



Local Search

Chapter 4

4.1 Give the name of the algorithm that results from each of the following special cases:

- ✓ a. Local beam search with $k = 1$.
- ~~b.~~ Local beam search with one initial state and no limit on the number of states retained.
- ✓ c. Simulated annealing with $T = 0$ at all times (and omitting the termination test).
- ✓ d. Simulated annealing with $T = \infty$ at all times.
- e. Genetic algorithm with population size $N = 1$.

a. Local beam search with $k = 1$ is hill-climbing search.

b. Local beam search with one initial state and no limit on the number of states retained, resembles **breadth-first search** in that it adds **one complete layer of nodes** before adding the next layer. Starting from one state, the algorithm would be essentially identical to breadth-first search except that each layer is generated all at once.

c. Simulated annealing with $T = 0$ at all times: ignoring the fact that the termination step would be triggered immediately, the search would be identical to first-choice hill climbing because every downward successor would be rejected with probability 1. (Exercise may be modified in future printings.)

d. Simulated annealing with $T = \infty$ at all times is a random-walk search: it always accepts a new state.

e. Genetic algorithm with population size $N = 1$: if the population size is 1, then the two selected parents will be the same individual; crossover yields an exact copy of the individual; then there is a small chance of mutation. Thus, the

algorithm executes a
random walk in the space of individuals.

Design an objective function for each of the following problems:

- ✓ a. 8 Queens
- ✓ b. Creating a Course Schedule
- c. Solving Equations
- d. Winning at Chess

- ✓ a. The number of queens under threat (minimize).
- b. The number of columns, rows and 3x3 squares that do not contain unique numbers (minimize). ✓
- c. The number of conflicts (minimize). → course schedule
- ✓ d. The absolute (or square) difference between the left and right hand side (minimize).
- e. The percentage of wins (maximize).

Suppose that we want to minimize the function:

$$f(x, y) = |2x| + |3y| + 4|x - y|, \quad x, y \in \mathbb{Z}$$

Using Hill Climbing where we have 4 possible actions:

1. Increment x
2. Decrement x
3. Increment y
4. Decrement y

Starting from $(x, y) = (4, 3)$, answer the following:

- a. At which point will hill climbing terminate? $(3, 3)$
- b. Is this the global minimum? No
- c. If not, what can we change such that we can reach the minimum from any initial state?

→ allow simulated annealing

$$(2, 1) \rightarrow 4 + 3 + 4 = 11$$

$$(1, 1) \rightarrow 2 + 3 + 0 = 5$$

$$(3, 2) \rightarrow 6 + 6 + 2 = 14$$

$$(2, 2) \rightarrow 4 + 6 + 0 = 10$$

$$4 + 6 = 10 < 15 \checkmark$$

Step 1:

$$f(4, 3) = 8 + 9 + 4 = 21$$

Successors:

$$f(5, 3) = 10 + 9 + 8 = 27$$

$$f(3, 3) = 6 + 9 + 0 = 15 \text{ (best)} \checkmark$$

$$f(4, 4) = 8 + 12 + 0 = 20$$

$$f(4, 2) = 8 + 6 + 8 = 22$$

Step 2:

$$f(3, 3) = 6 + 9 + 0 = 15 \text{ (best)}$$

Successors:

$$f(4, 3) = 8 + 9 + 4 = 21$$

$$f(2, 3) = 4 + 9 + 4 = 17$$

$$f(3, 4) = 6 + 12 + 4 = 22$$

$$f(3, 2) = 6 + 6 + 4 = 16$$

So hill climbing will stop at step 2 with the solution being $(x, y) = (3, 3)$

However, by inspecting the function, we can easily notice that $(x, y) = (0, 0)$ should be the global minimum.

Hill climbing failed since it got stuck in a ridge.

We can solve this problem by one of the following solutions:

- ✓ 1- Add diagonal movement to the actions where we can change both x and y in the same action. (e.g. decrement x and decrement y in the same action).
- ✓ 2- Use another search algorithm such as simulated annealing.