuristic ssuccessor: 1
Total gumbay of attack gains, 1
Total number of attack pairs: 1
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Successors with hueristic same as that of the current state: 5
Random index to choose one of the same heuristic ssuccessor: 1
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Total number of attack pairs: 1
Total number of attack pairs: 1 Q
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QQQQQQQQQQQ  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: 1QQ
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QQQQQQQQQQ 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: 1QQQ
QQQQQQQQQ 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: 1QQQQ
QQQQQQQQQ 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: 1QQQQ
QQQQQQQQQ 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: 1QQQQ

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

.QQ Q Q. Q
Total number of attack pairs: 0Q QQQQQQQ
*****SOLUTION FOUND*****
Total Runs: 300 Total Success: 277 Success Percentage: 92.333333333333333333333333333333333333
Random-restart hill-climbing with sideways move
======================================
Initial State:
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c.

. . . . . . . .

Q.
Total Number of attack pairs: 7Q QQ
Total Number of attack pairs: 3Q QQQQQQQQQ
Total Number of attack pairs: 2QQQ QQQQ
Total Number of attack pairs: 1QQQ Q Q QQ.QQ.

Initial State:

Q Q .QQ Q. Q. Q. Q.	
Total Number of attack pairs: 7QQQQQQQ Q Q.Q	,
Total Number of attack pairs: 4QQQQQQQQQ	ļ
Total Number of attack pairs: 3QQQQQQQQQQ	3
Total Number of attack pairs: 1QQQ	L

....Q...

Total Runs: 300
Total Success: 300

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

Success Percentage: 100.0 %

\*\*\*\*\*SOLUTION FOUND\*\*\*\*\*

Number of random restarts: 1734

Average number of random restarts: 5.78

Average number of steps: 27.95666666666667

## 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: 0.0466666666666667

Average number of steps: 22.623333333333333