

Intro to AI – ITCS 3153
Program Assignment #1

Instructions

Write a program that places 8 queens on an 8x8 board where none of the queens are in conflict with each other. You are to implement the solution by using the **Hill-Climbing algorithm with random restarts**.

Problem Overview & Algorithm Description

The 8-Queens problem requires that 8 queens be placed on a board with 8 rows and columns so that no queen occupies the same row, column or diagonal as another queen. To solve this problem using the Hill-Climbing with random restart algorithm, we must first generate a random starting state which places a queen in a random row of each column. From there, we first check to see if the state is a goal state (no queens are in conflict). If not, we evaluate all of the possible neighbor states by moving each column's queen through the rows of its column and generating a heuristic value for each of those states. When all of the neighbor states have been generated, we check to see if any states were generated that have a lower heuristic value than the current state. If a better state was not found, then we have reached the local minima and must perform a random restart. If a better (lower heuristic) state was found, then that state becomes the current state and the above process is repeated on that state.

Remember: your heuristic function is a representation of how close you are to the goal state. Unlike Pathfinding heuristics, we are not evaluating how close a particular node is to the goal node, but rather how close the current state (overall configuration) is to the goal state

Program Requirements

No graphics are required for this program. Instead, use a series of 0s (empty) and 1s (queen) in a grid style to represent each state. Every state generated should be output in this manner along with the current state's heuristic, the number of neighboring states with lower heuristics, and the action taken (restart or generate neighbor state). When a solution is reached, your program should display the number of restarts and the total number of state changes that have occurred. A sample execution using 10 queens has been provided. Your program output should match that format (except yours will be 8x8).

All program submissions should be done via Moodle.

The rubric below will be used in the grading of your program. Partial points may be awarded for each category.

Category	Value
Program is free of syntax and runtime errors	/ 10
Problem solved using the Hill-Climbing with random restarts algorithm	/ 10
Program successfully finds a solution	/ 40
Program outputs required information in the format described	/ 20
Program restarts when local minima is reached	/ 10
Program utilizes an appropriate heuristic	/10
Total Points	/ 100

Sample Execution Program Output

```
Current h: 8
Current State
0,0,0,0,1,0,0,0,0,0
0,0,0,0,0,0,0,0,0,0
0,0,0,0,0,0,0,0,0,0
0,0,0,1,0,0,0,0,0,0
1,0,1,0,0,0,0,0,0,0
0,0,0,0,0,0,0,0,0,0
0,0,0,0,0,0,0,1,1,0
0,0,0,0,0,0,1,0,0,0
0,0,0,0,1,0,0,0,1
0,1,0,0,0,0,0,0,0,0
Neighbors found with lower h: 2
Setting new current state
```

```
Current h: 5
Current State
0,0,0,0,1,0,0,0,0,0
0,0,0,0,0,0,0,1,0,0
0,0,0,0,0,0,0,0,0,0
0,0,0,1,0,0,0,0,0,0
1,0,1,0,0,0,0,0,0,0
0,0,0,0,0,0,0,0,0,0
0,0,0,0,0,0,0,0,1,0
0,0,0,0,0,0,1,0,0,0
0,0,0,0,0,1,0,0,0,1
0,1,0,0,0,0,0,0,0,0
Neighbors found with lower h: 2
Setting new current state
```

```
Current h: 3
Current State
0,0,0,0,1,0,0,0,0,0
0,0,0,0,0,0,0,1,0,0
0,0,0,0,0,0,0,0,0,0
0,0,0,1,0,0,0,0,0,0
0,0,1,0,0,0,0,0,0,0
1,0,0,0,0,0,0,0,0,0
0,0,0,0,0,0,0,0,1,0
0,0,0,0,0,0,1,0,0,0
0,0,0,0,0,1,0,0,0,1
0,1,0,0,0,0,0,0,0,0
Neighbors found with lower h: 1
Setting new current state
```

```
Current h: 1
Current State
0,0,0,0,1,0,0,0,0,0
0,0,0,0,0,0,0,1,0,0
0,0,0,0,0,1,0,0,0,0
0,0,0,1,0,0,0,0,0,0
0,0,1,0,0,0,0,0,0,0
1,0,0,0,0,0,0,0,0,0
0,0,0,0,0,0,0,0,1,0
0,0,0,0,0,0,1,0,0,0
0,0,0,0,0,0,0,0,0,1
0,1,0,0,0,0,0,0,0,0
Neighbors found with lower h: 0
RESTART
```

Current h: 10
Current State
0,0,0,0,0,0,0,0,0,0
0,0,0,0,0,0,0,0,0,0
0,0,0,0,0,0,0,0,0,0
0,0,0,0,1,0,0,0,0,0
0,0,0,0,0,0,0,1,0,0
0,0,0,1,0,0,0,0,1,0
1,1,0,0,0,0,0,0,0,0
0,0,0,0,0,0,0,0,0,0
0,0,0,0,0,1,0,0,1
0,0,1,0,0,1,0,0,0,0
Neighbors found with lower h: 20
Setting new current state

Current h: 8
Current State
0,0,0,0,0,1,0,0,0,0
0,0,0,0,0,0,0,0,0,0
0,0,0,0,0,0,0,0,0,0
0,0,0,0,1,0,0,0,0,0
0,0,0,0,0,0,0,1,0,0
0,0,0,1,0,0,0,0,1,0
1,1,0,0,0,0,0,0,0,0
0,0,0,0,0,0,0,0,0,0
0,0,0,0,0,0,1,0,0,1
0,0,1,0,0,0,0,0,0,0
Neighbors found with lower h: 8
Setting new current state

Current h: 6
Current State
0,0,0,0,0,1,0,0,0,0
0,1,0,0,0,0,0,0,0,0
0,0,0,0,0,0,0,0,0,0
0,0,0,0,1,0,0,0,0,0
0,0,0,0,0,0,0,1,0,0
0,0,0,1,0,0,0,0,1,0
1,0,0,0,0,0,0,0,0,0
0,0,0,0,0,0,0,0,0,0
0,0,0,0,0,0,1,0,0,1
0,0,1,0,0,0,0,0,0,0
Neighbors found with lower h: 3
Setting new current state

Current h: 4
Current State
0,0,0,0,0,1,0,0,0,0
0,1,0,0,0,0,0,0,0,0
0,0,0,0,0,0,0,0,0,0
0,0,0,0,1,0,0,0,0,0
0,0,0,0,0,0,0,1,0,0
0,0,0,1,0,0,0,0,1,0
1,0,0,0,0,0,0,0,0,0
0,0,0,0,0,0,0,0,0,1
0,0,0,0,0,0,1,0,0,0
0,0,1,0,0,0,0,0,0,0
Neighbors found with lower h: 1
Setting new current state

Current h: 2
Current State
0,0,0,0,0,1,0,0,0,0
0,1,0,0,0,0,0,0,0,0
0,0,0,0,0,0,0,0,1,0
0,0,0,0,1,0,0,0,0,0
0,0,0,0,0,0,0,1,0,0
0,0,0,1,0,0,0,0,0,0
1,0,0,0,0,0,0,0,0,0
0,0,0,0,0,0,0,0,0,1
0,0,0,0,0,1,0,0,0,0
0,0,1,0,0,0,0,0,0,0
Neighbors found with lower h: 0
RESTART

Current h: 10
Current State
0,1,0,1,0,0,0,0,0,0
0,0,1,0,0,0,0,0,0,0
1,0,0,0,0,0,0,0,0,0
0,0,0,0,0,1,0,0,0,0
0,0,0,0,0,0,0,0,1,0
0,0,0,0,0,0,0,0,0,0
0,0,0,0,1,0,1,1,0,1
0,0,0,0,0,0,0,0,0,0
0,0,0,0,0,0,0,0,0,0
0,0,0,0,0,0,0,0,0,0
Neighbors found with lower h: 1
Setting new current state

Current h: 7
Current State
0,1,0,0,0,0,0,0,0,0
0,0,1,0,0,0,0,0,0,0
1,0,0,0,0,0,0,0,0,0
0,0,0,0,0,1,0,0,0,0
0,0,0,0,0,0,0,0,1,0
0,0,0,0,0,0,0,0,0,0
0,0,0,0,1,0,1,1,0,1
0,0,0,0,0,0,0,0,0,0
0,0,0,1,0,0,0,0,0,0
0,0,0,0,0,0,0,0,0,0
Neighbors found with lower h: 1
Setting new current state

Current h: 5
Current State
0,1,0,0,0,0,0,0,0,0
0,0,1,0,0,0,0,0,0,0
1,0,0,0,0,0,0,0,0,0
0,0,0,0,0,1,0,0,0,0
0,0,0,0,0,0,0,0,1,0
0,0,0,0,1,0,0,0,0,0
0,0,0,0,0,0,1,1,0,1
0,0,0,0,0,0,0,0,0,0
0,0,0,1,0,0,0,0,0,0
0,0,0,0,0,0,0,0,0,0
Neighbors found with lower h: 7
Setting new current state
Current h: 4
Current State

```
0,0,0,0,0,0,0,0,0,0
0,0,1,0,0,0,0,0,0,0
1,0,0,0,0,0,0,0,0,0
0,0,0,0,0,1,0,0,0,0
0,0,0,0,0,0,0,0,1,0
0,0,0,0,1,0,0,0,0,0
0,0,0,0,0,0,1,1,0,1
0,0,0,0,0,0,0,0,0,0
0,0,0,1,0,0,0,0,0,0
0,1,0,0,0,0,0,0,0,0
```

Neighbors found with lower h: 2

Setting new current state

Current h: 2

Current State

```
0,0,0,0,0,0,0,1,0,0
0,0,1,0,0,0,0,0,0,0
1,0,0,0,0,0,0,0,0,0
0,0,0,0,0,1,0,0,0,0
0,0,0,0,0,0,0,0,1,0
0,0,0,0,1,0,0,0,0,0
0,0,0,0,0,0,1,0,0,1
0,0,0,0,0,0,0,0,0,0
0,0,0,1,0,0,0,0,0,0
0,1,0,0,0,0,0,0,0,0
```

Neighbors found with lower h: 2

Setting new current state

Current h: 1

Current State

```
0,0,0,0,0,0,1,1,0,0
0,0,1,0,0,0,0,0,0,0
1,0,0,0,0,0,0,0,0,0
0,0,0,0,0,1,0,0,0,0
0,0,0,0,0,0,0,0,1,0
0,0,0,0,1,0,0,0,0,0
0,0,0,0,0,0,0,0,0,1
0,0,0,0,0,0,0,0,0,0
0,0,0,1,0,0,0,0,0,0
0,1,0,0,0,0,0,0,0,0
```

Neighbors found with lower h: 1

Setting new current state

Current State

```
0,0,0,0,0,0,1,0,0,0
0,0,1,0,0,0,0,0,0,0
1,0,0,0,0,0,0,0,0,0
0,0,0,0,0,1,0,0,0,0
0,0,0,0,0,0,0,0,1,0
0,0,0,0,1,0,0,0,0,0
0,0,0,0,0,0,0,0,0,1
0,0,0,0,0,0,0,1,0,0
0,0,0,1,0,0,0,0,0,0
0,1,0,0,0,0,0,0,0,0
```

Solution Found!

State changes: 29

Restarts: 6