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Genetic algorithm-based analysis of base station siting optimization

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Abstract: *Due to the continuous development of mobile communication technology, users' demand for communication networks is gradually increasing, and the existing base stations can no longer meet the increasing demand. The base station siting problem is to select a suitable new base station to meet the services at the weak coverage points based on the existing base stations, and to consider the signal propagation range and the sub-regional management of each weak coverage point. Firstly, it is assumed that only new base stations are established at the weak coverage points to simplify the calculation. In this paper, a multi-objective planning model based on genetic algorithm is established, and since coverage and cost are negatively correlated, the total coverage service volume and total cost are solidly used as the objective function, whether base stations are established as the decision variables, and the threshold etc. are used as the constraints to establish the optimization model, and the Pareto front is plotted, and one of the dominant solutions that meets the requirements of the topic is selected, and finally The total coverage is 91.2%, with 312 macro base stations and 8431 micro base stations*

Keywords: *Genetic algorithm, multi-objective optimization, greedy algorithm, density clustering, improved Dbscan algorithm*

1. Introduction

With the rapid development of mobile communication technology, network coverage quality has always been the most critical performance evaluation metric in the field of communication. However, the number of users with large-scale access, treacherous geographical locations and high-density base stations have led to an increasing amount of counting calculations involved in coverage calculation and coverage optimization, which ultimately leads to a lower and lower energy coverage of existing base stations and an increasing variety of base stations and antennas. In the face of such a complex site selection problem, modelling and optimisation of the site has become a top priority. The site selection problem is to select a certain number of points in the weak coverage area of the existing network according to the coverage of the antennas, 2 the coverage of the weak coverage area of the existing network can be solved by building new base stations in these points.

According to the given information and the data in the annex, based on the coordinates of the given station sites and the type of base stations selected for each site, it is specified that the coordinates can only be selected among 2500 x 2500 points in the given area, and it is required that the site planning can be realised in such a way that 90% of the total business volume of the weak coverage points can be covered by the planned base stations. That is: the requirement is to give the lowest cost full coverage model to optimally analyse the siting problem.

In practice there are only 3 sectors on each station and the maximum coverage of each sector in the primary direction is given. When considering that the angle between the primary directions of any 2 sectors of each station cannot be less than 45 degrees, and considering other conditions such as the cost of the base station in the previous question, ask whether 90% of the total service volume of the weakly covered point can be achieved by the new station under the conditions of the optimal station site and sector angle. If yes, give the result for the optimal station site and sector angle, otherwise, give the result for the optimal station site and sector angle, and give the ratio of the total service volume at the maximum number of points that can be covered.

To better solve the weak coverage problem, area clustering of weak coverage points is required. It is required that if the distance between 2 coverage points is not greater than 20, then these 2 weak coverage points should be clustered into one class, and the clustering property is considered to have transferability,

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i.e. if point A and point B are of one class, and point B and point C are of one class, then points A, B and C are of one class. Try to cluster all weakly covered points and require that the total time complexity of the method used for clustering is as low as possible.

2. Establishment of Model

2.1. Model building and solving

2.1.1. Model Assumptions and Establishment

In this paper, a total of N base stations, Nh macro base stations and Nw micro base stations are required to be solved by genetic algorithm, the service volume of the weak coverage point is for for Wj , the cost is CI , to make 90% of the total service volume of the weak coverage point is covered by the new base station, assuming that only new base stations are established at the weak coverage point, the variable G is set at each point. 0=No base station, 1=Construction of micro base station,2=Building Hongji station

The flow chart for the solution is shown in the figure 1:

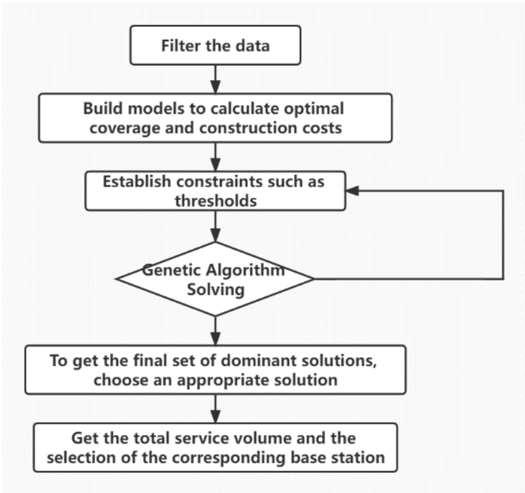

Figure 1: Flow chart for solving model

(1) for maximum coverage, mark every weak coverage point with an established base station within d*I* of it.

$$Cov(P)=\sqrt{(x-x_0)^2+(y-y_0)^2} < di \tag{1}$$

The points that meet this condition will be marked; the service volume of all the points marked by the new base station will be added up to obtain the service coverage in one iteration, and finally divided by the total service volume to obtain the service coverage ratio.

(2) for minimum costs, i.e.

$$C=\sum(CI*GI) \tag{2}$$

where C_I is the cost of the different base stations. Constraint limits: In order to reduce the amount of calculations to an acceptable range when calculating the constraint limits, the 2500*2500 area is chunked into smaller areas of 100*100 and when calculating the two point spacing, only the small area in which it is located and the eight adjacent areas need to be calculated, making the calculation much less laborious. The results of the chunking process are as follows.

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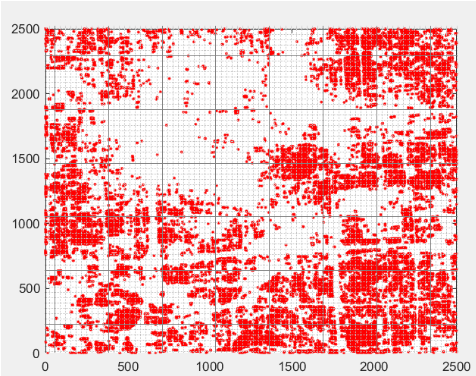

Figure 2: Chunking processing

In this way, a multi-objective planning model is carried out, where the decision variables, objective function and constraints are as follows. Decision variable: type of base station at weak coverage points. Objective function: total business volume of new base stations; total cost of new base stations. Constraint: The distance between two new base stations and between the old and new base stations is greater than the threshold 10. The selection of base stations as 0, 1, 2. The distance from the point being covered to the new base station is less than 10 or 30. In summary, the basic model can be obtained as follows: Genetic algorithm solving multi-objective planning model.

$$\min=\sum_{i=1}^{n} C(x_i) \tag{3}$$

$$\max=\sum_{i=1}^{n} F(x_i) \tag{4}$$

$$\begin{cases} \sqrt{(x_1-x_0)^2+(y_1-y_0)^2} \leq 30 \\ \sqrt{(x_2-x_0)^2+(y_2-y_0)^2} \leq 10 \\ \sqrt{(x_I-x_0)^2+(y_I-y_0)^2} > 10 \end{cases} \tag{5}$$

where (x ,y_{11}) denote the horizontal and vertical coordinates of the macro base station, (x_2 ,y_2) denote the horizontal and vertical coordinates of the micro base station and (x_I ,y_I) denote the horizontal and vertical coordinates of the new base station, respectively. $C(xi)$ is the individual cost calculation function, and $F(xi)$ is the calculation function for the individual coverage volume. 5.1.2 Model solving Given that this question is a discrete large-scale combinatorial optimisation problem, a genetic algorithm is used as the solution method for the problem. Introduction to the algorithm: Genetic algorithm is an intelligent algorithm that mimics the mechanism of genetic evolution and variation in natural organisms and can be used to optimise models by using population search techniques to evolve generation by generation according to the principle of survival of the fittest and ultimately to obtain the optimal solution. The flow chart of the genetic algorithm is shown in Figure 3.

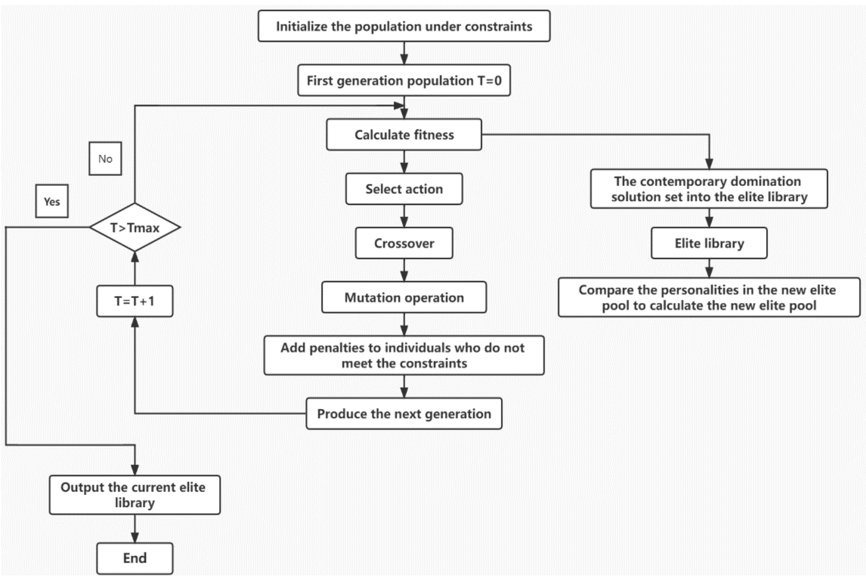

Figure 3: Genetic algorithm flow chart

Table 1: Parameter setting

Parameter setting table	
Number of populations	Q=100000
Maximum number of iterations	T=1000
Elite Pool Capacity	Pr=500
Selection rate	0.6
Crossover rate	0.4
Variation rate	0. 02

3. Model Evaluation and Analysis

3.1. Model solving

Finally the solution is solved using matlab to plot the final Pareto front, from which a solution is selected that fits the problem and has a coverage of approximately 90% that minimises the cost. The final results are as follows Figure 4.

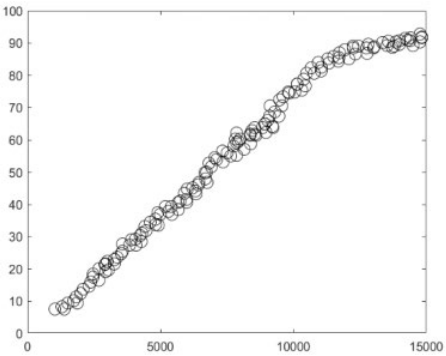

Figure 4: Parameter setting

After the iterations, some of the calculations are as follows.

The results of the solution are as follows. It was calculated that 312 macro base stations and 8,431 micro base stations would need to be established, with the new base stations addressing 91.2% coverage, and the results were visualised as shown below.

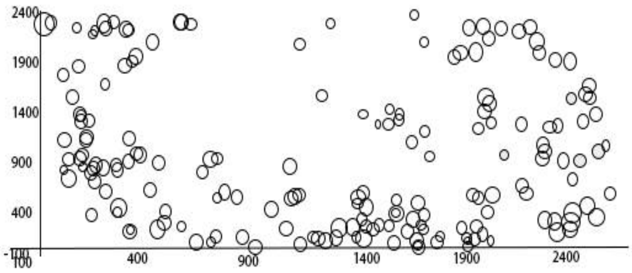

Figure 5: Visualisation of macro base station distribution

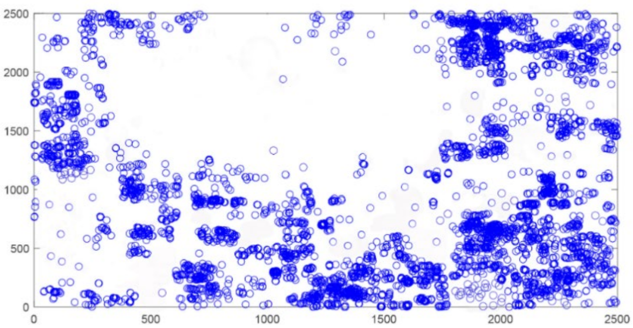

Figure 6: Visualisation of micro-base station distribution

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4. Conclusion

Reduced computational effort and faster model convergence through chunked calculations. The genetic algorithm crossover and variation mechanism makes it less likely to fall into a local optimum solution. Accurate calculations on a more complex theoretical basis are used to improve accuracy, and multiple objectives can be reduced to a single objective to solve the problem of increasing complexity.

The number of variables is so large that the population size is reduced in 13 order to keep the time complexity within acceptable limits, and the final results are hardly close to the optimal solution. Only rough calculations have been made for some of the results, and the theoretical rationale has not been specifically analysed.

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