Metaheuristics
- Simulated Annealing-

Hyunsoo Lee, Ph. D.

References

- X.S. Yang, “Harmony Search as a Metaheuristic Algorithm”, Music-Inspired Harmony Search Algorithm: Theory and Applications (Editor Z.W. Geem), Studies in Computational Intelligence, Springer, Vol. 191, 1-14, 2009

Origin

- Inventor
  - Kirkpatrick, Gelatt and Vecchi (1983)(The Hebrew University of Jerusalem)

Idea (1/3)

- 2D NLP

Idea (3/3)

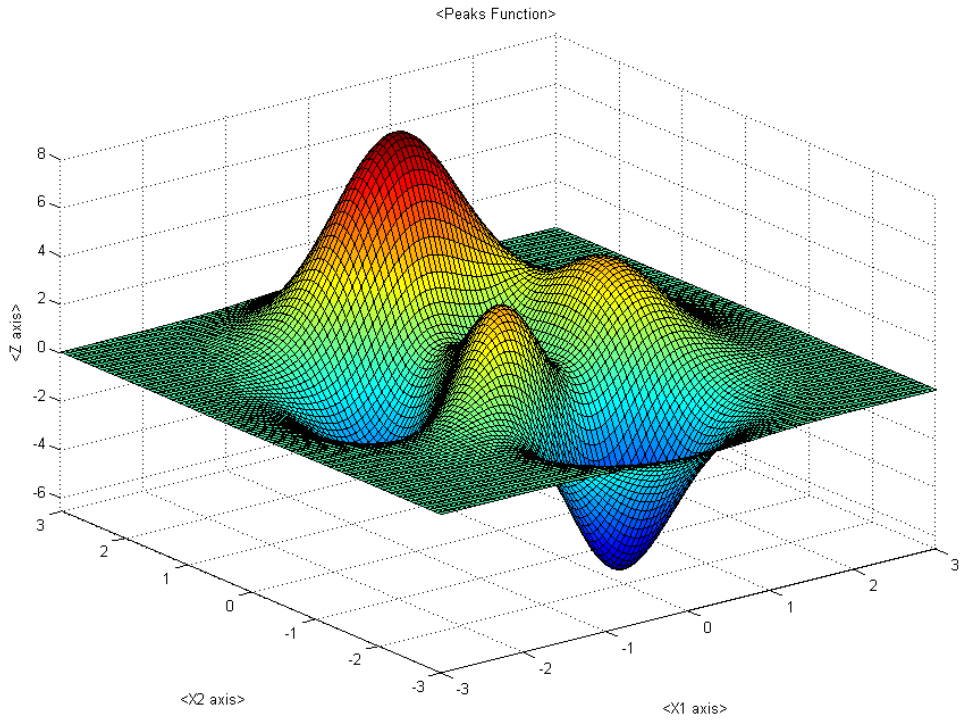
- Cont’d

Idea (3/3)

- Cont’d

Motivation (1/4)

- Quick example

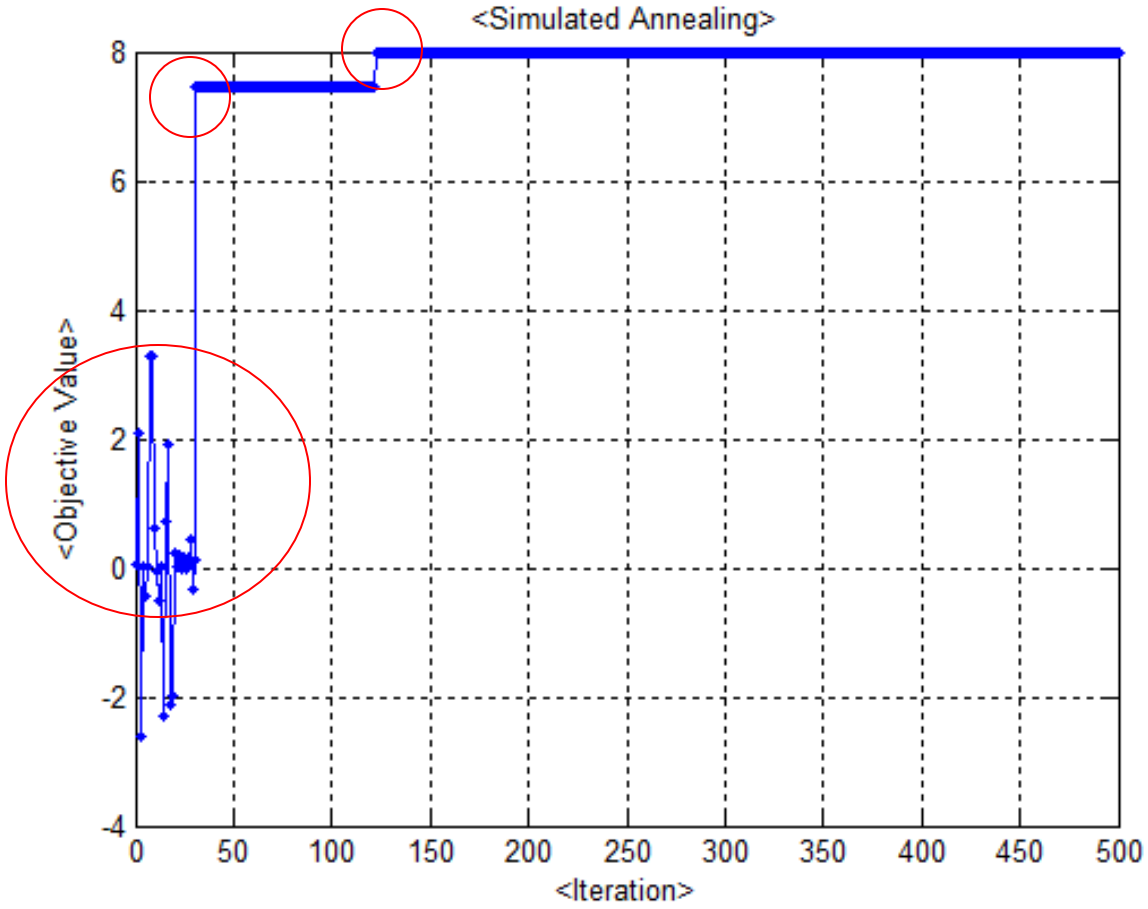


$$\begin{cases} X_{\min} = (0.23, -1.64) \\ Z_{\min} = -6.55 \end{cases}$$

$$z = 3(1-x_1)^2 e^{-(x_1^2+(x_2+1)^2)} - 10\left(\frac{x_1}{5} - x_1^3 - x_2^5\right)e^{-(x_1^2+x_2^2)} - \frac{1}{3}e^{-((x_1+1)^2+x_2^2)}$$

Motivation (2/4)

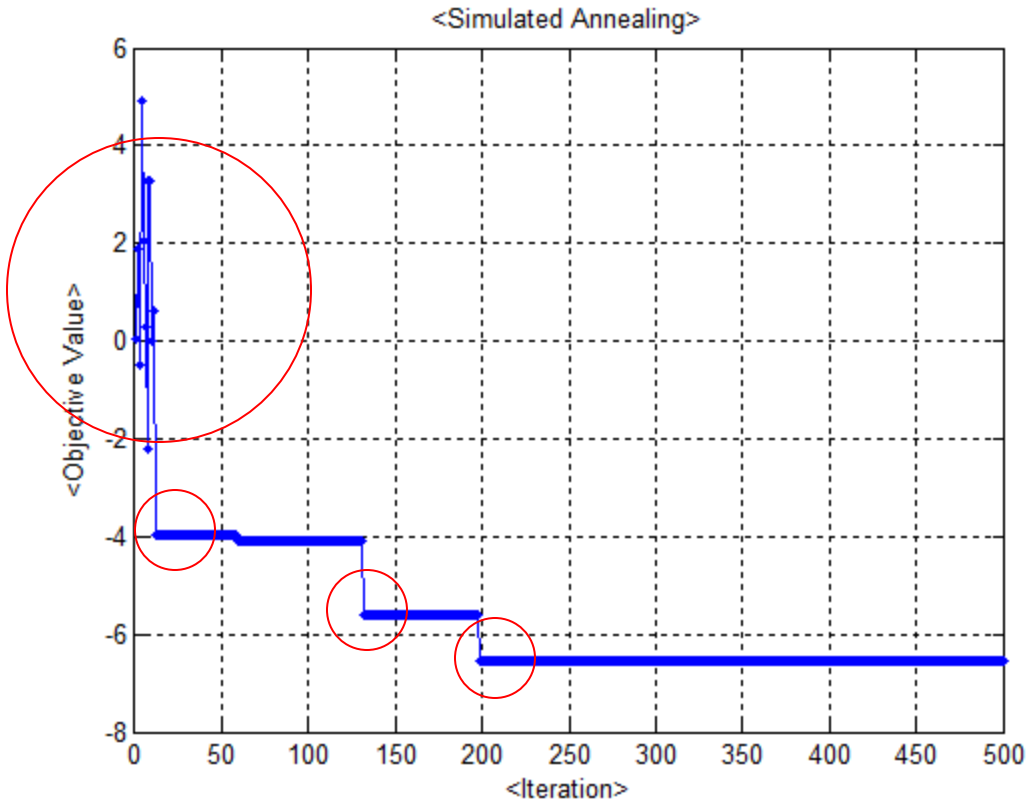
- Maximization



1.Random Search
2. Gradient Search

Motivation (3/4)

- Minimization



1.Random Search
2. Gradient Search

Motivation (4/4)

- Checklist / Doubt from previous example
  - Implement
  - and check “Metropolis algorithm”

$$rand < e^{-\frac{E}{T_j}}$$

$$rand < e^{-\frac{|E|}{T_j}}$$

$$rand < e^{-\frac{\delta E}{T_j}}$$

Terms and Concept

- Perturb

- Term
  - Design Vector
  - System Energy
  - System Temperature
  - Difference in System Energy

Control Parameter

- Control Parameters for SA
  - 1) Initial Input
  - 2) Neighbor Strategy
    - Random or Structured
  - 3) Energy fun. (almost given)
  - 4) Equilibrium state
    - Q) Can it be skipped?
  - 5) Cooling Schedule

Algorithm

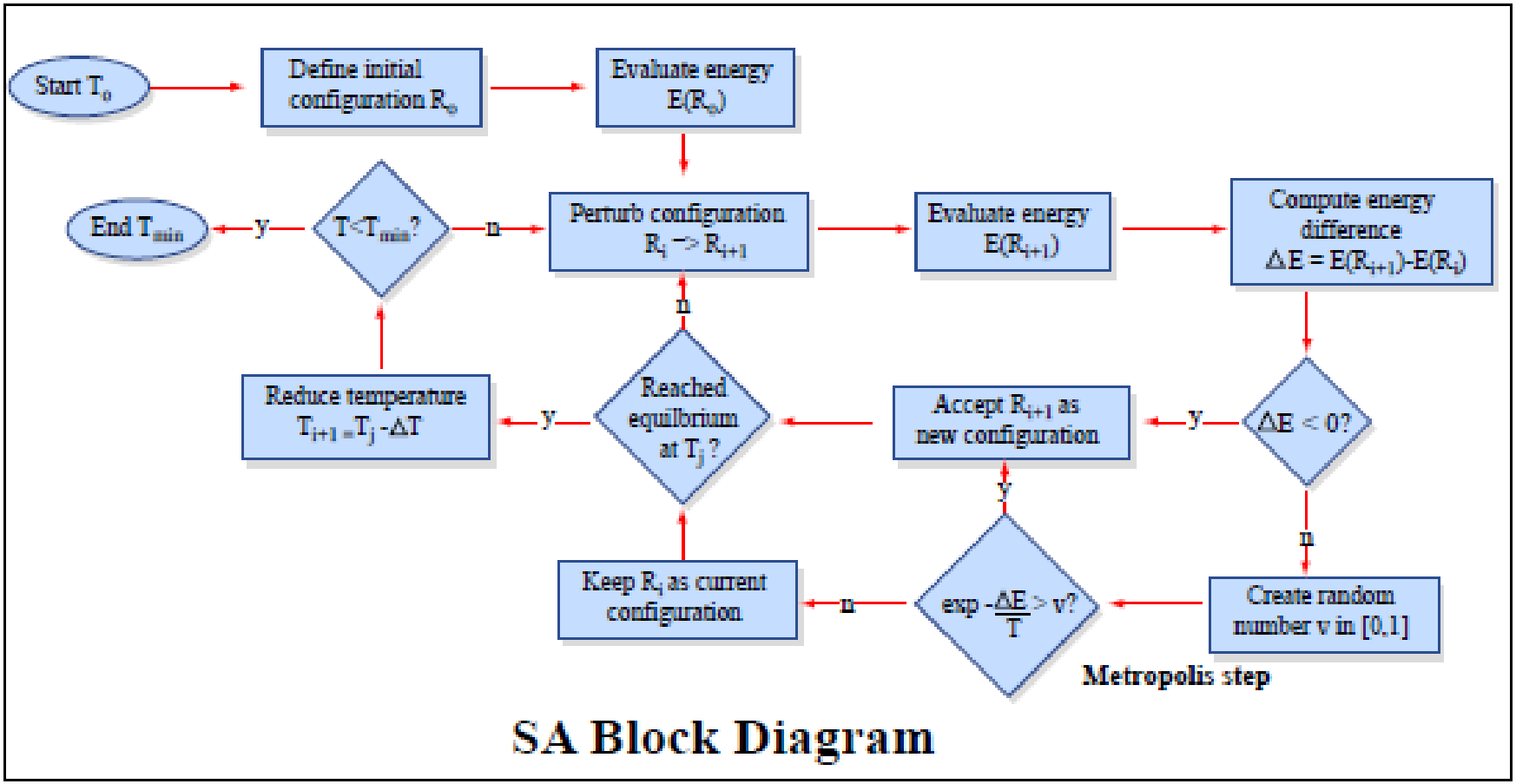


Image by MIT OpenCourseWare.

Cooling Strategy

- Monotonic Cooling

$$T(t) = T_0 \alpha^t$$

$$\alpha \in (0,1)$$

$$t \equiv time\ \ step\ \ or\ \ iteration$$

  - $\alpha \to 0$: too quick freezing
  - $\alpha \to 1$: slow convergence

- Non-monotonic cooling

Limitation

- Pros
- Cons
  - Repetition possibility from “Perturbation process” → Emergence of “”