Project Report

On

Solving N-queens problem using hill-climbing and its variants

Project Guidance By

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Problem Statement:

The N-queens problem involves placing 'n' chess queens on an n * n chessboard in such a way that no two queens are attacking each other. Here in this report, we are choosing to solve the n queens problem (8 is our default value if no value is specified) by taking a random state by placing n queens in the n*n chessboard by placing each queen in a column.

Various Hill climbing search techniques can be used to solve this problem. Hill-climbing search has its success rate around 14%. In order to optimize this search, we use search techniques like Hill Climbing with sideways move and Random Restart Hill Climbing.

- **Hill Climbing with sideways move:** If no downhill or uphill moves yields a better state than the current one then we allow sideways moves in hope that the algorithm can escape from a shoulder. This algorithm significantly improves the success rate of the algorithm from 14% to 94%.

- **Random Restart Hill Climbing:** Random-restart hill-climbing conducts a series of hill-climbing searches from randomly generated initial states, running each until it halts or makes no discernible progress. This enables comparison of many optimization trials and finding a most optimal solution.

Each step the queen takes is determined by the heuristic function h which calculates the total number of pairs of queens that can attack each other directly or indirectly.

Program Structure:

Classes and methods:

1. **Hill_Climbing_Search:**

    - **__init__** : Initializes the variables startingState(Initial state), max_side(Maximum number of steps that sideways move can perform), rem_side(Remaining Sideways moves), total_step_count(Total number of steps taken by the algorithm) and n_queen(number of queens).
    - **get_diagonal_right**: Returns all the cells which are present diagonally right to the current cell.
    - **get_horizontal_right**: Returns the cells which are present horizontally right to the current cell.
    - **cells_to_right**: Combines the above two methods to get all the cells to the right.
    - **get_queens_state**: Get cell positions of the queens for the given state.
    - **calculate_heuristic**: Calculate the heuristic value for a given state.
    - **print_state**: Display the N-Queens Problem for the current state as a Matrix.

- **heuristic_matrix**: Calculate heuristic values for all the cells to take the next step.
- **steepest_ascent_algorithm**: Implementation of the Steepest Ascent Hill Climbing Search. This method calculates the least heuristic value and moves forward with execution.
- **random_state**: Generates and returns a random state everytime.
- **random_restart_hill_climbing**: This method is used to implement Random Restart Hill Climbing Search by using Steepest Ascent as Base.

2. **Hill_Climbing_Analysis:**

- **__init__** : Initializes the variables max_iterations(Maximum number of iterations), n_value (number of queens), steepest_ascent_stats(Store the statistics of Steepest ascent hill climbing without sideways move), steepest_ascent_with_side_stats(Store the statistics of Steepest ascent hill climbing with sideways move), random_restart_stats(Store the statistics of random restart hill climbing without sideways move) and random_restart_with_side_stats (Store the statistics of random restart hill climbing with sideways move).
- **do_analysis**: Performs the analysis of Steepest Ascent and Random Restart Hill Climbing max_iterations (Say max_iterations = 100) times.
- **print_analysis**: Prints the final analysis report of all the four algorithms.
- **print_random_restart_stats**: Display Random Restart Hill Climbing Search Analysis Report.
- **print_steepest_ascent_stats**: Displays the report for Steepest Ascent algorithm with and without sideways move.

The search sequences from four random initial configurations:

Hill Climbing Search Analysis:

```
Hill Climbing Search Analysis
Initial:
[(6, 0), (6, 1), (1, 2), (3, 3), (1, 4), (4, 5), (4, 6), (0, 7)]
|*|*|*|*|*|*|*|Q|
|*|*|Q|*|Q|*|*|*|
|*|*|*|*|*|*|*|*|
|*|*|*|Q|*|*|*|*|
|*|*|*|*|*|Q|Q|*|
|*|*|*|*|*|*|*|*|
|Q|Q|*|*|*|*|*|*|
|*|*|*|*|*|*|*|*|
Step:  2
[(2, 0), (6, 1), (1, 2), (3, 3), (1, 4), (4, 5), (4, 6), (0, 7)]
|*|*|*|*|*|*|*|Q|
|*|*|Q|*|Q|*|*|*|
|Q|*|*|*|*|*|*|*|
|*|*|*|Q|*|*|*|*|
|*|*|*|*|*|Q|Q|*|
|*|*|*|*|*|*|*|*|
|*|Q|*|*|*|*|*|*|
|*|*|*|*|*|*|*|*|
Step:  3
[(2, 0), (6, 1), (1, 2), (3, 3), (1, 4), (7, 5), (4, 6), (0, 7)]
|*|*|*|*|*|*|*|Q|
|*|*|Q|*|Q|*|*|*|
|Q|*|*|*|*|*|*|*|
|*|*|*|Q|*|*|*|*|
|*|*|*|*|*|*|Q|*|
|*|*|*|*|*|*|*|*|
|*|Q|*|*|*|*|*|*|
|*|*|*|*|*|Q|*|*|
Step:  4
[(2, 0), (6, 1), (1, 2), (3, 3), (5, 4), (7, 5), (4, 6), (0, 7)]
|*|*|*|*|*|*|*|Q|
|*|*|Q|*|*|*|*|*|
|Q|*|*|*|*|*|*|*|
|*|*|*|Q|*|*|*|*|
|*|*|*|*|*|*|Q|*|
|*|*|*|*|Q|*|*|*|
|*|Q|*|*|*|*|*|*|
|*|*|*|*|*|Q|*|*|
Search Failed
```

```
Hill climbing Search with Sideways Analysis
Initial:
[(6, 0), (6, 1), (1, 2), (3, 3), (1, 4), (4, 5), (4, 6), (0, 7)]
|*|*|*|*|*|*|*|Q|
|*|*|Q|*|Q|*|*|*|
|*|*|*|*|*|*|*|*|
|*|*|*|Q|*|*|*|*|
|*|*|*|*|*|Q|Q|*|
|*|*|*|*|*|*|*|*|
|Q|Q|*|*|*|*|*|*|
|*|*|*|*|*|*|*|*|
Step:  2
[(2, 0), (6, 1), (1, 2), (3, 3), (1, 4), (4, 5), (4, 6), (0, 7)]
|*|*|*|*|*|*|*|Q|
|*|*|Q|*|Q|*|*|*|
|Q|*|*|*|*|*|*|*|
|*|*|*|Q|*|*|*|*|
|*|*|*|*|*|Q|Q|*|
|*|*|*|*|*|*|*|*|
|*|Q|*|*|*|*|*|*|
|*|*|*|*|*|*|*|*|
Step:  3
[(2, 0), (6, 1), (1, 2), (3, 3), (1, 4), (4, 5), (7, 6), (0, 7)]
|*|*|*|*|*|*|*|Q|
|*|*|Q|*|Q|*|*|*|
|Q|*|*|*|*|*|*|*|
|*|*|*|Q|*|*|*|*|
|*|*|*|*|*|Q|*|*|
|*|*|*|*|*|*|*|*|
|*|Q|*|*|*|*|*|*|
|*|*|*|*|*|*|Q|*|
Step:  4
[(2, 0), (6, 1), (1, 2), (3, 3), (1, 4), (4, 5), (7, 6), (5, 7)]
|*|*|*|*|*|*|*|*|
|*|*|Q|*|Q|*|*|*|
|Q|*|*|*|*|*|*|*|
|*|*|*|Q|*|*|*|*|
|*|*|*|*|*|Q|*|*|
|*|*|*|*|*|*|*|Q|
|*|Q|*|*|*|*|*|*|
|*|*|*|*|*|*|Q|*|
Step:  5
[(2, 0), (6, 1), (6, 2), (3, 3), (1, 4), (4, 5), (7, 6), (5, 7)]
|*|*|*|*|*|*|*|*|
|*|*|*|*|Q|*|*|*|
|Q|*|*|*|*|*|*|*|
|*|*|*|Q|*|*|*|*|
|*|*|*|*|*|Q|*|*|
|*|*|*|*|*|*|*|Q|
|*|Q|Q|*|*|*|*|*|
|*|*|*|*|*|*|Q|*|
```

```
Step:  6
[(2, 0), (0, 1), (6, 2), (3, 3), (1, 4), (4, 5), (7, 6), (5, 7)]
|*|Q|*|*|*|*|*|*|
|*|*|*|*|Q|*|*|*|
|Q|*|*|*|*|*|*|*|
|*|*|*|Q|*|*|*|*|
|*|*|*|*|*|Q|*|*|
|*|*|*|*|*|*|*|Q|
|*|*|Q|*|*|*|*|*|
|*|*|*|*|*|*|Q|*|
Step:  7
[(2, 0), (6, 1), (6, 2), (3, 3), (1, 4), (4, 5), (7, 6), (5, 7)]
|*|*|*|*|*|*|*|*|
|*|*|*|*|Q|*|*|*|
|Q|*|*|*|*|*|*|*|
|*|*|*|Q|*|*|*|*|
|*|*|*|*|*|Q|*|*|
|*|*|*|*|*|*|*|Q|
|*|Q|Q|*|*|*|*|*|
|*|*|*|*|*|*|Q|*|
Step:  8
[(2, 0), (0, 1), (6, 2), (3, 3), (1, 4), (4, 5), (7, 6), (5, 7)]
|*|Q|*|*|*|*|*|*|
|*|*|*|*|Q|*|*|*|
|Q|*|*|*|*|*|*|*|
|*|*|*|Q|*|*|*|*|
|*|*|*|*|*|Q|*|*|
|*|*|*|*|*|*|*|Q|
|*|*|Q|*|*|*|*|*|
|*|*|*|*|*|*|Q|*|
Step:  9
[(2, 0), (6, 1), (6, 2), (3, 3), (1, 4), (4, 5), (7, 6), (5, 7)]
|*|*|*|*|*|*|*|*|
|*|*|*|*|Q|*|*|*|
|Q|*|*|*|*|*|*|*|
|*|*|*|Q|*|*|*|*|
|*|*|*|*|*|Q|*|*|
|*|*|*|*|*|*|*|Q|
|*|Q|Q|*|*|*|*|*|
|*|*|*|*|*|*|Q|*|
Step:  10
[(2, 0), (6, 1), (6, 2), (3, 3), (0, 4), (4, 5), (7, 6), (5, 7)]
|*|*|*|*|Q|*|*|*|
|*|*|*|*|*|*|*|*|
|Q|*|*|*|*|*|*|*|
|*|*|*|Q|*|*|*|*|
|*|*|*|*|*|Q|*|*|
|*|*|*|*|*|*|*|Q|
|*|Q|Q|*|*|*|*|*|
|*|*|*|*|*|*|Q|*|
```

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Step:  11
[(2, 0), (6, 1), (6, 2), (3, 3), (1, 4), (4, 5), (7, 6), (5, 7)]
|*|*|*|*|*|*|*|*|
|*|*|*|*|Q|*|*|*|
|Q|*|*|*|*|*|*|*|
|*|*|*|Q|*|*|*|*|
|*|*|*|*|*|Q|*|*|
|*|*|*|*|*|*|*|Q|
|*|Q|Q|*|*|*|*|*|
|*|*|*|*|*|*|Q|*|
Step:  12
[(2, 0), (6, 1), (6, 2), (3, 3), (0, 4), (4, 5), (7, 6), (5, 7)]
|*|*|*|*|Q|*|*|*|
|*|*|*|*|*|*|*|*|
|Q|*|*|*|*|*|*|*|
|*|*|*|Q|*|*|*|*|
|*|*|*|*|*|Q|*|*|
|*|*|*|*|*|*|*|Q|
|*|Q|Q|*|*|*|*|*|
|*|*|*|*|*|*|Q|*|
Step:  13
[(2, 0), (6, 1), (1, 2), (3, 3), (0, 4), (4, 5), (7, 6), (5, 7)]
|*|*|*|*|Q|*|*|*|
|*|*|Q|*|*|*|*|*|
|Q|*|*|*|*|*|*|*|
|*|*|*|Q|*|*|*|*|
|*|*|*|*|*|Q|*|*|
|*|*|*|*|*|*|*|Q|
|*|Q|*|*|*|*|*|*|
|*|*|*|*|*|*|Q|*|
Step:  14
[(2, 0), (6, 1), (1, 2), (3, 3), (0, 4), (0, 5), (7, 6), (5, 7)]
|*|*|*|*|Q|Q|*|*|
|*|*|Q|*|*|*|*|*|
|Q|*|*|*|*|*|*|*|
|*|*|*|Q|*|*|*|*|
|*|*|*|*|*|*|*|*|
|*|*|*|*|*|*|*|Q|
|*|Q|*|*|*|*|*|*|
|*|*|*|*|*|*|Q|*|
Step:  15
[(2, 0), (6, 1), (1, 2), (3, 3), (0, 4), (4, 5), (7, 6), (5, 7)]
|*|*|*|*|Q|*|*|*|
|*|*|Q|*|*|*|*|*|
|Q|*|*|*|*|*|*|*|
|*|*|*|Q|*|*|*|*|
|*|*|*|*|*|Q|*|*|
|*|*|*|*|*|*|*|Q|
|*|Q|*|*|*|*|*|*|
|*|*|*|*|*|*|Q|*|
```

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Step:  16
[(2, 0), (6, 1), (1, 2), (3, 3), (0, 4), (0, 5), (7, 6), (5, 7)]
|*|*|*|*|Q|Q|*|*|
|*|*|Q|*|*|*|*|*|
|Q|*|*|*|*|*|*|*|
|*|*|*|Q|*|*|*|*|
|*|*|*|*|*|*|*|*|
|*|*|*|*|*|*|*|Q|
|*|Q|*|*|*|*|*|*|
|*|*|*|*|*|*|Q|*|
Step:  17
[(2, 0), (6, 1), (1, 2), (3, 3), (7, 4), (0, 5), (7, 6), (5, 7)]
|*|*|*|*|*|Q|*|*|
|*|*|Q|*|*|*|*|*|
|Q|*|*|*|*|*|*|*|
|*|*|*|Q|*|*|*|*|
|*|*|*|*|*|*|*|*|
|*|*|*|*|*|*|*|Q|
|*|Q|*|*|*|*|*|*|
|*|*|*|*|Q|*|Q|*|
Step:  18
[(4, 0), (6, 1), (1, 2), (3, 3), (7, 4), (0, 5), (7, 6), (5, 7)]
|*|*|*|*|*|Q|*|*|
|*|*|Q|*|*|*|*|*|
|*|*|*|*|*|*|*|*|
|*|*|*|Q|*|*|*|*|
|Q|*|*|*|*|*|*|*|
|*|*|*|*|*|*|*|Q|
|*|Q|*|*|*|*|*|*|
|*|*|*|*|Q|*|Q|*|
Success:
[(4, 0), (6, 1), (1, 2), (3, 3), (7, 4), (0, 5), (2, 6), (5, 7)]
|*|*|*|*|*|Q|*|*|
|*|*|Q|*|*|*|*|*|
|*|*|*|*|*|*|Q|*|
|*|*|*|Q|*|*|*|*|
|Q|*|*|*|*|*|*|*|
|*|*|*|*|*|*|*|Q|
|*|Q|*|*|*|*|*|*|
|*|*|*|*|Q|*|*|*|

Random Restart Hill Climbing Search
Initial:
[(7, 0), (6, 1), (3, 2), (3, 3), (3, 4), (3, 5), (5, 6), (0, 7)]
|*|*|*|*|*|*|*|Q|
|*|*|*|*|*|*|*|*|
|*|*|*|*|*|*|*|*|
|*|*|Q|Q|Q|Q|*|*|
|*|*|*|*|*|*|*|*|
|*|*|*|*|*|*|Q|*|
|*|Q|*|*|*|*|*|*|
|Q|*|*|*|*|*|*|*|
```

```
Step:  2
[(7, 0), (6, 1), (3, 2), (3, 3), (6, 4), (3, 5), (5, 6), (0, 7)]
|*|*|*|*|*|*|*|Q|
|*|*|*|*|*|*|*|*|
|*|*|*|*|*|*|*|*|
|*|*|Q|Q|*|Q|*|*|
|*|*|*|*|*|*|*|*|
|*|*|*|*|*|*|Q|*|
|*|Q|*|*|Q|*|*|*|
|Q|*|*|*|*|*|*|*|
Step:  3
[(4, 0), (6, 1), (3, 2), (3, 3), (6, 4), (3, 5), (5, 6), (0, 7)]
|*|*|*|*|*|*|*|Q|
|*|*|*|*|*|*|*|*|
|*|*|*|*|*|*|*|*|
|*|*|Q|Q|*|Q|*|*|
|Q|*|*|*|*|*|*|*|
|*|*|*|*|*|*|Q|*|
|*|Q|*|*|Q|*|*|*|
|*|*|*|*|*|*|*|*|
Step:  4
[(4, 0), (6, 1), (3, 2), (3, 3), (6, 4), (1, 5), (5, 6), (0, 7)]
|*|*|*|*|*|*|*|Q|
|*|*|*|*|*|Q|*|*|
|*|*|*|*|*|*|*|*|
|*|*|Q|Q|*|*|*|*|
|Q|*|*|*|*|*|*|*|
|*|*|*|*|*|*|Q|*|
|*|Q|*|*|Q|*|*|*|
|*|*|*|*|*|*|*|*|
Step:  5
[(4, 0), (7, 1), (3, 2), (3, 3), (6, 4), (1, 5), (5, 6), (0, 7)]
|*|*|*|*|*|*|*|Q|
|*|*|*|*|*|Q|*|*|
|*|*|*|*|*|*|*|*|
|*|*|Q|Q|*|*|*|*|
|Q|*|*|*|*|*|*|*|
|*|*|*|*|*|*|Q|*|
|*|*|*|*|Q|*|*|*|
|*|Q|*|*|*|*|*|*|
Step:  6
[(4, 0), (7, 1), (3, 2), (0, 3), (6, 4), (1, 5), (5, 6), (0, 7)]
|*|*|*|Q|*|*|*|Q|
|*|*|*|*|*|Q|*|*|
|*|*|*|*|*|*|*|*|
|*|*|Q|*|*|*|*|*|
|Q|*|*|*|*|*|*|*|
|*|*|*|*|*|*|Q|*|
|*|*|*|*|Q|*|*|*|
|*|Q|*|*|*|*|*|*|
```

```
Success:
[(4, 0), (7, 1), (3, 2), (0, 3), (6, 4), (1, 5), (5, 6), (2, 7)]
|*|*|*|Q|*|*|*|*|
|*|*|*|*|*|Q|*|*|
|*|*|*|*|*|*|*|Q|
|*|*|Q|*|*|*|*|*|
|Q|*|*|*|*|*|*|*|
|*|*|*|*|*|*|Q|*|
|*|*|*|*|Q|*|*|*|
|*|Q|*|*|*|*|*|*|

Random Restart Hill Climbing Search with Sideways Analysis
Initial:
[(4, 0), (2, 1), (4, 2), (4, 3), (6, 4), (6, 5), (1, 6), (6, 7)]
|*|*|*|*|*|*|*|*|
|*|*|*|*|*|*|Q|*|
|*|Q|*|*|*|*|*|*|
|*|*|*|*|*|*|*|*|
|Q|*|Q|Q|*|*|*|*|
|*|*|*|*|*|*|*|*|
|*|*|*|*|Q|Q|*|Q|
|*|*|*|*|*|*|*|*|
Step:  2
[(4, 0), (2, 1), (4, 2), (0, 3), (6, 4), (6, 5), (1, 6), (6, 7)]
|*|*|*|Q|*|*|*|*|
|*|*|*|*|*|*|Q|*|
|*|Q|*|*|*|*|*|*|
|*|*|*|*|*|*|*|*|
|Q|*|Q|*|*|*|*|*|
|*|*|*|*|*|*|*|*|
|*|*|*|*|Q|Q|*|Q|
|*|*|*|*|*|*|*|*|
Step:  3
[(4, 0), (2, 1), (4, 2), (0, 3), (6, 4), (3, 5), (1, 6), (6, 7)]
|*|*|*|Q|*|*|*|*|
|*|*|*|*|*|*|Q|*|
|*|Q|*|*|*|*|*|*|
|*|*|*|*|*|Q|*|*|
|Q|*|Q|*|*|*|*|*|
|*|*|*|*|*|*|*|*|
|*|*|*|*|Q|*|*|Q|
|*|*|*|*|*|*|*|*|
Step:  4
[(4, 0), (2, 1), (4, 2), (0, 3), (7, 4), (3, 5), (1, 6), (6, 7)]
|*|*|*|Q|*|*|*|*|
|*|*|*|*|*|*|Q|*|
|*|Q|*|*|*|*|*|*|
|*|*|*|*|*|Q|*|*|
|Q|*|Q|*|*|*|*|*|
|*|*|*|*|*|*|*|*|
|*|*|*|*|*|*|*|Q|
|*|*|*|*|Q|*|*|*|
```

```
Step:  5
[(5, 0), (2, 1), (4, 2), (0, 3), (7, 4), (3, 5), (1, 6), (6, 7)]
|*|*|*|Q|*|*|*|*|
|*|*|*|*|*|*|Q|*|
|*|Q|*|*|*|*|*|*|
|*|*|*|*|*|Q|*|*|
|*|*|Q|*|*|*|*|*|
|Q|*|*|*|*|*|*|*|
|*|*|*|*|*|*|*|Q|
|*|*|*|*|Q|*|*|*|
Step:  6
[(5, 0), (2, 1), (4, 2), (7, 3), (7, 4), (3, 5), (1, 6), (6, 7)]
|*|*|*|*|*|*|*|*|
|*|*|*|*|*|*|Q|*|
|*|Q|*|*|*|*|*|*|
|*|*|*|*|*|Q|*|*|
|*|*|Q|*|*|*|*|*|
|Q|*|*|*|*|*|*|*|
|*|*|*|*|*|*|*|Q|
|*|*|*|Q|Q|*|*|*|
Success:
[(5, 0), (2, 1), (4, 2), (7, 3), (0, 4), (3, 5), (1, 6), (6, 7)]
|*|*|*|*|Q|*|*|*|
|*|*|*|*|*|*|Q|*|
|*|Q|*|*|*|*|*|*|
|*|*|*|*|*|Q|*|*|
|*|*|Q|*|*|*|*|*|
|Q|*|*|*|*|*|*|*|
|*|*|*|*|*|*|*|Q|
|*|*|*|Q|*|*|*|*|

Hill Climbing Search Analysis
Initial:
[(7, 0), (5, 1), (2, 2), (3, 3), (3, 4), (6, 5), (3, 6), (0, 7)]
|*|*|*|*|*|*|*|Q|
|*|*|*|*|*|*|*|*|
|*|*|Q|*|*|*|*|*|
|*|*|*|Q|Q|*|Q|*|
|*|*|*|*|*|*|*|*|
|*|Q|*|*|*|*|*|*|
|*|*|*|*|*|Q|*|*|
|Q|*|*|*|*|*|*|*|
Step:  2
[(7, 0), (5, 1), (2, 2), (3, 3), (1, 4), (6, 5), (3, 6), (0, 7)]
|*|*|*|*|*|*|*|Q|
|*|*|*|*|Q|*|*|*|
|*|*|Q|*|*|*|*|*|
|*|*|*|Q|*|*|Q|*|
|*|*|*|*|*|*|*|*|
|*|Q|*|*|*|*|*|*|
|*|*|*|*|*|Q|*|*|
|Q|*|*|*|*|*|*|*|
```

```
Step:  3
[(7, 0), (5, 1), (2, 2), (3, 3), (1, 4), (6, 5), (4, 6), (0, 7)]
|*|*|*|*|*|*|*|Q|
|*|*|*|*|Q|*|*|*|
|*|*|Q|*|*|*|*|*|
|*|*|*|Q|*|*|*|*|
|*|*|*|*|*|*|Q|*|
|*|Q|*|*|*|*|*|*|
|*|*|*|*|*|Q|*|*|
|Q|*|*|*|*|*|*|*|
Step:  4
[(7, 0), (5, 1), (2, 2), (6, 3), (1, 4), (6, 5), (4, 6), (0, 7)]
|*|*|*|*|*|*|*|Q|
|*|*|*|*|Q|*|*|*|
|*|*|Q|*|*|*|*|*|
|*|*|*|*|*|*|*|*|
|*|*|*|*|*|*|Q|*|
|*|Q|*|*|*|*|*|*|
|*|*|*|Q|*|Q|*|*|
|Q|*|*|*|*|*|*|*|
Search Failed

Hill climbing Search with Sideways Analysis
Initial:
[(7, 0), (5, 1), (2, 2), (3, 3), (3, 4), (6, 5), (3, 6), (0, 7)]
|*|*|*|*|*|*|*|Q|
|*|*|*|*|*|*|*|*|
|*|*|Q|*|*|*|*|*|
|*|*|*|Q|Q|*|Q|*|
|*|*|*|*|*|*|*|*|
|*|Q|*|*|*|*|*|*|
|*|*|*|*|*|Q|*|*|
|Q|*|*|*|*|*|*|*|
Step:  2
[(7, 0), (5, 1), (2, 2), (3, 3), (1, 4), (6, 5), (3, 6), (0, 7)]
|*|*|*|*|*|*|*|Q|
|*|*|*|*|Q|*|*|*|
|*|*|Q|*|*|*|*|*|
|*|*|*|Q|*|*|Q|*|
|*|*|*|*|*|*|*|*|
|*|Q|*|*|*|*|*|*|
|*|*|*|*|*|Q|*|*|
|Q|*|*|*|*|*|*|*|
```

```
Step:  3
[(7, 0), (5, 1), (2, 2), (3, 3), (1, 4), (6, 5), (4, 6), (0, 7)]
|*|*|*|*|*|*|*|Q|
|*|*|*|*|Q|*|*|*|
|*|*|Q|*|*|*|*|*|
|*|*|*|Q|*|*|*|*|
|*|*|*|*|*|*|Q|*|
|*|Q|*|*|*|*|*|*|
|*|*|*|*|*|Q|*|*|
|Q|*|*|*|*|*|*|*|
Step:  4
[(7, 0), (5, 1), (2, 2), (6, 3), (1, 4), (6, 5), (4, 6), (0, 7)]
|*|*|*|*|*|*|*|Q|
|*|*|*|*|Q|*|*|*|
|*|*|Q|*|*|*|*|*|
|*|*|*|*|*|*|*|*|
|*|*|*|*|*|*|Q|*|
|*|Q|*|*|*|*|*|*|
|*|*|*|Q|*|Q|*|*|
|Q|*|*|*|*|*|*|*|
Step:  5
[(7, 0), (5, 1), (2, 2), (6, 3), (1, 4), (6, 5), (4, 6), (3, 7)]
|*|*|*|*|*|*|*|*|
|*|*|*|*|Q|*|*|*|
|*|*|Q|*|*|*|*|*|
|*|*|*|*|*|*|*|Q|
|*|*|*|*|*|*|Q|*|
|*|Q|*|*|*|*|*|*|
|*|*|*|Q|*|Q|*|*|
|Q|*|*|*|*|*|*|*|
Step:  6
[(7, 0), (5, 1), (2, 2), (6, 3), (1, 4), (0, 5), (4, 6), (3, 7)]
|*|*|*|*|*|Q|*|*|
|*|*|*|*|Q|*|*|*|
|*|*|Q|*|*|*|*|*|
|*|*|*|*|*|*|*|Q|
|*|*|*|*|*|*|Q|*|
|*|Q|*|*|*|*|*|*|
|*|*|*|Q|*|*|*|*|
|Q|*|*|*|*|*|*|*|
Step:  7
[(7, 0), (5, 1), (2, 2), (6, 3), (1, 4), (0, 5), (5, 6), (3, 7)]
|*|*|*|*|*|Q|*|*|
|*|*|*|*|Q|*|*|*|
|*|*|Q|*|*|*|*|*|
|*|*|*|*|*|*|*|Q|
|*|*|*|*|*|*|*|*|
|*|Q|*|*|*|*|Q|*|
|*|*|*|Q|*|*|*|*|
|Q|*|*|*|*|*|*|*|
```

```
Step:  8
[(7, 0), (2, 1), (2, 2), (6, 3), (1, 4), (0, 5), (5, 6), (3, 7)]
|*|*|*|*|*|Q|*|*|
|*|*|*|*|Q|*|*|*|
|*|Q|Q|*|*|*|*|*|
|*|*|*|*|*|*|*|Q|
|*|*|*|*|*|*|*|*|
|*|*|*|*|*|*|Q|*|
|*|*|*|Q|*|*|*|*|
|Q|*|*|*|*|*|*|*|
Step:  9
[(7, 0), (2, 1), (4, 2), (6, 3), (1, 4), (0, 5), (5, 6), (3, 7)]
|*|*|*|*|*|Q|*|*|
|*|*|*|*|Q|*|*|*|
|*|Q|*|*|*|*|*|*|
|*|*|*|*|*|*|*|Q|
|*|*|Q|*|*|*|*|*|
|*|*|*|*|*|*|Q|*|
|*|*|*|Q|*|*|*|*|
|Q|*|*|*|*|*|*|*|
Step:  10
[(7, 0), (2, 1), (4, 2), (6, 3), (4, 4), (0, 5), (5, 6), (3, 7)]
|*|*|*|*|*|Q|*|*|
|*|*|*|*|*|*|*|*|
|*|Q|*|*|*|*|*|*|
|*|*|*|*|*|*|*|Q|
|*|*|Q|*|Q|*|*|*|
|*|*|*|*|*|*|Q|*|
|*|*|*|Q|*|*|*|*|
|Q|*|*|*|*|*|*|*|
Step:  11
[(7, 0), (2, 1), (4, 2), (6, 3), (1, 4), (0, 5), (5, 6), (3, 7)]
|*|*|*|*|*|Q|*|*|
|*|*|*|*|Q|*|*|*|
|*|Q|*|*|*|*|*|*|
|*|*|*|*|*|*|*|Q|
|*|*|Q|*|*|*|*|*|
|*|*|*|*|*|*|Q|*|
|*|*|*|Q|*|*|*|*|
|Q|*|*|*|*|*|*|*|
Step:  12
[(7, 0), (2, 1), (4, 2), (6, 3), (1, 4), (3, 5), (5, 6), (3, 7)]
|*|*|*|*|*|*|*|*|
|*|*|*|*|Q|*|*|*|
|*|Q|*|*|*|*|*|*|
|*|*|*|*|*|Q|*|Q|
|*|*|Q|*|*|*|*|*|
|*|*|*|*|*|*|Q|*|
|*|*|*|Q|*|*|*|*|
|Q|*|*|*|*|*|*|*|
```

```
Step:  13
[(7, 0), (2, 1), (4, 2), (6, 3), (1, 4), (3, 5), (5, 6), (0, 7)]
|*|*|*|*|*|*|*|Q|
|*|*|*|*|Q|*|*|*|
|*|Q|*|*|*|*|*|*|
|*|*|*|*|*|Q|*|*|
|*|*|Q|*|*|*|*|*|
|*|*|*|*|*|*|Q|*|
|*|*|*|Q|*|*|*|*|
|Q|*|*|*|*|*|*|*|
Step:  14
[(0, 0), (2, 1), (4, 2), (6, 3), (1, 4), (3, 5), (5, 6), (0, 7)]
|Q|*|*|*|*|*|*|Q|
|*|*|*|*|Q|*|*|*|
|*|Q|*|*|*|*|*|*|
|*|*|*|*|*|Q|*|*|
|*|*|Q|*|*|*|*|*|
|*|*|*|*|*|*|Q|*|
|*|*|*|Q|*|*|*|*|
|*|*|*|*|*|*|*|*|
Step:  15
[(0, 0), (2, 1), (4, 2), (6, 3), (1, 4), (3, 5), (5, 6), (3, 7)]
|Q|*|*|*|*|*|*|*|
|*|*|*|*|Q|*|*|*|
|*|Q|*|*|*|*|*|*|
|*|*|*|*|*|Q|*|Q|
|*|*|Q|*|*|*|*|*|
|*|*|*|*|*|*|Q|*|
|*|*|*|Q|*|*|*|*|
|*|*|*|*|*|*|*|*|
Step:  16
[(0, 0), (2, 1), (4, 2), (6, 3), (1, 4), (3, 5), (5, 6), (0, 7)]
|Q|*|*|*|*|*|*|Q|
|*|*|*|*|Q|*|*|*|
|*|Q|*|*|*|*|*|*|
|*|*|*|*|*|Q|*|*|
|*|*|Q|*|*|*|*|*|
|*|*|*|*|*|*|Q|*|
|*|*|*|Q|*|*|*|*|
|*|*|*|*|*|*|*|*|
Step:  17
[(0, 0), (2, 1), (4, 2), (7, 3), (1, 4), (3, 5), (5, 6), (0, 7)]
|Q|*|*|*|*|*|*|Q|
|*|*|*|*|Q|*|*|*|
|*|Q|*|*|*|*|*|*|
|*|*|*|*|*|Q|*|*|
|*|*|Q|*|*|*|*|*|
|*|*|*|*|*|*|Q|*|
|*|*|*|*|*|*|*|*|
|*|*|*|Q|*|*|*|*|
```

```
Step:  18
[(0, 0), (2, 1), (4, 2), (7, 3), (1, 4), (3, 5), (5, 6), (2, 7)]
|Q|*|*|*|*|*|*|*|
|*|*|*|*|Q|*|*|*|
|*|Q|*|*|*|*|*|Q|
|*|*|*|*|*|Q|*|*|
|*|*|Q|*|*|*|*|*|
|*|*|*|*|*|*|Q|*|
|*|*|*|*|*|*|*|*|
|*|*|*|Q|*|*|*|*|
Success:
[(0, 0), (6, 1), (4, 2), (7, 3), (1, 4), (3, 5), (5, 6), (2, 7)]
|Q|*|*|*|*|*|*|*|
|*|*|*|*|Q|*|*|*|
|*|*|*|*|*|*|*|Q|
|*|*|*|*|*|*|Q|*|
|*|*|Q|*|*|*|*|*|
|*|*|*|*|*|*|Q|*|
|*|Q|*|*|*|*|*|*|
|*|*|*|Q|*|*|*|*|

Random Restart Hill Climbing Search
Initial:
[(1, 0), (4, 1), (3, 2), (2, 3), (6, 4), (2, 5), (3, 6), (3, 7)]
|*|*|*|*|*|*|*|*|
|Q|*|*|*|*|*|*|*|
|*|*|*|Q|*|Q|*|*|
|*|*|Q|*|*|*|Q|Q|
|*|Q|*|*|*|*|*|*|
|*|*|*|*|*|*|*|*|
|*|*|*|*|Q|*|*|*|
|*|*|*|*|*|*|*|*|
Step:  2
[(1, 0), (4, 1), (0, 2), (2, 3), (6, 4), (2, 5), (3, 6), (3, 7)]
|*|*|Q|*|*|*|*|*|
|Q|*|*|*|*|*|*|*|
|*|*|*|Q|*|Q|*|*|
|*|*|*|*|*|*|Q|Q|
|*|Q|*|*|*|*|*|*|
|*|*|*|*|*|*|*|*|
|*|*|*|*|Q|*|*|*|
|*|*|*|*|*|*|*|*|
Step:  3
[(1, 0), (4, 1), (0, 2), (2, 3), (6, 4), (2, 5), (3, 6), (7, 7)]
|*|*|Q|*|*|*|*|*|
|Q|*|*|*|*|*|*|*|
|*|*|*|Q|*|Q|*|*|
|*|*|*|*|*|*|Q|*|
|*|Q|*|*|*|*|*|*|
|*|*|*|*|*|*|*|*|
|*|*|*|*|Q|*|*|*|
|*|*|*|*|*|*|*|Q|
```

```
Step:  4
[(1, 0), (5, 1), (0, 2), (2, 3), (6, 4), (2, 5), (3, 6), (7, 7)]
|*|*|Q|*|*|*|*|*|
|Q|*|*|*|*|*|*|*|
|*|*|*|Q|*|Q|*|*|
|*|*|*|*|*|*|Q|*|
|*|*|*|*|*|*|*|*|
|*|Q|*|*|*|*|*|*|
|*|*|*|*|Q|*|*|*|
|*|*|*|*|*|*|*|Q|
Search Failed

Initial:
[(1, 0), (3, 1), (5, 2), (7, 3), (3, 4), (0, 5), (2, 6), (4, 7)]
|*|*|*|*|*|Q|*|*|
|Q|*|*|*|*|*|*|*|
|*|*|*|*|*|*|Q|*|
|*|Q|*|*|Q|*|*|*|
|*|*|*|*|*|*|*|Q|
|*|*|Q|*|*|*|*|*|
|*|*|*|*|*|*|*|*|
|*|*|*|Q|*|*|*|*|
Step:  2
[(1, 0), (3, 1), (5, 2), (7, 3), (2, 4), (0, 5), (2, 6), (4, 7)]
|*|*|*|*|*|Q|*|*|
|Q|*|*|*|*|*|*|*|
|*|*|*|*|Q|*|Q|*|
|*|Q|*|*|*|*|*|*|
|*|*|*|*|*|*|*|Q|
|*|*|Q|*|*|*|*|*|
|*|*|*|*|*|*|*|*|
|*|*|*|Q|*|*|*|*|
Success:
[(1, 0), (3, 1), (5, 2), (7, 3), (2, 4), (0, 5), (6, 6), (4, 7)]
|*|*|*|*|*|Q|*|*|
|Q|*|*|*|*|*|*|*|
|*|*|*|*|Q|*|*|*|
|*|Q|*|*|*|*|*|*|
|*|*|*|*|*|*|*|Q|
|*|*|Q|*|*|*|*|*|
|*|*|*|*|*|*|Q|*|
|*|*|*|Q|*|*|*|*|

Random Restart Hill Climbing Search with Sideways Analysis
Initial:
[(0, 0), (0, 1), (0, 2), (1, 3), (3, 4), (3, 5), (2, 6), (2, 7)]
|Q|Q|Q|*|*|*|*|*|
|*|*|*|Q|*|*|*|*|
|*|*|*|*|*|*|Q|Q|
|*|*|*|*|Q|Q|*|*|
|*|*|*|*|*|*|*|*|
|*|*|*|*|*|*|*|*|
```

```
|*|*|*|*|*|*|*|*|
|*|*|*|*|*|*|*|*|
Step:  2
[(0, 0), (0, 1), (0, 2), (1, 3), (3, 4), (7, 5), (2, 6), (2, 7)]
|Q|Q|Q|*|*|*|*|*|
|*|*|*|Q|*|*|*|*|
|*|*|*|*|*|*|Q|Q|
|*|*|*|*|Q|*|*|*|
|*|*|*|*|*|*|*|*|
|*|*|*|*|*|*|*|*|
|*|*|*|*|*|*|*|*|
|*|*|*|*|*|Q|*|*|
Step:  3
[(0, 0), (4, 1), (0, 2), (1, 3), (3, 4), (7, 5), (2, 6), (2, 7)]
|Q|*|Q|*|*|*|*|*|
|*|*|*|Q|*|*|*|*|
|*|*|*|*|*|*|Q|Q|
|*|*|*|*|Q|*|*|*|
|*|Q|*|*|*|*|*|*|
|*|*|*|*|*|*|*|*|
|*|*|*|*|*|*|*|*|
|*|*|*|*|*|Q|*|*|
Step:  4
[(6, 0), (4, 1), (0, 2), (1, 3), (3, 4), (7, 5), (2, 6), (2, 7)]
|*|*|Q|*|*|*|*|*|
|*|*|*|Q|*|*|*|*|
|*|*|*|*|*|*|Q|Q|
|*|*|*|*|Q|*|*|*|
|*|Q|*|*|*|*|*|*|
|*|*|*|*|*|*|*|*|
|Q|*|*|*|*|*|*|*|
|*|*|*|*|*|Q|*|*|
Step:  5
[(6, 0), (4, 1), (0, 2), (1, 3), (3, 4), (5, 5), (2, 6), (2, 7)]
|*|*|Q|*|*|*|*|*|
|*|*|*|Q|*|*|*|*|
|*|*|*|*|*|*|Q|Q|
|*|*|*|*|Q|*|*|*|
|*|Q|*|*|*|*|*|*|
|*|*|*|*|*|Q|*|*|
|Q|*|*|*|*|*|*|*|
|*|*|*|*|*|*|*|*|
Step:  6
[(6, 0), (4, 1), (0, 2), (1, 3), (3, 4), (5, 5), (7, 6), (2, 7)]
|*|*|Q|*|*|*|*|*|
|*|*|*|Q|*|*|*|*|
|*|*|*|*|*|*|*|Q|
|*|*|*|*|Q|*|*|*|
|*|Q|*|*|*|*|*|*|
|*|*|*|*|*|Q|*|*|
|Q|*|*|*|*|*|*|*|
|*|*|*|*|*|*|Q|*|
```

```
Step:  7
[(6, 0), (4, 1), (0, 2), (5, 3), (3, 4), (5, 5), (7, 6), (2, 7)]
|*|*|Q|*|*|*|*|*|
|*|*|*|*|*|*|*|*|
|*|*|*|*|*|*|*|Q|
|*|*|*|*|Q|*|*|*|
|*|Q|*|*|*|*|*|*|
|*|*|*|Q|*|Q|*|*|
|Q|*|*|*|*|*|*|*|
|*|*|*|*|*|*|Q|*|
Step:  8
[(6, 0), (4, 1), (0, 2), (0, 3), (3, 4), (5, 5), (7, 6), (2, 7)]
|*|*|Q|Q|*|*|*|*|
|*|*|*|*|*|*|*|*|
|*|*|*|*|*|*|*|Q|
|*|*|*|*|Q|*|*|*|
|*|Q|*|*|*|*|*|*|
|*|*|*|*|*|Q|*|*|
|Q|*|*|*|*|*|*|*|
|*|*|*|*|*|*|Q|*|
Step:  9
[(6, 0), (4, 1), (6, 2), (0, 3), (3, 4), (5, 5), (7, 6), (2, 7)]
|*|*|*|Q|*|*|*|*|
|*|*|*|*|*|*|*|*|
|*|*|*|*|*|*|*|Q|
|*|*|*|*|Q|*|*|*|
|*|Q|*|*|*|*|*|*|
|*|*|*|*|*|Q|*|*|
|Q|*|Q|*|*|*|*|*|
|*|*|*|*|*|*|Q|*|
Step:  10
[(6, 0), (4, 1), (6, 2), (1, 3), (3, 4), (5, 5), (7, 6), (2, 7)]
|*|*|*|*|*|*|*|*|
|*|*|*|Q|*|*|*|*|
|*|*|*|*|*|*|*|Q|
|*|*|*|*|Q|*|*|*|
|*|Q|*|*|*|*|*|*|
|*|*|*|*|*|Q|*|*|
|Q|*|Q|*|*|*|*|*|
|*|*|*|*|*|*|Q|*|
Step:  11
[(6, 0), (4, 1), (6, 2), (0, 3), (3, 4), (5, 5), (7, 6), (2, 7)]
|*|*|*|Q|*|*|*|*|
|*|*|*|*|*|*|*|*|
|*|*|*|*|*|*|*|Q|
|*|*|*|*|Q|*|*|*|
|*|Q|*|*|*|*|*|*|
|*|*|*|*|*|Q|*|*|
|Q|*|Q|*|*|*|*|*|
|*|*|*|*|*|*|Q|*|
```

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Step:  12
[(6, 0), (4, 1), (6, 2), (1, 3), (3, 4), (5, 5), (7, 6), (2, 7)]
|*|*|*|*|*|*|*|*|
|*|*|*|Q|*|*|*|*|
|*|*|*|*|*|*|*|Q|
|*|*|*|*|Q|*|*|*|
|*|Q|*|*|*|*|*|*|
|*|*|*|*|*|Q|*|*|
|Q|*|Q|*|*|*|*|*|
|*|*|*|*|*|*|Q|*|
Step:  13
[(6, 0), (4, 1), (0, 2), (1, 3), (3, 4), (5, 5), (7, 6), (2, 7)]
|*|*|Q|*|*|*|*|*|
|*|*|*|Q|*|*|*|*|
|*|*|*|*|*|*|*|Q|
|*|*|*|*|Q|*|*|*|
|*|Q|*|*|*|*|*|*|
|*|*|*|*|*|Q|*|*|
|Q|*|*|*|*|*|*|*|
|*|*|*|*|*|*|Q|*|
Step:  14
[(6, 0), (4, 1), (6, 2), (1, 3), (3, 4), (5, 5), (7, 6), (2, 7)]
|*|*|*|*|*|*|*|*|
|*|*|*|Q|*|*|*|*|
|*|*|*|*|*|*|*|Q|
|*|*|*|*|Q|*|*|*|
|*|Q|*|*|*|*|*|*|
|*|*|*|*|*|Q|*|*|
|Q|*|Q|*|*|*|*|*|
|*|*|*|*|*|*|Q|*|
Step:  15
[(2, 0), (4, 1), (6, 2), (1, 3), (3, 4), (5, 5), (7, 6), (2, 7)]
|*|*|*|*|*|*|*|*|
|*|*|*|Q|*|*|*|*|
|Q|*|*|*|*|*|*|Q|
|*|*|*|*|Q|*|*|*|
|*|Q|*|*|*|*|*|*|
|*|*|*|*|*|Q|*|*|
|*|*|Q|*|*|*|*|*|
|*|*|*|*|*|*|Q|*|
Step:  16
[(2, 0), (4, 1), (6, 2), (1, 3), (3, 4), (5, 5), (7, 6), (0, 7)]
|*|*|*|*|*|*|*|Q|
|*|*|*|Q|*|*|*|*|
|Q|*|*|*|*|*|*|*|
|*|*|*|*|Q|*|*|*|
|*|Q|*|*|*|*|*|*|
|*|*|*|*|*|Q|*|*|
|*|*|Q|*|*|*|*|*|
|*|*|*|*|*|*|Q|*|
```

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Step:  17
[(2, 0), (4, 1), (6, 2), (1, 3), (3, 4), (5, 5), (7, 6), (2, 7)]
|*|*|*|*|*|*|*|*|
|*|*|*|Q|*|*|*|*|
|Q|*|*|*|*|*|*|Q|
|*|*|*|*|Q|*|*|*|
|*|Q|*|*|*|*|*|*|
|*|*|*|*|*|Q|*|*|
|*|*|Q|*|*|*|*|*|
|*|*|*|*|*|*|Q|*|
Step:  18
[(2, 0), (4, 1), (6, 2), (1, 3), (3, 4), (5, 5), (7, 6), (4, 7)]
|*|*|*|*|*|*|*|*|
|*|*|*|Q|*|*|*|*|
|Q|*|*|*|*|*|*|*|
|*|*|*|*|Q|*|*|*|
|*|Q|*|*|*|*|*|Q|
|*|*|*|*|*|Q|*|*|
|*|*|Q|*|*|*|*|*|
|*|*|*|*|*|*|Q|*|
Step:  19
[(2, 0), (0, 1), (6, 2), (1, 3), (3, 4), (5, 5), (7, 6), (4, 7)]
|*|Q|*|*|*|*|*|*|
|*|*|*|Q|*|*|*|*|
|Q|*|*|*|*|*|*|*|
|*|*|*|*|Q|*|*|*|
|*|*|*|*|*|*|*|Q|
|*|*|*|*|*|Q|*|*|
|*|*|Q|*|*|*|*|*|
|*|*|*|*|*|*|Q|*|
Step:  20
[(2, 0), (4, 1), (6, 2), (1, 3), (3, 4), (5, 5), (7, 6), (4, 7)]
|*|*|*|*|*|*|*|*|
|*|*|*|Q|*|*|*|*|
|Q|*|*|*|*|*|*|*|
|*|*|*|*|Q|*|*|*|
|*|Q|*|*|*|*|*|Q|
|*|*|*|*|*|Q|*|*|
|*|*|Q|*|*|*|*|*|
|*|*|*|*|*|*|Q|*|
Step:  21
[(2, 0), (4, 1), (6, 2), (1, 3), (3, 4), (5, 5), (0, 6), (4, 7)]
|*|*|*|*|*|*|Q|*|
|*|*|*|Q|*|*|*|*|
|Q|*|*|*|*|*|*|*|
|*|*|*|*|Q|*|*|*|
|*|Q|*|*|*|*|*|Q|
|*|*|*|*|*|Q|*|*|
|*|*|Q|*|*|*|*|*|
|*|*|*|*|*|*|*|*|
```

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Step:  22
[(2, 0), (4, 1), (6, 2), (1, 3), (3, 4), (5, 5), (7, 6), (4, 7)]
|*|*|*|*|*|*|*|*|
|*|*|*|Q|*|*|*|*|
|Q|*|*|*|*|*|*|*|
|*|*|*|*|Q|*|*|*|
|*|Q|*|*|*|*|*|Q|
|*|*|*|*|*|Q|*|*|
|*|*|Q|*|*|*|*|*|
|*|*|*|*|*|*|Q|*|
Step:  23
[(2, 0), (4, 1), (6, 2), (1, 3), (3, 4), (5, 5), (7, 6), (2, 7)]
|*|*|*|*|*|*|*|*|
|*|*|*|Q|*|*|*|*|
|Q|*|*|*|*|*|*|Q|
|*|*|*|*|Q|*|*|*|
|*|Q|*|*|*|*|*|*|
|*|*|*|*|*|Q|*|*|
|*|*|Q|*|*|*|*|*|
|*|*|*|*|*|*|Q|*|
Step:  24
[(2, 0), (4, 1), (6, 2), (1, 3), (3, 4), (5, 5), (0, 6), (2, 7)]
|*|*|*|*|*|*|Q|*|
|*|*|*|Q|*|*|*|*|
|Q|*|*|*|*|*|*|Q|
|*|*|*|*|Q|*|*|*|
|*|Q|*|*|*|*|*|*|
|*|*|*|*|*|Q|*|*|
|*|*|Q|*|*|*|*|*|
|*|*|*|*|*|*|*|*|
Step:  25
[(2, 0), (4, 1), (6, 2), (1, 3), (3, 4), (5, 5), (7, 6), (2, 7)]
|*|*|*|*|*|*|*|*|
|*|*|*|Q|*|*|*|*|
|Q|*|*|*|*|*|*|Q|
|*|*|*|*|Q|*|*|*|
|*|Q|*|*|*|*|*|*|
|*|*|*|*|*|Q|*|*|
|*|*|Q|*|*|*|*|*|
|*|*|*|*|*|*|Q|*|
Step:  26
[(2, 0), (4, 1), (6, 2), (0, 3), (3, 4), (5, 5), (7, 6), (2, 7)]
|*|*|*|Q|*|*|*|*|
|*|*|*|*|*|*|*|*|
|Q|*|*|*|*|*|*|Q|
|*|*|*|*|Q|*|*|*|
|*|Q|*|*|*|*|*|*|
|*|*|*|*|*|Q|*|*|
|*|*|Q|*|*|*|*|*|
|*|*|*|*|*|*|Q|*|
```

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Step:  27
[(6, 0), (4, 1), (6, 2), (0, 3), (3, 4), (5, 5), (7, 6), (2, 7)]
|*|*|*|Q|*|*|*|*|
|*|*|*|*|*|*|*|*|
|*|*|*|*|*|*|*|Q|
|*|*|*|*|Q|*|*|*|
|*|Q|*|*|*|*|*|*|
|*|*|*|*|*|Q|*|*|
|Q|*|Q|*|*|*|*|*|
|*|*|*|*|*|*|Q|*|
Step:  28
[(1, 0), (4, 1), (6, 2), (0, 3), (3, 4), (5, 5), (7, 6), (2, 7)]
|*|*|*|Q|*|*|*|*|
|Q|*|*|*|*|*|*|*|
|*|*|*|*|*|*|*|Q|
|*|*|*|*|Q|*|*|*|
|*|Q|*|*|*|*|*|*|
|*|*|*|*|*|Q|*|*|
|*|*|Q|*|*|*|*|*|
|*|*|*|*|*|*|Q|*|
Step:  29
[(6, 0), (4, 1), (6, 2), (0, 3), (3, 4), (5, 5), (7, 6), (2, 7)]
|*|*|*|Q|*|*|*|*|
|*|*|*|*|*|*|*|*|
|*|*|*|*|*|*|*|Q|
|*|*|*|*|Q|*|*|*|
|*|Q|*|*|*|*|*|*|
|*|*|*|*|*|Q|*|*|
|Q|*|Q|*|*|*|*|*|
|*|*|*|*|*|*|Q|*|
Step:  30
[(6, 0), (4, 1), (6, 2), (1, 3), (3, 4), (5, 5), (7, 6), (2, 7)]
|*|*|*|*|*|*|*|*|
|*|*|*|Q|*|*|*|*|
|*|*|*|*|*|*|*|Q|
|*|*|*|*|Q|*|*|*|
|*|Q|*|*|*|*|*|*|
|*|*|*|*|*|Q|*|*|
|Q|*|Q|*|*|*|*|*|
|*|*|*|*|*|*|Q|*|
Step:  31
[(6, 0), (4, 1), (6, 2), (0, 3), (3, 4), (5, 5), (7, 6), (2, 7)]
|*|*|*|Q|*|*|*|*|
|*|*|*|*|*|*|*|*|
|*|*|*|*|*|*|*|Q|
|*|*|*|*|Q|*|*|*|
|*|Q|*|*|*|*|*|*|
|*|*|*|*|*|Q|*|*|
|Q|*|Q|*|*|*|*|*|
|*|*|*|*|*|*|Q|*|
```

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Step:  32
[(6, 0), (4, 1), (0, 2), (0, 3), (3, 4), (5, 5), (7, 6), (2, 7)]
|*|*|Q|Q|*|*|*|*|
|*|*|*|*|*|*|*|*|
|*|*|*|*|*|*|*|Q|
|*|*|*|*|Q|*|*|*|
|*|Q|*|*|*|*|*|*|
|*|*|*|*|*|Q|*|*|
|Q|*|*|*|*|*|*|*|
|*|*|*|*|*|*|Q|*|
Step:  33
[(6, 0), (4, 1), (0, 2), (1, 3), (3, 4), (5, 5), (7, 6), (2, 7)]
|*|*|Q|*|*|*|*|*|
|*|*|*|Q|*|*|*|*|
|*|*|*|*|*|*|*|Q|
|*|*|*|*|Q|*|*|*|
|*|Q|*|*|*|*|*|*|
|*|*|*|*|*|Q|*|*|
|Q|*|*|*|*|*|*|*|
|*|*|*|*|*|*|Q|*|
Step:  34
[(6, 0), (4, 1), (0, 2), (5, 3), (3, 4), (5, 5), (7, 6), (2, 7)]
|*|*|Q|*|*|*|*|*|
|*|*|*|*|*|*|*|*|
|*|*|*|*|*|*|*|Q|
|*|*|*|*|Q|*|*|*|
|*|Q|*|*|*|*|*|*|
|*|*|*|Q|*|Q|*|*|
|Q|*|*|*|*|*|*|*|
|*|*|*|*|*|*|Q|*|
Step:  35
[(6, 0), (4, 1), (0, 2), (0, 3), (3, 4), (5, 5), (7, 6), (2, 7)]
|*|*|Q|Q|*|*|*|*|
|*|*|*|*|*|*|*|*|
|*|*|*|*|*|*|*|Q|
|*|*|*|*|Q|*|*|*|
|*|Q|*|*|*|*|*|*|
|*|*|*|*|*|Q|*|*|
|Q|*|*|*|*|*|*|*|
|*|*|*|*|*|*|Q|*|
Step:  36
[(6, 0), (4, 1), (6, 2), (0, 3), (3, 4), (5, 5), (7, 6), (2, 7)]
|*|*|*|Q|*|*|*|*|
|*|*|*|*|*|*|*|*|
|*|*|*|*|*|*|*|Q|
|*|*|*|*|Q|*|*|*|
|*|Q|*|*|*|*|*|*|
|*|*|*|*|*|Q|*|*|
|Q|*|Q|*|*|*|*|*|
|*|*|*|*|*|*|Q|*|
```

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Step:  37
[(1, 0), (4, 1), (6, 2), (0, 3), (3, 4), (5, 5), (7, 6), (2, 7)]
|*|*|*|Q|*|*|*|*|
|Q|*|*|*|*|*|*|*|
|*|*|*|*|*|*|*|Q|
|*|*|*|*|Q|*|*|*|
|*|Q|*|*|*|*|*|*|
|*|*|*|*|*|Q|*|*|
|*|*|Q|*|*|*|*|*|
|*|*|*|*|*|*|Q|*|
Step:  38
[(6, 0), (4, 1), (6, 2), (0, 3), (3, 4), (5, 5), (7, 6), (2, 7)]
|*|*|*|Q|*|*|*|*|
|*|*|*|*|*|*|*|*|
|*|*|*|*|*|*|*|Q|
|*|*|*|*|Q|*|*|*|
|*|Q|*|*|*|*|*|*|
|*|*|*|*|*|Q|*|*|
|Q|*|Q|*|*|*|*|*|
|*|*|*|*|*|*|Q|*|
Step:  39
[(6, 0), (4, 1), (6, 2), (1, 3), (3, 4), (5, 5), (7, 6), (2, 7)]
|*|*|*|*|*|*|*|*|
|*|*|*|Q|*|*|*|*|
|*|*|*|*|*|*|*|Q|
|*|*|*|*|Q|*|*|*|
|*|Q|*|*|*|*|*|*|
|*|*|*|*|*|Q|*|*|
|Q|*|Q|*|*|*|*|*|
|*|*|*|*|*|*|Q|*|
Step:  40
[(6, 0), (4, 1), (0, 2), (1, 3), (3, 4), (5, 5), (7, 6), (2, 7)]
|*|*|Q|*|*|*|*|*|
|*|*|*|Q|*|*|*|*|
|*|*|*|*|*|*|*|Q|
|*|*|*|*|Q|*|*|*|
|*|Q|*|*|*|*|*|*|
|*|*|*|*|*|Q|*|*|
|Q|*|*|*|*|*|*|*|
|*|*|*|*|*|*|Q|*|
Step:  41
[(6, 0), (4, 1), (6, 2), (1, 3), (3, 4), (5, 5), (7, 6), (2, 7)]
|*|*|*|*|*|*|*|*|
|*|*|*|Q|*|*|*|*|
|*|*|*|*|*|*|*|Q|
|*|*|*|*|Q|*|*|*|
|*|Q|*|*|*|*|*|*|
|*|*|*|*|*|Q|*|*|
|Q|*|Q|*|*|*|*|*|
|*|*|*|*|*|*|Q|*|
```

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Step:  42
[(0, 0), (4, 1), (6, 2), (1, 3), (3, 4), (5, 5), (7, 6), (2, 7)]
|Q|*|*|*|*|*|*|*|
|*|*|*|Q|*|*|*|*|
|*|*|*|*|*|*|*|Q|
|*|*|*|*|Q|*|*|*|
|*|Q|*|*|*|*|*|*|
|*|*|*|*|*|Q|*|*|
|*|*|Q|*|*|*|*|*|
|*|*|*|*|*|*|Q|*|
Step:  43
[(0, 0), (4, 1), (6, 2), (1, 3), (3, 4), (7, 5), (7, 6), (2, 7)]
|Q|*|*|*|*|*|*|*|
|*|*|*|Q|*|*|*|*|
|*|*|*|*|*|*|*|Q|
|*|*|*|*|Q|*|*|*|
|*|Q|*|*|*|*|*|*|
|*|*|*|*|*|*|*|*|
|*|*|Q|*|*|*|*|*|
|*|*|*|*|*|Q|Q|*|
Step:  44
[(0, 0), (4, 1), (6, 2), (1, 3), (3, 4), (7, 5), (5, 6), (2, 7)]
|Q|*|*|*|*|*|*|*|
|*|*|*|Q|*|*|*|*|
|*|*|*|*|*|*|*|Q|
|*|*|*|*|Q|*|*|*|
|*|Q|*|*|*|*|*|*|
|*|*|*|*|*|*|Q|*|
|*|*|Q|*|*|*|*|*|
|*|*|*|*|*|Q|*|*|
Step:  45
[(0, 0), (4, 1), (6, 2), (1, 3), (3, 4), (7, 5), (0, 6), (2, 7)]
|Q|*|*|*|*|*|Q|*|
|*|*|*|Q|*|*|*|*|
|*|*|*|*|*|*|*|Q|
|*|*|*|*|Q|*|*|*|
|*|Q|*|*|*|*|*|*|
|*|*|*|*|*|*|*|*|
|*|*|Q|*|*|*|*|*|
|*|*|*|*|*|Q|*|*|
Step:  46
[(1, 0), (4, 1), (6, 2), (1, 3), (3, 4), (7, 5), (0, 6), (2, 7)]
|*|*|*|*|*|*|Q|*|
|Q|*|*|Q|*|*|*|*|
|*|*|*|*|*|*|*|Q|
|*|*|*|*|Q|*|*|*|
|*|Q|*|*|*|*|*|*|
|*|*|*|*|*|*|*|*|
|*|*|Q|*|*|*|*|*|
|*|*|*|*|*|Q|*|*|
```

```
Step:  47
[(0, 0), (4, 1), (6, 2), (1, 3), (3, 4), (7, 5), (0, 6), (2, 7)]
|Q|*|*|*|*|*|Q|*|
|*|*|*|Q|*|*|*|*|
|*|*|*|*|*|*|*|Q|
|*|*|*|*|Q|*|*|*|
|*|Q|*|*|*|*|*|*|
|*|*|*|*|*|*|*|*|
|*|*|Q|*|*|*|*|*|
|*|*|*|*|*|Q|*|*|
Step:  48
[(0, 0), (4, 1), (6, 2), (1, 3), (3, 4), (7, 5), (7, 6), (2, 7)]
|Q|*|*|*|*|*|*|*|
|*|*|*|Q|*|*|*|*|
|*|*|*|*|*|*|*|Q|
|*|*|*|*|Q|*|*|*|
|*|Q|*|*|*|*|*|*|
|*|*|*|*|*|*|*|*|
|*|*|Q|*|*|*|*|*|
|*|*|*|*|*|Q|Q|*|
Step:  49
[(0, 0), (4, 1), (6, 2), (1, 3), (3, 4), (7, 5), (5, 6), (2, 7)]
|Q|*|*|*|*|*|*|*|
|*|*|*|Q|*|*|*|*|
|*|*|*|*|*|*|*|Q|
|*|*|*|*|Q|*|*|*|
|*|Q|*|*|*|*|*|*|
|*|*|*|*|*|*|Q|*|
|*|*|Q|*|*|*|*|*|
|*|*|*|*|*|Q|*|*|
Step:  50
[(0, 0), (4, 1), (6, 2), (1, 3), (3, 4), (7, 5), (7, 6), (2, 7)]
|Q|*|*|*|*|*|*|*|
|*|*|*|Q|*|*|*|*|
|*|*|*|*|*|*|*|Q|
|*|*|*|*|Q|*|*|*|
|*|Q|*|*|*|*|*|*|
|*|*|*|*|*|*|*|*|
|*|*|Q|*|*|*|*|*|
|*|*|*|*|*|Q|Q|*|
Step:  51
[(0, 0), (4, 1), (6, 2), (1, 3), (3, 4), (7, 5), (0, 6), (2, 7)]
|Q|*|*|*|*|*|Q|*|
|*|*|*|Q|*|*|*|*|
|*|*|*|*|*|*|*|Q|
|*|*|*|*|Q|*|*|*|
|*|Q|*|*|*|*|*|*|
|*|*|*|*|*|*|*|*|
|*|*|Q|*|*|*|*|*|
|*|*|*|*|*|Q|*|*|
```

```
Step:  52
[(0, 0), (4, 1), (6, 2), (1, 3), (3, 4), (7, 5), (5, 6), (2, 7)]
|Q|*|*|*|*|*|*|*|
|*|*|*|Q|*|*|*|*|
|*|*|*|*|*|*|*|Q|
|*|*|*|*|Q|*|*|*|
|*|Q|*|*|*|*|*|*|
|*|*|*|*|*|*|Q|*|
|*|*|Q|*|*|*|*|*|
|*|*|*|*|*|Q|*|*|
Step:  53
[(0, 0), (4, 1), (6, 2), (1, 3), (3, 4), (7, 5), (7, 6), (2, 7)]
|Q|*|*|*|*|*|*|*|
|*|*|*|Q|*|*|*|*|
|*|*|*|*|*|*|*|Q|
|*|*|*|*|Q|*|*|*|
|*|Q|*|*|*|*|*|*|
|*|*|*|*|*|*|*|*|
|*|*|Q|*|*|*|*|*|
|*|*|*|*|*|Q|Q|*|
Step:  54
[(0, 0), (4, 1), (6, 2), (1, 3), (3, 4), (1, 5), (7, 6), (2, 7)]
|Q|*|*|*|*|*|*|*|
|*|*|*|Q|*|Q|*|*|
|*|*|*|*|*|*|*|Q|
|*|*|*|*|Q|*|*|*|
|*|Q|*|*|*|*|*|*|
|*|*|*|*|*|*|*|*|
|*|*|Q|*|*|*|*|*|
|*|*|*|*|*|*|Q|*|
Step:  55
[(0, 0), (4, 1), (6, 2), (0, 3), (3, 4), (1, 5), (7, 6), (2, 7)]
|Q|*|*|Q|*|*|*|*|
|*|*|*|*|*|Q|*|*|
|*|*|*|*|*|*|*|Q|
|*|*|*|*|Q|*|*|*|
|*|Q|*|*|*|*|*|*|
|*|*|*|*|*|*|*|*|
|*|*|Q|*|*|*|*|*|
|*|*|*|*|*|*|Q|*|
Step:  56
[(5, 0), (4, 1), (6, 2), (0, 3), (3, 4), (1, 5), (7, 6), (2, 7)]
|*|*|*|Q|*|*|*|*|
|*|*|*|*|*|Q|*|*|
|*|*|*|*|*|*|*|Q|
|*|*|*|*|Q|*|*|*|
|*|Q|*|*|*|*|*|*|
|Q|*|*|*|*|*|*|*|
|*|*|Q|*|*|*|*|*|
|*|*|*|*|*|*|Q|*|
```

```
Step:  57
[(5, 0), (1, 1), (6, 2), (0, 3), (3, 4), (1, 5), (7, 6), (2, 7)]
|*|*|*|Q|*|*|*|*|
|*|Q|*|*|*|Q|*|*|
|*|*|*|*|*|*|*|Q|
|*|*|*|*|Q|*|*|*|
|*|*|*|*|*|*|*|*|
|Q|*|*|*|*|*|*|*|
|*|*|Q|*|*|*|*|*|
|*|*|*|*|*|*|Q|*|
Step:  58
[(5, 0), (1, 1), (6, 2), (0, 3), (3, 4), (7, 5), (7, 6), (2, 7)]
|*|*|*|Q|*|*|*|*|
|*|Q|*|*|*|*|*|*|
|*|*|*|*|*|*|*|Q|
|*|*|*|*|Q|*|*|*|
|*|*|*|*|*|*|*|*|
|Q|*|*|*|*|*|*|*|
|*|*|Q|*|*|*|*|*|
|*|*|*|*|*|Q|Q|*|
Success:
[(5, 0), (1, 1), (6, 2), (0, 3), (3, 4), (7, 5), (4, 6), (2, 7)]
|*|*|*|Q|*|*|*|*|
|*|Q|*|*|*|*|*|*|
|*|*|*|*|*|*|*|Q|
|*|*|*|*|Q|*|*|*|
|*|*|*|*|*|*|Q|*|
|Q|*|*|*|*|*|*|*|
|*|*|Q|*|*|*|*|*|
|*|*|*|*|*|Q|*|*|

Hill Climbing Search Analysis
Initial:
[(0, 0), (6, 1), (7, 2), (6, 3), (0, 4), (6, 5), (4, 6), (3, 7)]
|Q|*|*|*|Q|*|*|*|
|*|*|*|*|*|*|*|*|
|*|*|*|*|*|*|*|*|
|*|*|*|*|*|*|*|Q|
|*|*|*|*|*|*|Q|*|
|*|*|*|*|*|*|*|*|
|*|Q|*|Q|*|Q|*|*|
|*|*|Q|*|*|*|*|*|
Step:  2
[(0, 0), (6, 1), (7, 2), (2, 3), (0, 4), (6, 5), (4, 6), (3, 7)]
|Q|*|*|*|Q|*|*|*|
|*|*|*|*|*|*|*|*|
|*|*|*|Q|*|*|*|*|
|*|*|*|*|*|*|*|Q|
|*|*|*|*|*|*|Q|*|
|*|*|*|*|*|*|*|*|
|*|Q|*|*|*|Q|*|*|
|*|*|Q|*|*|*|*|*|
```

```
Step:  3
[(0, 0), (6, 1), (7, 2), (2, 3), (0, 4), (6, 5), (4, 6), (1, 7)]
|Q|*|*|*|Q|*|*|*|
|*|*|*|*|*|*|*|Q|
|*|*|*|Q|*|*|*|*|
|*|*|*|*|*|*|*|*|
|*|*|*|*|*|*|Q|*|
|*|*|*|*|*|*|*|*|
|*|Q|*|*|*|Q|*|*|
|*|*|Q|*|*|*|*|*|
Step:  4
[(0, 0), (5, 1), (7, 2), (2, 3), (0, 4), (6, 5), (4, 6), (1, 7)]
|Q|*|*|*|Q|*|*|*|
|*|*|*|*|*|*|*|Q|
|*|*|*|Q|*|*|*|*|
|*|*|*|*|*|*|*|*|
|*|*|*|*|*|*|Q|*|
|*|Q|*|*|*|*|*|*|
|*|*|*|*|*|Q|*|*|
|*|*|Q|*|*|*|*|*|
Success:
[(3, 0), (5, 1), (7, 2), (2, 3), (0, 4), (6, 5), (4, 6), (1, 7)]
|*|*|*|*|Q|*|*|*|
|*|*|*|*|*|*|*|Q|
|*|*|*|Q|*|*|*|*|
|Q|*|*|*|*|*|*|*|
|*|*|*|*|*|*|Q|*|
|*|Q|*|*|*|*|*|*|
|*|*|*|*|*|Q|*|*|
|*|*|Q|*|*|*|*|*|

Hill climbing Search with Sideways Analysis
Initial:
[(0, 0), (6, 1), (7, 2), (6, 3), (0, 4), (6, 5), (4, 6), (3, 7)]
|Q|*|*|*|Q|*|*|*|
|*|*|*|*|*|*|*|*|
|*|*|*|*|*|*|*|*|
|*|*|*|*|*|*|*|Q|
|*|*|*|*|*|*|Q|*|
|*|*|*|*|*|*|*|*|
|*|Q|*|Q|*|Q|*|*|
|*|*|Q|*|*|*|*|*|
Step:  2
[(0, 0), (6, 1), (7, 2), (2, 3), (0, 4), (6, 5), (4, 6), (3, 7)]
|Q|*|*|*|Q|*|*|*|
|*|*|*|*|*|*|*|*|
|*|*|*|Q|*|*|*|*|
|*|*|*|*|*|*|*|Q|
|*|*|*|*|*|*|Q|*|
|*|*|*|*|*|*|*|*|
|*|Q|*|*|*|Q|*|*|
|*|*|Q|*|*|*|*|*|
```

```
Step:  3
[(0, 0), (5, 1), (7, 2), (2, 3), (0, 4), (6, 5), (4, 6), (3, 7)]
|Q|*|*|*|Q|*|*|*|
|*|*|*|*|*|*|*|*|
|*|*|*|Q|*|*|*|*|
|*|*|*|*|*|*|*|Q|
|*|*|*|*|*|*|Q|*|
|*|Q|*|*|*|*|*|*|
|*|*|*|*|*|Q|*|*|
|*|*|Q|*|*|*|*|*|
Step:  4
[(0, 0), (5, 1), (7, 2), (2, 3), (0, 4), (6, 5), (4, 6), (1, 7)]
|Q|*|*|*|Q|*|*|*|
|*|*|*|*|*|*|*|Q|
|*|*|*|Q|*|*|*|*|
|*|*|*|*|*|*|*|*|
|*|*|*|*|*|*|Q|*|
|*|Q|*|*|*|*|*|*|
|*|*|*|*|*|Q|*|*|
|*|*|Q|*|*|*|*|*|
Success:
[(3, 0), (5, 1), (7, 2), (2, 3), (0, 4), (6, 5), (4, 6), (1, 7)]
|*|*|*|*|Q|*|*|*|
|*|*|*|*|*|*|*|Q|
|*|*|*|Q|*|*|*|*|
|Q|*|*|*|*|*|*|*|
|*|*|*|*|*|*|Q|*|
|*|Q|*|*|*|*|*|*|
|*|*|*|*|*|Q|*|*|
|*|*|Q|*|*|*|*|*|

Random Restart Hill Climbing Search
Initial:
[(3, 0), (0, 1), (7, 2), (2, 3), (6, 4), (6, 5), (4, 6), (7, 7)]
|*|Q|*|*|*|*|*|*|
|*|*|*|*|*|*|*|*|
|*|*|*|Q|*|*|*|*|
|Q|*|*|*|*|*|*|*|
|*|*|*|*|*|*|Q|*|
|*|*|*|*|*|*|*|*|
|*|*|*|*|Q|Q|*|*|
|*|*|Q|*|*|*|*|Q|
Step:  2
[(3, 0), (0, 1), (7, 2), (2, 3), (6, 4), (6, 5), (1, 6), (7, 7)]
|*|Q|*|*|*|*|*|*|
|*|*|*|*|*|*|Q|*|
|*|*|*|Q|*|*|*|*|
|Q|*|*|*|*|*|*|*|
|*|*|*|*|*|*|*|*|
|*|*|*|*|*|*|*|*|
|*|*|*|*|Q|Q|*|*|
|*|*|Q|*|*|*|*|Q|
```

```
Step:  3
[(3, 0), (0, 1), (7, 2), (2, 3), (6, 4), (6, 5), (1, 6), (5, 7)]
|*|Q|*|*|*|*|*|*|
|*|*|*|*|*|*|Q|*|
|*|*|*|Q|*|*|*|*|
|Q|*|*|*|*|*|*|*|
|*|*|*|*|*|*|*|*|
|*|*|*|*|*|*|*|Q|
|*|*|*|*|Q|Q|*|*|
|*|*|Q|*|*|*|*|*|
Step:  4
[(3, 0), (0, 1), (7, 2), (2, 3), (4, 4), (6, 5), (1, 6), (5, 7)]
|*|Q|*|*|*|*|*|*|
|*|*|*|*|*|*|Q|*|
|*|*|*|Q|*|*|*|*|
|Q|*|*|*|*|*|*|*|
|*|*|*|*|Q|*|*|*|
|*|*|*|*|*|*|*|Q|
|*|*|*|*|*|Q|*|*|
|*|*|Q|*|*|*|*|*|
Search Failed

Initial:
[(4, 0), (2, 1), (0, 2), (6, 3), (0, 4), (7, 5), (0, 6), (1, 7)]
|*|*|Q|*|Q|*|Q|*|
|*|*|*|*|*|*|*|Q|
|*|Q|*|*|*|*|*|*|
|*|*|*|*|*|*|*|*|
|Q|*|*|*|*|*|*|*|
|*|*|*|*|*|*|*|*|
|*|*|*|Q|*|*|*|*|
|*|*|*|*|*|Q|*|*|
Step:  2
[(4, 0), (2, 1), (0, 2), (6, 3), (3, 4), (7, 5), (0, 6), (1, 7)]
|*|*|Q|*|*|*|Q|*|
|*|*|*|*|*|*|*|Q|
|*|Q|*|*|*|*|*|*|
|*|*|*|*|Q|*|*|*|
|Q|*|*|*|*|*|*|*|
|*|*|*|*|*|*|*|*|
|*|*|*|Q|*|*|*|*|
|*|*|*|*|*|Q|*|*|
Step:  3
[(4, 0), (2, 1), (0, 2), (6, 3), (3, 4), (7, 5), (5, 6), (1, 7)]
|*|*|Q|*|*|*|*|*|
|*|*|*|*|*|*|*|Q|
|*|Q|*|*|*|*|*|*|
|*|*|*|*|Q|*|*|*|
|Q|*|*|*|*|*|*|*|
|*|*|*|*|*|*|Q|*|
|*|*|*|Q|*|*|*|*|
|*|*|*|*|*|Q|*|*|
```

```
Search Failed

Initial:
[(7, 0), (4, 1), (6, 2), (7, 3), (6, 4), (7, 5), (3, 6), (1, 7)]
|*|*|*|*|*|*|*|*|
|*|*|*|*|*|*|*|Q|
|*|*|*|*|*|*|*|*|
|*|*|*|*|*|*|Q|*|
|*|Q|*|*|*|*|*|*|
|*|*|*|*|*|*|*|*|
|*|*|Q|*|Q|*|*|*|
|Q|*|*|Q|*|Q|*|*|
Step:  2
[(7, 0), (4, 1), (6, 2), (7, 3), (2, 4), (7, 5), (3, 6), (1, 7)]
|*|*|*|*|*|*|*|*|
|*|*|*|*|*|*|*|Q|
|*|*|*|*|Q|*|*|*|
|*|*|*|*|*|*|Q|*|
|*|Q|*|*|*|*|*|*|
|*|*|*|*|*|*|*|*|
|*|*|Q|*|*|*|*|*|
|Q|*|*|Q|*|Q|*|*|
Step:  3
[(0, 0), (4, 1), (6, 2), (7, 3), (2, 4), (7, 5), (3, 6), (1, 7)]
|Q|*|*|*|*|*|*|*|
|*|*|*|*|*|*|*|Q|
|*|*|*|*|Q|*|*|*|
|*|*|*|*|*|*|Q|*|
|*|Q|*|*|*|*|*|*|
|*|*|*|*|*|*|*|*|
|*|*|Q|*|*|*|*|*|
|*|*|*|Q|*|Q|*|*|
Step:  4
[(0, 0), (4, 1), (5, 2), (7, 3), (2, 4), (7, 5), (3, 6), (1, 7)]
|Q|*|*|*|*|*|*|*|
|*|*|*|*|*|*|*|Q|
|*|*|*|*|Q|*|*|*|
|*|*|*|*|*|*|Q|*|
|*|Q|*|*|*|*|*|*|
|*|*|Q|*|*|*|*|*|
|*|*|*|*|*|*|*|*|
|*|*|*|Q|*|Q|*|*|
Step:  5
[(0, 0), (4, 1), (5, 2), (7, 3), (2, 4), (6, 5), (3, 6), (1, 7)]
|Q|*|*|*|*|*|*|*|
|*|*|*|*|*|*|*|Q|
|*|*|*|*|Q|*|*|*|
|*|*|*|*|*|*|Q|*|
|*|Q|*|*|*|*|*|*|
|*|*|Q|*|*|*|*|*|
|*|*|*|*|*|Q|*|*|
|*|*|*|Q|*|*|*|*|
```

```
Search Failed

Initial:
[(6, 0), (0, 1), (1, 2), (6, 3), (5, 4), (1, 5), (3, 6), (0, 7)]
|*|Q|*|*|*|*|*|Q|
|*|*|Q|*|*|Q|*|*|
|*|*|*|*|*|*|*|*|
|*|*|*|*|*|*|Q|*|
|*|*|*|*|*|*|*|*|
|*|*|*|*|Q|*|*|*|
|Q|*|*|Q|*|*|*|*|
|*|*|*|*|*|*|*|*|
Step:  2
[(6, 0), (0, 1), (1, 2), (7, 3), (5, 4), (1, 5), (3, 6), (0, 7)]
|*|Q|*|*|*|*|*|Q|
|*|*|Q|*|*|Q|*|*|
|*|*|*|*|*|*|*|*|
|*|*|*|*|*|*|Q|*|
|*|*|*|*|*|*|*|*|
|*|*|*|*|Q|*|*|*|
|Q|*|*|*|*|*|*|*|
|*|*|*|Q|*|*|*|*|
Step:  3
[(6, 0), (0, 1), (2, 2), (7, 3), (5, 4), (1, 5), (3, 6), (0, 7)]
|*|Q|*|*|*|*|*|Q|
|*|*|*|*|*|Q|*|*|
|*|*|Q|*|*|*|*|*|
|*|*|*|*|*|*|Q|*|
|*|*|*|*|*|*|*|*|
|*|*|*|*|Q|*|*|*|
|Q|*|*|*|*|*|*|*|
|*|*|*|Q|*|*|*|*|
Step:  4
[(6, 0), (4, 1), (2, 2), (7, 3), (5, 4), (1, 5), (3, 6), (0, 7)]
|*|*|*|*|*|*|*|Q|
|*|*|*|*|*|Q|*|*|
|*|*|Q|*|*|*|*|*|
|*|*|*|*|*|*|Q|*|
|*|Q|*|*|*|*|*|*|
|*|*|*|*|Q|*|*|*|
|Q|*|*|*|*|*|*|*|
|*|*|*|Q|*|*|*|*|
Search Failed
```

```
Initial:
[(5, 0), (3, 1), (6, 2), (4, 3), (2, 4), (3, 5), (0, 6), (4, 7)]
|*|*|*|*|*|*|Q|*|
|*|*|*|*|*|*|*|*|
|*|*|*|*|Q|*|*|*|
|*|Q|*|*|*|Q|*|*|
|*|*|*|Q|*|*|*|Q|
|Q|*|*|*|*|*|*|*|
|*|*|Q|*|*|*|*|*|
|*|*|*|*|*|*|*|*|
Step:  2
[(5, 0), (3, 1), (6, 2), (4, 3), (2, 4), (5, 5), (0, 6), (4, 7)]
|*|*|*|*|*|*|Q|*|
|*|*|*|*|*|*|*|*|
|*|*|*|*|Q|*|*|*|
|*|Q|*|*|*|*|*|*|
|*|*|*|Q|*|*|*|Q|
|Q|*|*|*|*|Q|*|*|
|*|*|Q|*|*|*|*|*|
|*|*|*|*|*|*|*|*|
Search Failed

Initial:
[(5, 0), (1, 1), (6, 2), (7, 3), (6, 4), (1, 5), (1, 6), (5, 7)]
|*|*|*|*|*|*|*|*|
|*|Q|*|*|*|Q|Q|*|
|*|*|*|*|*|*|*|*|
|*|*|*|*|*|*|*|*|
|*|*|*|*|*|*|*|*|
|Q|*|*|*|*|*|*|Q|
|*|*|Q|*|Q|*|*|*|
|*|*|*|Q|*|*|*|*|
Step:  2
[(5, 0), (2, 1), (6, 2), (7, 3), (6, 4), (1, 5), (1, 6), (5, 7)]
|*|*|*|*|*|*|*|*|
|*|*|*|*|*|Q|Q|*|
|*|Q|*|*|*|*|*|*|
|*|*|*|*|*|*|*|*|
|*|*|*|*|*|*|*|*|
|Q|*|*|*|*|*|*|Q|
|*|*|Q|*|Q|*|*|*|
|*|*|*|Q|*|*|*|*|
Step:  3
[(5, 0), (2, 1), (6, 2), (7, 3), (6, 4), (1, 5), (1, 6), (4, 7)]
|*|*|*|*|*|*|*|*|
|*|*|*|*|*|Q|Q|*|
|*|Q|*|*|*|*|*|*|
|*|*|*|*|*|*|*|*|
|*|*|*|*|*|*|*|Q|
|Q|*|*|*|*|*|*|*|
|*|*|Q|*|Q|*|*|*|
|*|*|*|Q|*|*|*|*|
```

```
Step:  4
[(5, 0), (2, 1), (0, 2), (7, 3), (6, 4), (1, 5), (1, 6), (4, 7)]
|*|*|Q|*|*|*|*|*|
|*|*|*|*|*|Q|Q|*|
|*|Q|*|*|*|*|*|*|
|*|*|*|*|*|*|*|*|
|*|*|*|*|*|*|*|Q|
|Q|*|*|*|*|*|*|*|
|*|*|*|*|Q|*|*|*|
|*|*|*|Q|*|*|*|*|
Search Failed

Initial:
[(6, 0), (3, 1), (1, 2), (7, 3), (7, 4), (4, 5), (7, 6), (7, 7)]
|*|*|*|*|*|*|*|*|
|*|*|Q|*|*|*|*|*|
|*|*|*|*|*|*|*|*|
|*|Q|*|*|*|*|*|*|
|*|*|*|*|*|Q|*|*|
|*|*|*|*|*|*|*|*|
|Q|*|*|*|*|*|*|*|
|*|*|*|Q|Q|*|Q|Q|
Step:  2
[(6, 0), (3, 1), (1, 2), (7, 3), (7, 4), (4, 5), (2, 6), (7, 7)]
|*|*|*|*|*|*|*|*|
|*|*|Q|*|*|*|*|*|
|*|*|*|*|*|*|Q|*|
|*|Q|*|*|*|*|*|*|
|*|*|*|*|*|Q|*|*|
|*|*|*|*|*|*|*|*|
|Q|*|*|*|*|*|*|*|
|*|*|*|Q|Q|*|*|Q|
Step:  3
[(6, 0), (3, 1), (1, 2), (7, 3), (7, 4), (4, 5), (2, 6), (5, 7)]
|*|*|*|*|*|*|*|*|
|*|*|Q|*|*|*|*|*|
|*|*|*|*|*|*|Q|*|
|*|Q|*|*|*|*|*|*|
|*|*|*|*|*|Q|*|*|
|*|*|*|*|*|*|*|Q|
|Q|*|*|*|*|*|*|*|
|*|*|*|Q|Q|*|*|*|
Step:  4
[(6, 0), (3, 1), (1, 2), (7, 3), (7, 4), (0, 5), (2, 6), (5, 7)]
|*|*|*|*|*|Q|*|*|
|*|*|Q|*|*|*|*|*|
|*|*|*|*|*|*|Q|*|
|*|Q|*|*|*|*|*|*|
|*|*|*|*|*|*|*|*|
|*|*|*|*|*|*|*|Q|
|Q|*|*|*|*|*|*|*|
|*|*|*|Q|Q|*|*|*|
```

```
Success:
[(6, 0), (3, 1), (1, 2), (4, 3), (7, 4), (0, 5), (2, 6), (5, 7)]
|*|*|*|*|*|Q|*|*|
|*|*|Q|*|*|*|*|*|
|*|*|*|*|*|*|Q|*|
|*|Q|*|*|*|*|*|*|
|*|*|*|Q|*|*|*|*|
|*|*|*|*|*|*|*|Q|
|Q|*|*|*|*|*|*|*|
|*|*|*|*|Q|*|*|*|

Random Restart Hill Climbing Search with Sideways Analysis
Initial:
[(4, 0), (6, 1), (7, 2), (1, 3), (0, 4), (6, 5), (3, 6), (6, 7)]
|*|*|*|*|Q|*|*|*|
|*|*|*|Q|*|*|*|*|
|*|*|*|*|*|*|*|*|
|*|*|*|*|*|*|Q|*|
|Q|*|*|*|*|*|*|*|
|*|*|*|*|*|*|*|*|
|*|Q|*|*|*|Q|*|Q|
|*|*|Q|*|*|*|*|*|
Step:  2
[(4, 0), (2, 1), (7, 2), (1, 3), (0, 4), (6, 5), (3, 6), (6, 7)]
|*|*|*|*|Q|*|*|*|
|*|*|*|Q|*|*|*|*|
|*|Q|*|*|*|*|*|*|
|*|*|*|*|*|*|Q|*|
|Q|*|*|*|*|*|*|*|
|*|*|*|*|*|*|*|*|
|*|*|*|*|*|Q|*|Q|
|*|*|Q|*|*|*|*|*|
Step:  3
[(4, 0), (2, 1), (7, 2), (5, 3), (0, 4), (6, 5), (3, 6), (6, 7)]
|*|*|*|*|Q|*|*|*|
|*|*|*|*|*|*|*|*|
|*|Q|*|*|*|*|*|*|
|*|*|*|*|*|*|Q|*|
|Q|*|*|*|*|*|*|*|
|*|*|*|Q|*|*|*|*|
|*|*|*|*|*|Q|*|Q|
|*|*|Q|*|*|*|*|*|
Step:  4
[(4, 0), (2, 1), (7, 2), (5, 3), (0, 4), (0, 5), (3, 6), (6, 7)]
|*|*|*|*|Q|Q|*|*|
|*|*|*|*|*|*|*|*|
|*|Q|*|*|*|*|*|*|
|*|*|*|*|*|*|Q|*|
|Q|*|*|*|*|*|*|*|
|*|*|*|Q|*|*|*|*|
|*|*|*|*|*|*|*|Q|
|*|*|Q|*|*|*|*|*|
```

```
Step:  5
[(4, 0), (2, 1), (7, 2), (5, 3), (2, 4), (0, 5), (3, 6), (6, 7)]
|*|*|*|*|*|Q|*|*|
|*|*|*|*|*|*|*|*|
|*|Q|*|*|Q|*|*|*|
|*|*|*|*|*|*|Q|*|
|Q|*|*|*|*|*|*|*|
|*|*|*|Q|*|*|*|*|
|*|*|*|*|*|*|*|Q|
|*|*|Q|*|*|*|*|*|
Step:  6
[(4, 0), (1, 1), (7, 2), (5, 3), (2, 4), (0, 5), (3, 6), (6, 7)]
|*|*|*|*|*|Q|*|*|
|*|Q|*|*|*|*|*|*|
|*|*|*|*|Q|*|*|*|
|*|*|*|*|*|*|Q|*|
|Q|*|*|*|*|*|*|*|
|*|*|*|Q|*|*|*|*|
|*|*|*|*|*|*|*|Q|
|*|*|Q|*|*|*|*|*|
Step:  7
[(4, 0), (1, 1), (5, 2), (5, 3), (2, 4), (0, 5), (3, 6), (6, 7)]
|*|*|*|*|*|Q|*|*|
|*|Q|*|*|*|*|*|*|
|*|*|*|*|Q|*|*|*|
|*|*|*|*|*|*|Q|*|
|Q|*|*|*|*|*|*|*|
|*|*|Q|Q|*|*|*|*|
|*|*|*|*|*|*|*|Q|
|*|*|*|*|*|*|*|*|
Step:  8
[(4, 0), (1, 1), (5, 2), (7, 3), (2, 4), (0, 5), (3, 6), (6, 7)]
|*|*|*|*|*|Q|*|*|
|*|Q|*|*|*|*|*|*|
|*|*|*|*|Q|*|*|*|
|*|*|*|*|*|*|Q|*|
|Q|*|*|*|*|*|*|*|
|*|*|Q|*|*|*|*|*|
|*|*|*|*|*|*|*|Q|
|*|*|*|Q|*|*|*|*|
Step:  9
[(4, 0), (1, 1), (5, 2), (5, 3), (2, 4), (0, 5), (3, 6), (6, 7)]
|*|*|*|*|*|Q|*|*|
|*|Q|*|*|*|*|*|*|
|*|*|*|*|Q|*|*|*|
|*|*|*|*|*|*|Q|*|
|Q|*|*|*|*|*|*|*|
|*|*|Q|Q|*|*|*|*|
|*|*|*|*|*|*|*|Q|
|*|*|*|*|*|*|*|*|
```

```
Step:  10
[(4, 0), (1, 1), (7, 2), (5, 3), (2, 4), (0, 5), (3, 6), (6, 7)]
|*|*|*|*|*|Q|*|*|
|*|Q|*|*|*|*|*|*|
|*|*|*|*|Q|*|*|*|
|*|*|*|*|*|*|Q|*|
|Q|*|*|*|*|*|*|*|
|*|*|*|Q|*|*|*|*|
|*|*|*|*|*|*|*|Q|
|*|*|Q|*|*|*|*|*|
Step:  11
[(4, 0), (1, 1), (5, 2), (5, 3), (2, 4), (0, 5), (3, 6), (6, 7)]
|*|*|*|*|*|Q|*|*|
|*|Q|*|*|*|*|*|*|
|*|*|*|*|Q|*|*|*|
|*|*|*|*|*|*|Q|*|
|Q|*|*|*|*|*|*|*|
|*|*|Q|Q|*|*|*|*|
|*|*|*|*|*|*|*|Q|
|*|*|*|*|*|*|*|*|
Step:  12
[(4, 0), (1, 1), (7, 2), (5, 3), (2, 4), (0, 5), (3, 6), (6, 7)]
|*|*|*|*|*|Q|*|*|
|*|Q|*|*|*|*|*|*|
|*|*|*|*|Q|*|*|*|
|*|*|*|*|*|*|Q|*|
|Q|*|*|*|*|*|*|*|
|*|*|*|Q|*|*|*|*|
|*|*|*|*|*|*|*|Q|
|*|*|Q|*|*|*|*|*|
Step:  13
[(4, 0), (1, 1), (5, 2), (5, 3), (2, 4), (0, 5), (3, 6), (6, 7)]
|*|*|*|*|*|Q|*|*|
|*|Q|*|*|*|*|*|*|
|*|*|*|*|Q|*|*|*|
|*|*|*|*|*|*|Q|*|
|Q|*|*|*|*|*|*|*|
|*|*|Q|Q|*|*|*|*|
|*|*|*|*|*|*|*|Q|
|*|*|*|*|*|*|*|*|
Step:  14
[(4, 0), (1, 1), (5, 2), (7, 3), (2, 4), (0, 5), (3, 6), (6, 7)]
|*|*|*|*|*|Q|*|*|
|*|Q|*|*|*|*|*|*|
|*|*|*|*|Q|*|*|*|
|*|*|*|*|*|*|Q|*|
|Q|*|*|*|*|*|*|*|
|*|*|Q|*|*|*|*|*|
|*|*|*|*|*|*|*|Q|
|*|*|*|Q|*|*|*|*|
```

```
Step:  15
[(4, 0), (1, 1), (5, 2), (5, 3), (2, 4), (0, 5), (3, 6), (6, 7)]
|*|*|*|*|*|Q|*|*|
|*|Q|*|*|*|*|*|*|
|*|*|*|*|Q|*|*|*|
|*|*|*|*|*|*|Q|*|
|Q|*|*|*|*|*|*|*|
|*|*|Q|Q|*|*|*|*|
|*|*|*|*|*|*|*|Q|
|*|*|*|*|*|*|*|*|
Step:  16
[(4, 0), (1, 1), (7, 2), (5, 3), (2, 4), (0, 5), (3, 6), (6, 7)]
|*|*|*|*|*|Q|*|*|
|*|Q|*|*|*|*|*|*|
|*|*|*|*|Q|*|*|*|
|*|*|*|*|*|*|Q|*|
|Q|*|*|*|*|*|*|*|
|*|*|*|Q|*|*|*|*|
|*|*|*|*|*|*|*|Q|
|*|*|Q|*|*|*|*|*|
Step:  17
[(4, 0), (1, 1), (5, 2), (5, 3), (2, 4), (0, 5), (3, 6), (6, 7)]
|*|*|*|*|*|Q|*|*|
|*|Q|*|*|*|*|*|*|
|*|*|*|*|Q|*|*|*|
|*|*|*|*|*|*|Q|*|
|Q|*|*|*|*|*|*|*|
|*|*|Q|Q|*|*|*|*|
|*|*|*|*|*|*|*|Q|
|*|*|*|*|*|*|*|*|
Step:  18
[(4, 0), (1, 1), (7, 2), (5, 3), (2, 4), (0, 5), (3, 6), (6, 7)]
|*|*|*|*|*|Q|*|*|
|*|Q|*|*|*|*|*|*|
|*|*|*|*|Q|*|*|*|
|*|*|*|*|*|*|Q|*|
|Q|*|*|*|*|*|*|*|
|*|*|*|Q|*|*|*|*|
|*|*|*|*|*|*|*|Q|
|*|*|Q|*|*|*|*|*|
Step:  19
[(4, 0), (1, 1), (5, 2), (5, 3), (2, 4), (0, 5), (3, 6), (6, 7)]
|*|*|*|*|*|Q|*|*|
|*|Q|*|*|*|*|*|*|
|*|*|*|*|Q|*|*|*|
|*|*|*|*|*|*|Q|*|
|Q|*|*|*|*|*|*|*|
|*|*|Q|Q|*|*|*|*|
|*|*|*|*|*|*|*|Q|
|*|*|*|*|*|*|*|*|
```

```
Step:  20
[(4, 0), (1, 1), (7, 2), (5, 3), (2, 4), (0, 5), (3, 6), (6, 7)]
|*|*|*|*|*|Q|*|*|
|*|Q|*|*|*|*|*|*|
|*|*|*|*|Q|*|*|*|
|*|*|*|*|*|*|Q|*|
|Q|*|*|*|*|*|*|*|
|*|*|*|Q|*|*|*|*|
|*|*|*|*|*|*|*|Q|
|*|*|Q|*|*|*|*|*|
Step:  21
[(4, 0), (1, 1), (5, 2), (5, 3), (2, 4), (0, 5), (3, 6), (6, 7)]
|*|*|*|*|*|Q|*|*|
|*|Q|*|*|*|*|*|*|
|*|*|*|*|Q|*|*|*|
|*|*|*|*|*|*|Q|*|
|Q|*|*|*|*|*|*|*|
|*|*|Q|Q|*|*|*|*|
|*|*|*|*|*|*|*|Q|
|*|*|*|*|*|*|*|*|
Step:  22
[(4, 0), (1, 1), (5, 2), (7, 3), (2, 4), (0, 5), (3, 6), (6, 7)]
|*|*|*|*|*|Q|*|*|
|*|Q|*|*|*|*|*|*|
|*|*|*|*|Q|*|*|*|
|*|*|*|*|*|*|Q|*|
|Q|*|*|*|*|*|*|*|
|*|*|Q|*|*|*|*|*|
|*|*|*|*|*|*|*|Q|
|*|*|*|Q|*|*|*|*|
Step:  23
[(4, 0), (1, 1), (5, 2), (5, 3), (2, 4), (0, 5), (3, 6), (6, 7)]
|*|*|*|*|*|Q|*|*|
|*|Q|*|*|*|*|*|*|
|*|*|*|*|Q|*|*|*|
|*|*|*|*|*|*|Q|*|
|Q|*|*|*|*|*|*|*|
|*|*|Q|Q|*|*|*|*|
|*|*|*|*|*|*|*|Q|
|*|*|*|*|*|*|*|*|
Step:  24
[(4, 0), (1, 1), (7, 2), (5, 3), (2, 4), (0, 5), (3, 6), (6, 7)]
|*|*|*|*|*|Q|*|*|
|*|Q|*|*|*|*|*|*|
|*|*|*|*|Q|*|*|*|
|*|*|*|*|*|*|Q|*|
|Q|*|*|*|*|*|*|*|
|*|*|*|Q|*|*|*|*|
|*|*|*|*|*|*|*|Q|
|*|*|Q|*|*|*|*|*|
```

```
Step:  25
[(4, 0), (1, 1), (5, 2), (5, 3), (2, 4), (0, 5), (3, 6), (6, 7)]
|*|*|*|*|*|Q|*|*|
|*|Q|*|*|*|*|*|*|
|*|*|*|*|Q|*|*|*|
|*|*|*|*|*|*|Q|*|
|Q|*|*|*|*|*|*|*|
|*|*|Q|Q|*|*|*|*|
|*|*|*|*|*|*|*|Q|
|*|*|*|*|*|*|*|*|
Step:  26
[(4, 0), (1, 1), (7, 2), (5, 3), (2, 4), (0, 5), (3, 6), (6, 7)]
|*|*|*|*|*|Q|*|*|
|*|Q|*|*|*|*|*|*|
|*|*|*|*|Q|*|*|*|
|*|*|*|*|*|*|Q|*|
|Q|*|*|*|*|*|*|*|
|*|*|*|Q|*|*|*|*|
|*|*|*|*|*|*|*|Q|
|*|*|Q|*|*|*|*|*|
Step:  27
[(4, 0), (1, 1), (5, 2), (5, 3), (2, 4), (0, 5), (3, 6), (6, 7)]
|*|*|*|*|*|Q|*|*|
|*|Q|*|*|*|*|*|*|
|*|*|*|*|Q|*|*|*|
|*|*|*|*|*|*|Q|*|
|Q|*|*|*|*|*|*|*|
|*|*|Q|Q|*|*|*|*|
|*|*|*|*|*|*|*|Q|
|*|*|*|*|*|*|*|*|
Step:  28
[(4, 0), (1, 1), (5, 2), (7, 3), (2, 4), (0, 5), (3, 6), (6, 7)]
|*|*|*|*|*|Q|*|*|
|*|Q|*|*|*|*|*|*|
|*|*|*|*|Q|*|*|*|
|*|*|*|*|*|*|Q|*|
|Q|*|*|*|*|*|*|*|
|*|*|Q|*|*|*|*|*|
|*|*|*|*|*|*|*|Q|
|*|*|*|Q|*|*|*|*|
Step:  29
[(1, 0), (1, 1), (5, 2), (7, 3), (2, 4), (0, 5), (3, 6), (6, 7)]
|*|*|*|*|*|Q|*|*|
|Q|Q|*|*|*|*|*|*|
|*|*|*|*|Q|*|*|*|
|*|*|*|*|*|*|Q|*|
|*|*|*|*|*|*|*|*|
|*|*|Q|*|*|*|*|*|
|*|*|*|*|*|*|*|Q|
|*|*|*|Q|*|*|*|*|
```

```
Step:  30
[(1, 0), (7, 1), (5, 2), (7, 3), (2, 4), (0, 5), (3, 6), (6, 7)]
|*|*|*|*|*|Q|*|*|
|Q|*|*|*|*|*|*|*|
|*|*|*|*|Q|*|*|*|
|*|*|*|*|*|*|Q|*|
|*|*|*|*|*|*|*|*|
|*|*|Q|*|*|*|*|*|
|*|*|*|*|*|*|*|Q|
|*|Q|*|Q|*|*|*|*|
Step:  31
[(1, 0), (1, 1), (5, 2), (7, 3), (2, 4), (0, 5), (3, 6), (6, 7)]
|*|*|*|*|*|Q|*|*|
|Q|Q|*|*|*|*|*|*|
|*|*|*|*|Q|*|*|*|
|*|*|*|*|*|*|Q|*|
|*|*|*|*|*|*|*|*|
|*|*|Q|*|*|*|*|*|
|*|*|*|*|*|*|*|Q|
|*|*|*|Q|*|*|*|*|
Step:  32
[(4, 0), (1, 1), (5, 2), (7, 3), (2, 4), (0, 5), (3, 6), (6, 7)]
|*|*|*|*|*|Q|*|*|
|*|Q|*|*|*|*|*|*|
|*|*|*|*|Q|*|*|*|
|*|*|*|*|*|*|Q|*|
|Q|*|*|*|*|*|*|*|
|*|*|Q|*|*|*|*|*|
|*|*|*|*|*|*|*|Q|
|*|*|*|Q|*|*|*|*|
Step:  33
[(1, 0), (1, 1), (5, 2), (7, 3), (2, 4), (0, 5), (3, 6), (6, 7)]
|*|*|*|*|*|Q|*|*|
|Q|Q|*|*|*|*|*|*|
|*|*|*|*|Q|*|*|*|
|*|*|*|*|*|*|Q|*|
|*|*|*|*|*|*|*|*|
|*|*|Q|*|*|*|*|*|
|*|*|*|*|*|*|*|Q|
|*|*|*|Q|*|*|*|*|
Step:  34
[(1, 0), (7, 1), (5, 2), (7, 3), (2, 4), (0, 5), (3, 6), (6, 7)]
|*|*|*|*|*|Q|*|*|
|Q|*|*|*|*|*|*|*|
|*|*|*|*|Q|*|*|*|
|*|*|*|*|*|*|Q|*|
|*|*|*|*|*|*|*|*|
|*|*|Q|*|*|*|*|*|
|*|*|*|*|*|*|*|Q|
|*|Q|*|Q|*|*|*|*|
```

```
Step:  35
[(1, 0), (3, 1), (5, 2), (7, 3), (2, 4), (0, 5), (3, 6), (6, 7)]
|*|*|*|*|*|Q|*|*|
|Q|*|*|*|*|*|*|*|
|*|*|*|*|Q|*|*|*|
|*|Q|*|*|*|*|Q|*|
|*|*|*|*|*|*|*|*|
|*|*|Q|*|*|*|*|*|
|*|*|*|*|*|*|*|Q|
|*|*|*|Q|*|*|*|*|
Step:  36
[(1, 0), (3, 1), (5, 2), (7, 3), (2, 4), (0, 5), (6, 6), (6, 7)]
|*|*|*|*|*|Q|*|*|
|Q|*|*|*|*|*|*|*|
|*|*|*|*|Q|*|*|*|
|*|Q|*|*|*|*|*|*|
|*|*|*|*|*|*|*|*|
|*|*|Q|*|*|*|*|*|
|*|*|*|*|*|*|Q|Q|
|*|*|*|Q|*|*|*|*|
Success:
[(1, 0), (3, 1), (5, 2), (7, 3), (2, 4), (0, 5), (6, 6), (4, 7)]
|*|*|*|*|*|Q|*|*|
|Q|*|*|*|*|*|*|*|
|*|*|*|*|Q|*|*|*|
|*|Q|*|*|*|*|*|*|
|*|*|*|*|*|*|*|Q|
|*|*|Q|*|*|*|*|*|
|*|*|*|*|*|*|Q|*|
|*|*|*|Q|*|*|*|*|

Hill Climbing Search Analysis
Initial:
[(6, 0), (7, 1), (4, 2), (1, 3), (5, 4), (5, 5), (5, 6), (3, 7)]
|*|*|*|*|*|*|*|*|
|*|*|*|Q|*|*|*|*|
|*|*|*|*|*|*|*|*|
|*|*|*|*|*|*|*|Q|
|*|*|Q|*|*|*|*|*|
|*|*|*|*|Q|Q|Q|*|
|Q|*|*|*|*|*|*|*|
|*|Q|*|*|*|*|*|*|
Step:  2
[(6, 0), (7, 1), (4, 2), (1, 3), (5, 4), (2, 5), (5, 6), (3, 7)]
|*|*|*|*|*|*|*|*|
|*|*|*|Q|*|*|*|*|
|*|*|*|*|*|Q|*|*|
|*|*|*|*|*|*|*|Q|
|*|*|Q|*|*|*|*|*|
|*|*|*|*|Q|*|Q|*|
|Q|*|*|*|*|*|*|*|
|*|Q|*|*|*|*|*|*|
```

```
Step:  3
[(0, 0), (7, 1), (4, 2), (1, 3), (5, 4), (2, 5), (5, 6), (3, 7)]
|Q|*|*|*|*|*|*|*|
|*|*|*|Q|*|*|*|*|
|*|*|*|*|*|Q|*|*|
|*|*|*|*|*|*|*|Q|
|*|*|Q|*|*|*|*|*|
|*|*|*|*|Q|*|Q|*|
|*|*|*|*|*|*|*|*|
|*|Q|*|*|*|*|*|*|
Search Failed

Hill climbing Search with Sideways Analysis
Initial:
[(6, 0), (7, 1), (4, 2), (1, 3), (5, 4), (5, 5), (5, 6), (3, 7)]
|*|*|*|*|*|*|*|*|
|*|*|*|Q|*|*|*|*|
|*|*|*|*|*|*|*|*|
|*|*|*|*|*|*|*|Q|
|*|*|Q|*|*|*|*|*|
|*|*|*|*|Q|Q|Q|*|
|Q|*|*|*|*|*|*|*|
|*|Q|*|*|*|*|*|*|
Step:  2
[(6, 0), (7, 1), (4, 2), (1, 3), (5, 4), (2, 5), (5, 6), (3, 7)]
|*|*|*|*|*|*|*|*|
|*|*|*|Q|*|*|*|*|
|*|*|*|*|*|Q|*|*|
|*|*|*|*|*|*|*|Q|
|*|*|Q|*|*|*|*|*|
|*|*|*|*|Q|*|Q|*|
|Q|*|*|*|*|*|*|*|
|*|Q|*|*|*|*|*|*|
Step:  3
[(0, 0), (7, 1), (4, 2), (1, 3), (5, 4), (2, 5), (5, 6), (3, 7)]
|Q|*|*|*|*|*|*|*|
|*|*|*|Q|*|*|*|*|
|*|*|*|*|*|Q|*|*|
|*|*|*|*|*|*|*|Q|
|*|*|Q|*|*|*|*|*|
|*|*|*|*|Q|*|Q|*|
|*|*|*|*|*|*|*|*|
|*|Q|*|*|*|*|*|*|
```

```
Step:  4
[(0, 0), (7, 1), (4, 2), (1, 3), (5, 4), (2, 5), (6, 6), (3, 7)]
|Q|*|*|*|*|*|*|*|
|*|*|*|Q|*|*|*|*|
|*|*|*|*|*|Q|*|*|
|*|*|*|*|*|*|*|Q|
|*|*|Q|*|*|*|*|*|
|*|*|*|*|Q|*|*|*|
|*|*|*|*|*|*|Q|*|
|*|Q|*|*|*|*|*|*|
Step:  5
[(0, 0), (7, 1), (4, 2), (1, 3), (5, 4), (2, 5), (5, 6), (3, 7)]
|Q|*|*|*|*|*|*|*|
|*|*|*|Q|*|*|*|*|
|*|*|*|*|*|Q|*|*|
|*|*|*|*|*|*|*|Q|
|*|*|Q|*|*|*|*|*|
|*|*|*|*|Q|*|Q|*|
|*|*|*|*|*|*|*|*|
|*|Q|*|*|*|*|*|*|
Step:  6
[(0, 0), (7, 1), (4, 2), (1, 3), (5, 4), (2, 5), (6, 6), (3, 7)]
|Q|*|*|*|*|*|*|*|
|*|*|*|Q|*|*|*|*|
|*|*|*|*|*|Q|*|*|
|*|*|*|*|*|*|*|Q|
|*|*|Q|*|*|*|*|*|
|*|*|*|*|Q|*|*|*|
|*|*|*|*|*|*|Q|*|
|*|Q|*|*|*|*|*|*|
Step:  7
[(3, 0), (7, 1), (4, 2), (1, 3), (5, 4), (2, 5), (6, 6), (3, 7)]
|*|*|*|*|*|*|*|*|
|*|*|*|Q|*|*|*|*|
|*|*|*|*|*|Q|*|*|
|Q|*|*|*|*|*|*|Q|
|*|*|Q|*|*|*|*|*|
|*|*|*|*|Q|*|*|*|
|*|*|*|*|*|*|Q|*|
|*|Q|*|*|*|*|*|*|
Step:  8
[(5, 0), (7, 1), (4, 2), (1, 3), (5, 4), (2, 5), (6, 6), (3, 7)]
|*|*|*|*|*|*|*|*|
|*|*|*|Q|*|*|*|*|
|*|*|*|*|*|Q|*|*|
|*|*|*|*|*|*|*|Q|
|*|*|Q|*|*|*|*|*|
|Q|*|*|*|Q|*|*|*|
|*|*|*|*|*|*|Q|*|
|*|Q|*|*|*|*|*|*|
```

```
Step:  9
[(0, 0), (7, 1), (4, 2), (1, 3), (5, 4), (2, 5), (6, 6), (3, 7)]
|Q|*|*|*|*|*|*|*|
|*|*|*|Q|*|*|*|*|
|*|*|*|*|*|Q|*|*|
|*|*|*|*|*|*|*|Q|
|*|*|Q|*|*|*|*|*|
|*|*|*|*|Q|*|*|*|
|*|*|*|*|*|*|Q|*|
|*|Q|*|*|*|*|*|*|
Step:  10
[(0, 0), (7, 1), (4, 2), (1, 3), (5, 4), (2, 5), (5, 6), (3, 7)]
|Q|*|*|*|*|*|*|*|
|*|*|*|Q|*|*|*|*|
|*|*|*|*|*|Q|*|*|
|*|*|*|*|*|*|*|Q|
|*|*|Q|*|*|*|*|*|
|*|*|*|*|Q|*|Q|*|
|*|*|*|*|*|*|*|*|
|*|Q|*|*|*|*|*|*|
Step:  11
[(0, 0), (7, 1), (4, 2), (1, 3), (5, 4), (2, 5), (6, 6), (3, 7)]
|Q|*|*|*|*|*|*|*|
|*|*|*|Q|*|*|*|*|
|*|*|*|*|*|Q|*|*|
|*|*|*|*|*|*|*|Q|
|*|*|Q|*|*|*|*|*|
|*|*|*|*|Q|*|*|*|
|*|*|*|*|*|*|Q|*|
|*|Q|*|*|*|*|*|*|
Step:  12
[(5, 0), (7, 1), (4, 2), (1, 3), (5, 4), (2, 5), (6, 6), (3, 7)]
|*|*|*|*|*|*|*|*|
|*|*|*|Q|*|*|*|*|
|*|*|*|*|*|Q|*|*|
|*|*|*|*|*|*|*|Q|
|*|*|Q|*|*|*|*|*|
|Q|*|*|*|Q|*|*|*|
|*|*|*|*|*|*|Q|*|
|*|Q|*|*|*|*|*|*|
Step:  13
[(3, 0), (7, 1), (4, 2), (1, 3), (5, 4), (2, 5), (6, 6), (3, 7)]
|*|*|*|*|*|*|*|*|
|*|*|*|Q|*|*|*|*|
|*|*|*|*|*|Q|*|*|
|Q|*|*|*|*|*|*|Q|
|*|*|Q|*|*|*|*|*|
|*|*|*|*|Q|*|*|*|
|*|*|*|*|*|*|Q|*|
|*|Q|*|*|*|*|*|*|
```

```
Step:  14
[(3, 0), (0, 1), (4, 2), (1, 3), (5, 4), (2, 5), (6, 6), (3, 7)]
|*|Q|*|*|*|*|*|*|
|*|*|*|Q|*|*|*|*|
|*|*|*|*|*|Q|*|*|
|Q|*|*|*|*|*|*|Q|
|*|*|Q|*|*|*|*|*|
|*|*|*|*|Q|*|*|*|
|*|*|*|*|*|*|Q|*|
|*|*|*|*|*|*|*|*|
Step:  15
[(3, 0), (7, 1), (4, 2), (1, 3), (5, 4), (2, 5), (6, 6), (3, 7)]
|*|*|*|*|*|*|*|*|
|*|*|*|Q|*|*|*|*|
|*|*|*|*|*|Q|*|*|
|Q|*|*|*|*|*|*|Q|
|*|*|Q|*|*|*|*|*|
|*|*|*|*|Q|*|*|*|
|*|*|*|*|*|*|Q|*|
|*|Q|*|*|*|*|*|*|
Step:  16
[(3, 0), (7, 1), (4, 2), (1, 3), (5, 4), (0, 5), (6, 6), (3, 7)]
|*|*|*|*|*|Q|*|*|
|*|*|*|Q|*|*|*|*|
|*|*|*|*|*|*|*|*|
|Q|*|*|*|*|*|*|Q|
|*|*|Q|*|*|*|*|*|
|*|*|*|*|Q|*|*|*|
|*|*|*|*|*|*|Q|*|
|*|Q|*|*|*|*|*|*|
Step:  17
[(3, 0), (7, 1), (4, 2), (1, 3), (5, 4), (0, 5), (6, 6), (0, 7)]
|*|*|*|*|*|Q|*|Q|
|*|*|*|Q|*|*|*|*|
|*|*|*|*|*|*|*|*|
|Q|*|*|*|*|*|*|*|
|*|*|Q|*|*|*|*|*|
|*|*|*|*|Q|*|*|*|
|*|*|*|*|*|*|Q|*|
|*|Q|*|*|*|*|*|*|
Step:  18
[(3, 0), (7, 1), (4, 2), (1, 3), (5, 4), (0, 5), (6, 6), (3, 7)]
|*|*|*|*|*|Q|*|*|
|*|*|*|Q|*|*|*|*|
|*|*|*|*|*|*|*|*|
|Q|*|*|*|*|*|*|Q|
|*|*|Q|*|*|*|*|*|
|*|*|*|*|Q|*|*|*|
|*|*|*|*|*|*|Q|*|
|*|Q|*|*|*|*|*|*|
```

```
Step:  19
[(3, 0), (7, 1), (4, 2), (1, 3), (5, 4), (0, 5), (6, 6), (4, 7)]
|*|*|*|*|*|Q|*|*|
|*|*|*|Q|*|*|*|*|
|*|*|*|*|*|*|*|*|
|Q|*|*|*|*|*|*|*|
|*|*|Q|*|*|*|*|Q|
|*|*|*|*|Q|*|*|*|
|*|*|*|*|*|*|Q|*|
|*|Q|*|*|*|*|*|*|
Step:  20
[(3, 0), (7, 1), (4, 2), (1, 3), (5, 4), (0, 5), (6, 6), (0, 7)]
|*|*|*|*|*|Q|*|Q|
|*|*|*|Q|*|*|*|*|
|*|*|*|*|*|*|*|*|
|Q|*|*|*|*|*|*|*|
|*|*|Q|*|*|*|*|*|
|*|*|*|*|Q|*|*|*|
|*|*|*|*|*|*|Q|*|
|*|Q|*|*|*|*|*|*|
Step:  21
[(3, 0), (7, 1), (4, 2), (1, 3), (5, 4), (0, 5), (6, 6), (6, 7)]
|*|*|*|*|*|Q|*|*|
|*|*|*|Q|*|*|*|*|
|*|*|*|*|*|*|*|*|
|Q|*|*|*|*|*|*|*|
|*|*|Q|*|*|*|*|*|
|*|*|*|*|Q|*|*|*|
|*|*|*|*|*|*|Q|Q|
|*|Q|*|*|*|*|*|*|
Step:  22
[(3, 0), (7, 1), (4, 2), (1, 3), (5, 4), (0, 5), (6, 6), (3, 7)]
|*|*|*|*|*|Q|*|*|
|*|*|*|Q|*|*|*|*|
|*|*|*|*|*|*|*|*|
|Q|*|*|*|*|*|*|Q|
|*|*|Q|*|*|*|*|*|
|*|*|*|*|Q|*|*|*|
|*|*|*|*|*|*|Q|*|
|*|Q|*|*|*|*|*|*|
Step:  23
[(7, 0), (7, 1), (4, 2), (1, 3), (5, 4), (0, 5), (6, 6), (3, 7)]
|*|*|*|*|*|Q|*|*|
|*|*|*|Q|*|*|*|*|
|*|*|*|*|*|*|*|*|
|*|*|*|*|*|*|*|Q|
|*|*|Q|*|*|*|*|*|
|*|*|*|*|Q|*|*|*|
|*|*|*|*|*|*|Q|*|
|Q|Q|*|*|*|*|*|*|
```

```
Step:  24
[(7, 0), (2, 1), (4, 2), (1, 3), (5, 4), (0, 5), (6, 6), (3, 7)]
|*|*|*|*|*|Q|*|*|
|*|*|*|Q|*|*|*|*|
|*|Q|*|*|*|*|*|*|
|*|*|*|*|*|*|*|Q|
|*|*|Q|*|*|*|*|*|
|*|*|*|*|Q|*|*|*|
|*|*|*|*|*|*|Q|*|
|Q|*|*|*|*|*|*|*|
Step:  25
[(7, 0), (2, 1), (4, 2), (1, 3), (7, 4), (0, 5), (6, 6), (3, 7)]
|*|*|*|*|*|Q|*|*|
|*|*|*|Q|*|*|*|*|
|*|Q|*|*|*|*|*|*|
|*|*|*|*|*|*|*|Q|
|*|*|Q|*|*|*|*|*|
|*|*|*|*|*|*|*|*|
|*|*|*|*|*|*|Q|*|
|Q|*|*|*|Q|*|*|*|
Step:  26
[(7, 0), (2, 1), (4, 2), (1, 3), (5, 4), (0, 5), (6, 6), (3, 7)]
|*|*|*|*|*|Q|*|*|
|*|*|*|Q|*|*|*|*|
|*|Q|*|*|*|*|*|*|
|*|*|*|*|*|*|*|Q|
|*|*|Q|*|*|*|*|*|
|*|*|*|*|Q|*|*|*|
|*|*|*|*|*|*|Q|*|
|Q|*|*|*|*|*|*|*|
Step:  27
[(7, 0), (0, 1), (4, 2), (1, 3), (5, 4), (0, 5), (6, 6), (3, 7)]
|*|Q|*|*|*|Q|*|*|
|*|*|*|Q|*|*|*|*|
|*|*|*|*|*|*|*|*|
|*|*|*|*|*|*|*|Q|
|*|*|Q|*|*|*|*|*|
|*|*|*|*|Q|*|*|*|
|*|*|*|*|*|*|Q|*|
|Q|*|*|*|*|*|*|*|
Step:  28
[(7, 0), (7, 1), (4, 2), (1, 3), (5, 4), (0, 5), (6, 6), (3, 7)]
|*|*|*|*|*|Q|*|*|
|*|*|*|Q|*|*|*|*|
|*|*|*|*|*|*|*|*|
|*|*|*|*|*|*|*|Q|
|*|*|Q|*|*|*|*|*|
|*|*|*|*|Q|*|*|*|
|*|*|*|*|*|*|Q|*|
|Q|Q|*|*|*|*|*|*|
```

```
Step:  29
[(7, 0), (2, 1), (4, 2), (1, 3), (5, 4), (0, 5), (6, 6), (3, 7)]
|*|*|*|*|*|Q|*|*|
|*|*|*|Q|*|*|*|*|
|*|Q|*|*|*|*|*|*|
|*|*|*|*|*|*|*|Q|
|*|*|Q|*|*|*|*|*|
|*|*|*|*|Q|*|*|*|
|*|*|*|*|*|*|Q|*|
|Q|*|*|*|*|*|*|*|
Step:  30
[(7, 0), (7, 1), (4, 2), (1, 3), (5, 4), (0, 5), (6, 6), (3, 7)]
|*|*|*|*|*|Q|*|*|
|*|*|*|Q|*|*|*|*|
|*|*|*|*|*|*|*|*|
|*|*|*|*|*|*|*|Q|
|*|*|Q|*|*|*|*|*|
|*|*|*|*|Q|*|*|*|
|*|*|*|*|*|*|Q|*|
|Q|Q|*|*|*|*|*|*|
Step:  31
[(7, 0), (0, 1), (4, 2), (1, 3), (5, 4), (0, 5), (6, 6), (3, 7)]
|*|Q|*|*|*|Q|*|*|
|*|*|*|Q|*|*|*|*|
|*|*|*|*|*|*|*|*|
|*|*|*|*|*|*|*|Q|
|*|*|Q|*|*|*|*|*|
|*|*|*|*|Q|*|*|*|
|*|*|*|*|*|*|Q|*|
|Q|*|*|*|*|*|*|*|
Step:  32
[(7, 0), (2, 1), (4, 2), (1, 3), (5, 4), (0, 5), (6, 6), (3, 7)]
|*|*|*|*|*|Q|*|*|
|*|*|*|Q|*|*|*|*|
|*|Q|*|*|*|*|*|*|
|*|*|*|*|*|*|*|Q|
|*|*|Q|*|*|*|*|*|
|*|*|*|*|Q|*|*|*|
|*|*|*|*|*|*|Q|*|
|Q|*|*|*|*|*|*|*|
Step:  33
[(7, 0), (2, 1), (4, 2), (1, 3), (7, 4), (0, 5), (6, 6), (3, 7)]
|*|*|*|*|*|Q|*|*|
|*|*|*|Q|*|*|*|*|
|*|Q|*|*|*|*|*|*|
|*|*|*|*|*|*|*|Q|
|*|*|Q|*|*|*|*|*|
|*|*|*|*|*|*|*|*|
|*|*|*|*|*|*|Q|*|
|Q|*|*|*|Q|*|*|*|
Step:  34
[(7, 0), (2, 1), (4, 2), (1, 3), (5, 4), (0, 5), (6, 6), (3, 7)]
```

```
|*|*|*|*|*|Q|*|*|
|*|*|*|Q|*|*|*|*|
|*|Q|*|*|*|*|*|*|
|*|*|*|*|*|*|*|Q|
|*|*|Q|*|*|*|*|*|
|*|*|*|*|Q|*|*|*|
|*|*|*|*|*|*|Q|*|
|Q|*|*|*|*|*|*|*|
Step:  35
[(7, 0), (7, 1), (4, 2), (1, 3), (5, 4), (0, 5), (6, 6), (3, 7)]
|*|*|*|*|*|Q|*|*|
|*|*|*|Q|*|*|*|*|
|*|*|*|*|*|*|*|*|
|*|*|*|*|*|*|*|Q|
|*|*|Q|*|*|*|*|*|
|*|*|*|*|Q|*|*|*|
|*|*|*|*|*|*|Q|*|
|Q|Q|*|*|*|*|*|*|
Step:  36
[(7, 0), (0, 1), (4, 2), (1, 3), (5, 4), (0, 5), (6, 6), (3, 7)]
|*|Q|*|*|*|Q|*|*|
|*|*|*|Q|*|*|*|*|
|*|*|*|*|*|*|*|*|
|*|*|*|*|*|*|*|Q|
|*|*|Q|*|*|*|*|*|
|*|*|*|*|Q|*|*|*|
|*|*|*|*|*|*|Q|*|
|Q|*|*|*|*|*|*|*|
Step:  37
[(7, 0), (7, 1), (4, 2), (1, 3), (5, 4), (0, 5), (6, 6), (3, 7)]
|*|*|*|*|*|Q|*|*|
|*|*|*|Q|*|*|*|*|
|*|*|*|*|*|*|*|*|
|*|*|*|*|*|*|*|Q|
|*|*|Q|*|*|*|*|*|
|*|*|*|*|Q|*|*|*|
|*|*|*|*|*|*|Q|*|
|Q|Q|*|*|*|*|*|*|
Step:  38
[(7, 0), (2, 1), (4, 2), (1, 3), (5, 4), (0, 5), (6, 6), (3, 7)]
|*|*|*|*|*|Q|*|*|
|*|*|*|Q|*|*|*|*|
|*|Q|*|*|*|*|*|*|
|*|*|*|*|*|*|*|Q|
|*|*|Q|*|*|*|*|*|
|*|*|*|*|Q|*|*|*|
|*|*|*|*|*|*|Q|*|
|Q|*|*|*|*|*|*|*|
```

```
Step:  39
[(7, 0), (7, 1), (4, 2), (1, 3), (5, 4), (0, 5), (6, 6), (3, 7)]
|*|*|*|*|*|Q|*|*|
|*|*|*|Q|*|*|*|*|
|*|*|*|*|*|*|*|*|
|*|*|*|*|*|*|*|Q|
|*|*|Q|*|*|*|*|*|
|*|*|*|*|Q|*|*|*|
|*|*|*|*|*|*|Q|*|
|Q|Q|*|*|*|*|*|*|
Step:  40
[(7, 0), (2, 1), (4, 2), (1, 3), (5, 4), (0, 5), (6, 6), (3, 7)]
|*|*|*|*|*|Q|*|*|
|*|*|*|Q|*|*|*|*|
|*|Q|*|*|*|*|*|*|
|*|*|*|*|*|*|*|Q|
|*|*|Q|*|*|*|*|*|
|*|*|*|*|Q|*|*|*|
|*|*|*|*|*|*|Q|*|
|Q|*|*|*|*|*|*|*|
Step:  41
[(7, 0), (7, 1), (4, 2), (1, 3), (5, 4), (0, 5), (6, 6), (3, 7)]
|*|*|*|*|*|Q|*|*|
|*|*|*|Q|*|*|*|*|
|*|*|*|*|*|*|*|*|
|*|*|*|*|*|*|*|Q|
|*|*|Q|*|*|*|*|*|
|*|*|*|*|Q|*|*|*|
|*|*|*|*|*|*|Q|*|
|Q|Q|*|*|*|*|*|*|
Step:  42
[(2, 0), (7, 1), (4, 2), (1, 3), (5, 4), (0, 5), (6, 6), (3, 7)]
|*|*|*|*|*|Q|*|*|
|*|*|*|Q|*|*|*|*|
|Q|*|*|*|*|*|*|*|
|*|*|*|*|*|*|*|Q|
|*|*|Q|*|*|*|*|*|
|*|*|*|*|Q|*|*|*|
|*|*|*|*|*|*|Q|*|
|*|Q|*|*|*|*|*|*|
Step:  43
[(2, 0), (7, 1), (5, 2), (1, 3), (5, 4), (0, 5), (6, 6), (3, 7)]
|*|*|*|*|*|Q|*|*|
|*|*|*|Q|*|*|*|*|
|Q|*|*|*|*|*|*|*|
|*|*|*|*|*|*|*|Q|
|*|*|*|*|*|*|*|*|
|*|*|Q|*|Q|*|*|*|
|*|*|*|*|*|*|Q|*|
|*|Q|*|*|*|*|*|*|
```

```
Step:  44
[(2, 0), (7, 1), (5, 2), (1, 3), (5, 4), (0, 5), (6, 6), (4, 7)]
|*|*|*|*|*|Q|*|*|
|*|*|*|Q|*|*|*|*|
|Q|*|*|*|*|*|*|*|
|*|*|*|*|*|*|*|*|
|*|*|*|*|*|*|*|Q|
|*|*|Q|*|Q|*|*|*|
|*|*|*|*|*|*|Q|*|
|*|Q|*|*|*|*|*|*|
Step:  45
[(2, 0), (7, 1), (1, 2), (1, 3), (5, 4), (0, 5), (6, 6), (4, 7)]
|*|*|*|*|*|Q|*|*|
|*|*|Q|Q|*|*|*|*|
|Q|*|*|*|*|*|*|*|
|*|*|*|*|*|*|*|*|
|*|*|*|*|*|*|*|Q|
|*|*|*|*|Q|*|*|*|
|*|*|*|*|*|*|Q|*|
|*|Q|*|*|*|*|*|*|
Step:  46
[(2, 0), (7, 1), (1, 2), (1, 3), (5, 4), (0, 5), (6, 6), (3, 7)]
|*|*|*|*|*|Q|*|*|
|*|*|Q|Q|*|*|*|*|
|Q|*|*|*|*|*|*|*|
|*|*|*|*|*|*|*|Q|
|*|*|*|*|*|*|*|*|
|*|*|*|*|Q|*|*|*|
|*|*|*|*|*|*|Q|*|
|*|Q|*|*|*|*|*|*|
Step:  47
[(2, 0), (7, 1), (1, 2), (4, 3), (5, 4), (0, 5), (6, 6), (3, 7)]
|*|*|*|*|*|Q|*|*|
|*|*|Q|*|*|*|*|*|
|Q|*|*|*|*|*|*|*|
|*|*|*|*|*|*|*|Q|
|*|*|*|Q|*|*|*|*|
|*|*|*|*|Q|*|*|*|
|*|*|*|*|*|*|Q|*|
|*|Q|*|*|*|*|*|*|
Step:  48
[(2, 0), (7, 1), (1, 2), (4, 3), (2, 4), (0, 5), (6, 6), (3, 7)]
|*|*|*|*|*|Q|*|*|
|*|*|Q|*|*|*|*|*|
|Q|*|*|*|Q|*|*|*|
|*|*|*|*|*|*|*|Q|
|*|*|*|Q|*|*|*|*|
|*|*|*|*|*|*|*|*|
|*|*|*|*|*|*|Q|*|
|*|Q|*|*|*|*|*|*|
```

```
Step:  49
[(4, 0), (7, 1), (1, 2), (4, 3), (2, 4), (0, 5), (6, 6), (3, 7)]
|*|*|*|*|*|Q|*|*|
|*|*|Q|*|*|*|*|*|
|*|*|*|*|Q|*|*|*|
|*|*|*|*|*|*|*|Q|
|Q|*|*|Q|*|*|*|*|
|*|*|*|*|*|*|*|*|
|*|*|*|*|*|*|Q|*|
|*|Q|*|*|*|*|*|*|
Step:  50
[(4, 0), (7, 1), (1, 2), (5, 3), (2, 4), (0, 5), (6, 6), (3, 7)]
|*|*|*|*|*|Q|*|*|
|*|*|Q|*|*|*|*|*|
|*|*|*|*|Q|*|*|*|
|*|*|*|*|*|*|*|Q|
|Q|*|*|*|*|*|*|*|
|*|*|*|Q|*|*|*|*|
|*|*|*|*|*|*|Q|*|
|*|Q|*|*|*|*|*|*|
Step:  51
[(4, 0), (7, 1), (1, 2), (6, 3), (2, 4), (0, 5), (6, 6), (3, 7)]
|*|*|*|*|*|Q|*|*|
|*|*|Q|*|*|*|*|*|
|*|*|*|*|Q|*|*|*|
|*|*|*|*|*|*|*|Q|
|Q|*|*|*|*|*|*|*|
|*|*|*|*|*|*|*|*|
|*|*|*|Q|*|*|Q|*|
|*|Q|*|*|*|*|*|*|
Step:  52
[(4, 0), (7, 1), (1, 2), (6, 3), (2, 4), (0, 5), (7, 6), (3, 7)]
|*|*|*|*|*|Q|*|*|
|*|*|Q|*|*|*|*|*|
|*|*|*|*|Q|*|*|*|
|*|*|*|*|*|*|*|Q|
|Q|*|*|*|*|*|*|*|
|*|*|*|*|*|*|*|*|
|*|*|*|Q|*|*|*|*|
|*|Q|*|*|*|*|Q|*|
Step:  53
[(4, 0), (7, 1), (1, 2), (6, 3), (2, 4), (0, 5), (5, 6), (3, 7)]
|*|*|*|*|*|Q|*|*|
|*|*|Q|*|*|*|*|*|
|*|*|*|*|Q|*|*|*|
|*|*|*|*|*|*|*|Q|
|Q|*|*|*|*|*|*|*|
|*|*|*|*|*|*|Q|*|
|*|*|*|Q|*|*|*|*|
|*|Q|*|*|*|*|*|*|
```

```
Step:  54
[(4, 0), (7, 1), (1, 2), (6, 3), (2, 4), (0, 5), (7, 6), (3, 7)]
|*|*|*|*|*|Q|*|*|
|*|*|Q|*|*|*|*|*|
|*|*|*|*|Q|*|*|*|
|*|*|*|*|*|*|*|Q|
|Q|*|*|*|*|*|*|*|
|*|*|*|*|*|*|*|*|
|*|*|*|Q|*|*|*|*|
|*|Q|*|*|*|*|Q|*|
Step:  55
[(4, 0), (7, 1), (1, 2), (6, 3), (2, 4), (0, 5), (6, 6), (3, 7)]
|*|*|*|*|*|Q|*|*|
|*|*|Q|*|*|*|*|*|
|*|*|*|*|Q|*|*|*|
|*|*|*|*|*|*|*|Q|
|Q|*|*|*|*|*|*|*|
|*|*|*|*|*|*|*|*|
|*|*|*|Q|*|*|Q|*|
|*|Q|*|*|*|*|*|*|
Step:  56
[(4, 0), (7, 1), (1, 2), (5, 3), (2, 4), (0, 5), (6, 6), (3, 7)]
|*|*|*|*|*|Q|*|*|
|*|*|Q|*|*|*|*|*|
|*|*|*|*|Q|*|*|*|
|*|*|*|*|*|*|*|Q|
|Q|*|*|*|*|*|*|*|
|*|*|*|Q|*|*|*|*|
|*|*|*|*|*|*|Q|*|
|*|Q|*|*|*|*|*|*|
Step:  57
[(4, 0), (7, 1), (1, 2), (4, 3), (2, 4), (0, 5), (6, 6), (3, 7)]
|*|*|*|*|*|Q|*|*|
|*|*|Q|*|*|*|*|*|
|*|*|*|*|Q|*|*|*|
|*|*|*|*|*|*|*|Q|
|Q|*|*|Q|*|*|*|*|
|*|*|*|*|*|*|*|*|
|*|*|*|*|*|*|Q|*|
|*|Q|*|*|*|*|*|*|
Step:  58
[(2, 0), (7, 1), (1, 2), (4, 3), (2, 4), (0, 5), (6, 6), (3, 7)]
|*|*|*|*|*|Q|*|*|
|*|*|Q|*|*|*|*|*|
|Q|*|*|*|Q|*|*|*|
|*|*|*|*|*|*|*|Q|
|*|*|*|Q|*|*|*|*|
|*|*|*|*|*|*|*|*|
|*|*|*|*|*|*|Q|*|
|*|Q|*|*|*|*|*|*|
Step:  59
[(2, 0), (7, 1), (1, 2), (4, 3), (7, 4), (0, 5), (6, 6), (3, 7)]
```

```
|*|*|*|*|Q|*|*|
|*|*|Q|*|*|*|*|*|
|Q|*|*|*|*|*|*|*|
|*|*|*|*|*|*|*|Q|
|*|*|*|Q|*|*|*|*|
|*|*|*|*|*|*|*|*|
|*|*|*|*|*|*|Q|*|
|*|Q|*|*|Q|*|*|*|
Success:
[(2, 0), (5, 1), (1, 2), (4, 3), (7, 4), (0, 5), (6, 6), (3, 7)]
|*|*|*|*|*|Q|*|*|
|*|*|Q|*|*|*|*|*|
|Q|*|*|*|*|*|*|*|
|*|*|*|*|*|*|*|Q|
|*|*|*|Q|*|*|*|*|
|*|Q|*|*|*|*|*|*|
|*|*|*|*|*|*|Q|*|
|*|*|*|*|Q|*|*|*|

Random Restart Hill Climbing Search
Initial:
[(5, 0), (0, 1), (5, 2), (7, 3), (6, 4), (4, 5), (2, 6), (2, 7)]
|*|Q|*|*|*|*|*|*|
|*|*|*|*|*|*|*|*|
|*|*|*|*|*|*|Q|Q|
|*|*|*|*|*|*|*|*|
|*|*|*|*|*|Q|*|*|
|Q|*|Q|*|*|*|*|*|
|*|*|*|*|Q|*|*|*|
|*|*|*|Q|*|*|*|*|
Step:  2
[(5, 0), (0, 1), (5, 2), (1, 3), (6, 4), (4, 5), (2, 6), (2, 7)]
|*|Q|*|*|*|*|*|*|
|*|*|*|Q|*|*|*|*|
|*|*|*|*|*|*|Q|Q|
|*|*|*|*|*|*|*|*|
|*|*|*|*|*|Q|*|*|
|Q|*|Q|*|*|*|*|*|
|*|*|*|*|Q|*|*|*|
|*|*|*|*|*|*|*|*|
Step:  3
[(5, 0), (0, 1), (5, 2), (1, 3), (6, 4), (4, 5), (2, 6), (7, 7)]
|*|Q|*|*|*|*|*|*|
|*|*|*|Q|*|*|*|*|
|*|*|*|*|*|*|Q|*|
|*|*|*|*|*|*|*|*|
|*|*|*|*|*|Q|*|*|
|Q|*|Q|*|*|*|*|*|
|*|*|*|*|Q|*|*|*|
|*|*|*|*|*|*|*|Q|
Search Failed
```

```
Initial:
[(4, 0), (2, 1), (7, 2), (7, 3), (7, 4), (7, 5), (0, 6), (5, 7)]
|*|*|*|*|*|*|Q|*|
|*|*|*|*|*|*|*|*|
|*|Q|*|*|*|*|*|*|
|*|*|*|*|*|*|*|*|
|Q|*|*|*|*|*|*|*|
|*|*|*|*|*|*|*|Q|
|*|*|*|*|*|*|*|*|
|*|*|Q|Q|Q|Q|*|*|
Step:  2
[(4, 0), (2, 1), (7, 2), (7, 3), (7, 4), (3, 5), (0, 6), (5, 7)]
|*|*|*|*|*|*|Q|*|
|*|*|*|*|*|*|*|*|
|*|Q|*|*|*|*|*|*|
|*|*|*|*|*|Q|*|*|
|Q|*|*|*|*|*|*|*|
|*|*|*|*|*|*|*|Q|
|*|*|*|*|*|*|*|*|
|*|*|Q|Q|Q|*|*|*|
Step:  3
[(4, 0), (2, 1), (7, 2), (7, 3), (1, 4), (3, 5), (0, 6), (5, 7)]
|*|*|*|*|*|*|Q|*|
|*|*|*|*|Q|*|*|*|
|*|Q|*|*|*|*|*|*|
|*|*|*|*|*|Q|*|*|
|Q|*|*|*|*|*|*|*|
|*|*|*|*|*|*|*|Q|
|*|*|*|*|*|*|*|*|
|*|*|Q|Q|*|*|*|*|
Step:  4
[(4, 0), (2, 1), (7, 2), (7, 3), (1, 4), (3, 5), (0, 6), (6, 7)]
|*|*|*|*|*|*|Q|*|
|*|*|*|*|Q|*|*|*|
|*|Q|*|*|*|*|*|*|
|*|*|*|*|*|Q|*|*|
|Q|*|*|*|*|*|*|*|
|*|*|*|*|*|*|*|*|
|*|*|*|*|*|*|*|Q|
|*|*|Q|Q|*|*|*|*|
Step:  5
[(4, 0), (2, 1), (7, 2), (5, 3), (1, 4), (3, 5), (0, 6), (6, 7)]
|*|*|*|*|*|*|Q|*|
|*|*|*|*|Q|*|*|*|
|*|Q|*|*|*|*|*|*|
|*|*|*|*|*|Q|*|*|
|Q|*|*|*|*|*|*|*|
|*|*|*|Q|*|*|*|*|
|*|*|*|*|*|*|*|Q|
|*|*|Q|*|*|*|*|*|
Search Failed
```

```
Initial:
[(6, 0), (4, 1), (4, 2), (4, 3), (5, 4), (4, 5), (4, 6), (3, 7)]
|*|*|*|*|*|*|*|*|
|*|*|*|*|*|*|*|*|
|*|*|*|*|*|*|*|*|
|*|*|*|*|*|*|*|Q|
|*|Q|Q|Q|*|Q|Q|*|
|*|*|*|*|Q|*|*|*|
|Q|*|*|*|*|*|*|*|
|*|*|*|*|*|*|*|*|
Step:  2
[(6, 0), (4, 1), (2, 2), (4, 3), (5, 4), (4, 5), (4, 6), (3, 7)]
|*|*|*|*|*|*|*|*|
|*|*|*|*|*|*|*|*|
|*|*|Q|*|*|*|*|*|
|*|*|*|*|*|*|*|Q|
|*|Q|*|Q|*|Q|Q|*|
|*|*|*|*|Q|*|*|*|
|Q|*|*|*|*|*|*|*|
|*|*|*|*|*|*|*|*|
Step:  3
[(6, 0), (4, 1), (2, 2), (0, 3), (5, 4), (4, 5), (4, 6), (3, 7)]
|*|*|*|Q|*|*|*|*|
|*|*|*|*|*|*|*|*|
|*|*|Q|*|*|*|*|*|
|*|*|*|*|*|*|*|Q|
|*|Q|*|*|*|Q|Q|*|
|*|*|*|*|Q|*|*|*|
|Q|*|*|*|*|*|*|*|
|*|*|*|*|*|*|*|*|
Step:  4
[(6, 0), (4, 1), (2, 2), (0, 3), (5, 4), (4, 5), (1, 6), (3, 7)]
|*|*|*|Q|*|*|*|*|
|*|*|*|*|*|*|Q|*|
|*|*|Q|*|*|*|*|*|
|*|*|*|*|*|*|*|Q|
|*|Q|*|*|*|Q|*|*|
|*|*|*|*|Q|*|*|*|
|Q|*|*|*|*|*|*|*|
|*|*|*|*|*|*|*|*|
Success:
[(6, 0), (4, 1), (2, 2), (0, 3), (5, 4), (7, 5), (1, 6), (3, 7)]
|*|*|*|Q|*|*|*|*|
|*|*|*|*|*|*|Q|*|
|*|*|Q|*|*|*|*|*|
|*|*|*|*|*|*|*|Q|
|*|Q|*|*|*|*|*|*|
|*|*|*|*|Q|*|*|*|
|Q|*|*|*|*|*|*|*|
|*|*|*|*|*|Q|*|*|
```

```
Random Restart Hill Climbing Search with Sideways Analysis
Initial:
[(6, 0), (0, 1), (1, 2), (4, 3), (5, 4), (7, 5), (2, 6), (0, 7)]
|*|Q|*|*|*|*|Q|
|*|*|Q|*|*|*|*|*|
|*|*|*|*|*|*|Q|*|
|*|*|*|*|*|*|*|*|
|*|*|*|Q|*|*|*|*|
|*|*|*|*|Q|*|*|*|
|Q|*|*|*|*|*|*|*|
|*|*|*|*|*|Q|*|*|
Step:  2
[(6, 0), (0, 1), (1, 2), (4, 3), (5, 4), (7, 5), (2, 6), (4, 7)]
|*|Q|*|*|*|*|*|*|
|*|*|Q|*|*|*|*|*|
|*|*|*|*|*|*|Q|*|
|*|*|*|*|*|*|*|*|
|*|*|*|Q|*|*|*|Q|
|*|*|*|*|Q|*|*|*|
|Q|*|*|*|*|*|*|*|
|*|*|*|*|*|Q|*|*|
Step:  3
[(6, 0), (0, 1), (1, 2), (1, 3), (5, 4), (7, 5), (2, 6), (4, 7)]
|*|Q|*|*|*|*|*|*|
|*|*|Q|Q|*|*|*|*|
|*|*|*|*|*|*|Q|*|
|*|*|*|*|*|*|*|*|
|*|*|*|*|*|*|*|Q|
|*|*|*|*|Q|*|*|*|
|Q|*|*|*|*|*|*|*|
|*|*|*|*|*|Q|*|*|
Step:  4
[(6, 0), (0, 1), (3, 2), (1, 3), (5, 4), (7, 5), (2, 6), (4, 7)]
|*|Q|*|*|*|*|*|*|
|*|*|*|Q|*|*|*|*|
|*|*|*|*|*|*|Q|*|
|*|*|Q|*|*|*|*|*|
|*|*|*|*|*|*|*|Q|
|*|*|*|*|Q|*|*|*|
|Q|*|*|*|*|*|*|*|
|*|*|*|*|*|Q|*|*|
Step:  5
[(6, 0), (0, 1), (5, 2), (1, 3), (5, 4), (7, 5), (2, 6), (4, 7)]
|*|Q|*|*|*|*|*|*|
|*|*|*|Q|*|*|*|*|
|*|*|*|*|*|*|Q|*|
|*|*|*|*|*|*|*|*|
|*|*|*|*|*|*|*|Q|
|*|*|Q|*|Q|*|*|*|
|Q|*|*|*|*|*|*|*|
|*|*|*|*|*|Q|*|*|
```

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Step:  6
[(6, 0), (0, 1), (3, 2), (1, 3), (5, 4), (7, 5), (2, 6), (4, 7)]
|*|Q|*|*|*|*|*|*|
|*|*|*|Q|*|*|*|*|
|*|*|*|*|*|*|Q|*|
|*|*|Q|*|*|*|*|*|
|*|*|*|*|*|*|*|Q|
|*|*|*|*|Q|*|*|*|
|Q|*|*|*|*|*|*|*|
|*|*|*|*|*|Q|*|*|
Step:  7
[(6, 0), (0, 1), (5, 2), (1, 3), (5, 4), (7, 5), (2, 6), (4, 7)]
|*|Q|*|*|*|*|*|*|
|*|*|*|Q|*|*|*|*|
|*|*|*|*|*|*|Q|*|
|*|*|*|*|*|*|*|*|
|*|*|*|*|*|*|*|Q|
|*|*|Q|*|Q|*|*|*|
|Q|*|*|*|*|*|*|*|
|*|*|*|*|*|Q|*|*|
Step:  8
[(6, 0), (0, 1), (3, 2), (1, 3), (5, 4), (7, 5), (2, 6), (4, 7)]
|*|Q|*|*|*|*|*|*|
|*|*|*|Q|*|*|*|*|
|*|*|*|*|*|*|Q|*|
|*|*|Q|*|*|*|*|*|
|*|*|*|*|*|*|*|Q|
|*|*|*|*|Q|*|*|*|
|Q|*|*|*|*|*|*|*|
|*|*|*|*|*|Q|*|*|
Step:  9
[(6, 0), (0, 1), (5, 2), (1, 3), (5, 4), (7, 5), (2, 6), (4, 7)]
|*|Q|*|*|*|*|*|*|
|*|*|*|Q|*|*|*|*|
|*|*|*|*|*|*|Q|*|
|*|*|*|*|*|*|*|*|
|*|*|*|*|*|*|*|Q|
|*|*|Q|*|Q|*|*|*|
|Q|*|*|*|*|*|*|*|
|*|*|*|*|*|Q|*|*|
Step:  10
[(6, 0), (0, 1), (3, 2), (1, 3), (5, 4), (7, 5), (2, 6), (4, 7)]
|*|Q|*|*|*|*|*|*|
|*|*|*|Q|*|*|*|*|
|*|*|*|*|*|*|Q|*|
|*|*|Q|*|*|*|*|*|
|*|*|*|*|*|*|*|Q|
|*|*|*|*|Q|*|*|*|
|Q|*|*|*|*|*|*|*|
|*|*|*|*|*|Q|*|*|
```

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Step:  11
[(6, 0), (0, 1), (5, 2), (1, 3), (5, 4), (7, 5), (2, 6), (4, 7)]
|*|Q|*|*|*|*|*|*|
|*|*|*|Q|*|*|*|*|
|*|*|*|*|*|*|Q|*|
|*|*|*|*|*|*|*|*|
|*|*|*|*|*|*|*|Q|
|*|*|Q|*|Q|*|*|*|
|Q|*|*|*|*|*|*|*|
|*|*|*|*|*|Q|*|*|
Step:  12
[(6, 0), (0, 1), (3, 2), (1, 3), (5, 4), (7, 5), (2, 6), (4, 7)]
|*|Q|*|*|*|*|*|*|
|*|*|*|Q|*|*|*|*|
|*|*|*|*|*|*|Q|*|
|*|*|Q|*|*|*|*|*|
|*|*|*|*|*|*|*|Q|
|*|*|*|*|Q|*|*|*|
|Q|*|*|*|*|*|*|*|
|*|*|*|*|*|Q|*|*|
Step:  13
[(6, 0), (0, 1), (5, 2), (1, 3), (5, 4), (7, 5), (2, 6), (4, 7)]
|*|Q|*|*|*|*|*|*|
|*|*|*|Q|*|*|*|*|
|*|*|*|*|*|*|Q|*|
|*|*|*|*|*|*|*|*|
|*|*|*|*|*|*|*|Q|
|*|*|Q|*|Q|*|*|*|
|Q|*|*|*|*|*|*|*|
|*|*|*|*|*|Q|*|*|
Step:  14
[(6, 0), (0, 1), (3, 2), (1, 3), (5, 4), (7, 5), (2, 6), (4, 7)]
|*|Q|*|*|*|*|*|*|
|*|*|*|Q|*|*|*|*|
|*|*|*|*|*|*|Q|*|
|*|*|Q|*|*|*|*|*|
|*|*|*|*|*|*|*|Q|
|*|*|*|*|Q|*|*|*|
|Q|*|*|*|*|*|*|*|
|*|*|*|*|*|Q|*|*|
Step:  15
[(6, 0), (0, 1), (5, 2), (1, 3), (5, 4), (7, 5), (2, 6), (4, 7)]
|*|Q|*|*|*|*|*|*|
|*|*|*|Q|*|*|*|*|
|*|*|*|*|*|*|Q|*|
|*|*|*|*|*|*|*|*|
|*|*|*|*|*|*|*|Q|
|*|*|Q|*|Q|*|*|*|
|Q|*|*|*|*|*|*|*|
|*|*|*|*|*|Q|*|*|
```

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Step:  16
[(6, 0), (0, 1), (3, 2), (1, 3), (5, 4), (7, 5), (2, 6), (4, 7)]
|*|Q|*|*|*|*|*|*|
|*|*|*|Q|*|*|*|*|
|*|*|*|*|*|*|Q|*|
|*|*|Q|*|*|*|*|*|
|*|*|*|*|*|*|*|Q|
|*|*|*|*|Q|*|*|*|
|Q|*|*|*|*|*|*|*|
|*|*|*|*|*|Q|*|*|
Step:  17
[(6, 0), (0, 1), (5, 2), (1, 3), (5, 4), (7, 5), (2, 6), (4, 7)]
|*|Q|*|*|*|*|*|*|
|*|*|*|Q|*|*|*|*|
|*|*|*|*|*|*|Q|*|
|*|*|*|*|*|*|*|*|
|*|*|*|*|*|*|*|Q|
|*|*|Q|*|Q|*|*|*|
|Q|*|*|*|*|*|*|*|
|*|*|*|*|*|Q|*|*|
Step:  18
[(6, 0), (0, 1), (3, 2), (1, 3), (5, 4), (7, 5), (2, 6), (4, 7)]
|*|Q|*|*|*|*|*|*|
|*|*|*|Q|*|*|*|*|
|*|*|*|*|*|*|Q|*|
|*|*|Q|*|*|*|*|*|
|*|*|*|*|*|*|*|Q|
|*|*|*|*|Q|*|*|*|
|Q|*|*|*|*|*|*|*|
|*|*|*|*|*|Q|*|*|
Step:  19
[(6, 0), (0, 1), (5, 2), (1, 3), (5, 4), (7, 5), (2, 6), (4, 7)]
|*|Q|*|*|*|*|*|*|
|*|*|*|Q|*|*|*|*|
|*|*|*|*|*|*|Q|*|
|*|*|*|*|*|*|*|*|
|*|*|*|*|*|*|*|Q|
|*|*|Q|*|Q|*|*|*|
|Q|*|*|*|*|*|*|*|
|*|*|*|*|*|Q|*|*|
Step:  20
[(6, 0), (0, 1), (3, 2), (1, 3), (5, 4), (7, 5), (2, 6), (4, 7)]
|*|Q|*|*|*|*|*|*|
|*|*|*|Q|*|*|*|*|
|*|*|*|*|*|*|Q|*|
|*|*|Q|*|*|*|*|*|
|*|*|*|*|*|*|*|Q|
|*|*|*|*|Q|*|*|*|
|Q|*|*|*|*|*|*|*|
|*|*|*|*|*|Q|*|*|
```

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Step:  21
[(6, 0), (0, 1), (5, 2), (1, 3), (5, 4), (7, 5), (2, 6), (4, 7)]
|*|Q|*|*|*|*|*|*|
|*|*|*|Q|*|*|*|*|
|*|*|*|*|*|*|Q|*|
|*|*|*|*|*|*|*|*|
|*|*|*|*|*|*|*|Q|
|*|*|Q|*|Q|*|*|*|
|Q|*|*|*|*|*|*|*|
|*|*|*|*|*|Q|*|*|
Step:  22
[(6, 0), (0, 1), (3, 2), (1, 3), (5, 4), (7, 5), (2, 6), (4, 7)]
|*|Q|*|*|*|*|*|*|
|*|*|*|Q|*|*|*|*|
|*|*|*|*|*|*|Q|*|
|*|*|Q|*|*|*|*|*|
|*|*|*|*|*|*|*|Q|
|*|*|*|*|Q|*|*|*|
|Q|*|*|*|*|*|*|*|
|*|*|*|*|*|Q|*|*|
Step:  23
[(6, 0), (0, 1), (5, 2), (1, 3), (5, 4), (7, 5), (2, 6), (4, 7)]
|*|Q|*|*|*|*|*|*|
|*|*|*|Q|*|*|*|*|
|*|*|*|*|*|*|Q|*|
|*|*|*|*|*|*|*|*|
|*|*|*|*|*|*|*|Q|
|*|*|Q|*|Q|*|*|*|
|Q|*|*|*|*|*|*|*|
|*|*|*|*|*|Q|*|*|
Step:  24
[(6, 0), (0, 1), (3, 2), (1, 3), (5, 4), (7, 5), (2, 6), (4, 7)]
|*|Q|*|*|*|*|*|*|
|*|*|*|Q|*|*|*|*|
|*|*|*|*|*|*|Q|*|
|*|*|Q|*|*|*|*|*|
|*|*|*|*|*|*|*|Q|
|*|*|*|*|Q|*|*|*|
|Q|*|*|*|*|*|*|*|
|*|*|*|*|*|Q|*|*|
Step:  25
[(6, 0), (0, 1), (5, 2), (1, 3), (5, 4), (7, 5), (2, 6), (4, 7)]
|*|Q|*|*|*|*|*|*|
|*|*|*|Q|*|*|*|*|
|*|*|*|*|*|*|Q|*|
|*|*|*|*|*|*|*|*|
|*|*|*|*|*|*|*|Q|
|*|*|Q|*|Q|*|*|*|
|Q|*|*|*|*|*|*|*|
|*|*|*|*|*|Q|*|*|
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Step:  26
[(6, 0), (0, 1), (3, 2), (1, 3), (5, 4), (7, 5), (2, 6), (4, 7)]
|*|Q|*|*|*|*|*|*|
|*|*|*|Q|*|*|*|*|
|*|*|*|*|*|*|Q|*|
|*|*|Q|*|*|*|*|*|
|*|*|*|*|*|*|*|Q|
|*|*|*|*|Q|*|*|*|
|Q|*|*|*|*|*|*|*|
|*|*|*|*|*|Q|*|*|
Step:  27
[(6, 0), (0, 1), (5, 2), (1, 3), (5, 4), (7, 5), (2, 6), (4, 7)]
|*|Q|*|*|*|*|*|*|
|*|*|*|Q|*|*|*|*|
|*|*|*|*|*|*|Q|*|
|*|*|*|*|*|*|*|*|
|*|*|*|*|*|*|*|Q|
|*|*|Q|*|Q|*|*|*|
|Q|*|*|*|*|*|*|*|
|*|*|*|*|*|Q|*|*|
Step:  28
[(6, 0), (0, 1), (3, 2), (1, 3), (5, 4), (7, 5), (2, 6), (4, 7)]
|*|Q|*|*|*|*|*|*|
|*|*|*|Q|*|*|*|*|
|*|*|*|*|*|*|Q|*|
|*|*|Q|*|*|*|*|*|
|*|*|*|*|*|*|*|Q|
|*|*|*|*|Q|*|*|*|
|Q|*|*|*|*|*|*|*|
|*|*|*|*|*|Q|*|*|
Step:  29
[(6, 0), (0, 1), (5, 2), (1, 3), (5, 4), (7, 5), (2, 6), (4, 7)]
|*|Q|*|*|*|*|*|*|
|*|*|*|Q|*|*|*|*|
|*|*|*|*|*|*|Q|*|
|*|*|*|*|*|*|*|*|
|*|*|*|*|*|*|*|Q|
|*|*|Q|*|Q|*|*|*|
|Q|*|*|*|*|*|*|*|
|*|*|*|*|*|Q|*|*|
Step:  30
[(6, 0), (0, 1), (3, 2), (1, 3), (5, 4), (7, 5), (2, 6), (4, 7)]
|*|Q|*|*|*|*|*|*|
|*|*|*|Q|*|*|*|*|
|*|*|*|*|*|*|Q|*|
|*|*|Q|*|*|*|*|*|
|*|*|*|*|*|*|*|Q|
|*|*|*|*|Q|*|*|*|
|Q|*|*|*|*|*|*|*|
|*|*|*|*|*|Q|*|*|
Step:  31
[(6, 0), (0, 1), (5, 2), (1, 3), (5, 4), (7, 5), (2, 6), (4, 7)]
```

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|*|Q|*|*|*|*|*|*|
|*|*|*|Q|*|*|*|*|
|*|*|*|*|*|*|Q|*|
|*|*|*|*|*|*|*|*|
|*|*|*|*|*|*|*|Q|
|*|*|Q|*|Q|*|*|*|
|Q|*|*|*|*|*|*|*|
|*|*|*|*|*|Q|*|*|
Step:  32
[(6, 0), (0, 1), (3, 2), (1, 3), (5, 4), (7, 5), (2, 6), (4, 7)]
|*|Q|*|*|*|*|*|*|
|*|*|*|Q|*|*|*|*|
|*|*|*|*|*|*|Q|*|
|*|*|Q|*|*|*|*|*|
|*|*|*|*|*|*|*|Q|
|*|*|*|*|Q|*|*|*|
|Q|*|*|*|*|*|*|*|
|*|*|*|*|*|Q|*|*|
Step:  33
[(6, 0), (0, 1), (5, 2), (1, 3), (5, 4), (7, 5), (2, 6), (4, 7)]
|*|Q|*|*|*|*|*|*|
|*|*|*|Q|*|*|*|*|
|*|*|*|*|*|*|Q|*|
|*|*|*|*|*|*|*|*|
|*|*|*|*|*|*|*|Q|
|*|*|Q|*|Q|*|*|*|
|Q|*|*|*|*|*|*|*|
|*|*|*|*|*|Q|*|*|
Step:  34
[(6, 0), (0, 1), (3, 2), (1, 3), (5, 4), (7, 5), (2, 6), (4, 7)]
|*|Q|*|*|*|*|*|*|
|*|*|*|Q|*|*|*|*|
|*|*|*|*|*|*|Q|*|
|*|*|Q|*|*|*|*|*|
|*|*|*|*|*|*|*|Q|
|*|*|*|*|Q|*|*|*|
|Q|*|*|*|*|*|*|*|
|*|*|*|*|*|Q|*|*|
Step:  35
[(6, 0), (0, 1), (5, 2), (1, 3), (5, 4), (7, 5), (2, 6), (4, 7)]
|*|Q|*|*|*|*|*|*|
|*|*|*|Q|*|*|*|*|
|*|*|*|*|*|*|Q|*|
|*|*|*|*|*|*|*|*|
|*|*|*|*|*|*|*|Q|
|*|*|Q|*|Q|*|*|*|
|Q|*|*|*|*|*|*|*|
|*|*|*|*|Q|*|*|
```

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Step:  36
[(6, 0), (0, 1), (3, 2), (1, 3), (5, 4), (7, 5), (2, 6), (4, 7)]
|*|Q|*|*|*|*|*|*|
|*|*|*|Q|*|*|*|*|
|*|*|*|*|*|*|Q|*|
|*|*|Q|*|*|*|*|*|
|*|*|*|*|*|*|*|Q|
|*|*|*|*|Q|*|*|*|
|Q|*|*|*|*|*|*|*|
|*|*|*|*|*|Q|*|*|
Step:  37
[(6, 0), (0, 1), (5, 2), (1, 3), (5, 4), (7, 5), (2, 6), (4, 7)]
|*|Q|*|*|*|*|*|*|
|*|*|*|Q|*|*|*|*|
|*|*|*|*|*|*|Q|*|
|*|*|*|*|*|*|*|*|
|*|*|*|*|*|*|*|Q|
|*|*|Q|*|Q|*|*|*|
|Q|*|*|*|*|*|*|*|
|*|*|*|*|*|Q|*|*|
Step:  38
[(6, 0), (0, 1), (3, 2), (1, 3), (5, 4), (7, 5), (2, 6), (4, 7)]
|*|Q|*|*|*|*|*|*|
|*|*|*|Q|*|*|*|*|
|*|*|*|*|*|*|Q|*|
|*|*|Q|*|*|*|*|*|
|*|*|*|*|*|*|*|Q|
|*|*|*|*|Q|*|*|*|
|Q|*|*|*|*|*|*|*|
|*|*|*|*|*|Q|*|*|
Step:  39
[(6, 0), (0, 1), (5, 2), (1, 3), (5, 4), (7, 5), (2, 6), (4, 7)]
|*|Q|*|*|*|*|*|*|
|*|*|*|Q|*|*|*|*|
|*|*|*|*|*|*|Q|*|
|*|*|*|*|*|*|*|*|
|*|*|*|*|*|*|*|Q|
|*|*|Q|*|Q|*|*|*|
|Q|*|*|*|*|*|*|*|
|*|*|*|*|*|Q|*|*|
Step:  40
[(6, 0), (0, 1), (3, 2), (1, 3), (5, 4), (7, 5), (2, 6), (4, 7)]
|*|Q|*|*|*|*|*|*|
|*|*|*|Q|*|*|*|*|
|*|*|*|*|*|*|Q|*|
|*|*|Q|*|*|*|*|*|
|*|*|*|*|*|*|*|Q|
|*|*|*|*|Q|*|*|*|
|Q|*|*|*|*|*|*|*|
|*|*|*|*|*|Q|*|*|
```

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Step:  41
[(6, 0), (0, 1), (5, 2), (1, 3), (5, 4), (7, 5), (2, 6), (4, 7)]
|*|Q|*|*|*|*|*|*|
|*|*|*|Q|*|*|*|*|
|*|*|*|*|*|*|Q|*|
|*|*|*|*|*|*|*|*|
|*|*|*|*|*|*|*|Q|
|*|*|Q|*|Q|*|*|*|
|Q|*|*|*|*|*|*|*|
|*|*|*|*|*|Q|*|*|
Step:  42
[(6, 0), (0, 1), (3, 2), (1, 3), (5, 4), (7, 5), (2, 6), (4, 7)]
|*|Q|*|*|*|*|*|*|
|*|*|*|Q|*|*|*|*|
|*|*|*|*|*|*|Q|*|
|*|*|Q|*|*|*|*|*|
|*|*|*|*|*|*|*|Q|
|*|*|*|*|Q|*|*|*|
|Q|*|*|*|*|*|*|*|
|*|*|*|*|*|Q|*|*|
Step:  43
[(6, 0), (0, 1), (5, 2), (1, 3), (5, 4), (7, 5), (2, 6), (4, 7)]
|*|Q|*|*|*|*|*|*|
|*|*|*|Q|*|*|*|*|
|*|*|*|*|*|*|Q|*|
|*|*|*|*|*|*|*|*|
|*|*|*|*|*|*|*|Q|
|*|*|Q|*|Q|*|*|*|
|Q|*|*|*|*|*|*|*|
|*|*|*|*|*|Q|*|*|
Step:  44
[(6, 0), (0, 1), (3, 2), (1, 3), (5, 4), (7, 5), (2, 6), (4, 7)]
|*|Q|*|*|*|*|*|*|
|*|*|*|Q|*|*|*|*|
|*|*|*|*|*|*|Q|*|
|*|*|Q|*|*|*|*|*|
|*|*|*|*|*|*|*|Q|
|*|*|*|*|Q|*|*|*|
|Q|*|*|*|*|*|*|*|
|*|*|*|*|*|Q|*|*|
Step:  45
[(6, 0), (0, 1), (5, 2), (1, 3), (5, 4), (7, 5), (2, 6), (4, 7)]
|*|Q|*|*|*|*|*|*|
|*|*|*|Q|*|*|*|*|
|*|*|*|*|*|*|Q|*|
|*|*|*|*|*|*|*|*|
|*|*|*|*|*|*|*|Q|
|*|*|Q|*|Q|*|*|*|
|Q|*|*|*|*|*|*|*|
|*|*|*|*|*|Q|*|*|
```

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Step:  46
[(6, 0), (0, 1), (3, 2), (1, 3), (5, 4), (7, 5), (2, 6), (4, 7)]
|*|Q|*|*|*|*|*|*|
|*|*|*|Q|*|*|*|*|
|*|*|*|*|*|*|Q|*|
|*|*|Q|*|*|*|*|*|
|*|*|*|*|*|*|*|Q|
|*|*|*|*|Q|*|*|*|
|Q|*|*|*|*|*|*|*|
|*|*|*|*|*|Q|*|*|
Step:  47
[(6, 0), (0, 1), (5, 2), (1, 3), (5, 4), (7, 5), (2, 6), (4, 7)]
|*|Q|*|*|*|*|*|*|
|*|*|*|Q|*|*|*|*|
|*|*|*|*|*|*|Q|*|
|*|*|*|*|*|*|*|*|
|*|*|*|*|*|*|*|Q|
|*|*|Q|*|Q|*|*|*|
|Q|*|*|*|*|*|*|*|
|*|*|*|*|*|Q|*|*|
Step:  48
[(6, 0), (0, 1), (3, 2), (1, 3), (5, 4), (7, 5), (2, 6), (4, 7)]
|*|Q|*|*|*|*|*|*|
|*|*|*|Q|*|*|*|*|
|*|*|*|*|*|*|Q|*|
|*|*|Q|*|*|*|*|*|
|*|*|*|*|*|*|*|Q|
|*|*|*|*|Q|*|*|*|
|Q|*|*|*|*|*|*|*|
|*|*|*|*|*|Q|*|*|
Step:  49
[(6, 0), (0, 1), (5, 2), (1, 3), (5, 4), (7, 5), (2, 6), (4, 7)]
|*|Q|*|*|*|*|*|*|
|*|*|*|Q|*|*|*|*|
|*|*|*|*|*|*|Q|*|
|*|*|*|*|*|*|*|*|
|*|*|*|*|*|*|*|Q|
|*|*|Q|*|Q|*|*|*|
|Q|*|*|*|*|*|*|*|
|*|*|*|*|*|Q|*|*|
Step:  50
[(6, 0), (0, 1), (3, 2), (1, 3), (5, 4), (7, 5), (2, 6), (4, 7)]
|*|Q|*|*|*|*|*|*|
|*|*|*|Q|*|*|*|*|
|*|*|*|*|*|*|Q|*|
|*|*|Q|*|*|*|*|*|
|*|*|*|*|*|*|*|Q|
|*|*|*|*|Q|*|*|*|
|Q|*|*|*|*|*|*|*|
|*|*|*|*|*|Q|*|*|
Step:  51
[(6, 0), (0, 1), (5, 2), (1, 3), (5, 4), (7, 5), (2, 6), (4, 7)]
```

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|*|Q|*|*|*|*|*|*|
|*|*|*|Q|*|*|*|*|
|*|*|*|*|*|*|Q|*|
|*|*|*|*|*|*|*|*|
|*|*|*|*|*|*|*|Q|
|*|*|Q|*|Q|*|*|*|
|Q|*|*|*|*|*|*|*|
|*|*|*|*|*|Q|*|*|
Step:  52
[(6, 0), (0, 1), (3, 2), (1, 3), (5, 4), (7, 5), (2, 6), (4, 7)]
|*|Q|*|*|*|*|*|*|
|*|*|*|Q|*|*|*|*|
|*|*|*|*|*|*|Q|*|
|*|*|Q|*|*|*|*|*|
|*|*|*|*|*|*|*|Q|
|*|*|*|*|Q|*|*|*|
|Q|*|*|*|*|*|*|*|
|*|*|*|*|*|Q|*|*|
Step:  53
[(6, 0), (0, 1), (5, 2), (1, 3), (5, 4), (7, 5), (2, 6), (4, 7)]
|*|Q|*|*|*|*|*|*|
|*|*|*|Q|*|*|*|*|
|*|*|*|*|*|*|Q|*|
|*|*|*|*|*|*|*|*|
|*|*|*|*|*|*|*|Q|
|*|*|Q|*|Q|*|*|*|
|Q|*|*|*|*|*|*|*|
|*|*|*|*|*|Q|*|*|
Step:  54
[(6, 0), (0, 1), (3, 2), (1, 3), (5, 4), (7, 5), (2, 6), (4, 7)]
|*|Q|*|*|*|*|*|*|
|*|*|*|Q|*|*|*|*|
|*|*|*|*|*|*|Q|*|
|*|*|Q|*|*|*|*|*|
|*|*|*|*|*|*|*|Q|
|*|*|*|*|Q|*|*|*|
|Q|*|*|*|*|*|*|*|
|*|*|*|*|*|Q|*|*|
Step:  55
[(6, 0), (0, 1), (5, 2), (1, 3), (5, 4), (7, 5), (2, 6), (4, 7)]
|*|Q|*|*|*|*|*|*|
|*|*|*|Q|*|*|*|*|
|*|*|*|*|*|*|Q|*|
|*|*|*|*|*|*|*|*|
|*|*|*|*|*|*|*|Q|
|*|*|Q|*|Q|*|*|*|
|Q|*|*|*|*|*|*|*|
|*|*|*|*|*|Q|*|*|
Step:  56
[(6, 0), (0, 1), (3, 2), (1, 3), (5, 4), (7, 5), (2, 6), (4, 7)]
|*|Q|*|*|*|*|*|*|
|*|*|*|Q|*|*|*|*|
```

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|*|*|*|*|*|*|Q|*|
|*|*|Q|*|*|*|*|*|
|*|*|*|*|*|*|*|Q|
|*|*|*|*|Q|*|*|*|
|Q|*|*|*|*|*|*|*|
|*|*|*|*|*|Q|*|*|
Step:  57
[(6, 0), (0, 1), (5, 2), (1, 3), (5, 4), (7, 5), (2, 6), (4, 7)]
|*|Q|*|*|*|*|*|*|
|*|*|*|Q|*|*|*|*|
|*|*|*|*|*|*|Q|*|
|*|*|*|*|*|*|*|*|
|*|*|*|*|*|*|*|Q|
|*|*|Q|*|Q|*|*|*|
|Q|*|*|*|*|*|*|*|
|*|*|*|*|*|Q|*|*|
Step:  58
[(6, 0), (0, 1), (3, 2), (1, 3), (5, 4), (7, 5), (2, 6), (4, 7)]
|*|Q|*|*|*|*|*|*|
|*|*|*|Q|*|*|*|*|
|*|*|*|*|*|*|Q|*|
|*|*|Q|*|*|*|*|*|
|*|*|*|*|*|*|*|Q|
|*|*|*|*|Q|*|*|*|
|Q|*|*|*|*|*|*|*|
|*|*|*|*|*|Q|*|*|
Step:  59
[(6, 0), (0, 1), (5, 2), (1, 3), (5, 4), (7, 5), (2, 6), (4, 7)]
|*|Q|*|*|*|*|*|*|
|*|*|*|Q|*|*|*|*|
|*|*|*|*|*|*|Q|*|
|*|*|*|*|*|*|*|*|
|*|*|*|*|*|*|*|Q|
|*|*|Q|*|Q|*|*|*|
|Q|*|*|*|*|*|*|*|
|*|*|*|*|*|Q|*|*|
Step:  60
[(6, 0), (0, 1), (3, 2), (1, 3), (5, 4), (7, 5), (2, 6), (4, 7)]
|*|Q|*|*|*|*|*|*|
|*|*|*|Q|*|*|*|*|
|*|*|*|*|*|*|Q|*|
|*|*|Q|*|*|*|*|*|
|*|*|*|*|*|*|*|Q|
|*|*|*|*|Q|*|*|*|
|Q|*|*|*|*|*|*|*|
|*|*|*|*|*|Q|*|*|
Step:  61
[(6, 0), (0, 1), (5, 2), (1, 3), (5, 4), (7, 5), (2, 6), (4, 7)]
|*|Q|*|*|*|*|*|*|
|*|*|*|Q|*|*|*|*|
|*|*|*|*|*|*|Q|*|
|*|*|*|*|*|*|*|*|
```

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|*|*|*|*|*|*|Q|
|*|*|Q|*|Q|*|*|*|
|Q|*|*|*|*|*|*|*|
|*|*|*|*|*|Q|*|*|
Step:  62
[(6, 0), (0, 1), (3, 2), (1, 3), (5, 4), (7, 5), (2, 6), (4, 7)]
|*|Q|*|*|*|*|*|*|
|*|*|*|Q|*|*|*|*|
|*|*|*|*|*|*|Q|*|
|*|*|Q|*|*|*|*|*|
|*|*|*|*|*|*|*|Q|
|*|*|*|*|Q|*|*|*|
|Q|*|*|*|*|*|*|*|
|*|*|*|*|*|Q|*|*|
Step:  63
[(6, 0), (0, 1), (5, 2), (1, 3), (5, 4), (7, 5), (2, 6), (4, 7)]
|*|Q|*|*|*|*|*|*|
|*|*|*|Q|*|*|*|*|
|*|*|*|*|*|*|Q|*|
|*|*|*|*|*|*|*|*|
|*|*|*|*|*|*|*|Q|
|*|*|Q|*|Q|*|*|*|
|Q|*|*|*|*|*|*|*|
|*|*|*|*|*|Q|*|*|
Step:  64
[(6, 0), (0, 1), (3, 2), (1, 3), (5, 4), (7, 5), (2, 6), (4, 7)]
|*|Q|*|*|*|*|*|*|
|*|*|*|Q|*|*|*|*|
|*|*|*|*|*|*|Q|*|
|*|*|Q|*|*|*|*|*|
|*|*|*|*|*|*|*|Q|
|*|*|*|*|Q|*|*|*|
|Q|*|*|*|*|*|*|*|
|*|*|*|*|*|Q|*|*|
Step:  65
[(6, 0), (0, 1), (5, 2), (1, 3), (5, 4), (7, 5), (2, 6), (4, 7)]
|*|Q|*|*|*|*|*|*|
|*|*|*|Q|*|*|*|*|
|*|*|*|*|*|*|Q|*|
|*|*|*|*|*|*|*|*|
|*|*|*|*|*|*|*|Q|
|*|*|Q|*|Q|*|*|*|
|Q|*|*|*|*|*|*|*|
|*|*|*|*|*|Q|*|*|
Step:  66
[(6, 0), (0, 1), (3, 2), (1, 3), (5, 4), (7, 5), (2, 6), (4, 7)]
|*|Q|*|*|*|*|*|*|
|*|*|*|Q|*|*|*|*|
|*|*|*|*|*|*|Q|*|
|*|*|Q|*|*|*|*|*|
|*|*|*|*|*|*|*|Q|
|*|*|*|*|Q|*|*|*|
```

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|Q|*|*|*|*|*|*|*|
|*|*|*|*|*|Q|*|*|
Step:  67
[(6, 0), (0, 1), (5, 2), (1, 3), (5, 4), (7, 5), (2, 6), (4, 7)]
|*|Q|*|*|*|*|*|*|
|*|*|*|Q|*|*|*|*|
|*|*|*|*|*|*|Q|*|
|*|*|*|*|*|*|*|*|
|*|*|*|*|*|*|*|Q|
|*|*|Q|*|Q|*|*|*|
|Q|*|*|*|*|*|*|*|
|*|*|*|*|*|Q|*|*|
Step:  68
[(6, 0), (0, 1), (3, 2), (1, 3), (5, 4), (7, 5), (2, 6), (4, 7)]
|*|Q|*|*|*|*|*|*|
|*|*|*|Q|*|*|*|*|
|*|*|*|*|*|*|Q|*|
|*|*|Q|*|*|*|*|*|
|*|*|*|*|*|*|*|Q|
|*|*|*|*|Q|*|*|*|
|Q|*|*|*|*|*|*|*|
|*|*|*|*|*|Q|*|*|
Step:  69
[(6, 0), (0, 1), (5, 2), (1, 3), (5, 4), (7, 5), (2, 6), (4, 7)]
|*|Q|*|*|*|*|*|*|
|*|*|*|Q|*|*|*|*|
|*|*|*|*|*|*|Q|*|
|*|*|*|*|*|*|*|*|
|*|*|*|*|*|*|*|Q|
|*|*|Q|*|Q|*|*|*|
|Q|*|*|*|*|*|*|*|
|*|*|*|*|*|Q|*|*|
Step:  70
[(6, 0), (0, 1), (3, 2), (1, 3), (5, 4), (7, 5), (2, 6), (4, 7)]
|*|Q|*|*|*|*|*|*|
|*|*|*|Q|*|*|*|*|
|*|*|*|*|*|*|Q|*|
|*|*|Q|*|*|*|*|*|
|*|*|*|*|*|*|*|Q|
|*|*|*|*|Q|*|*|*|
|Q|*|*|*|*|*|*|*|
|*|*|*|*|*|Q|*|*|
Step:  71
[(6, 0), (0, 1), (5, 2), (1, 3), (5, 4), (7, 5), (2, 6), (4, 7)]
|*|Q|*|*|*|*|*|*|
|*|*|*|Q|*|*|*|*|
|*|*|*|*|*|*|Q|*|
|*|*|*|*|*|*|*|*|
|*|*|*|*|*|*|*|Q|
|*|*|Q|*|Q|*|*|*|
|Q|*|*|*|*|*|*|*|
|*|*|*|*|*|Q|*|*|
```

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Step:  72
[(6, 0), (0, 1), (3, 2), (1, 3), (5, 4), (7, 5), (2, 6), (4, 7)]
|*|Q|*|*|*|*|*|*|
|*|*|*|Q|*|*|*|*|
|*|*|*|*|*|*|Q|*|
|*|*|Q|*|*|*|*|*|
|*|*|*|*|*|*|*|Q|
|*|*|*|*|Q|*|*|*|
|Q|*|*|*|*|*|*|*|
|*|*|*|*|*|Q|*|*|
Step:  73
[(6, 0), (0, 1), (5, 2), (1, 3), (5, 4), (7, 5), (2, 6), (4, 7)]
|*|Q|*|*|*|*|*|*|
|*|*|*|Q|*|*|*|*|
|*|*|*|*|*|*|Q|*|
|*|*|*|*|*|*|*|*|
|*|*|*|*|*|*|*|Q|
|*|*|Q|*|Q|*|*|*|
|Q|*|*|*|*|*|*|*|
|*|*|*|*|*|Q|*|*|
Step:  74
[(6, 0), (0, 1), (3, 2), (1, 3), (5, 4), (7, 5), (2, 6), (4, 7)]
|*|Q|*|*|*|*|*|*|
|*|*|*|Q|*|*|*|*|
|*|*|*|*|*|*|Q|*|
|*|*|Q|*|*|*|*|*|
|*|*|*|*|*|*|*|Q|
|*|*|*|*|Q|*|*|*|
|Q|*|*|*|*|*|*|*|
|*|*|*|*|*|Q|*|*|
Step:  75
[(6, 0), (0, 1), (5, 2), (1, 3), (5, 4), (7, 5), (2, 6), (4, 7)]
|*|Q|*|*|*|*|*|*|
|*|*|*|Q|*|*|*|*|
|*|*|*|*|*|*|Q|*|
|*|*|*|*|*|*|*|*|
|*|*|*|*|*|*|*|Q|
|*|*|Q|*|Q|*|*|*|
|Q|*|*|*|*|*|*|*|
|*|*|*|*|*|Q|*|*|
Step:  76
[(6, 0), (0, 1), (3, 2), (1, 3), (5, 4), (7, 5), (2, 6), (4, 7)]
|*|Q|*|*|*|*|*|*|
|*|*|*|Q|*|*|*|*|
|*|*|*|*|*|*|Q|*|
|*|*|Q|*|*|*|*|*|
|*|*|*|*|*|*|*|Q|
|*|*|*|*|Q|*|*|*|
|Q|*|*|*|*|*|*|*|
|*|*|*|*|*|Q|*|*|
```

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Step:  77
[(6, 0), (0, 1), (5, 2), (1, 3), (5, 4), (7, 5), (2, 6), (4, 7)]
|*|Q|*|*|*|*|*|*|
|*|*|*|Q|*|*|*|*|
|*|*|*|*|*|*|Q|*|
|*|*|*|*|*|*|*|*|
|*|*|*|*|*|*|*|Q|
|*|*|Q|*|Q|*|*|*|
|Q|*|*|*|*|*|*|*|
|*|*|*|*|*|Q|*|*|
Step:  78
[(6, 0), (0, 1), (3, 2), (1, 3), (5, 4), (7, 5), (2, 6), (4, 7)]
|*|Q|*|*|*|*|*|*|
|*|*|*|Q|*|*|*|*|
|*|*|*|*|*|*|Q|*|
|*|*|Q|*|*|*|*|*|
|*|*|*|*|*|*|*|Q|
|*|*|*|*|Q|*|*|*|
|Q|*|*|*|*|*|*|*|
|*|*|*|*|*|Q|*|*|
Step:  79
[(6, 0), (0, 1), (5, 2), (1, 3), (5, 4), (7, 5), (2, 6), (4, 7)]
|*|Q|*|*|*|*|*|*|
|*|*|*|Q|*|*|*|*|
|*|*|*|*|*|*|Q|*|
|*|*|*|*|*|*|*|*|
|*|*|*|*|*|*|*|Q|
|*|*|Q|*|Q|*|*|*|
|Q|*|*|*|*|*|*|*|
|*|*|*|*|*|Q|*|*|
Step:  80
[(6, 0), (0, 1), (3, 2), (1, 3), (5, 4), (7, 5), (2, 6), (4, 7)]
|*|Q|*|*|*|*|*|*|
|*|*|*|Q|*|*|*|*|
|*|*|*|*|*|*|Q|*|
|*|*|Q|*|*|*|*|*|
|*|*|*|*|*|*|*|Q|
|*|*|*|*|Q|*|*|*|
|Q|*|*|*|*|*|*|*|
|*|*|*|*|*|Q|*|*|
Step:  81
[(6, 0), (0, 1), (5, 2), (1, 3), (5, 4), (7, 5), (2, 6), (4, 7)]
|*|Q|*|*|*|*|*|*|
|*|*|*|Q|*|*|*|*|
|*|*|*|*|*|*|Q|*|
|*|*|*|*|*|*|*|*|
|*|*|*|*|*|*|*|Q|
|*|*|Q|*|Q|*|*|*|
|Q|*|*|*|*|*|*|*|
|*|*|*|*|*|Q|*|*|
```

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Step:  82
[(6, 0), (0, 1), (3, 2), (1, 3), (5, 4), (7, 5), (2, 6), (4, 7)]
|*|Q|*|*|*|*|*|*|
|*|*|*|Q|*|*|*|*|
|*|*|*|*|*|*|Q|*|
|*|*|Q|*|*|*|*|*|
|*|*|*|*|*|*|*|Q|
|*|*|*|*|Q|*|*|*|
|Q|*|*|*|*|*|*|*|
|*|*|*|*|*|Q|*|*|
Step:  83
[(6, 0), (0, 1), (5, 2), (1, 3), (5, 4), (7, 5), (2, 6), (4, 7)]
|*|Q|*|*|*|*|*|*|
|*|*|*|Q|*|*|*|*|
|*|*|*|*|*|*|Q|*|
|*|*|*|*|*|*|*|*|
|*|*|*|*|*|*|*|Q|
|*|*|Q|*|Q|*|*|*|
|Q|*|*|*|*|*|*|*|
|*|*|*|*|*|Q|*|*|
Step:  84
[(6, 0), (0, 1), (3, 2), (1, 3), (5, 4), (7, 5), (2, 6), (4, 7)]
|*|Q|*|*|*|*|*|*|
|*|*|*|Q|*|*|*|*|
|*|*|*|*|*|*|Q|*|
|*|*|Q|*|*|*|*|*|
|*|*|*|*|*|*|*|Q|
|*|*|*|*|Q|*|*|*|
|Q|*|*|*|*|*|*|*|
|*|*|*|*|*|Q|*|*|
Step:  85
[(6, 0), (0, 1), (5, 2), (1, 3), (5, 4), (7, 5), (2, 6), (4, 7)]
|*|Q|*|*|*|*|*|*|
|*|*|*|Q|*|*|*|*|
|*|*|*|*|*|*|Q|*|
|*|*|*|*|*|*|*|*|
|*|*|*|*|*|*|*|Q|
|*|*|Q|*|Q|*|*|*|
|Q|*|*|*|*|*|*|*|
|*|*|*|*|*|Q|*|*|
Step:  86
[(6, 0), (0, 1), (3, 2), (1, 3), (5, 4), (7, 5), (2, 6), (4, 7)]
|*|Q|*|*|*|*|*|*|
|*|*|*|Q|*|*|*|*|
|*|*|*|*|*|*|Q|*|
|*|*|Q|*|*|*|*|*|
|*|*|*|*|*|*|*|Q|
|*|*|*|*|Q|*|*|*|
|Q|*|*|*|*|*|*|*|
|*|*|*|*|*|Q|*|*|
```

```
Step:  87
[(6, 0), (0, 1), (5, 2), (1, 3), (5, 4), (7, 5), (2, 6), (4, 7)]
|*|Q|*|*|*|*|*|*|
|*|*|*|Q|*|*|*|*|
|*|*|*|*|*|*|Q|*|
|*|*|*|*|*|*|*|*|
|*|*|*|*|*|*|*|Q|
|*|*|Q|*|Q|*|*|*|
|Q|*|*|*|*|*|*|*|
|*|*|*|*|*|Q|*|*|
Step:  88
[(6, 0), (0, 1), (3, 2), (1, 3), (5, 4), (7, 5), (2, 6), (4, 7)]
|*|Q|*|*|*|*|*|*|
|*|*|*|Q|*|*|*|*|
|*|*|*|*|*|*|Q|*|
|*|*|Q|*|*|*|*|*|
|*|*|*|*|*|*|*|Q|
|*|*|*|*|Q|*|*|*|
|Q|*|*|*|*|*|*|*|
|*|*|*|*|*|Q|*|*|
Step:  89
[(6, 0), (0, 1), (5, 2), (1, 3), (5, 4), (7, 5), (2, 6), (4, 7)]
|*|Q|*|*|*|*|*|*|
|*|*|*|Q|*|*|*|*|
|*|*|*|*|*|*|Q|*|
|*|*|*|*|*|*|*|*|
|*|*|*|*|*|*|*|Q|
|*|*|Q|*|Q|*|*|*|
|Q|*|*|*|*|*|*|*|
|*|*|*|*|*|Q|*|*|
Step:  90
[(6, 0), (0, 1), (3, 2), (1, 3), (5, 4), (7, 5), (2, 6), (4, 7)]
|*|Q|*|*|*|*|*|*|
|*|*|*|Q|*|*|*|*|
|*|*|*|*|*|*|Q|*|
|*|*|Q|*|*|*|*|*|
|*|*|*|*|*|*|*|Q|
|*|*|*|*|Q|*|*|*|
|Q|*|*|*|*|*|*|*|
|*|*|*|*|*|Q|*|*|
Step:  91
[(6, 0), (0, 1), (5, 2), (1, 3), (5, 4), (7, 5), (2, 6), (4, 7)]
|*|Q|*|*|*|*|*|*|
|*|*|*|Q|*|*|*|*|
|*|*|*|*|*|*|Q|*|
|*|*|*|*|*|*|*|*|
|*|*|*|*|*|*|*|Q|
|*|*|Q|*|Q|*|*|*|
|Q|*|*|*|*|*|*|*|
|*|*|*|*|*|Q|*|*|
```

```
Step:  92
[(6, 0), (0, 1), (3, 2), (1, 3), (5, 4), (7, 5), (2, 6), (4, 7)]
|*|Q|*|*|*|*|*|*|
|*|*|*|Q|*|*|*|*|
|*|*|*|*|*|*|Q|*|
|*|*|Q|*|*|*|*|*|
|*|*|*|*|*|*|*|Q|
|*|*|*|*|Q|*|*|*|
|Q|*|*|*|*|*|*|*|
|*|*|*|*|*|Q|*|*|
Step:  93
[(6, 0), (0, 1), (5, 2), (1, 3), (5, 4), (7, 5), (2, 6), (4, 7)]
|*|Q|*|*|*|*|*|*|
|*|*|*|Q|*|*|*|*|
|*|*|*|*|*|*|Q|*|
|*|*|*|*|*|*|*|*|
|*|*|*|*|*|*|*|Q|
|*|*|Q|*|Q|*|*|*|
|Q|*|*|*|*|*|*|*|
|*|*|*|*|*|Q|*|*|
Step:  94
[(6, 0), (0, 1), (3, 2), (1, 3), (5, 4), (7, 5), (2, 6), (4, 7)]
|*|Q|*|*|*|*|*|*|
|*|*|*|Q|*|*|*|*|
|*|*|*|*|*|*|Q|*|
|*|*|Q|*|*|*|*|*|
|*|*|*|*|*|*|*|Q|
|*|*|*|*|Q|*|*|*|
|Q|*|*|*|*|*|*|*|
|*|*|*|*|*|Q|*|*|
Step:  95
[(6, 0), (0, 1), (5, 2), (1, 3), (5, 4), (7, 5), (2, 6), (4, 7)]
|*|Q|*|*|*|*|*|*|
|*|*|*|Q|*|*|*|*|
|*|*|*|*|*|*|Q|*|
|*|*|*|*|*|*|*|*|
|*|*|*|*|*|*|*|Q|
|*|*|Q|*|Q|*|*|*|
|Q|*|*|*|*|*|*|*|
|*|*|*|*|*|Q|*|*|
Step:  96
[(6, 0), (0, 1), (3, 2), (1, 3), (5, 4), (7, 5), (2, 6), (4, 7)]
|*|Q|*|*|*|*|*|*|
|*|*|*|Q|*|*|*|*|
|*|*|*|*|*|*|Q|*|
|*|*|Q|*|*|*|*|*|
|*|*|*|*|*|*|*|Q|
|*|*|*|*|Q|*|*|*|
|Q|*|*|*|*|*|*|*|
|*|*|*|*|*|Q|*|*|
```

```
Step:  97
[(6, 0), (0, 1), (5, 2), (1, 3), (5, 4), (7, 5), (2, 6), (4, 7)]
|*|Q|*|*|*|*|*|*|
|*|*|*|Q|*|*|*|*|
|*|*|*|*|*|*|Q|*|
|*|*|*|*|*|*|*|*|
|*|*|*|*|*|*|*|Q|
|*|*|Q|*|Q|*|*|*|
|Q|*|*|*|*|*|*|*|
|*|*|*|*|*|Q|*|*|
Step:  98
[(6, 0), (0, 1), (3, 2), (1, 3), (5, 4), (7, 5), (2, 6), (4, 7)]
|*|Q|*|*|*|*|*|*|
|*|*|*|Q|*|*|*|*|
|*|*|*|*|*|*|Q|*|
|*|*|Q|*|*|*|*|*|
|*|*|*|*|*|*|*|Q|
|*|*|*|*|Q|*|*|*|
|Q|*|*|*|*|*|*|*|
|*|*|*|*|*|Q|*|*|
Step:  99
[(6, 0), (0, 1), (5, 2), (1, 3), (5, 4), (7, 5), (2, 6), (4, 7)]
|*|Q|*|*|*|*|*|*|
|*|*|*|Q|*|*|*|*|
|*|*|*|*|*|*|Q|*|
|*|*|*|*|*|*|*|*|
|*|*|*|*|*|*|*|Q|
|*|*|Q|*|Q|*|*|*|
|Q|*|*|*|*|*|*|*|
|*|*|*|*|*|Q|*|*|
Step:  100
[(6, 0), (0, 1), (3, 2), (1, 3), (5, 4), (7, 5), (2, 6), (4, 7)]
|*|Q|*|*|*|*|*|*|
|*|*|*|Q|*|*|*|*|
|*|*|*|*|*|*|Q|*|
|*|*|Q|*|*|*|*|*|
|*|*|*|*|*|*|*|Q|
|*|*|*|*|Q|*|*|*|
|Q|*|*|*|*|*|*|*|
|*|*|*|*|*|Q|*|*|
Step:  101
[(6, 0), (0, 1), (5, 2), (1, 3), (5, 4), (7, 5), (2, 6), (4, 7)]
|*|Q|*|*|*|*|*|*|
|*|*|*|Q|*|*|*|*|
|*|*|*|*|*|*|Q|*|
|*|*|*|*|*|*|*|*|
|*|*|*|*|*|*|*|Q|
|*|*|Q|*|Q|*|*|*|
|Q|*|*|*|*|*|*|*|
|*|*|*|*|*|Q|*|*|
```

```
Step:  102
[(6, 0), (0, 1), (3, 2), (1, 3), (5, 4), (7, 5), (2, 6), (4, 7)]
|*|Q|*|*|*|*|*|*|
|*|*|*|Q|*|*|*|*|
|*|*|*|*|*|*|Q|*|
|*|*|Q|*|*|*|*|*|
|*|*|*|*|*|*|*|Q|
|*|*|*|*|Q|*|*|*|
|Q|*|*|*|*|*|*|*|
|*|*|*|*|*|Q|*|*|
Step:  103
[(6, 0), (0, 1), (5, 2), (1, 3), (5, 4), (7, 5), (2, 6), (4, 7)]
|*|Q|*|*|*|*|*|*|
|*|*|*|Q|*|*|*|*|
|*|*|*|*|*|*|Q|*|
|*|*|*|*|*|*|*|*|
|*|*|*|*|*|*|*|Q|
|*|*|Q|*|Q|*|*|*|
|Q|*|*|*|*|*|*|*|
|*|*|*|*|*|Q|*|*|
Step:  104
[(6, 0), (0, 1), (3, 2), (1, 3), (5, 4), (7, 5), (2, 6), (4, 7)]
|*|Q|*|*|*|*|*|*|
|*|*|*|Q|*|*|*|*|
|*|*|*|*|*|*|Q|*|
|*|*|Q|*|*|*|*|*|
|*|*|*|*|*|*|*|Q|
|*|*|*|*|Q|*|*|*|
|Q|*|*|*|*|*|*|*|
|*|*|*|*|*|Q|*|*|
Search Failed

Initial:
[(6, 0), (1, 1), (3, 2), (3, 3), (4, 4), (6, 5), (3, 6), (4, 7)]
|*|*|*|*|*|*|*|*|
|*|Q|*|*|*|*|*|*|
|*|*|*|*|*|*|*|*|
|*|*|Q|Q|*|*|Q|*|
|*|*|*|*|Q|*|*|Q|
|*|*|*|*|*|*|*|*|
|Q|*|*|*|*|Q|*|*|
|*|*|*|*|*|*|*|*|
Step:  2
[(6, 0), (1, 1), (3, 2), (7, 3), (4, 4), (6, 5), (3, 6), (4, 7)]
|*|*|*|*|*|*|*|*|
|*|Q|*|*|*|*|*|*|
|*|*|*|*|*|*|*|*|
|*|*|Q|*|*|*|Q|*|
|*|*|*|*|Q|*|*|Q|
|*|*|*|*|*|*|*|*|
|Q|*|*|*|*|Q|*|*|
|*|*|*|Q|*|*|*|*|
```

```
Step:  3
[(6, 0), (1, 1), (3, 2), (7, 3), (4, 4), (6, 5), (3, 6), (0, 7)]
|*|*|*|*|*|*|*|Q|
|*|Q|*|*|*|*|*|*|
|*|*|*|*|*|*|*|*|
|*|*|Q|*|*|*|Q|*|
|*|*|*|*|Q|*|*|*|
|*|*|*|*|*|*|*|*|
|Q|*|*|*|*|Q|*|*|
|*|*|*|Q|*|*|*|*|
Step:  4
[(6, 0), (1, 1), (5, 2), (7, 3), (4, 4), (6, 5), (3, 6), (0, 7)]
|*|*|*|*|*|*|*|Q|
|*|Q|*|*|*|*|*|*|
|*|*|*|*|*|*|*|*|
|*|*|*|*|*|*|Q|*|
|*|*|*|*|Q|*|*|*|
|*|*|Q|*|*|*|*|*|
|Q|*|*|*|*|Q|*|*|
|*|*|*|Q|*|*|*|*|
Search Failed

Initial:
[(0, 0), (7, 1), (6, 2), (4, 3), (0, 4), (7, 5), (5, 6), (6, 7)]
|Q|*|*|*|Q|*|*|*|
|*|*|*|*|*|*|*|*|
|*|*|*|*|*|*|*|*|
|*|*|*|*|*|*|*|*|
|*|*|*|Q|*|*|*|*|
|*|*|*|*|*|*|Q|*|
|*|*|Q|*|*|*|*|Q|
|*|Q|*|*|*|Q|*|*|
Step:  2
[(0, 0), (7, 1), (6, 2), (4, 3), (0, 4), (7, 5), (5, 6), (2, 7)]
|Q|*|*|*|Q|*|*|*|
|*|*|*|*|*|*|*|*|
|*|*|*|*|*|*|*|Q|
|*|*|*|*|*|*|*|*|
|*|*|*|Q|*|*|*|*|
|*|*|*|*|*|*|Q|*|
|*|*|Q|*|*|*|*|*|
|*|Q|*|*|*|Q|*|*|
Step:  3
[(0, 0), (4, 1), (6, 2), (4, 3), (0, 4), (7, 5), (5, 6), (2, 7)]
|Q|*|*|*|Q|*|*|*|
|*|*|*|*|*|*|*|*|
|*|*|*|*|*|*|*|Q|
|*|*|*|*|*|*|*|*|
|*|Q|*|Q|*|*|*|*|
|*|*|*|*|*|*|Q|*|
|*|*|Q|*|*|*|*|*|
|*|*|*|*|*|Q|*|*|
```

```
Search Failed

Initial:
[(2, 0), (6, 1), (0, 2), (4, 3), (7, 4), (2, 5), (6, 6), (3, 7)]
|*|*|Q|*|*|*|*|*|
|*|*|*|*|*|*|*|*|
|Q|*|*|*|*|Q|*|*|
|*|*|*|*|*|*|*|Q|
|*|*|*|Q|*|*|*|*|
|*|*|*|*|*|*|*|*|
|*|Q|*|*|*|*|Q|*|
|*|*|*|*|Q|*|*|*|
Step:  2
[(2, 0), (5, 1), (0, 2), (4, 3), (7, 4), (2, 5), (6, 6), (3, 7)]
|*|*|Q|*|*|*|*|*|
|*|*|*|*|*|*|*|*|
|Q|*|*|*|*|Q|*|*|
|*|*|*|*|*|*|*|Q|
|*|*|*|Q|*|*|*|*|
|*|Q|*|*|*|*|*|*|
|*|*|*|*|*|*|Q|*|
|*|*|*|*|Q|*|*|*|
Step:  3
[(2, 0), (5, 1), (0, 2), (4, 3), (7, 4), (4, 5), (6, 6), (3, 7)]
|*|*|Q|*|*|*|*|*|
|*|*|*|*|*|*|*|*|
|Q|*|*|*|*|*|*|*|
|*|*|*|*|*|*|*|Q|
|*|*|*|Q|*|Q|*|*|
|*|Q|*|*|*|*|*|*|
|*|*|*|*|*|*|Q|*|
|*|*|*|*|Q|*|*|*|
Search Failed

Initial:
[(5, 0), (3, 1), (3, 2), (3, 3), (5, 4), (2, 5), (6, 6), (4, 7)]
|*|*|*|*|*|*|*|*|
|*|*|*|*|*|*|*|*|
|*|*|*|*|*|Q|*|*|
|*|Q|Q|Q|*|*|*|*|
|*|*|*|*|*|*|*|Q|
|Q|*|*|*|Q|*|*|*|
|*|*|*|*|*|*|Q|*|
|*|*|*|*|*|*|*|*|
Step:  2
[(5, 0), (3, 1), (0, 2), (3, 3), (5, 4), (2, 5), (6, 6), (4, 7)]
|*|*|Q|*|*|*|*|*|
|*|*|*|*|*|*|*|*|
|*|*|*|*|*|Q|*|*|
|*|Q|*|Q|*|*|*|*|
|*|*|*|*|*|*|*|Q|
|Q|*|*|*|Q|*|*|*|
```

```
|*|*|*|*|*|Q|*|
|*|*|*|*|*|*|*|
Step:  3
[(5, 0), (3, 1), (0, 2), (7, 3), (5, 4), (2, 5), (6, 6), (4, 7)]
|*|*|Q|*|*|*|*|*|
|*|*|*|*|*|*|*|*|
|*|*|*|*|*|Q|*|*|
|*|Q|*|*|*|*|*|*|
|*|*|*|*|*|*|*|Q|
|Q|*|*|*|Q|*|*|*|
|*|*|*|*|*|*|Q|*|
|*|*|*|Q|*|*|*|*|
Step:  4
[(5, 0), (3, 1), (0, 2), (7, 3), (5, 4), (2, 5), (6, 6), (1, 7)]
|*|*|Q|*|*|*|*|*|
|*|*|*|*|*|*|*|Q|
|*|*|*|*|*|Q|*|*|
|*|Q|*|*|*|*|*|*|
|*|*|*|*|*|*|*|*|
|Q|*|*|*|Q|*|*|*|
|*|*|*|*|*|*|Q|*|
|*|*|*|Q|*|*|*|*|
Search Failed

Initial:
[(3, 0), (2, 1), (4, 2), (6, 3), (5, 4), (0, 5), (3, 6), (5, 7)]
|*|*|*|*|*|Q|*|*|
|*|*|*|*|*|*|*|*|
|*|Q|*|*|*|*|*|*|
|Q|*|*|*|*|*|Q|*|
|*|*|Q|*|*|*|*|*|
|*|*|*|*|Q|*|*|Q|
|*|*|*|Q|*|*|*|*|
|*|*|*|*|*|*|*|*|
Step:  2
[(3, 0), (2, 1), (4, 2), (7, 3), (5, 4), (0, 5), (3, 6), (5, 7)]
|*|*|*|*|*|Q|*|*|
|*|*|*|*|*|*|*|*|
|*|Q|*|*|*|*|*|*|
|Q|*|*|*|*|*|Q|*|
|*|*|Q|*|*|*|*|*|
|*|*|*|*|Q|*|*|Q|
|*|*|*|*|*|*|*|*|
|*|*|*|Q|*|*|*|*|
```

```
Step:  3
[(3, 0), (6, 1), (4, 2), (7, 3), (5, 4), (0, 5), (3, 6), (5, 7)]
|*|*|*|*|Q|*|*|
|*|*|*|*|*|*|*|
|*|*|*|*|*|*|*|
|Q|*|*|*|*|Q|*|
|*|*|Q|*|*|*|*|
|*|*|*|*|Q|*|*|Q|
|*|Q|*|*|*|*|*|*|
|*|*|*|Q|*|*|*|*|
Step:  4
[(3, 0), (6, 1), (4, 2), (7, 3), (5, 4), (0, 5), (2, 6), (5, 7)]
|*|*|*|*|Q|*|*|
|*|*|*|*|*|*|*|
|*|*|*|*|*|Q|*|
|Q|*|*|*|*|*|*|
|*|*|Q|*|*|*|*|
|*|*|*|*|Q|*|*|Q|
|*|Q|*|*|*|*|*|*|
|*|*|*|Q|*|*|*|*|
Search Failed

Initial:
[(3, 0), (2, 1), (1, 2), (1, 3), (0, 4), (2, 5), (0, 6), (3, 7)]
|*|*|*|*|Q|*|Q|*|
|*|*|Q|Q|*|*|*|*|
|*|Q|*|*|*|Q|*|*|
|Q|*|*|*|*|*|*|Q|
|*|*|*|*|*|*|*|*|
|*|*|*|*|*|*|*|*|
|*|*|*|*|*|*|*|*|
|*|*|*|*|*|*|*|*|
Step:  2
[(3, 0), (7, 1), (1, 2), (1, 3), (0, 4), (2, 5), (0, 6), (3, 7)]
|*|*|*|*|Q|*|Q|*|
|*|*|Q|Q|*|*|*|*|
|*|*|*|*|*|Q|*|*|
|Q|*|*|*|*|*|*|Q|
|*|*|*|*|*|*|*|*|
|*|*|*|*|*|*|*|*|
|*|*|*|*|*|*|*|*|
|*|Q|*|*|*|*|*|*|
Step:  3
[(3, 0), (7, 1), (1, 2), (1, 3), (5, 4), (2, 5), (0, 6), (3, 7)]
|*|*|*|*|*|*|Q|*|
|*|*|Q|Q|*|*|*|*|
|*|*|*|*|*|Q|*|*|
|Q|*|*|*|*|*|*|Q|
|*|*|*|*|*|*|*|*|
|*|*|*|*|Q|*|*|*|
|*|*|*|*|*|*|*|*|
|*|Q|*|*|*|*|*|*|
```

```
Step:  4
[(3, 0), (7, 1), (4, 2), (1, 3), (5, 4), (2, 5), (0, 6), (3, 7)]
|*|*|*|*|*|*|Q|*|
|*|*|*|Q|*|*|*|*|
|*|*|*|*|*|Q|*|*|
|Q|*|*|*|*|*|*|Q|
|*|*|Q|*|*|*|*|*|
|*|*|*|*|Q|*|*|*|
|*|*|*|*|*|*|*|*|
|*|Q|*|*|*|*|*|*|
Step:  5
[(3, 0), (7, 1), (4, 2), (1, 3), (5, 4), (2, 5), (0, 6), (6, 7)]
|*|*|*|*|*|*|Q|*|
|*|*|*|Q|*|*|*|*|
|*|*|*|*|*|Q|*|*|
|Q|*|*|*|*|*|*|*|
|*|*|Q|*|*|*|*|*|
|*|*|*|*|Q|*|*|*|
|*|*|*|*|*|*|*|Q|
|*|Q|*|*|*|*|*|*|
Search Failed

Initial:
[(1, 0), (1, 1), (1, 2), (5, 3), (3, 4), (2, 5), (1, 6), (1, 7)]
|*|*|*|*|*|*|*|*|
|Q|Q|Q|*|*|*|Q|Q|
|*|*|*|*|*|Q|*|*|
|*|*|*|*|Q|*|*|*|
|*|*|*|*|*|*|*|*|
|*|*|*|Q|*|*|*|*|
|*|*|*|*|*|*|*|*|
|*|*|*|*|*|*|*|*|
Step:  2
[(1, 0), (1, 1), (1, 2), (5, 3), (3, 4), (2, 5), (4, 6), (1, 7)]
|*|*|*|*|*|*|*|*|
|Q|Q|Q|*|*|*|*|Q|
|*|*|*|*|*|Q|*|*|
|*|*|*|*|Q|*|*|*|
|*|*|*|*|*|*|Q|*|
|*|*|*|Q|*|*|*|*|
|*|*|*|*|*|*|*|*|
|*|*|*|*|*|*|*|*|
Step:  3
[(1, 0), (1, 1), (7, 2), (5, 3), (3, 4), (2, 5), (4, 6), (1, 7)]
|*|*|*|*|*|*|*|*|
|Q|Q|*|*|*|*|*|Q|
|*|*|*|*|*|Q|*|*|
|*|*|*|*|Q|*|*|*|
|*|*|*|*|*|*|Q|*|
|*|*|*|Q|*|*|*|*|
|*|*|*|*|*|*|*|*|
|*|*|Q|*|*|*|*|*|
```

```
Step:  4
[(1, 0), (1, 1), (7, 2), (5, 3), (3, 4), (2, 5), (4, 6), (6, 7)]
|*|*|*|*|*|*|*|*|
|Q|Q|*|*|*|*|*|*|
|*|*|*|*|*|Q|*|*|
|*|*|*|*|Q|*|*|*|
|*|*|*|*|*|*|Q|*|
|*|*|*|Q|*|*|*|*|
|*|*|*|*|*|*|*|Q|
|*|*|Q|*|*|*|*|*|
Step:  5
[(1, 0), (1, 1), (7, 2), (5, 3), (0, 4), (2, 5), (4, 6), (6, 7)]
|*|*|*|*|Q|*|*|*|
|Q|Q|*|*|*|*|*|*|
|*|*|*|*|*|Q|*|*|
|*|*|*|*|*|*|*|*|
|*|*|*|*|*|*|Q|*|
|*|*|*|Q|*|*|*|*|
|*|*|*|*|*|*|*|Q|
|*|*|Q|*|*|*|*|*|
Success:
[(3, 0), (1, 1), (7, 2), (5, 3), (0, 4), (2, 5), (4, 6), (6, 7)]
|*|*|*|*|Q|*|*|*|
|*|Q|*|*|*|*|*|*|
|*|*|*|*|*|Q|*|*|
|Q|*|*|*|*|*|*|*|
|*|*|*|*|*|*|Q|*|
|*|*|*|Q|*|*|*|*|
|*|*|*|*|*|*|*|Q|
|*|*|Q|*|*|*|*|*|
```

Output:

For 100 iterations

```
Hill climbing Search Analysis
=============================
N value:  8  (i.e  8 x 8 )
Total Runs:  100

Success, Runs:  15
Success, Rate:  15.0 %
Success, Average Steps:  4.8

Failure, Runs:  85
Failure, Rate:  85.0 %
Failure, Average Steps:  4.13

Flat local maxima / Shoulder:  84
```

```
Hill climbing Search with sideways Analysis
==========================================
N value:  8  (i.e  8 x 8 )
Total Runs:  100

Success, Runs:  93
Success, Rate:  93.0 %
Success, Average Steps:  19.54

Failure, Runs:  7
Failure, Rate:  7.0 %
Failure, Average Steps:  47.71

Flat local maxima / Shoulder:  3

Random Restart Hill Climbing Search
===================================
N value:  8  (i.e  8 x 8 )
Total Runs:  100

Average Restarts:  6.65
Average Steps (last restart):  5.24
Average steps (all restarts):  28.42

Random Restart Hill Climbing Search with Sideways Analysis
==========================================================
N value:  8  (i.e  8 x 8 )
Total Runs:  100

Average Restarts:  1.24
Average Steps (last restart):  17.68
Average steps (all restarts):  24.72
```

For 200 iterations

```
Hill climbing Search Analysis
=============================
N value:  8  (i.e  8 x 8 )
Total Runs:  200

Success, Runs:  28
Success, Rate:  14.0 %
Success, Average Steps:  5.14

Failure, Runs:  172
Failure, Rate:  86.0 %
Failure, Average Steps:  4.1

Flat local maxima / Shoulder:  166
```

```
Hill climbing Search with sideways Analysis
==========================================
N value:  8  (i.e  8 x 8 )
Total Runs:  200

Success, Runs:  188
Success, Rate:  94.0 %
Success, Average Steps:  21.84

Failure, Runs:  12
Failure, Rate:  6.0 %
Failure, Average Steps:  88.67

Flat local maxima / Shoulder:  5

Random Restart Hill Climbing Search
===================================
N value:  8  (i.e  8 x 8 )
Total Runs:  200

Average Restarts:  7.23
Average Steps (last restart):  5.05
Average steps (all restarts):  30.33

Random Restart Hill Climbing Search with Sideways Analysis
==========================================================
N value:  8  (i.e  8 x 8 )
Total Runs:  200

Average Restarts:  1.21
Average Steps (last restart):  22.235
Average steps (all restarts):  27.095
```

For 300 iterations

```
Hill climbing Search Analysis
=============================
N value:  8  (i.e  8 x 8 )
Total Runs:  300

Success, Runs:  42
Success, Rate:  14.0 %
Success, Average Steps:  4.98

Failure, Runs:  258
Failure, Rate:  86.0 %
Failure, Average Steps:  4.06

Flat local maxima / Shoulder:  252
```

```
Hill climbing Search with sideways Analysis
==========================================
N value:  8  (i.e  8 x 8 )
Total Runs:  300

Success, Runs:  288
Success, Rate:  96.0 %
Success, Average Steps:  21.67

Failure, Runs:  12
Failure, Rate:  4.0 %
Failure, Average Steps:  130.17

Flat local maxima / Shoulder:  5

Random Restart Hill Climbing Search
===================================
N value:  8  (i.e  8 x 8 )
Total Runs:  300

Average Restarts:  7.11
Average Steps (last restart):  4.966666666666667
Average steps (all restarts):  29.71

Random Restart Hill Climbing Search with Sideways Analysis
==========================================================
N value:  8  (i.e  8 x 8 )
Total Runs:  300

Average Restarts:  1.18
Average Steps (last restart):  23.07
Average steps (all restarts):  29.86
```

For 400 iterations

```
Hill climbing Search Analysis
=============================
N value:  8  (i.e  8 x 8 )
Total Runs:  400

Success, Runs:  67
Success, Rate:  16.75 %
Success, Average Steps:  5.24

Failure, Runs:  333
Failure, Rate:  83.25 %
Failure, Average Steps:  4.11

Flat local maxima / Shoulder:  331
```

```
Hill climbing Search with sideways Analysis
==========================================
N value:  8  (i.e  8 x 8 )
Total Runs:  400

Success, Runs:  386
Success, Rate:  96.5 %
Success, Average Steps:  21.62

Failure, Runs:  14
Failure, Rate:  3.5 %
Failure, Average Steps:  119.79

Flat local maxima / Shoulder:  4

Random Restart Hill Climbing Search
===================================
N value:  8  (i.e  8 x 8 )
Total Runs:  400

Average Restarts:  6.965
Average Steps (last restart):  5.0675
Average steps (all restarts):  29.31

Random Restart Hill Climbing Search with Sideways Analysis
==========================================================
N value:  8  (i.e  8 x 8 )
Total Runs:  400

Average Restarts:  1.3425
Average Steps (last restart):  21.3325
Average steps (all restarts):  32.895
```

For 500 iterations

```
Hill climbing Search Analysis
=============================
N value:  8  (i.e  8 x 8 )
Total Runs:  500

Success, Runs:  79
Success, Rate:  15.8 %
Success, Average Steps:  5.16

Failure, Runs:  421
Failure, Rate:  84.2 %
Failure, Average Steps:  4.06

Flat local maxima / Shoulder:  416
```

```
Hill climbing Search with sideways Analysis
==========================================
N value:  8  (i.e  8 x 8 )
Total Runs:  500

Success, Runs:  481
Success, Rate:  96.2 %
Success, Average Steps:  24.83

Failure, Runs:  19
Failure, Rate:  3.8 %
Failure, Average Steps:  189.26

Flat local maxima / Shoulder:  7

Random Restart Hill Climbing Search
===================================
N value:  8  (i.e  8 x 8 )
Total Runs:  500

Average Restarts:  7.004
Average Steps (last restart):  5.048
Average steps (all restarts):  29.386

Random Restart Hill Climbing Search with Sideways Analysis
==========================================================
N value:  8  (i.e  8 x 8 )
Total Runs:  500

Average Restarts:  1.116
Average Steps (last restart):  24.066
Average steps (all restarts):  31.59
```

Analysis:

	Hill Climbing	Hill Climbing with sideways move	Random restart hill climbing	Random restart hill climbing with sideways move
Success rate	15	93	100	100
Average number of steps (Success case)	4.8	19.54	Last Restart – 5.24 All Restarts – 28.42	Last Restart – 17.68 All Restarts – 24.72
Number of restarts	N/A	N/A	6.65	1.24
Flat local maxima/shoulder	84	3	N/A	N/A
Failure rate	85	7	0	0
Average number of steps (Failure case)	4.13	47.71	N/A	N/A
Total Runs	100	100	100	100

	Hill Climbing	Hill Climbing with sideways move	Random restart hill climbing	Random restart hill climbing with sideways move
Success rate	14	94	200	200
Average number of steps (Success case)	5.14	21.84	Last Restart – 5.05 All Restart – 30.33	Last Restart – 22.235 All Restart – 27.095
Number of restarts	N/A	N/A	7.23	1.21
Flat local maxima/shoulder	166	5	N/A	N/A
Failure rate	86	6	0	0
Average number of steps (Failure case)	4.1	88.67	N/A	N/A
Total Runs	200	200	200	200

	Hill Climbing	Hill Climbing with sideways move	Random restart hill climbing	Random restart hill climbing with sideways move
Success rate	14	96	300	300
Average number of steps (Success case)	4.98	21.67	Last Restart – 4.966666666666667 All Restart – 29.71	Last Restart – 23.07 All Restart – 29.86
Number of restarts	N/A	N/A	7.11	1.18
Flat local maxima/shoulder	252	5	N/A	N/A
Failure rate	86	4	0	0
Average number of steps (Failure case)	4.06	130.17	N/A	N/A
Total Runs	300	300	300	300

	Hill Climbing	Hill Climbing with sideways move	Random restart hill climbing	Random restart hill climbing with sideways move
Success rate	16.75	96.5	400	400
Average number of steps (Success case)	5.24	21.62	Last Restart – 5.0675 All Restart – 29.31	Last Restart – 21.3325 All Restart – 32.895
Number of restarts	N/A	N/A	6.965	1.3425
Flat local maxima/shoulder	331	4	N/A	N/A
Failure rate	83.25	3.5	0	0
Average number of steps (Failure case)	4.11	119.79	N/A	N/A
Total Runs	400	400	400	400

	Hill Climbing	Hill Climbing with sideways move	Random restart hill climbing	Random restart hill climbing with sideways move
Success rate	15.8	96.2	500	500
Average number of steps (Success case)	5.16	24.83	Last Restart – 5.048 All Restart – 29.386	Last Restart – 24.066 All Restart – 31.59
Number of restarts	N/A	N/A	7.004	1.116
Flat local maxima/shoulder	416	7	N/A	N/A
Failure rate	84.2	3.8	0	0
Average number of steps (Failure case)	4.06	189.26	N/A	N/A
Total Runs	500	500	500	500

Source Code:

```
import random
import copy
import numpy as np
from os import system, name

class Hill_Climbing_Search:

    def __init__(self, state = None, max_side = 0, n_queen = 0):
        self.startingState = state

        if(state == None and n_queen):
            self.n_queen = n_queen
        elif(state == None and n_queen == 0):
            print("Invalid input value. Setting n_queen equal to 8 by Default")
            self.n_queen = 8
        else:
            self.n_queen = len(state)

        self.total_step_count = 0
        self.max_side = max_side
        self.rem_side = max_side


    # get_diagonal_right - Returns all the cells which are present diagonally right to the current cell.

    def get_diagonal_right(self, rows, columns):
        i = columns+1
        cells = []
        while i < self.n_queen:
            if rows-(i-columns) >= 0:
                cells.append((rows-(i-columns), i))
            if rows+(i-columns) <= self.n_queen-1:
                cells.append((rows+(i-columns), i))
            i+=1
        return cells


    # get_horizontal_right - Returns the cells which are present horizontally right to the current cell.

    def get_horizontal_right(self, rows, columns):
        i = columns+1
```

```
    cells = []
    while i < self.n_queen:
        cells.append((rows, i))
        i+=1
    return cells


#cells_to_right - Combines the above two methods to get all the cells to the right.

def cells_to_right(self, rows, columns):
    return self.get_horizontal_right(rows,columns) + self.get_diagonal_right(rows,columns)


# get_queens_state - Get cell positions of the queens of the given state

def get_queens_state(self, state):
    c = []
    for cols, rows in enumerate(state):
        c.append((rows,cols))
    return c


# calculate_heuristic - Calculate the heuristic value for a given state.

def calculate_heuristic(self, state_cell):
    h = 0
    for row,col in state_cell:
        x = set(state_cell)
        y = set(self.cells_to_right(row,col))
        inter = x.intersection(y)
        h += len(inter)
    return h


# print_state - Display the N-Queens Problem for the current state as a Matrix.

def print_state(self, state_cell):

    print(state_cell)
    for i in range(self.n_queen):
        s = '|'
        for j in range(self.n_queen):
            if((i,j) in state_cell):
```

```
                s += 'Q|'
            else:
                s += '*|'
        print(s)

    '''
    heuristic_matrix -
        Calculate heuristic values for all the cells to take the next step.
        Returns [
            'Matrix of Heuristics',
            'Least of Heuristics',
            '2 arrays containing rows and columns of cells containing Least of Heuristics'
        ]
    '''
    def heuristic_matrix(self, state_cell):
        heuristic_m = np.zeros((self.n_queen,self.n_queen), int) + -1
        heuristic_least = sum(range(self.n_queen)) + 1
        heuristic_least_state = None

        for (x,y) in state_cell:
            for i in range(self.n_queen):
                if(x == i):
                    pass
                else:
                    new_state = copy.deepcopy(state_cell)
                    new_state[y] = temp = (i, y)
                    heuristic_m[i,y] = self.calculate_heuristic(new_state)

                    heuristic_least = min(heuristic_least, heuristic_m[i,y])
                    heuristic_least_state = new_state

        return heuristic_m, heuristic_least, np.where(heuristic_m == heuristic_least)

    '''
    steepest_ascent_algorithm -
        Implementation of the Steepest Ascent Hill Climbing Search. This methods calculates the least heuristic value and moves forward with execution.
        Result:
            1 -> Flat, shoulder or Flat local maxima
            2 -> Local Maxima
            3 -> Success
    '''
    def steepest_ascent_algorithm(self, state = None, h = None, step_size = 0):
```

```
state_cell = None

if(step_size == 0):
    state = self.startingState
    state_cell = self.get_queens_state(state)
    h = self.calculate_heuristic(state_cell)
else:
    state_cell = self.get_queens_state(state)

step_size+=1
self.total_step_count+=1

if(h == 0):
    print("Success: ")
    self.print_state(state_cell)
    return 3, step_size

if(step_size == 1):
    print("Initial: ")
    self.print_state(state_cell)
else:
    print('Step: ', step_size)
    self.print_state(state_cell)

heuristic_m = self.heuristic_matrix(state_cell)
heuristic_least = heuristic_m[1]

rand = random.randint(0, len(heuristic_m[2][0])-1)
row = heuristic_m[2][0][rand]
col = heuristic_m[2][1][rand]

new_state = copy.deepcopy(state)
new_state[col] = row

if(heuristic_least < h):
    return self.steepest_ascent_algorithm(new_state, heuristic_least, step_size)
elif (heuristic_least > h):
    print("Search Failed")
    return 2, step_size
elif (heuristic_least == h):
    if(self.rem_side):
        self.rem_side-=1
```

```
            return self.steepest_ascent_algorithm(new_state, heuristic_least, step_size)
        else:
            print("Search Failed")
            return 1, step_size

    # random_state - Generates a new random state each time it is called.

    def random_state(self):
        s = []
        for i in range(self.n_queen):
            s.append(random.randint(0,self.n_queen-1))
        return s


    # random_restart_hill_climbing - This method is used to implement Random Restart Hill Climbing Search by using Steepest Ascent as Base.

    def random_restart_hill_climbing(self):
        r = 0
        while True:
            r+=1
            self.startingState = self.random_state()
            output = self.steepest_ascent_algorithm()
            if(output[0] == 3):
                return r, output[1], self.total_step_count
                break

class Hill_Climbing_Analysis:

    def __init__(self, n_value, max_iterations, max_side = 0):
        self.n_value = n_value
        self.max_iterations = max_iterations
        self.max_side = max_side
        self.steepest_ascent_stats = [[0,[]],[0,[]],[0,[]],[0,[]]]
        self.steepest_ascent_with_side_stats = [[0,[]],[0,[]],[0,[]],[0,[]]]
        self.random_restart_stats = [0, [], [], []]
        self.random_restart_with_side_stats = [0, [], [], []]


    # do_analysis - Performs Steepest Ascent and Random Restart Hill Climbing max_iterations (Say max_iterations = 100) times.

    def do_analysis(self):
```

```
if(self.n_value in range(4)):
    print('Please Enter a Value Greater Than 3.')
    return

if(self.max_iterations < 1):
    print('Please Enter a Value Greater Than 1.')
    return

for n in range(self.max_iterations):
    self.steepest_ascent_stats[0][0]+=1
    self.steepest_ascent_with_side_stats[0][0]+=1
    self.random_restart_stats[0]+=1
    self.random_restart_with_side_stats[0]+=1
    s = []

    for i in range(self.n_value):
        s.append(random.randint(0,self.n_value-1))

    print("Hill Climbing Search Analysis")
    hillClimbing = Hill_Climbing_Search(s)
    result = hillClimbing.steepest_ascent_algorithm()
    self.steepest_ascent_stats[result[0]][0]+=1
    self.steepest_ascent_stats[result[0]][1].append(result[1])

    print("Hill climbing Search with Sideways Analysis")
    hillClimbing = Hill_Climbing_Search(s, self.max_side)
    result = hillClimbing.steepest_ascent_algorithm()
    self.steepest_ascent_with_side_stats[result[0]][0]+=1
    self.steepest_ascent_with_side_stats[result[0]][1].append(result[1])

    print("Random Restart Hill Climbing Search")
    hillClimbing = Hill_Climbing_Search(None, 0, self.n_value)
    result = hillClimbing.random_restart_hill_climbing()
    self.random_restart_stats[1].append(result[0])
    self.random_restart_stats[2].append(result[1])
    self.random_restart_stats[3].append(result[2])

    print("Random Restart Hill Climbing Search with Sideways Analysis")
    hillClimbing = Hill_Climbing_Search(None, self.max_side, self.n_value)
    result = hillClimbing.random_restart_hill_climbing()
    self.random_restart_with_side_stats[1].append(result[0])
    self.random_restart_with_side_stats[2].append(result[1])
```

```
            self.random_restart_with_side_stats[3].append(result[2])

        self.print_analysis()


    # print_analysis - Prints the final analysis of all 4 algorithms

    def print_analysis(self):
        self.print_steepest_ascent_stats(self.steepest_ascent_stats, "Hill climbing Search Analysis")
        self.print_steepest_ascent_stats(self.steepest_ascent_with_side_stats, "Hill climbing Search with sideways Analysis")
        self.print_random_restart_stats(self.random_restart_stats, "Random Restart Hill Climbing Search")
        self.print_random_restart_stats(self.random_restart_with_side_stats, "Random Restart Hill Climbing Search with Sideways Analysis")


    #print_rand_restart_stat(self) - Display Random Restart Hill Climbing Search Analysis Report.

    def print_random_restart_stats(self, output, head):

        total_runs = output[0]
        restart_average = sum(output[1]) / total_runs
        last_steps_average = sum(output[2]) / total_runs
        total_steps_average = sum(output[3]) / total_runs

        print("\n\n"+head)
        underline = ''
        for i in range(len(head)): underline+="="
        print(underline)
        print()
        print("N value: ", self.n_value, " (i.e ",self.n_value,"x",self.n_value,")")
        print("Total Runs: ", total_runs)
        print()
        print("Average Restarts: ", restart_average)
        print("Average Steps (last restart): ", last_steps_average)
        print("Average steps (all restarts): ", total_steps_average)


    # print_steep_climb_stats - Displays the report for steepest ascent algorithm with and without sideways move.

    def print_steepest_ascent_stats(self, output, head):
```

```
        total_runs = output[0][0]

        success = output[3][0]

        if success:
            success_rate = round((success/total_runs)*100,2)
            success_steps = output[3][1]
            avg_success_steps = round(sum(success_steps)/success, 2)
        else:
            success_rate = success_steps = avg_success_steps = '-'

        failure = output[1][0]+output[2][0]

        if failure:
            failure_rate = round((failure/total_runs)*100,2)
            failure_steps = output[1][1]+output[2][1]
            failure_avg_steps = round(sum(failure_steps)/failure,2)
        else:
            failure_rate = failure_steps = failure_avg_steps = '-'

        flatRuns = output[1][0]

        print("\n\n"+head)
        underline = ''
        for i in range(len(head)): underline+="="
        print(underline)
        print("\nN value: ", self.n_value, " (i.e ",self.n_value,"x",self.n_value,")")
        print("Total Runs: ", total_runs)
        print("\nSuccess, Runs: ", success)
        print("Success, Rate: ", success_rate, "%")
        # print("Success, Steps: ", successSteps)
        print("Success, Average Steps: ", avg_success_steps)
        print("\nFailure, Runs: ", failure)
        print("Failure, Rate: ", failure_rate, "%")
        # print("Failure, Steps: ", failureSteps)
        print("Failure, Average Steps: ", failure_avg_steps)
        print("\n\nFlat local maxima / Shoulder: ", flatRuns)
        return

n_input = 0
input_iterations = 0
input_sideways = 0
```

```
#Reading N value of N Queens problem
while(True):
    try:
        n_input = (int)(input("Please enter N value: "))
        if(n_input < 4):
            print("Please enter a number that is above 3! ")
        else:
            break
    except ValueError:
        print("Please enter a number!")

#Reading maximum iterations value
while(True):
    try:
        input_iterations = (int)(input("Please enter iterations value: "))
        if(input_iterations < 1):
            print("Please enter a number that is 1 or above! ")
        else:
            break
    except ValueError:
        print("Please enter a number!")

#Reading maximum sideways value
while(True):
    try:
        input_sideways = (int)(input("Please enter a value for the maximum sideways move allowed: "))
        if(input_sideways < 1):
            print("Please enter a number that is 1 or above! ")
        else:
            break
    except ValueError:
        print("Please enter a number!")

if __name__ == "__main__":
    hill_climbing_analysis = Hill_Climbing_Analysis(n_input, input_iterations, input_sideways)
    hill_climbing_analysis.do_analysis()
```

Citation:

- https://en.wikipedia.org/wiki/Hill_climbing
- https://en.wikibooks.org/wiki/Artificial_Intelligence/Search/Iterative_Improvement/Hill_Climbing