Hill-Climbing Search

AI+X
INSTITUTE FOR ARTIFICIAL INTELLIGENCE

Local Search

- Sometimes we care only about the final state, not the path to get there
- Goal
  - Find the best state according to an objective function (heuristic)
- How?
  - Search from a start state to neighboring states (successors), without keeping track of the paths, nor the set of states that have been reached
- Applications
  - Integrated-circuit design, factory floor layout, job scheduling, automatic programming

Local Search

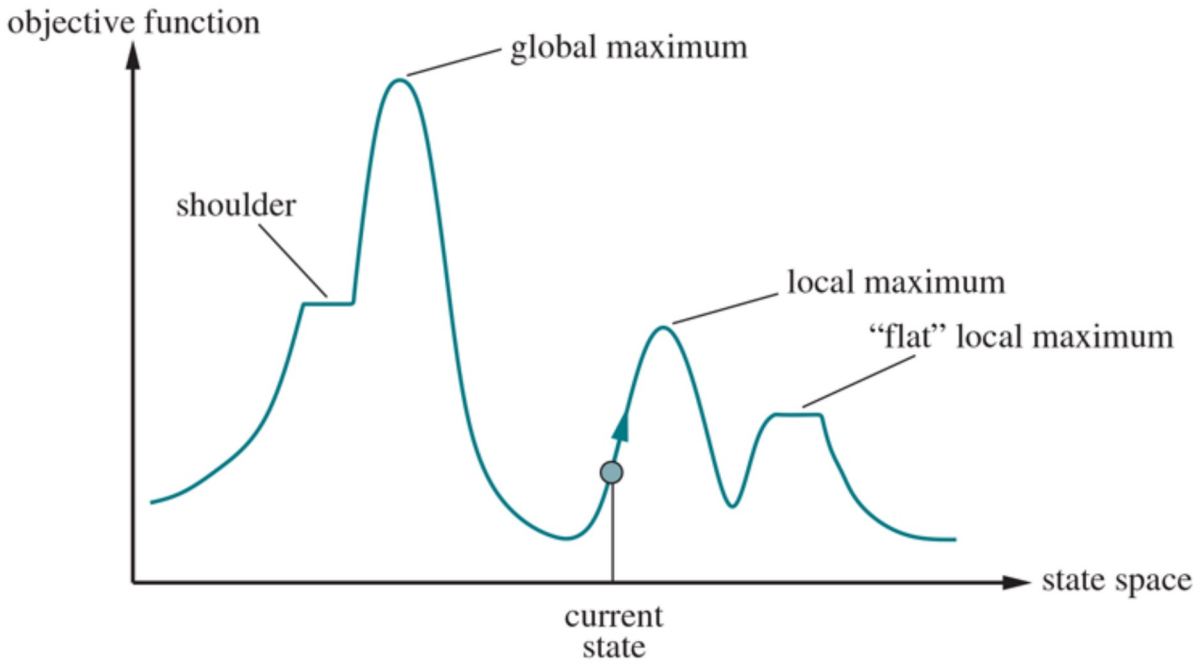


Figure 1. Landscape representing the objective function, and the aim is to find the global maximum.

Local Search

- Objective function and state neighborhood depend on the problem
- Example
  - 8-queens
  - Goal
    - Place 8 queens on a chess board so that no queen attacks another

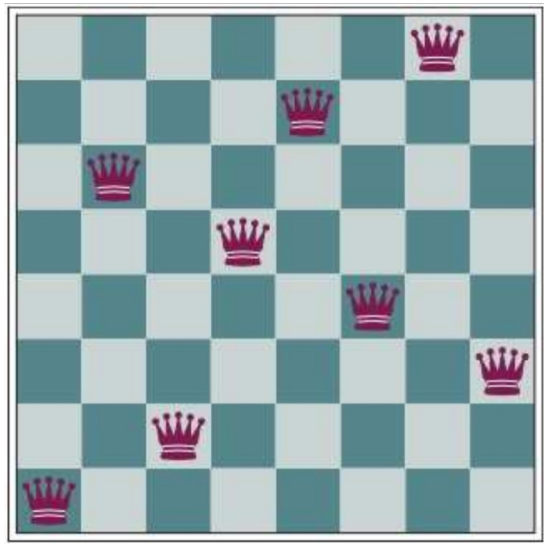


Figure 2. The 8-queens problem.

Local Search

- State
  - One queen per column
- Objective function
  - Number of queen pairs attacking each other
- State neighborhood
  - Move one queen to another row in the same column

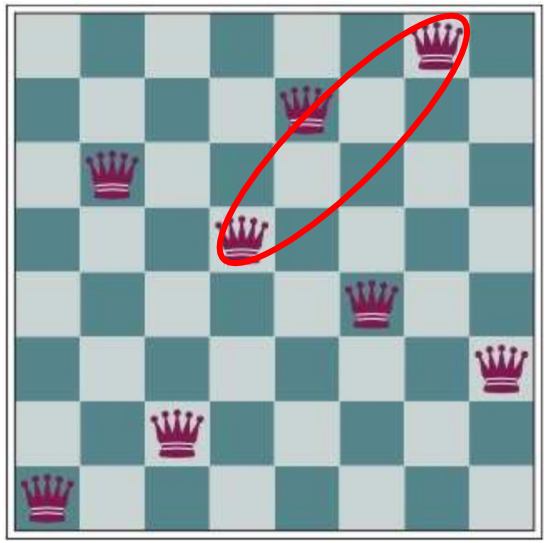


Figure 3. The 8-queens problem. The objective function value for this state is 1.

Local Search

- The objective function value for neighboring states can indicate a path to follow
- In this example, the current objective function value is 17

Figure 4. Value of objective function for each possible successor.

Hill-climbing Search

- Algorithm
  - Keeps track of one current state
  - On each iteration moves to the neighboring state with highest value
    - Heads in the direction that provides the steepest ascent
  - It terminates when it reaches a “peak” where no neighbor has a higher value
- Hill-climbing does not look ahead beyond the immediate neighbors of the current state
- Hill-climbing may NOT reach a solution

Knowledge Check 1

Which successor will be chosen by the Hill-climbing algorithm for the 8-queens configuration on the left?

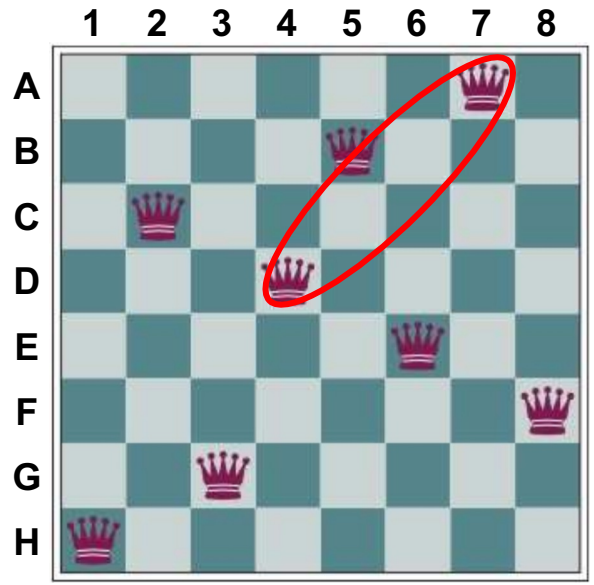


Figure 5. The 8-queens problem.

A. Move D4 to A4

B. Move A7 to H7

C. Move D4 to E4

D. None of the successors can improve upon the current state

Hill-climbing Search

Figure 6. Hill-climbing search.

Hill-climbing Search

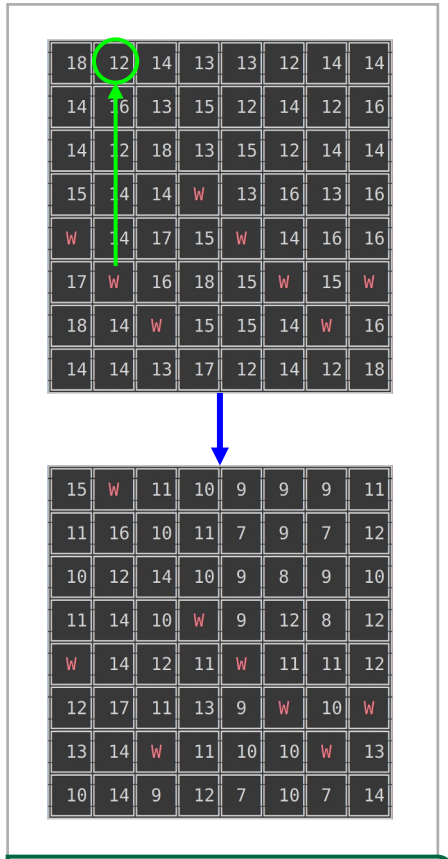


Figure 7. Hill-climbing search.

Hill-climbing Search

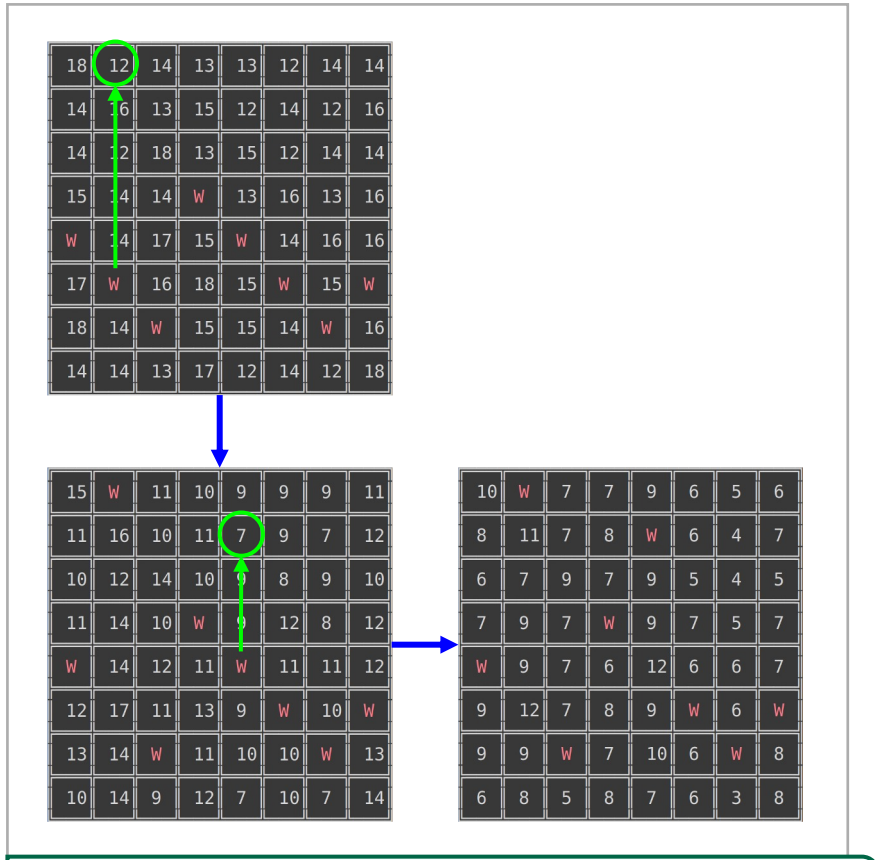


Figure 8. Hill-climbing search.

Hill-climbing Search

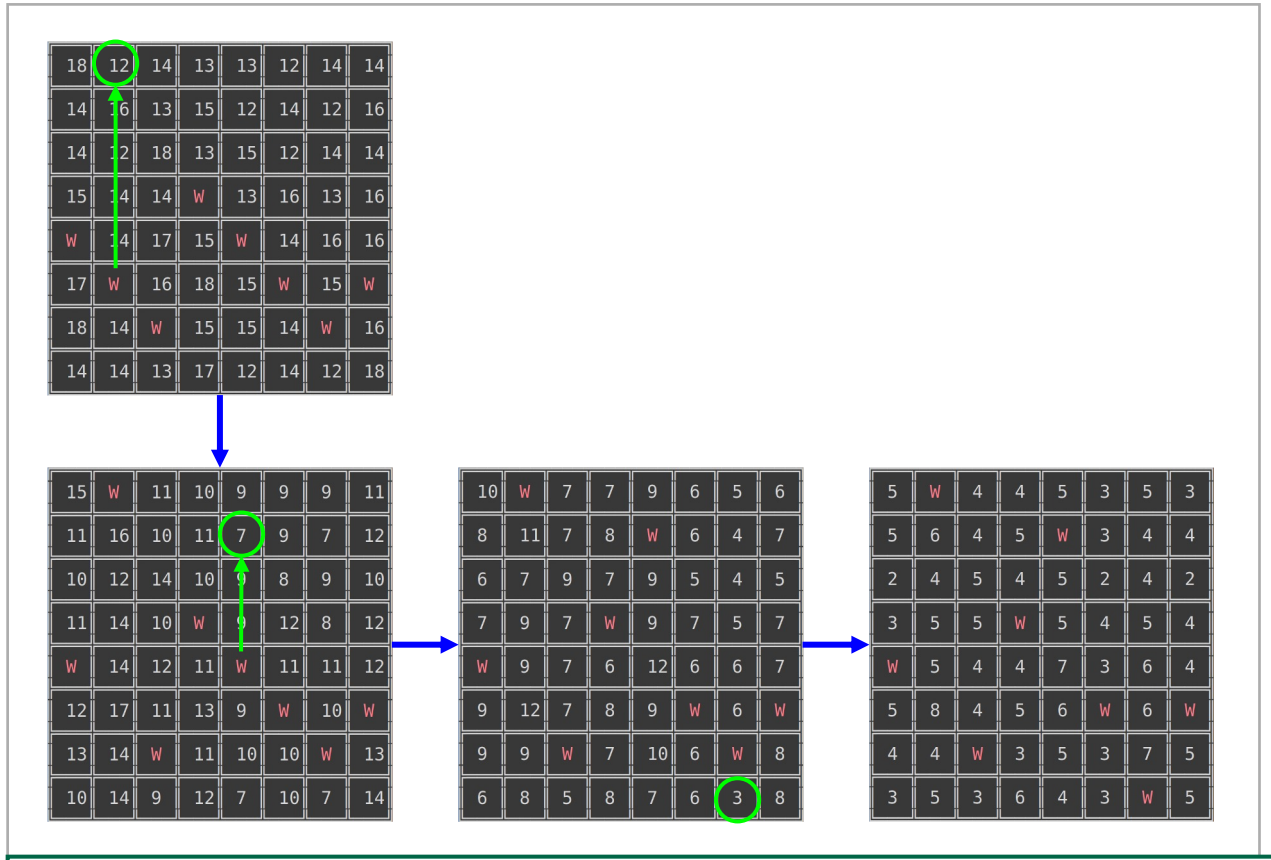


Figure 9. Hill-climbing search.

Hill-climbing Search

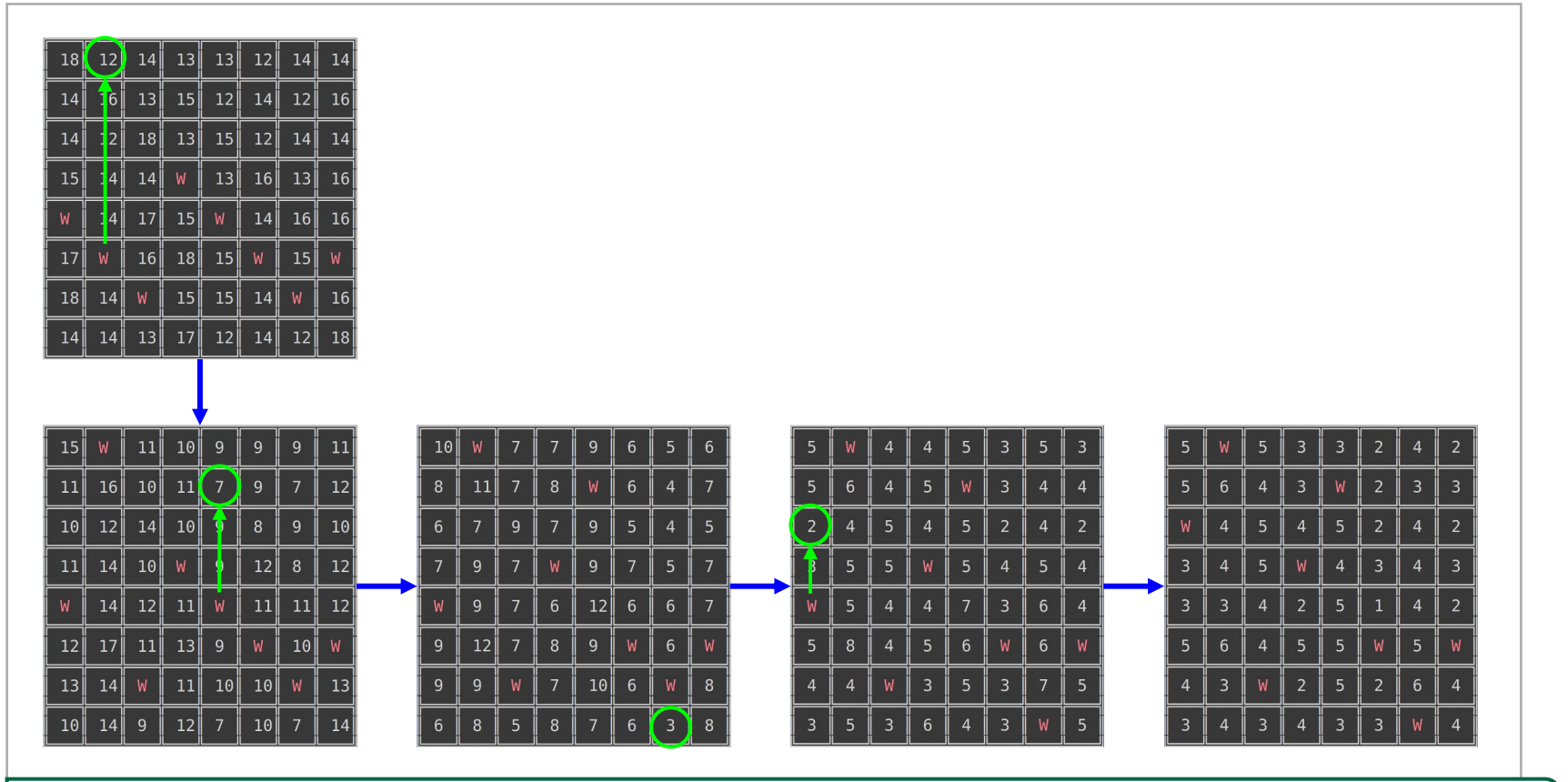


Figure 10. Hill-climbing search.

Hill-climbing Search

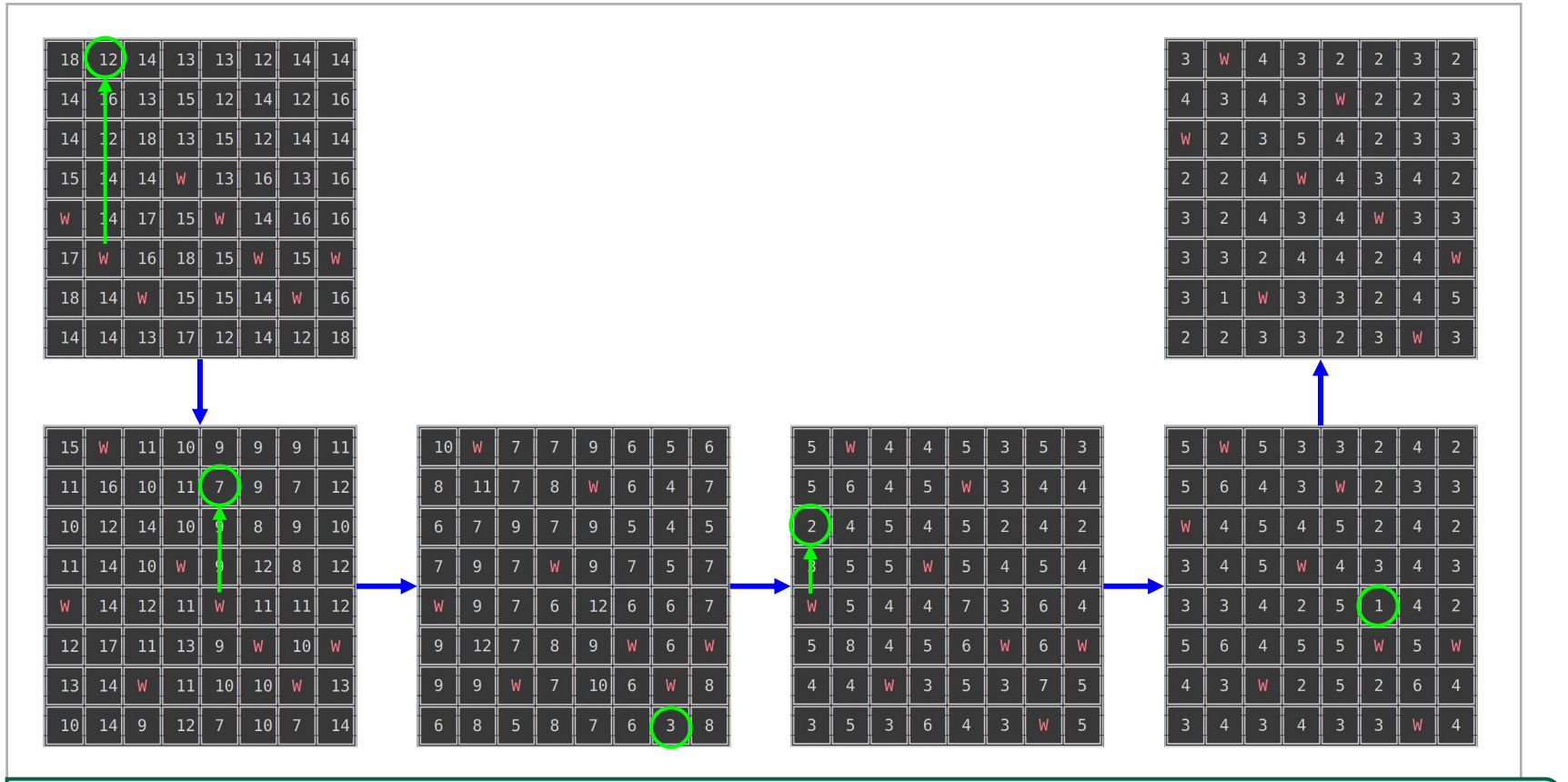
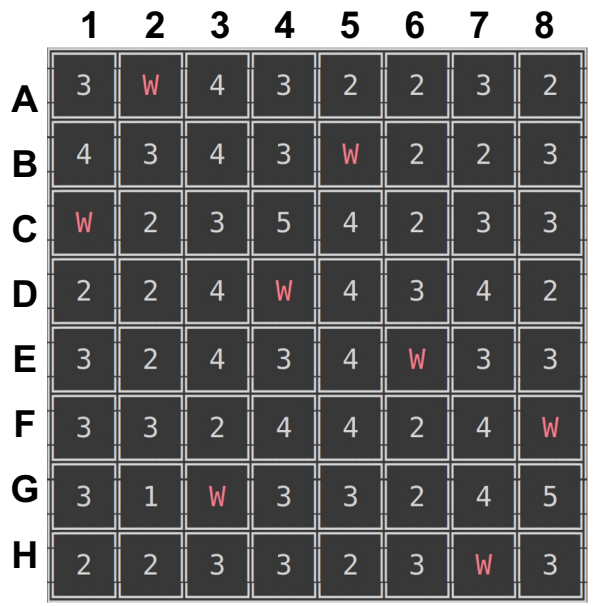


Figure 11. Hill-climbing search.

Knowledge Check 2

The value of the objective function for the 8-queens configuration on the left is 1. What will be the next step of the Hill-climbing algorithm?



	1	2	3	4	5	6	7	8
A	3	W	4	3	2	2	3	2
B	4	3	4	3	W	2	2	3
C	W	2	3	5	4	2	3	3
D	2	2	4	W	4	3	4	2
E	3	2	4	3	4	W	3	3
F	3	3	2	4	4	2	4	W
G	3	1	W	3	3	2	4	5
H	2	2	3	3	2	3	W	3

Figure 12. The 8-queens problem.

A. Move A2 to G2

B. Move G3 to G2

C. Stop because none of the successors can improve upon the current state

Hill-climbing Search

- Hill-climbing gets stuck 86% of the time in the 8-queens problem
  - Takes 4 steps on average to succeed and 3 to get stuck
- Solution
  - Keep going when reaching a plateau
  - Limit the number of consecutive sideways moves to avoid infinite loops
  - Raises the success rate from 14% to 94%
    - With a limit of 100 sideways moves, it takes 21 steps on average to succeed and 64 to fail

Hill-climbing Search

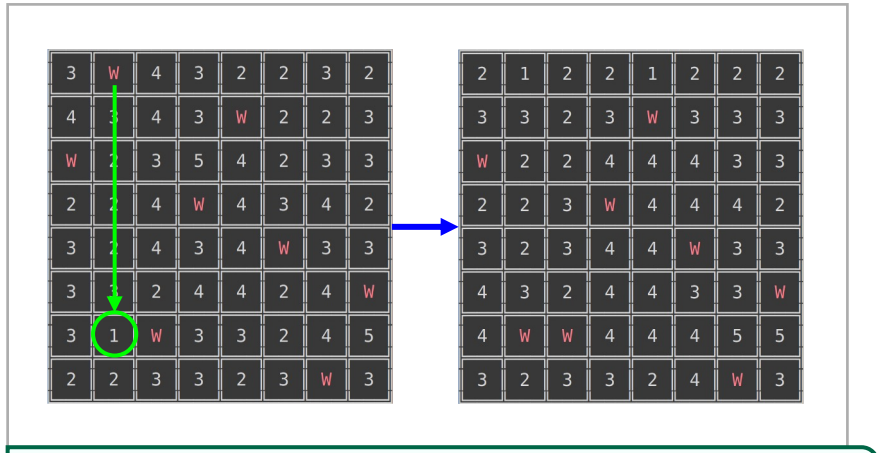


Figure 13. Hill-climbing search.

Hill-climbing Search

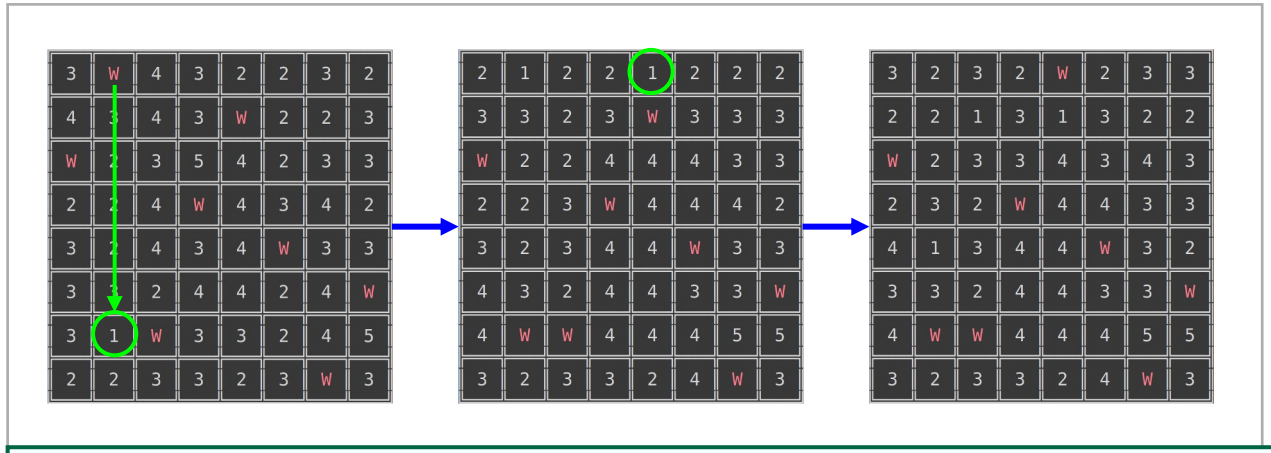


Figure 14. Hill-climbing search.

Hill-climbing Search

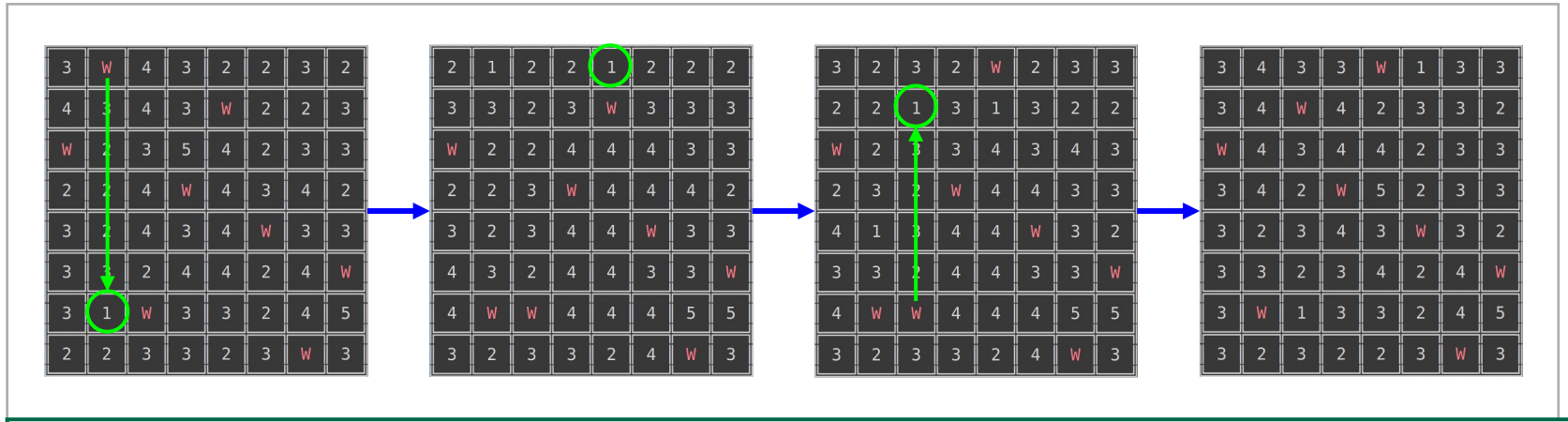


Figure 15. Hill-climbing search.

Hill-climbing Search

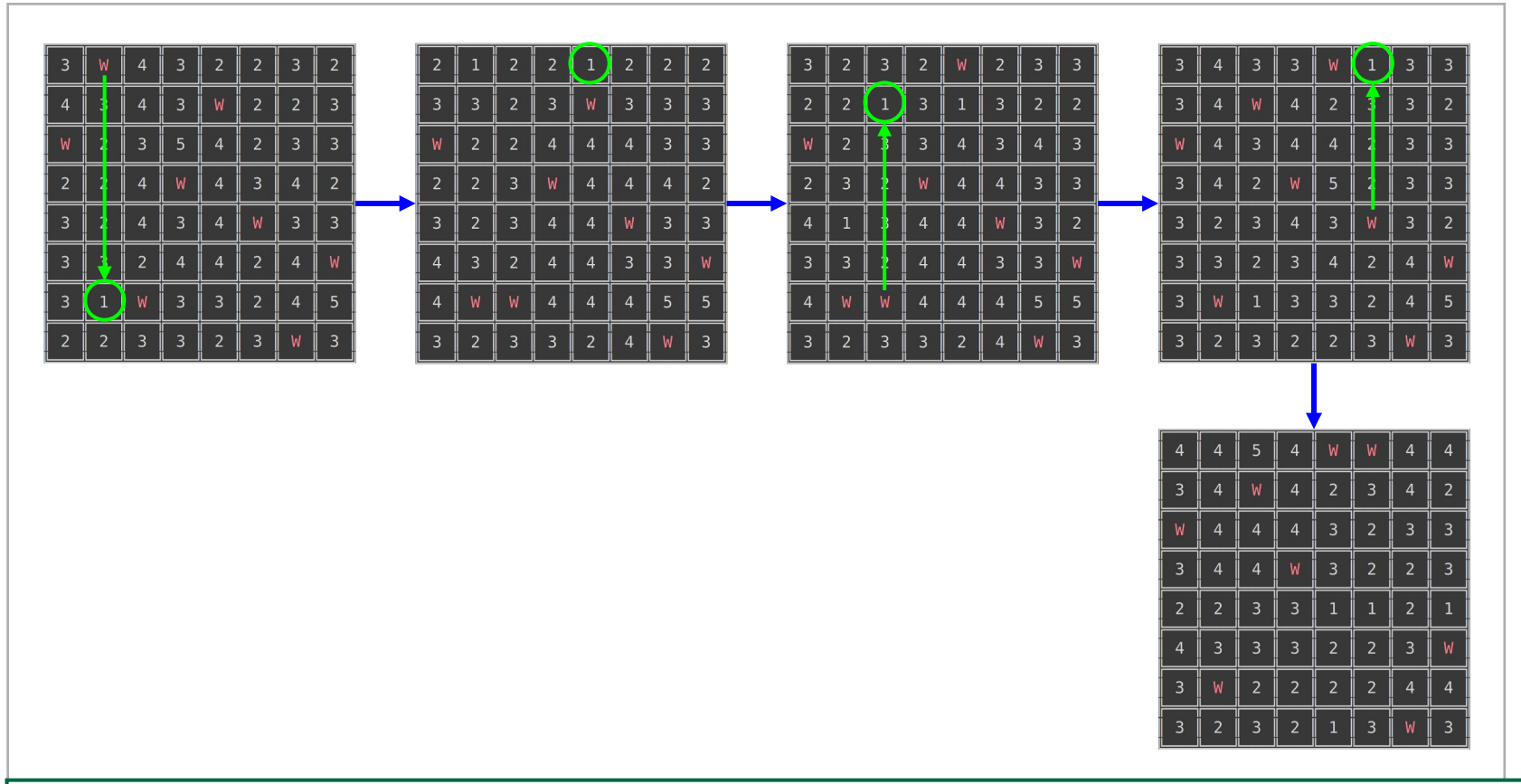


Figure 16. Hill-climbing search.

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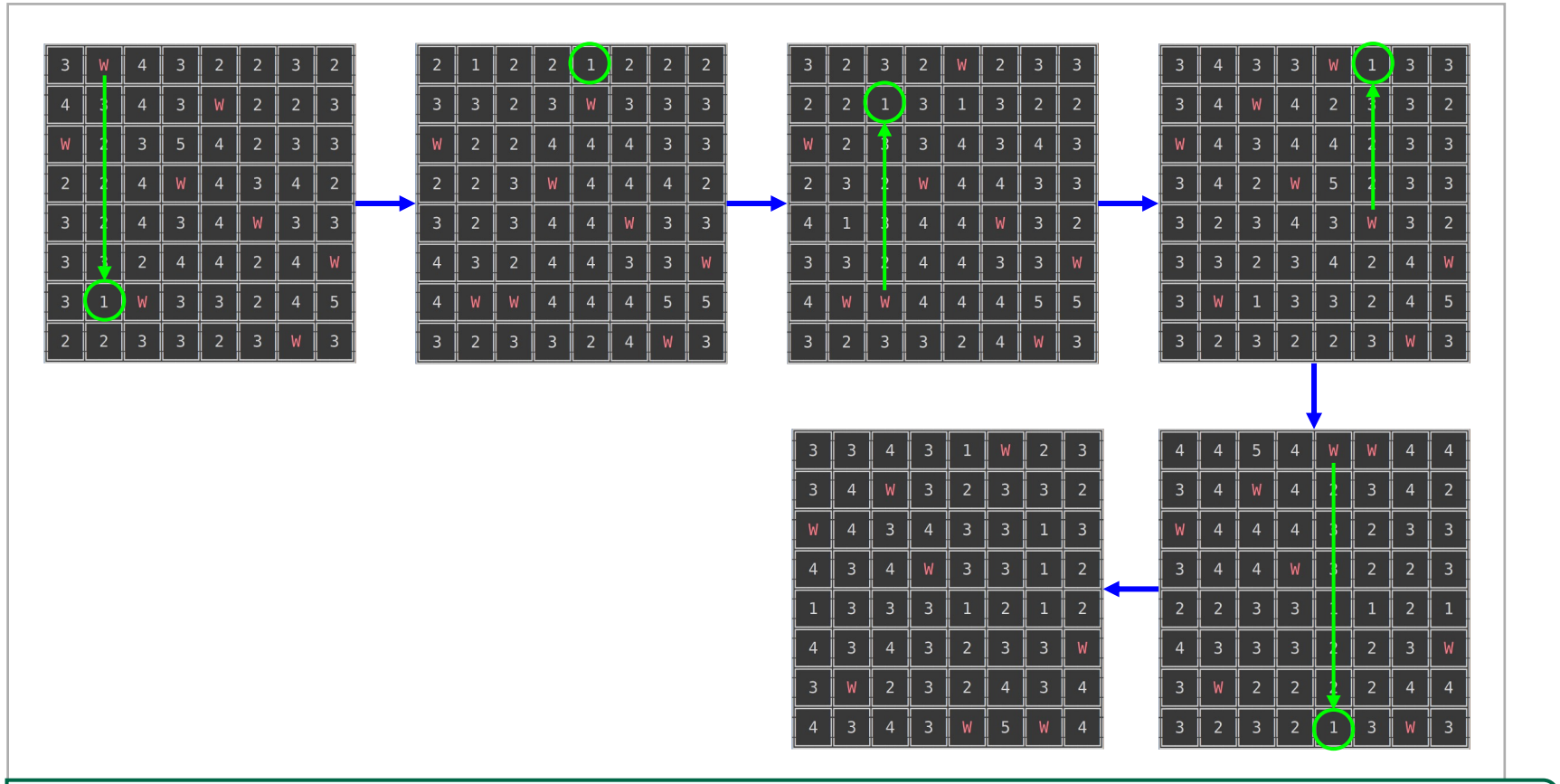

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Hill-climbing Search

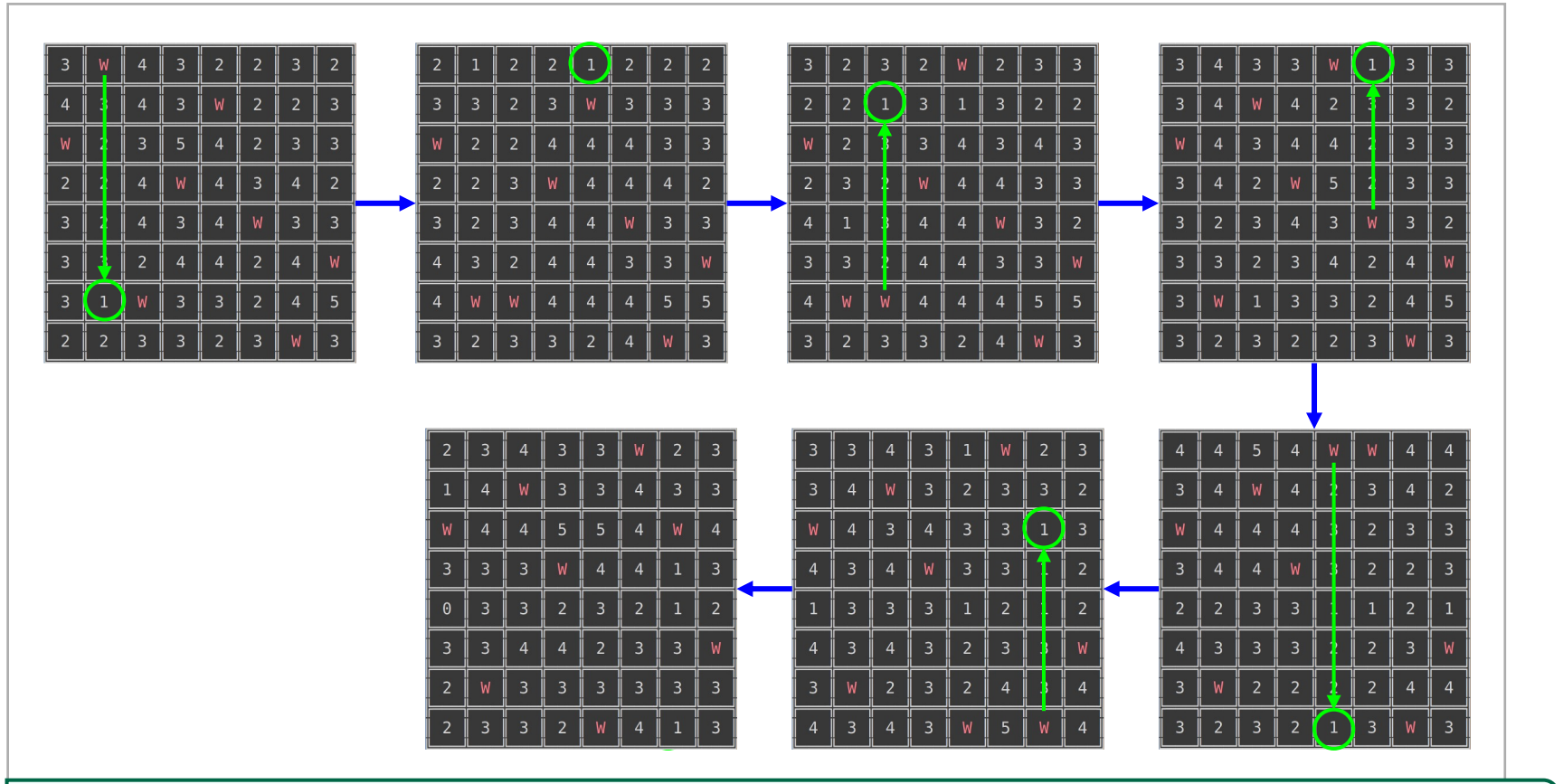

Figure 18. Hill-climbing search.

Hill-climbing Search

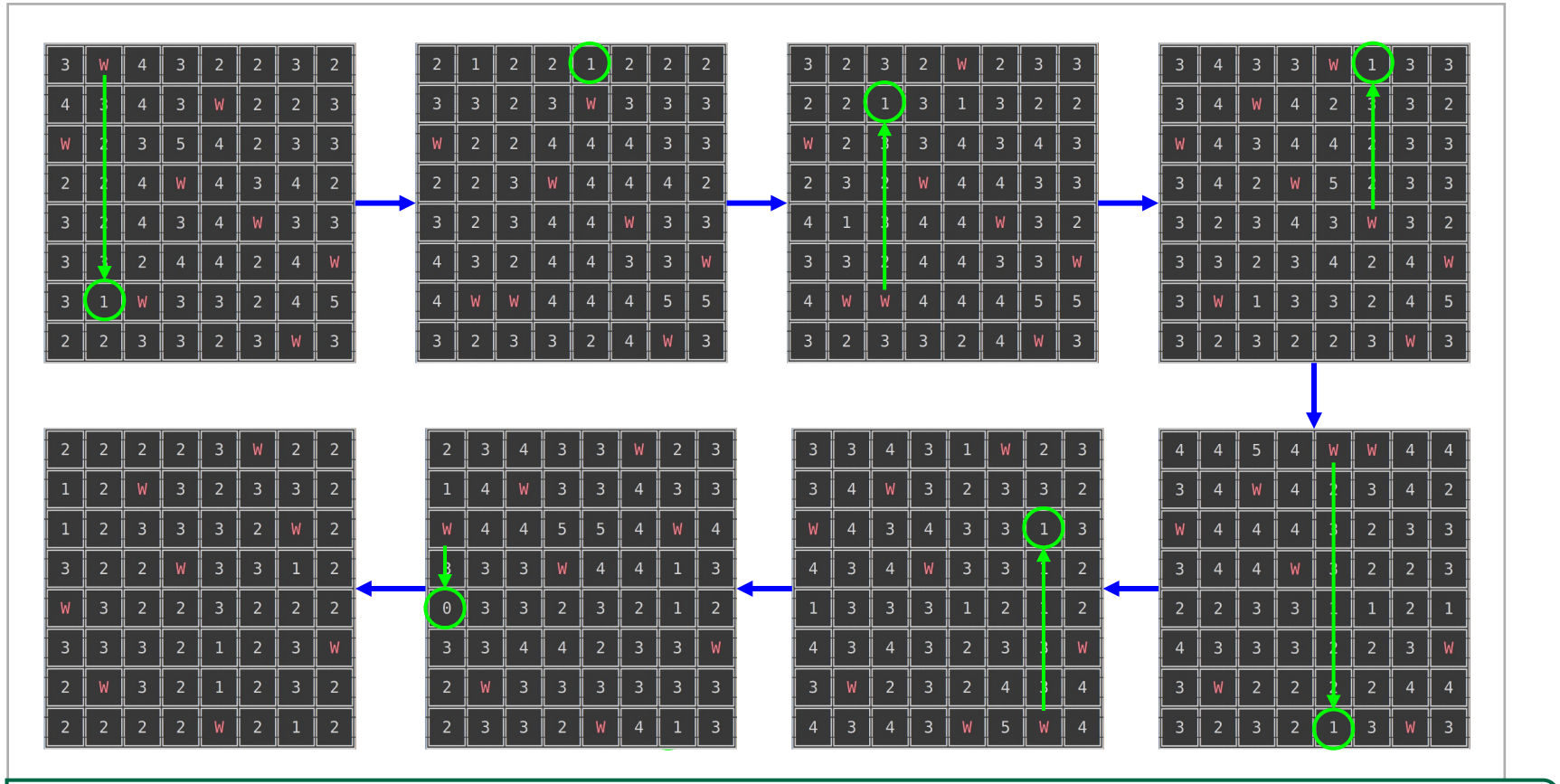

Figure 19. Hill-climbing search.

You have reached the end of the lecture.

Image/Figure References

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