International Journal of Advanced Research in Engineering and Applied Sciences
ISSN: 2278-6252

ANALYZE THE SIMULATED ANNEALING ALGORITHM

Navid Samimi Behbahan*

Milad Samimi Behbahan*

Abstract: *In this article we consider one of the problem optimizations named The Simulated Annealing. Indeed the SA is inspired from the act of melting and cooling materials (Annealing materials) so it's been called The Simulated Annealing. This article doesn't claim that the SA will offer the best answer, but the SA searches for an appropriate and optimized answer. SA is used in most of the problems including NP-Complete problems.*

*Department of Computer Engineering, Behbahan Branch, Islamic Azad University, Behbahan, Iran

1- INTRODUCTION

SA is based on the resemblance between finding the optimized answer and the formation of crystals in the plating. Molecules of a metal have specific potential energy than each other. After heating, the metal obtains more kinetic energy and as a result is freer to move. Molecules can leave their fixed positions in the metal crystal and sit in the different positions toward each other. Set of the particles are more likely to shape in a form in which the total energy of the system is the least. Cooling slowly (decreasing energy due to the thermal difference) gives the opportunity to the system to try all molecular states (even those in which the potential energy is high) until it gets the state which has less potential energy than the first state. Because of the less kinematic energy and as a result, less ability for molecules to move, system holds on its steady state (in metals molecules shape arranged crystals). The important point is that the ultimate steady state is independent from the first state.

2- ALGORITHM METHOD

At first, an arbitrary point of the space is chosen and the penalty function is calculated there. And then a initial temperature is ascribed to the system (equivalent to the kinetic energy). Choosing the initial temperature is arbitrary but we can choose the energy depending on the behavior of the function at the start point. For example if the changes of the function is low, we ascribe a small number so that the ability to move is less and if the changes of the function is high, we ascribe a larger number so that the ability to move and exiting from local minimum will be more- this kind of selecting depends on the question. For deciding about moving to the new point we perform as follow:

if the answer gets better, MOVE. Otherwise, go to the newer point with the Probability P. the Probability P is chosen according to the temperate of the system and the change in the penalty function (Difference between the first and the last point) [1].

One of the commonest functions used for deciding about how to move toward the new point is defined as below:

$$\begin{cases} P = \exp\{-\dfrac{U-U0}{T}\} & U-U0>0 \\ P = 1 & U-U0<0 \end{cases}$$

P: The possibility of move to a new point
U0: Potential energy at the point of origin
U: Potential energy at the point of destination
T: Temperature (proportional to the kinetic energy)

Inspired by the beauty of the probability that the energy E of a body at temperature T is expressed. The function is defined in a way in which if the temperature is higher, the ability to increase the kinetic energy is higher, vice versa- bigger T results in a smaller fraction and also a bigger P. the other parameter which play a rule in defying the probability of the P is the magnitude of the change of the function through the path. More oblique the function is, less probable the P is, vice versa [2].

After each move, the system temperature is slightly lowered. (Less energy lost). The high frequency of loss of kinetic energy of the system is expected to be less the potential energy (the lowest penalty function) is reached. The algorithm flowchart in Figure 1 is visible.

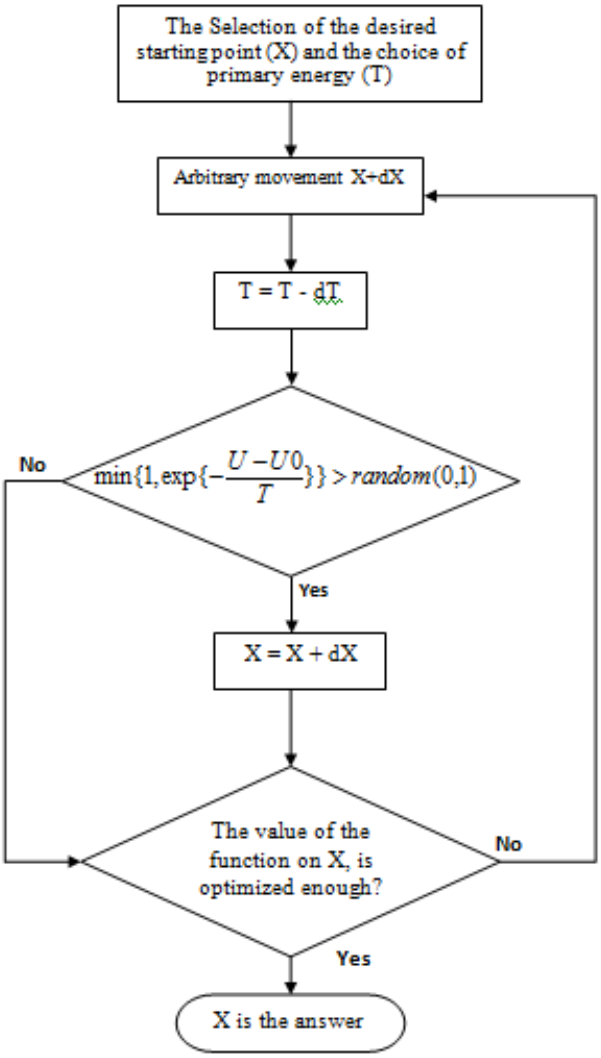

Figure 1: SA algorithm flowchart

3- COOLING PROCESS

Following are the containing parts of the cooling process:

- ✓ The initial temperature
- ✓ The final temperature
- ✓ Decreasing temperature in each step
- ✓ Repeating in each temperature

3-1- The Initial Temperature

Until the temperature is cooled down enough, finding an initial temperature is hard and there isn't any specific way to find it. If we know the maximum distance in neighborhoods, we can find out the initial temperature using this data (we can calculate the necessary energy).

It's recommended that we start with a high temperature and then quickly heated until 60% of the bad solutions can be accepted and then cooled very slowly. In this method, the temperature is starting to get real [3].

3-2- The Final Temperature

Usually the temperature is allowed to decrease until it's zero. Also the standard for stopping is an appropriate low temperature.

3-3- Decreasing Temperature in Each Step

We are usually able to calculate the decrease in the temperature with a simple linear equation.

$$t_i = \alpha t_{i-1}$$

Experiments have shown that α must be between 0.8 and 0.99 so the best result will be reached and the algorithm won't get so long.

3-4- Repeating in Each Temperature

The used equation is:

$$t = t(1 + \beta t)$$

β is an appropriate little value.

In low temperatures the Repeating number must be large and in high temperatures this number can be small.

4- COST FUNCTION

Methods of solutions for a problem must be the ways to measure the quality of that solution. Cost function is always complicated and is shown by ΔE .

ΔE : evaluating the difference between the current solution and the adjacent solution.

5- NEIGHBORHOOD

When you are thinking about a question, first you are searching for a way how to move from one state the other one. If we suppose each step as same as a node of a Graph, we will have specific neighborhoods. In SA we have to use neighbors in which the convergence of the solution to the right answer is kept [4].

Shift Methods in Neighborhood:

- ✓ DIS: if we suppose each neighborhood as a specific array, the first and the last arrays are shifted with its adjacent array and if the array is from the middle, it's shifted with the better adjacent array
- ✓ RIS: 2 arrays are shifted randomly
- ✓ AIS: as similar as DIS but in this method, from the both adjacent arrays, one is chosen randomly

6- CONCLUSION

Some problems which may be impossible to solve by the other methods, can be solved using the SA method. SA doesn't offer the best answer but offer an appropriate and more optimized answer (indeed if the necessary parameters are chosen properly). Totally SA has been successful in solving hard problems and also has offered more optimized answer than the other Meta heuristic algorithms.

REFERENCES

[1] Aarts, E.H.L. and Korst, J. (1989) Simulated Annealing and Boltzmann Machines: "A Stochastic Approach to Combinatorial Optimization and Neural Computing". John Wiley & Sons, Chichester, England.

[2] Salamon P, Nulton J, Harland J R, Pedersen J, Ruppeiner G and Liao L ,"Simulated annealing with constant thermodynamic speed Phys". Commun. 43 423–8, (1988).

[3] Hoffmann K H and Salamon P, "The optimal simulated annealing schedule for a simple model", J. Phys.A: Math. Gen. 23 3511–23, (1990).

[4] Anily, S. and Federgruen, A., "Simulated annealing methods with general acceptance probabilities". Journal of Applied Probability, 24, 657–667, (1987).