Modeling Supply Chain Facility Location Problem and Its Solution Using a Genetic Algorithm

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***Abstract*—The supply chain facility location problem is an important foundation in the supply chain. The quality of facilities location directly influences the production and operation status of enterprise. Therefore, it is critical for enterprises to adopt scientific and effective methods for facility location problem assessment and a smooth decision. This article concentrates on the development status of location problem, focusing on the linear programming model and a genetic algorithm in the location problem analysis and analytical method. In the linear programming model, because the given complex table calculation method is too complicated and the workload is very large, the Excel software is proposed to solve the location problem, which can greatly improve the efficiency of enterprise facility location problem. In addition, a genetic algorithm based on MATLAB toolbox is applied to another type of facility location problem, which provides a referential method for location decision under different conditions and different facilities.**

***Index Terms*—supply chain facility location problem, linear programming, EXCEL, MATLAB, genetic algorithm**

I. INTRODUCTION

The facility location problem is one of the most important issues in the supply chain, which plays a fundamental role in the survival and development of enterprises. Location problems are widely used in various fields, such as plant, medical site, rubbish station, hospital, school, shop, warehousing, sales outlets, logistics distribution center, and military base. It is obvious that the enterprise or country will pay more attention on the location problem, because the benefit of location for the enterprises will influence the mode of production, production quality, production efficiency and production cost closely linked with the people's living standards, quality of life. And thus it has an impact on the income of the enterprise and market position. What's more, it is critical for the enterprise and the country to play an important role in dealing with rivals. Good location site will bring more convenient life style, reduce the cost of living, but also to expand their market share and profit, improve service efficiency and competitiveness, whereas poor location will bring a lot of inconvenience and loss to people's life and work, even the crowning calamity. And therefore, the research on location problem of enterprises and countries has fundamental significance in political, cultural, economic, social and military fields.

For the enterprises, there are many factors influencing the enterprise location. From macro perspective, they are the national area selection, while from micro perspective, they are the specific location selection. Simply speaking, they can be divided into the cost factors and non-cost factors. Cost factors is very broad, which can be theoretically, also can be quantified, such as corporate acquisition of raw materials cost, transportation cost, manufacturing cost, labor cost, energy cost, hydropower cost, finished product promotion cost and store sales costs. In addition, although the non cost factors and cost factors do not matter very directly, they can affect indirectly the overall cost of the finished product to a great extent, so that the development strategy of enterprises plays an important role, such as the region's cultural etiquette, customs and habits, environment, climate conditions,

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political factors, peace status and regional development prospects [1]. So is the country. However, the supply chain facility location problem is a typical NP-hard problem and it is difficult to find out the optimal scheme [2-3]. Many researchers have tried to use exact algorithms to solve this problem and the quality of the solution is not very well. The motivation of this paper is to use different methods to solve facility location problems and compare their performance so as to deal with different types of location problems.

This paper focuses on the modeling and solving method towards facility location problem. The research mainly depends on operations research, management science and econometrics methods, discusses the process of solving the linear programming model and a genetic algorithm in the location problem, and verifies the analysis and explanation through the real case. The paper outline is presented as follows: the second section is the literature review. The third section is the process of location site modeling. The fourth section is a case study. The final section is the conclusion.

II. Literature Review

The research on typical location problems has been widely concerned by the scholars, such as Weber problem, the coverage problem, median problem, center problem, intercepting dynamic problem, random location problem [4]. At present, the main popular location problems are mainly divided into three categories. One is that how the location problems are formulated and how they relate to one another. The primary focus is on problems for which operations research-type models have been developed. Most of the problems have been formulated as optimization problems [5]. The complexity of this problem has limited much of the facility location literature to simplified static and deterministic models. Rosing reports on literature which explicitly addresses the strategic nature of facility location problems by considering either stochastic or dynamic problem characteristics. Dynamic formulations focus on the difficult timing issues involved in locating a facility (or facilities) over an extended horizon. Stochastic formulations attempt to capture the uncertainty in problem input parameters such as forecast demand or distance values. The stochastic literature is divided into two classes: that which explicitly considers the probability distribution of uncertain parameters, and that which captures uncertainty through scenario planning [6]. The second problem is *p* centre problem, namely the maximum and minimum value problem, which discusses how to choose *p* warehouses in the network. It is a problem of minimizing the maximum distance from any one point to the nearest warehouse [7]. Chen, Ward and Wendell present a broad review of facility location and location science research. The goal is not to provide an exhaustive list of location science topics (an undertaking far beyond the scope of a single journal article), but rather to provide the reader with a more general review of the location science research landscape. It starts with a short introduction to some of the more germane aspects of all location science research [8]. The third problem is the coverage problem, including the maximum coverage and set covering problem. It manages to make the warehouse service cost minimization, meeting the maximization of customer demand conditions. For example, it investigates the coverage problem of imported material transport location [9]. The location allocation problem is formulated as a mixed integer programming and an corresponding algorithm is put forward, which firstly planes location, and then planes resources allocation, and solves the location allocation problem of WISCO imported iron ore transportation case by the model and algorithm [10].

In addition, another research focus on facility location problem is the solution method. At present there are two main ways: qualitative analysis and quantitative analysis. Qualitative methods are mainly demonstrated by the expert scoring method. But there are many quantitative methods, such as mathematical programming method, heuristic algorithm and combining these methods etc. The qualitative research method is relatively acceptable. And thus, this article concentrates on the application of quantitative method in the linear programming and heuristic algorithm in the location problem. Mathematical programming algorithms include linear programming, nonlinear programming, mixed integer programming, integer programming and dynamic programming. Found in the research and exploration in recent years, many planning theory is introduced the concept of uncertainty, resulting in fuzzy programming, stochastic programming. The uncertainty are introduced into planning value vector, resource consumption vector, resource constrained vector and decision variables. Linear programming is one of the important branches of operations research. The Excel will make the application of the linear programming in economy and decision-making management more operative [11]. Usually, the NP-hard problem can often get better results by using the heuristic algorithm. Meanwhile, the heuristic algorithm and other optimization algorithms are used together, introducing both advantages in their algorithm, which would be better to deal with the problem. At present, the heuristic algorithm commonly uses include genetic algorithms [12], neural network algorithm [13] and so on. This paper uses genetic algorithm to solve the facility location problem. The detailed solution process would be described in this article.

III. Modeling Supply Chain Facility Location Problem

The supply chain facility location problem is summed up by many specific examples, such as factory location and warehouse locations etc. Although there is no frequent facility location decision planning, it is of strategic significance to facility planning in the supply chain. This section focuses on the process of building a basic model of linear programming method based on the EXCEL and the genetic algorithm for solving linear programming problems.

A. A Mathematical Model of Location Problem Based on Linear Programming Problem

Linear programming is one of the most common methods in the commercial location selection model. It is particularly suitable for composite facility location problem. For example, a company has a number of factories for the supply of products to multiple point of sale. When the production is in shortage of supply, the company needs to expand factory and warehouse. The linear programming model was used to select the best location in a number of solutions, so that the cost of production and transportation would reach the minimum level. Supply and demand model of the product are illustrated in Figure 1.

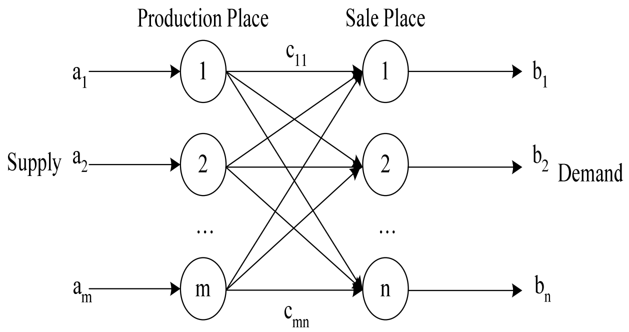

Figure 1. The supply and demand model

$$\sum_{i=1}^{m} a_i = \sum_{j=1}^{n} b_j$$

And thus, there needs a minimum cost solution for the transportation from places of origin *i* to sales destinations *j*.

The supply chain facility location problem could establish the model below, the signs of which are defined as following. x_{ij} denotes the transportation load from A_i to B_j, and Z is the total transportation cost.

$$\min Z = \sum_{i=1}^{m} \sum_{j=1}^{n} c_{ij} x_{ij} \quad (1)$$

$$s.t. \sum_{j=1}^{n} x_{ij} = a_i (i = 1,2,\ldots,m) \quad (2)$$

$$\sum_{i=1}^{m} x_{ij} = b_i (j = 1,2,\ldots,n) \quad (3)$$

$$x_{ij} \geq 0 (i = 1,2,\ldots,m; j = 1,2,\ldots,n) \quad (4)$$

B. The Mathematical Model of Location Problem Based on Genetic Algorithm

Genetic algorithm is a typical iterative algorithm. Every iteration would generate a new set of solutions. This solution is the beginning of a randomly generated one, resulting in a new set of solutions in the iteration. Each solution has a target function, be handed down from generation to generation, until finally a group of optimal solution.

Many scholars use various genetic operators to represent different biological genetic characteristics based on genetic and evolutionary mechanisms of different nature. But they imitate themselves by the biological genetic mechanism of selection, crossover and mutation. In light of the common point, Goldberg puts forward the basic genetic algorithm. Genetic algorithm has been widely used in the fields of combinatorial optimization [14,15], machine learning [16-18], aided design [19], adaptive control [20,21], partner selection in virtual enterprise [22], robotic assembly line balancing [23], electronics component placement design [24] , flexible manufacturing [25-27], resource scheduling problem [28-30] and so on. The operation process of basic genetic algorithm is easy to understand, which is the initial model and the basis of genetic algorithm.

The elements of the basic genetic algorithm [31,32]:

1) Chromosome coding method. The basic genetic algorithm uses binary string representing the individuals in population. The allele is composed of two value symbol set {0, 1}. The initial population of each individual gene values of random numbers is generated by the uniform distribution. For example, *X*=10100100101011101.

2) Individual fitness evaluation. According to the proportional probability of basic genetic algorithm and individual adaptation degree, it determines the current opportunity from each individual genetic group to the next generation. In order to test the probability, the individual fitness is required zero or positive. And thus, according to the different kinds of problems, it must be determined in advance by the objective function values to individual fitness between the conversion rules, in particular to a predetermined when the value of the object function method is negative.

3) Genetic operator. The basic genetic algorithm using the following three kinds of genetic operator:

a) The selection operation using proportional selection operator. It means that if the individual has a higher fitness, it has a higher possibility to be selected to inherit the next generation;

b) The crossover operation using single point crossover operator. For example, there are two individual X_1, X_2, where X_1=10101100 and X_2=01000100. The crossover point is the fourth bit. Using crossover operation, the new offspring individuals are X_1'=10100100 and X_2'=01001100 individually.

c) The mutation operation using the basic bit mutation operator and mutation operator. For example, if the individual *X*= 10100100101011101 and the sixth bit is the mutation bit, the new individual is *X*'=10100000101011101.

4) The basic genetic algorithm has 4 operating parameters:

N: The size of the population, the number of chromosomes in the population, generally from 20 to 100.

T: The number of iterations of genetic algorithms, generally from 100 to 500.

p_c: The crossover probability, generally from 0.4 to 0.99.

p_m: The mutation probability, generally from 0.001 to 0.1.

According to a specific location, e.g. a limited company has 6 customers in the Jiande area. Due to business proliferation, it intends to build a logistics center in Jiande. Given customer address coordinate known as (x_i, y_i), the demand of the products for customers w_i, the allowable range of maximum distance for distribution A_i. How to set up logistics center coordinates (X, Y) to obtain the minimum total transport turnover quantity in order to meet the customer the most distant delivery distance.

The mathematical model of such location problem can be expressed as follows:

$$\min(X,Y)=\sum_{i=1}^{n} w_i * \sqrt{(X-x_i)^2(Y-y_i)^2} \quad (5)$$

$$s.t. \sqrt{(X-x_i)^2(Y-y_i)^2}-A_i \le 0 \quad (6)$$

$$\min(x_i) \le X \le \max(x_i) \quad (7)$$

$$\min(y_i) \le Y \le \max(y_i) \quad (8)$$

$$\forall i \subseteq N \quad (9)$$

IV. CASE STUDY

This section firstly verifies a facility location case by linear programming method based on EXECL. And then the genetic algorithm is applied to solve it. It intends to discuss facility location problem solution from different two aspects.

A. The Case Application Based on EXCEL

A company has two factories, Xin'An River headquarters and Yang Xi branch. The products supply 4 sales points of Xin'An River, Shou Chang, Mei Cheng, Gan Tan, which are in shortage. The company decides to set up a new one factory. After the selecting and screening for a period of time, the Yang Cunqiao and Zhi Xia are chosen as an alternative address. The transportation costs of the various sites are as shown in Table I.

TABLE I

THE TARIFF OF PRODUCTION AND TRANSPORTATION COST

	Transportation cost /(Thousand Yuan)				Monthly production quantity /(Thousand boxes)	cost/(Thousand Yuan)
Factory	Xin'An River	Shou Chang	Mei Cheng	Gan Tan		
Xin'An River	0.8	1.2	2.4	3.3	10	83
Yang Xi	1.3	2	2.8	3.2	8.2	72
Yang Cunqiao	1.5	1.8	2.1	3	12.2	99
Zhi Xia	3.4	2.9	2.7	2.1	12.2	98
Monthly demand/(Thousand boxes)	15	8.6	9.2	8.9		

In order to facilitate the operation, the production cost is added to the transportation cost the Table 1, resulting in the total transportation costs, which are shown in Table II.

TABLE II

THE TOTAL TRANSPORTATION COSTS

	The total transportation costs /(Thousand Yuan)				Monthly production quantity/(Thousand boxes)
Factory	Xin'An River	Shou Chang	Mei Cheng	Gan Tan	
Xin'An River	83.8	84.2	85.4	86.3	10
Yang Xi	73.3	74	74.8	75.2	8.2
Yang Cunqiao	100.5	100.8	101.1	102	12.2
Zhi Xia	101.4	100.9	100.7	100.1	12.2
Monthly demand/(Thousand boxes)	9.2	7.8	7	6.4	

According to the above data, it establishes the objective function and the constraint conditions as follows:

$$\min Z=\sum_{i=1}^{3}\sum_{j=1}^{4} c_{ij}x_{ij} \quad (10)$$

$$s.t.\ x_{11}+x_{12}+x_{13}+x_{14}=10 \quad (11)$$

$$x_{21}+x_{22}+x_{23}+x_{24}=8.2 \quad (12)$$

$$x_{31}+x_{32}+x_{33}+x_{34}=12.2 \quad (13)$$

$$x_{11}+x_{21}+x_{31}=9.2 \quad (14)$$

$$x_{12}+x_{22}+x_{32}=7.8 \quad (15)$$

$$x_{13}+x_{23}+x_{33}=7 \quad (16)$$

$$x4+x_{24}+x_{34}=6.4 \quad (17)$$

$$x_{ij}\geq 0, i=1,2,3; j=1,2,3,4 \quad (18)$$

Using Excel software to solve the model of the specific steps as follows:

1) The data of alternative address Yang Cunqiao is input to Excel table. Next, enter "=B9+C9+D9+E9" in F9, which assigns sum capacity of Xin'An River factory to each sale point in Xin'An River, Shou Chang, Mei Cheng, Gan Tan. Similarly, enter "=B10+C10+D10+El0" in F10, "=B11+C11+D11+El1" in F11. Then enter "=B9+B10+B11" in the B12, which is sum allocation volume of the Xin'An River, from sale point of Yang Xi, Yang Cunqiao. Similarly enter "=C9+C10+C11" in C12, "=D9+D10+D11" in D12, "=E9+El0+El1" in El2. Then the enter " =B3 * B9+C3 * C9+D3 * D9+E3 * E9+B4 * B10+C4 * C10+D4 * D10+E4 * El0+B5 * B11+C5 * C11+D5 * D11+E5 * El1" in the B14. In other words, it is the total transportation cost at the production location of Yang Cunqiao.

2) Select the "tool" in EXCEL and select "add ins", then select the add "solver".

3) Open programming in the toolbar, it appears dialog box of "solver parameter". Enter the B14 in "target cell", select "minimum" in "equal to". "Variable cell" is B9:El1. Click "add", input constraints B12=B6, C12=C6, D12=D6, El2:E6, F9=F3, F10=F4, F11=F5, click "ok".

4) Click on the "solution" button, it will automatically display the results.

5) Similarly, it could obtain the allocation volume and the total transportation cost of Zhi Xia.

6) To sum up, it is obvious that Zhi Xia total cost is 2668680 Yuan, while Yang Cunqiao total cost is 2682560 Yuan. And therefore, the best new location address is Zhi Xia.

B.The Case Application Based on Genetic Algorithm

The company has 6 customers in the Jiande area, shown in Table 3. Assume maximum distribution range of A_i less than or equal to 50*km*.

TABLE III

CUSTOMER LOCATION AND DEMAND

Customer	*X*(*km*)	*Y*(*km*)	w_j(*kg*)
Xin'An River	52	9	300
Shou Chang	42	86	100
Mei Cheng	93	33	200
Shou Chang	62	78	150
Gan Tan	90	60	100
Xin'An River	70	30	250

Complete the following operations using Matlab toolbox.

Firstly: write Main files, including crossover, mutation, fitness, keep-best, selection, in accordance with the objective function $f=w_i*$ $sqrt((X-x_i)^2+(Y-y_i)^2)$. The objective function is regarded as the fitness function.

Secondly: set the related parameters of genetic algorithm with MATLAB toolbox requirements, specifically as follows: the number of variables =2, T=200, P_c =0.7, P_m =0.1.

Thirdly: write the genetic code in matlab7.0, click "run". The results are demonstrated in Figure 2 and Figure 3.

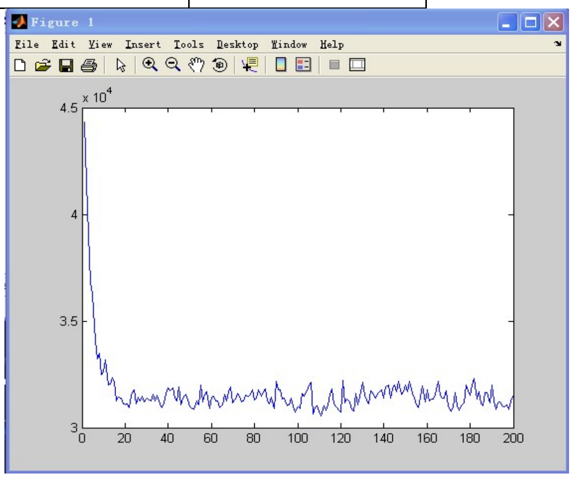

Figure 2 Total turnover

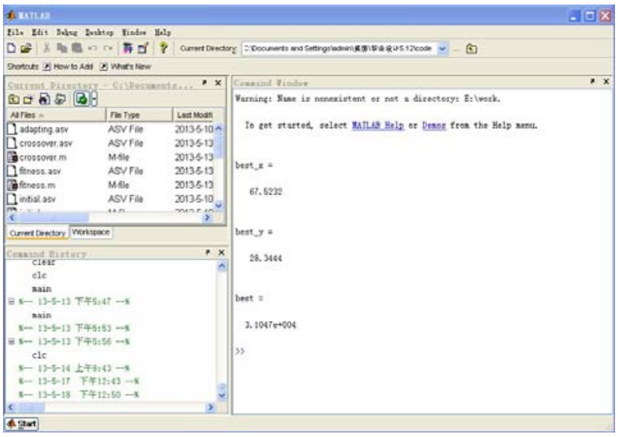

Figure 3 The worksheet in MATLAB

The corresponding optimal logistics center location is *X*= 67.5232km, *Y*=28.3444km.

In addition, if we modify the related parameters of GA and use to solve the same problem, we can find that the results are seldom changed. Fox example, if we set P_c be 0.5, 0.6 and 0.8 individually, the optimal results are the same to the one mentioned above. It means that the GA algorithm is a very efficient heuristic one to solve NP-hard problems and it has a strong searching ability combined with global and local searching strategies.

V. Conclusions

The facility location problem is a big issue in economics, operations research and computer science. There is a variety of reasons. For example: the development of location problem theory in classical median problem and covering problem is continuous, which can combine theory with practice, especially the latest theoretical research and practice. At the same time, an endless stream of mathematics research methods is emerging. The rapid development of computer technology is helpful to solve the facility location model. In this article, the linear programming method of EXCEL and the genetic algorithm are used to solve the location problem. And therefore, it greatly improves the operation efficiency of location problems solution under different conditions. More importantly, while the economic society is in the continuous development, the influence factors of facility location become more and more complex, which increases the difficulty of the location problem to a great extent. And thus, it is necessary to continue the more complex study such as the location problem under dynamic environment.

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References

[1] L. Yan, L. Zhang, Study on the evaluation of facilities location[J]. Journal of Xi'an University of Architecture &technology, 2004, 36(3): 314-316.
[2] S. H. A. Rahmati, V. Hajipour, S. T. A. Niaki, A soft-computing Pareto-based meta-heuristic algorithm for a multi-objective multi-server facility location problem[J]. Applied Soft Computing, 2013, 13(4): 1728-1740.
[3] S. Dantrakul, C. Likasiri, R. Pongvuthithum. Applied p-median and p-center algorithms for facility location problems[J]. Expert Systems with Applications, 2014, 41(8): 3596-3604.
[4] L. Deng, An economic and transport analysis on city public institution location problem[D]. Jilin: Northeast electricity press, 2008.
[5] M. L. Brandeau, S. S. Chiu, An overview of representative problem in location research[J]. Management Science, 1989, 35(6): 645-674.
[6] S. H. Owen, M. S. Daskin, Strategic facility location: a review[J]. European Journal of Operational Research, 1998, 111(3): 423-447.
[7] S. Hakimi, Optimum location of switching centers and the absolute centers and medians of a graph[J]. Operations Research, 1964, 12(3): 450-459.
[8] T. S. Hale, Location science research: a review[J]. Annals of Operations Research, 2003, 123(4): 21-35.
[9] H. Zhang, A Location Allocation Problem of the Imported Goods Transportation[D]. Wuhan, Huazhong University of Science & Technology Press, 2006.
[10] J. Ge, A civic design research on Dongjiang road logistic park based on MSFLB logistic amplification[D]. Xinjiang: Xinjiang agriculture university press, 2008.
[11] J. Liu, Use of Excel to Solve the Problems of Linear Programming[J]. Journal of Hunan Agricultural University, 2005, 31(5): 562-564.
[12] A. K. Nandi, K. Deb, S. Datta, Genetic algorithm-based design and development of particle-reinforced silicone rubber for soft tooling process[J]. Materials and Manufacturing Processes, 2013, 28(7): 753-760.
[13] N. A. Khuzani, S. A. Monadjemi, Vehicle license plate recognition using Hough transform and artificial neural networks[J]. International Review on Computers and Software, 2013, 7(6): 3177-3183.
[14] D. Bunnag, M. Sun, Genetic algorithm for constrained global optimization in continuous variables[J]. Applied Mathematics and Computation, 2005, 171(1): 604-636.
[15] C. K. Dimou, V. K. Koumousis, Competitive genetic algorithms with application to reliability optimal design[J]. Advances in Engineering Software, 2003, 34(11-12): 773-785.
[16] U. Maulik, S. Bandyopadhyay, Genetic algorithm –based clustering technique[J], Pattern Recognition, 2000, 33(9): 1455-1465.

[17] M. Ujjwal, B. Sanghamitra, Genetic algorithm-based clustering technique[J]. Pattern Recognition, 2000, 33(9): 1455-1465.
[18] A. Sibil, N. Godin, M. R. Mili, E. Maillet, G. Fantozzi, Optimization of Acoustic Emission Data Clustering by a Genetic Algorithm Method[J]. Journal of Nondestructive Evaluation, 2012, 31(2): 169-180.
[19] G. Renner, A. Ekart, Genetic algorithm in computer aided design[J]. Computer-Aided Design, 2003, 35(8): 709-726.
[20] M. Lozano, F. Herrera, J. R. Cano, Replacement strategies to preserve useful diversity in steady-state genetic algorithm[J]. Information Science, 2008, 178(23): 4421-4433.
[21] L. X. Huang, G. Evangelista, X. Y. Zhang, Adaptive bands filter bank optimized by genetic algorithm for robust speech recognition system[J]. Journal of Central South University of Technology, 2011, 18(5): 1595-1601.
[22] Y. Zhang, F. Tao, Y. Lai, B. Hou, L. Lv, L. Zhang, Green partner selection in virtual enterprise based on Pareto genetic algorithms[J]. 2012, forthcoming.
[23] L. Gregory, R. Jacob, S. Boris, A genetic algorithm for robotic assembly line balancing[J]. European Journal of Operational Research, 2006, 168(3): 811-825.
[24] F. S. Ismail, R. Yusof, M. Khalid, Optimization of electronics component placement design on PCB using self organizing genetic algorithm (SOGA)[J]. Journal of Intelligent Manufacturing, 2012, 23(3): 883-895.
[25] Z. Zakaria, S. Petrovic, Genetic algorithms for match-up rescheduling of the flexible manufacturing systems[J]. Computers & Industrial Engineering, 2012, 62(2): 670-686.
[26] L. H. Qiao, S. P. Lv, An improved genetic algorithm for integrated process planning and scheduling[J]. International Journal of Advanced Manufacturing Technology, 2012, 59(5-8): 727-740.
[27] A. Khormali, A. Mirzazadeh, F. Faez, The openshop batch processing problem with non-identical processing times, using simulated annealing and genetic algorithms approaches[J]. International Journal of Advanced Manufacturing Technology, 2012, 59(9-12): 1157-1165.
[28] J. F. Goncalves, J. J. M. Mendes, M. G. C. Resende, A genetic algorithm for the resource constrained multi-project scheduling problem[J]. European Journal of Operational Research, 2008, 189(3): 1171-1190.
[29] J. Z. Wu, X. C. Hao, C. F. Chien, M. Gen, A novel bi-vector encoding genetic algorithm for the simultaneous multiple resources scheduling problem[J]. Journal of Intelligent Manufacturing, 2012, 23(6): 2255-2270.
[30] G. Falzon, M. Li, Enhancing genetic algorithms for dependent job scheduling in grid computing environments[J]. Journal of Supercomputing, 2012, 62(1): 290-314.
[31] M. Zhou, S. Sun, The theory and application of genetic algorithm [M]. Beijing: Defense Press, 2002.
[32] A. Konak, Two-edge disjoint survivable network design problem with relays: a hybrid genetic algorithm and Lagrangian heuristic approach[J]. Engineering Optimization, 2014, 46(1): 130-145.
[33] H Dezani, R. D. S. Bassi, N. Marranghello, Optimizing urban traffic flow using Genetic Algorithm with Petri net analysis as fitness function[J]. Neurocomputing, 2014, 124(1): 162-167.

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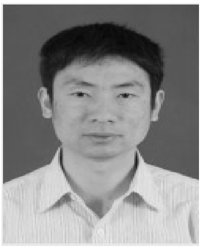

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