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 = ∞ 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).
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:

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

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?
b. Is this the global minimum?
c. If not, what can we change such that we can reach the minimum from any initial state?

Step 1:
f(4, 3) = 8 + 9 + 4 = 21
Successors:
f(5, 3) = 10 + 9 + 8 = 27
f(3, 3) = 6 + 9 + 0 = 15 (best)
f(4, 4) = 8 + 12 + 0 = 20
f(4, 2) = 8 + 6 + 8 = 22

Step 2:
f(3, 3) = 6 + 9 + 0 = 15 (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.