Solving *p-Hub* problem with a Steady State Genetic Algorithm

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1 Introduction

In this work I develop an algorithm aiming to solve the single hub location problem. Due to the nature of the hub location problem, the use of metaheuristics can simplify the process of finding an optimal solution.

In this work the optimal solution for the dataset provided in the original paper[1] is found. The solution for 2, 3 or 4 hubs is studied but this can this system can be expanded for more.

There is, also, a study of hyperparameters selection to achieve the solution in the least resource intensive way.

The code used in this work can be found here `https://github.com/sorny92/genetic_algorithm`.

2 *p-Hub* problem

A common problem to deal with in logistics is the hub location problem. A hub is a location that serves as a point of connections for different locations. If a person needs to go from A to B by plane is probable that there's no direct connection between this points so the user needs to traver to a hub that will connect them to the point B or a hub that is connected to the point B. Hubs have the purpose of connecting non-hub locations. Normally these hubs come with a cost, but they also bring economy of scales so transporting between hubs can be beneficial.

Knowing where to create a hub is important because it will help to decrease the cost of transportation optimizing the flows and inherit costs.

To define the problem we need to consider a series of nodes and each one of them has a flow that needs to go from the node i to the node j. This travel from node to node has a cost. So the goal to solve the problem is to minimize the cost of the whole network.

One of the key elements of this problem is that is not possible to have an optimal solution in an acceptable time due to the high combinatorial characteristics of it.

There are several variants of this problem. For example, the single hub problem which considers there is only one hub to allocate. Then you have the p-hub which you have a p number of hubs to allocate where every non-hub is connected to only one hub. These connections could be set through an optimal policy, so it's another part of the problem to optimize or could be allocated by distance/cost. There are more variants with multiple connections from non-hubs to different hubs, variants with limitations in the hub flows, variants with costs on setting up links, etc...

In this essay we will focus on the p-hub problem where the assignation of non-hubs to hubs is done through cost minimization. The code in this system allows to modify an α value to proportionally decrease the cost of hub to hub connection but because we use the minimum cost allocation this value does not change the result.

3 Method

The implementation of this solution is based on the code developed by E. Alba here `https://neo.lcc.uma.es/software/ssga/index.php`. This software is based on Java but the implementation used in this work is reimplemented in C++ to know more in deep how to develop this kind of systems.

4 Results

5 Conclusion

A complex version can be done where the allocation is not done to the closest but also be learnt changing the genome to a two pair set up and removing the nearest allocation mechanism. [2]

parameters inspiration got from here: [3]

References

[1] Morton E. O'kelly. A quadratic integer program for the location of interacting hub facilities. *European Journal of Operational Research*, 32(3):393–404, 1987.

[2] Zorica Stanimirović. Solving the capacitated single allocation hub location problem using genetic algorithm. 11 2007.

[3] YiYe Zhou, DengKai Yao, QianRui Sun, and QiKe Wu. Application of genetic algorithm in p-hub airline network design problem. In *Proceedings of the 2nd International Conference on Electronics, Network and Computer Engineering (ICENCE 2016)*, pages 298–303. Atlantis Press, 2016/09.