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Implementation of NP HARD Graph Problem with Simulated Annealing

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Abstract- In this paper we use travelling salesman problem where we have a list of cities and their distances from one city to another and the task is to find the shortest possible route that visit each city exactly once and returns to its original. So there are so many optimization techniques but here we are using simulated annealing in order to get best solution.

Keywords: Travelling salesman problem, Simulated annealing, graph search, starlight application, uphill climbing.

I. Introduction:

Simulated annealing is a method of finding optimal values numerically. It chooses a new point, and (for optimization) all uphill points are accepted while some downhill points are accepted depending on probabilistic criteria. For certain problems, simulated annealing may be more efficient than exhaustive enumeration — provided that the goal is to find an acceptably good solution in a fixed amount of time, rather than the best possible solution. Simulated Annealing is a local search method based on local optimization. In this method each trial solution in the solution space has a cost, and the objective is to find a feasible solution of least cost. The method is iterative. In each cycle we try to move from the current trial solution S to a neighboring point S' in the solution space in an effort to find a better trial solution.

II. Literature Review:

A. TRAVELLING SALESMAN PROBLEM: Traveling Salesman Problem (TSP) has been an interesting problem for a long time in classical optimization techniques which are based on linear and nonlinear programming. TSP can be described as follows: Given a number of cities to visit and their distances from all other cities know, an optimal travel route has to be found so that each city is visited one and only once with the least possible distance traveled. This is a simple problem with handful of cities but becomes complicated as the number increases.

B. SIMULATED ANNEALING (SA): Annealing is a process of metal casting where the metal is first melted at a high temperature beyond its melting point and then it allowed cooling down until it returns to its solid form. In the physical process of annealing the hot material gradually losses energy and finally at one point of time reaches a state of minimum energy. The probability of such transition to a higher energy states is given by $P=\exp(-\Delta E/KT)$ Simulated annealing is use to identify the direction of search when the function f yield no better next state then the current state under this circumstance E is computed for all possible legal next state and P is evaluated for each states. A random no in the interval of [0,1]is computed and compare with P if P is more, then it is selected for next transition.

C. ALGORITHM OF SA:

```
Procedure SA
 {
input a trial solution S; c = cost(S); c* = infinity; freezecount = 0; initialize temp;  initialize frzlim, sizefactor, tempfactor,
minpercent, tcent;
while ( freezecount<frzlim )
 {
changes = trials = 0;
while ( trials <sizefactor * N )
 {       /* N is determined by the size of the problem */
trials = trials + 1; generate a random neighbour S' of S;
c' = cost(S'); Δ = c'- c;
if (S' is feasible and cost(S') < c* )
  {
S* = S'; c* = cost(S');
 }    /* save best feasible solution found so far */    if (Δ < 0)
```



```
  {
changes = changes + 1;  c = c'; S = S';
 } /* downhill move */
else
{ /* possible uphill move */
choose a random number r in [0,1];
if ( r <= exp(-Δ/temp) )
{
changes = changes+1; c = c'; S = S';
 }
     }
 }
if  (changes/trials >tcent ) temp = 0.5 * temp;  /* reduce temperature quickly */   else temp = tempfactor * temp; /* reduce temperature slowly */
if ( changes/trials <minpercent ) freezecount = freezecount+1;
elsefreezecount = 0;
}
output the final solution S*;        /* S* is a feasible solution of minimum cost */ }
```

III. Problem Formulation:

A. STARLIGHT APPLICATION: The cities in the TSP are the celestial objects to be imaged, and the cost of travel is the amount of fuel needed to reposition the two satellites from one image to the next. At first we are considering 5 locations .there are links which shows the cost distance from each node to every other node. The satellite starts from any image place and visits every image place and finally returns to its original position. There are 5 locations so (5-1)!/2 Which is 12 .We have to consider 12 Hamilton circuit and find out the best solution which is cost less or optimum.

B. EXISTING SYSTEM: To solve a starlight problem we are using much optimization technique. The most straight forward way to solve the starlight to examine all possible Hamilton circuit and select one which is minimum cost. How many circuit we have to find if there is N? Once starting point is chosen then there is (N-1)! Circuits to be examined. Because Hamilton circuit can be travel in reverse order we have to find (N-1)! /2 to find our answer. Note that (N-1)! /2 grow extremely rapidly. For example for 25 location a total of 24!/2 approximately (3.1*10^23) different Hamilton circuit to be considered. If it took just one nano-second to examine one Hamilton circuit a total of 10 years would be required to find a minimum Hamilton circuit in this graph by exhaustive search technique.

C. PROPOSED SYSTEM: The proposed system where we are using Simulated annealing the concept from metallurgical subject to compute minimum Hamilton circuit in a efficient manner. It will take less time and will give more efficient results in compare to any other exhaustive search technique. A simulated annealing algorithm has both greedy (deterministic) and random (stochastic) characteristics. The deterministic aspect attempts to improve upon the current state using a predefined cost function. However, the stochastic aspect occasionally accepts a state that is NOT an improvement. Simulate annealing has proven an effective technique for problems where there are many solutions and currently no way to derive which is the best one. So we will use simulated annealing in our project to see how it will help us to solve TSP application starlight for a large set of data.

IV. Result Analysis:

A. Input method: initial temp:2000 ,cooling rate:0.970,max iteration:2000,city to swap:2,No of location point=50.

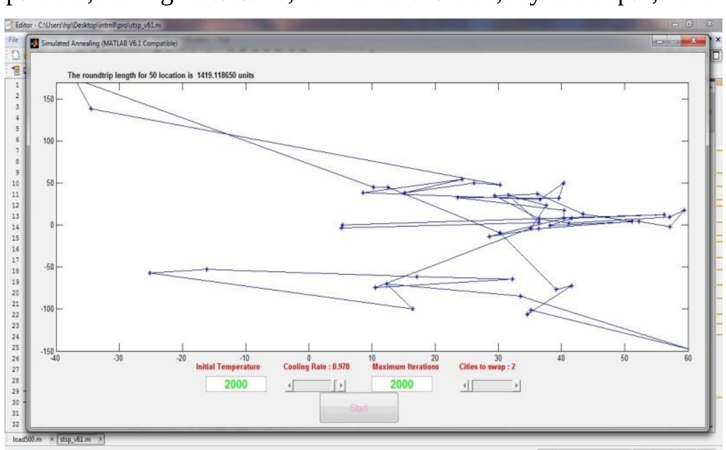

Fig: 6

OUTPUT: The round-trip length for 50 locations is 1419.118650 units.

B. Input method: initial temp:2000 ,cooling rate:0.970,max iteration:2000,city to swap:2,No of location point=100.

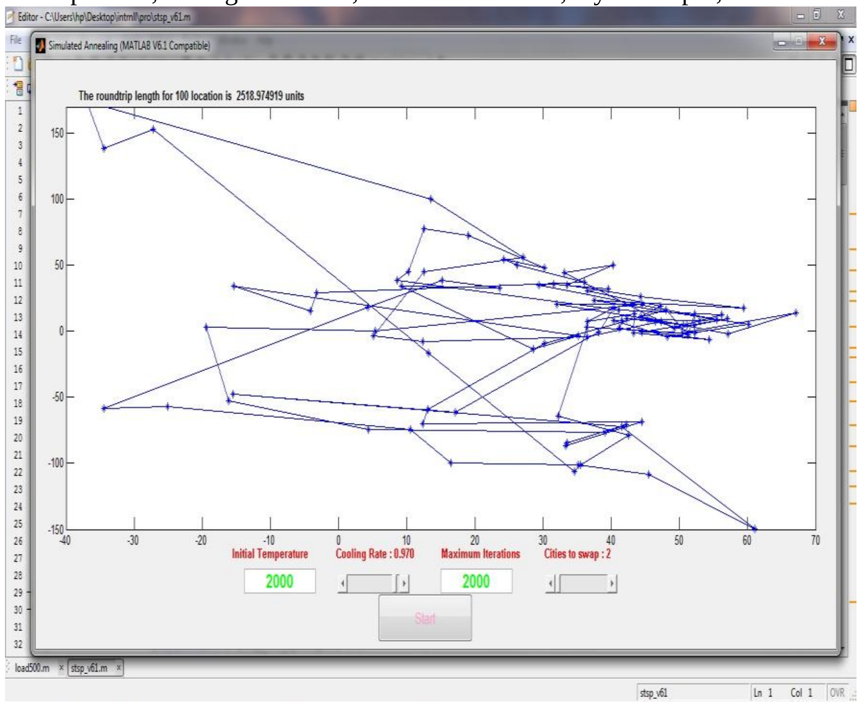

Fig:7

OUTPUT: The roundtrip length for 100 locations is 2518.974919 units.

C. Input method: initial temp:2000 ,cooling rate:0.970,max iteration:2000,city to swap:2,No of location point=200.

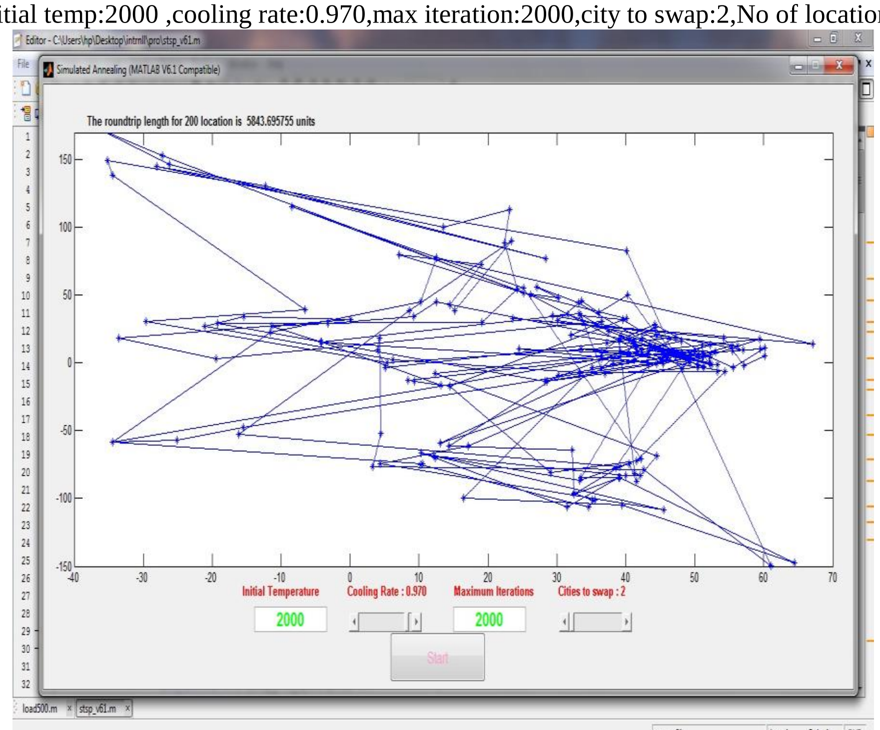

Fig: 8

OUTPUT: The roundtrip length for 200 locations is 5843.695755 units.

D. **Input method**: initial temp:2000 ,cooling rate:0.970,max iteration:2000,city to swap:2,No of location point=300.

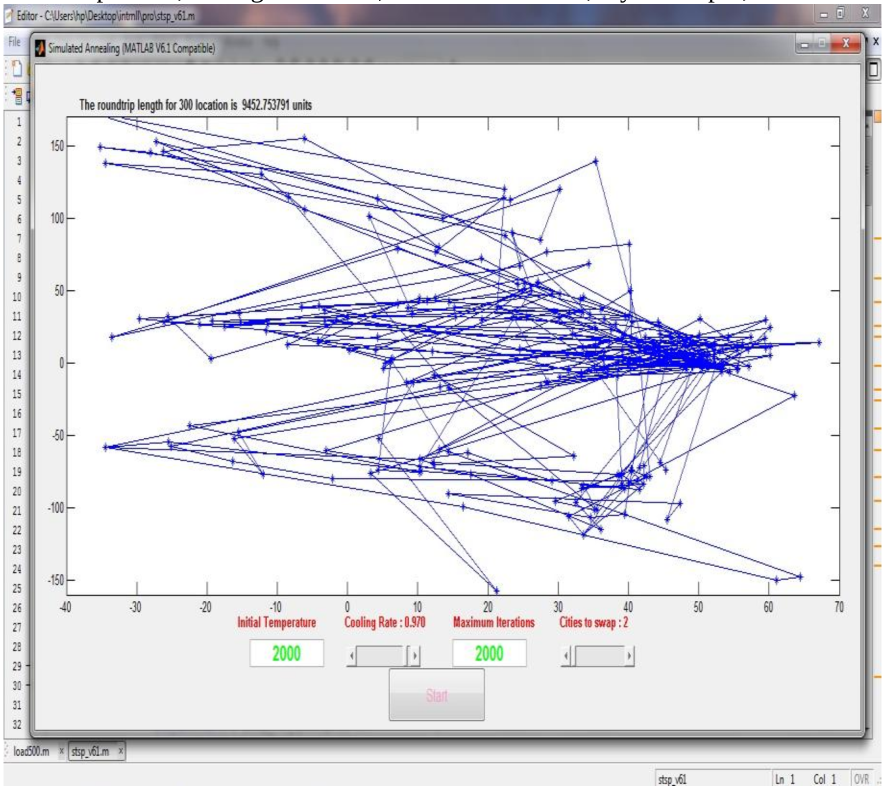

Fig: 9

OUTPUT: The roundtrip length for 300 locations is 9452.753791 units.

E. **Input method**: initial temp:2000 ,cooling rate:0.970,max iteration:2000,city to swap:2,No of location point=400.

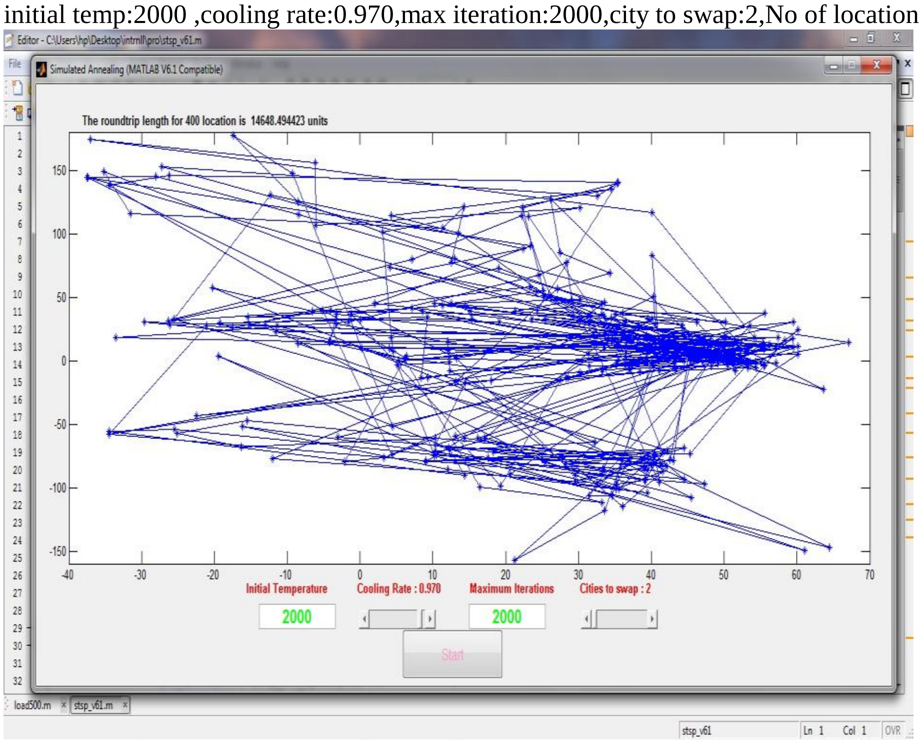

Fig: 10

OUTPUT: The roundtrip length for 400 locations is 14648.494423 units.

F. **Input method**: initial temp:2000 ,cooling rate:0.970,max iteration:2000,city to swap:2,No of location point=500.

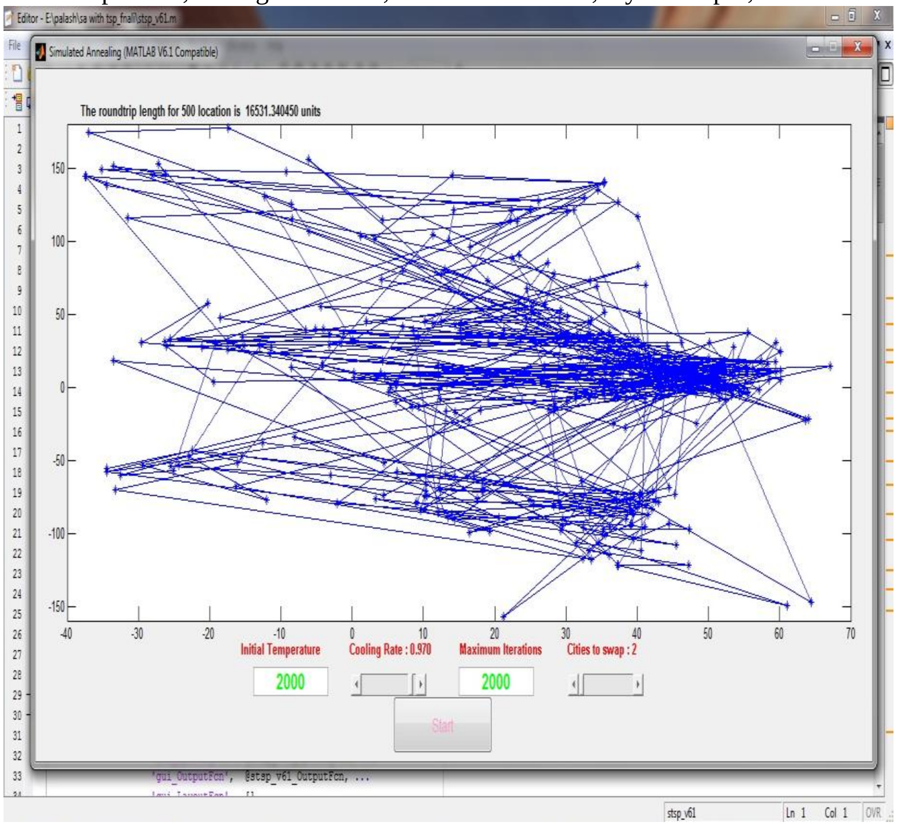

Fig: 11

OUTPUT: The roundtrip length for 500 locations is 16531.340450 units.

V. Conclusion:

Simulated annealing is a heuristic technique for combinational optimization problems which was capable of providing good solution to some very difficult problems. But SA can miss an optimal solution and not find it again (so try to remember the best solution found so far). SA is usually better than greedy algorithms, when it comes to problems that have numerous locally optimum solutions. Simulated Annealing always guarantees a convergence upon running sufficiently large number of iterations.

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