A Modified Simulated Annealing Algorithm for the Capacitated Vehicle Routing Problem

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WHAT is CVRP?

The CVRP problem is a typical NP-Hard problem. Due to the limitation in today's computation speed, it would take years to traverse all the routes and find the best solution. Therefore an evolution algorithm is needed to approaching the best solution.

The problem here is to deliver fruity buns from one depot to other 249 customers with different demands. One truck has 500 limit carry and every node can only be delivered once. Demands and 250 coordinates are given. Find the best solution to minimize total travelling distance.

WHY do I choose SA?

Simulated Annealing Algorithm (SA) is a simple and fast method that satisfies this requirement. SA has the potential to find the best solution, since it uses a function to generate a possibility to accept bad result, so as to avoid being caught in local optimum.

Other approach tried beside SA are Generic Algorithm and Greedy Search. Chromosome selection(Roulette) , crossover, mutation, inversion, insertion are used in GA to ensure randomness. However the result of GA was not ideal. It meet local optimum too early. Then I tried to apply Greedy Search with GA to minimize the route of every truck, since it is fast and may give some motivation when it reaches local optimum. After that the result was still over 7000. Then I tried to apply SA for the whole population to help accepting bad population. The result was the same as before. I started doing pure GA, pure Greedy Search and pure SA. It turned out that SA has the best result.

GA and Reedy Search both only accept best score, that can be the reason why they can not get down any deeper. Besides, the mix of algorithm is dangerous since the balance of every parameter in each algorithm can occupy too much time.
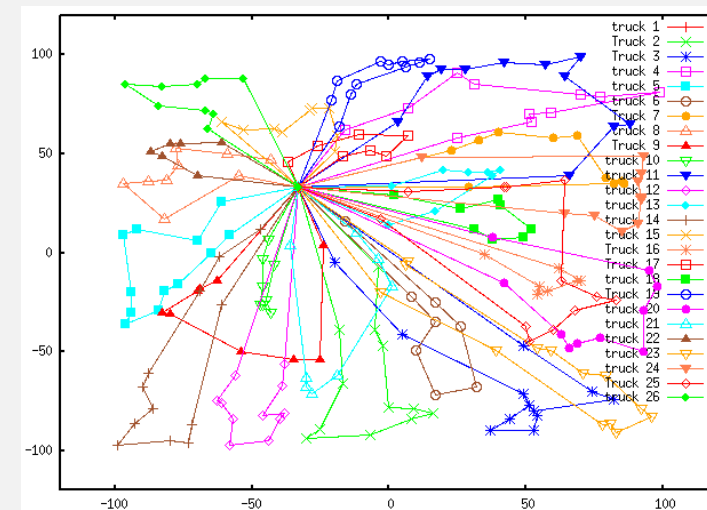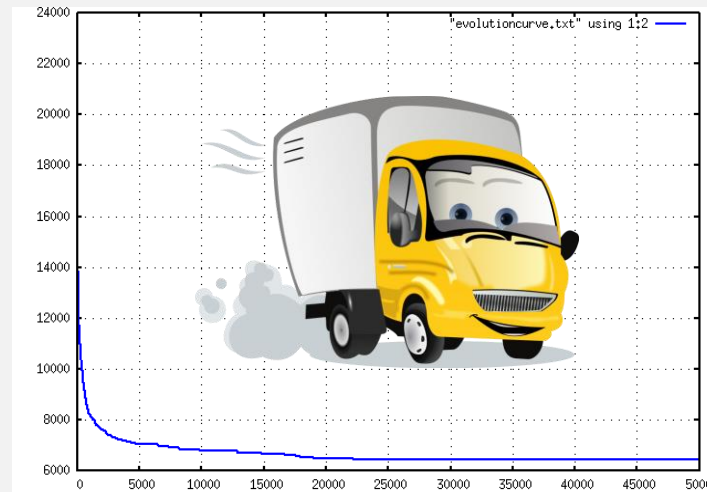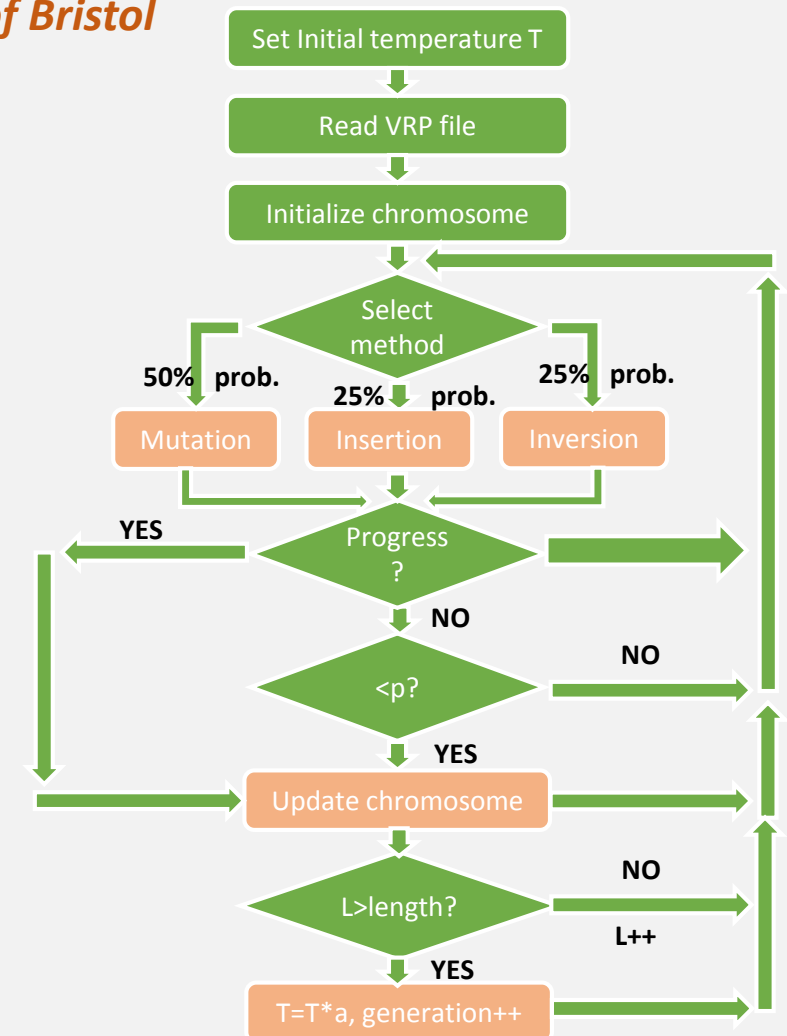
WHERE did I modify?

The original SA only has mutation where they swap 2 elements. However , pure mutation do not have good result, therefore insertion and inverse is added. Just like the flow chart shows above. The algorithm chooses which to use according to their possibility. When progress has been found after randomization, it will update and back to loop again. When there is no progress, it generates a random number to see if it lies in the possibility p.

Here $p = \exp(-delta/kT)$

Where delta is difference between old and new, k is constant value 0.95 and T is initial temperature and it goes down each generation by a.

Flow Chart

Set Initial temperature T → Read VRP file → Initialize chromosome → Select method

- **50% prob.** Mutation
- **25% prob.** Insertion
- **25% prob.** Inversion

Progress ? → **YES** / **NO**

<p? → **NO** / **YES**

Update chromosome

L>length? → **NO** L++ / **YES**

T=T*a, generation++

Result

The result shows in the middle. The first graph demonstrate a convergent process on best distance. The final result of route is printed in the diagram, which is much neater before applying the algorithm.
Here are parameters that can be modified in a range:

T=2, (2-10)
a = 0.95, (0.92,0.95,0.995)
Length = 200, (180-250)

References

1. Revised Simulated Annealing Algorithm, Jiang Longcong, Liu Jiangping, Chinese Journal of Engineering Geophysics, Vol 4, No 12, April 2007
2. Improved Simulated Annealing Algorithm for Global Optimization Problem of Optimal Solution, Pu Rongfu, Journal of Yibin University,2013.06.03