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# Study on Constructing the Optimization of Omni-Channel Marketing Resource Allocation Based on Dynamic Planning Algorithm in the Era of Digital Transformation

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ABSTRACT
Reasonable allocation of enterprise marketing resources can ensure that different target markets can be taken into account, but also to ensure that the newly developed markets can be cultivated, so as to maximize the economic benefits of limited resources. The article first combines the principles of marketing resource allocation, constructs a dynamic planning model of marketing resource allocation, and proposes a hybrid genetic algorithm improved by simulated annealing algorithm to solve the marketing resource allocation model. The effectiveness and superiority of the algorithm is tested through simulation and comparison experiments. And take an electrical appliance company as an example, based on the marketing resource allocation model to find the optimal program of the model, to explore the production and sales decision-making that is beneficial to the company. The results can be obtained, with the marketing resource allocation model set in the marketing department of the profit ratio from 10% to 25%, the total profit of the product is increasing, only the pursuit of product sales profit is maximized when the total profit can be obtained is about 17,956,500 yuan.

*Keywords:* dynamic planning, marketing resource allocation, genetic algorithm, simulated annealing algorithm

## 1. Introduction

Omni-channel marketing strategy is a comprehensive, multi-channel, multi-scenario strategy for enterprises to promote their products or services by comprehensively utilizing various channels and platforms [1-2]. It can improve the brand awareness, market share and sales performance of enterprises, provide customers with a better shopping experience, and achieve win-win results Omni-channel marketing is a very critical business model in today's enterprise development, which has been adopted by more and more enterprises [3-6]. Omni-channel marketing also has some shortcomings, such as the need to invest a large amount of manpower and capital, at the same time, the establishment

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of a complete data system also requires a certain amount of time and energy, requiring enterprises to have a high level of data management, in this context, the optimization of omni-channel marketing resource allocation is of great significance for the sustainable development of enterprises [7-10].

Marketing resource allocation optimization refers to the enterprise will omni-channel various marketing resources together, and through the reasonable allocation and optimal use of these resources, in order to achieve the purpose of improving the marketing effect [11-12]. In today's fiercely competitive market environment, the optimization of marketing resource allocation is crucial for the development of enterprises, which is mainly reflected in the enhancement of market development ability, strengthening brand image, and reducing costs [13-15]. Through the integration of various marketing resources, enterprises can better understand the market demand and competitive situation, so as to carry out targeted marketing activities, thereby improving the market development ability [16-18]. Based on the integration of brand resources, enterprises can unify the brand image, ensure the consistency of the brand in the market, enhance brand awareness and brand loyalty, in addition to the enterprise through the rational use of resources, to avoid the waste of resources, to reduce the cost of marketing, and improve the competitiveness of enterprises [19-22].

The article firstly designs a marketing resource allocation model according to the marketing resource allocation principle, and proposes an improved hybrid genetic algorithm containing adaptive crossover probability and mutation probability for the solution algorithm of the marketing resource allocation model. The algorithm adjusts the population after crossover and mutation of the genetic operator by utilizing simulated annealing and Levy flight perturbation strategies, so as to expand the scope of the search, increase the diversity of the population, and enhance the accuracy of the algorithm's global search and convergence. Subsequently, the improved algorithm proposed in this paper is tested for performance, and by analyzing the production capacity of an electrical appliance company in 2024, the model of this paper is used to design a production and sales plan for the company when its profit is maximized and when the company's profit is equalized with that of the marketing department.

## 2. Marketing resource allocation methods based on dynamic planning algorithms

### *2.1. Principles of Resource Allocation in Marketing*

The optimal allocation of marketing resources is a complex project, but, in the practice of optimizing the allocation of marketing resources, regardless of the method used, must follow certain principles.

1) The principle of planning. The market economy objectively requires different enterprises to maximize the production and operation activities to meet market demand, to be able to adapt to changes in the market at different times, which makes the enterprise in the market economy environment shows a certain degree of blindness, but in the enterprise internal production management are planned [23]. To achieve the marketing strategy objectives set by the enterprise, it is necessary to adhere to the principle of planning in the optimal allocation of marketing resources to follow the principle of planning, according to the expected profit target preparation of marketing resource plan, according to the plan to strictly control the input of marketing resources.

2) Systematic principle. Enterprise resources, including human resources, marketing, production, financial resources and other resources, the so-called systematic principle of optimization of the allocation of marketing resources, broadly speaking, it refers to its marketing resources to be optimized with other corporate resources in the allocation of the principle of compliance: interlinked, mutual influence, and jointly achieve the corporate marketing objectives. Narrowly refers to the distribution of marketing resources within the elements to comply with the principle of

reasonableness: on the one hand, to reasonably determine the quantitative relationship between the elements, the input time schedule, investment direction, on the other hand, to control the marketing resources of different elements of the reasonable substitution and influence, to ensure that the overall effectiveness of the marketing resources to play the marketing resources to achieve the optimal combination of marketing resources.

3) Flexibility principle. The optimal allocation of marketing resources is in order to be able to determine the cost of marketing activities in the future period of time and make the allocation plan, and predict the future activities itself is full of uncertainties that are more difficult to predict in advance. Therefore, in doing marketing resource allocation plan, the preparation of marketing programs, according to the actual situation, to retain a certain degree of flexibility and flexibility, not too rigid.

4) The principle of continuity. The principle of continuity of marketing resource allocation is that enterprises according to the marketing strategy to develop marketing resource allocation program, can not be limited to short-term interests, but to pay attention to maintain the enterprise in different planning period of the marketing resource input reasonable convergence, so that the enterprise marketing strategy for sustainable development. Marketing resource allocation program should not only combine the enterprise's short-term marketing plan, but also to maintain the enterprise's medium- and long-term sustainability. To ensure the sustainable development of enterprises

5) Objectives to lay the foundation. The principle of scientific marketing resource allocation program to develop a reasonable and effective, can not be separated from the scientific to evaluate. The development of marketing resource allocation program should adhere to the use of scientific and reasonable methods to analyze the actual enterprise, reduce the marketing resource allocation program and the actual deviation of the market, with scientific and effective distribution program to ensure that the enterprise's profit target.

### *2.2. Marketing Resource Allocation Model*

The fundamental purpose of business operation is to maximize profits. When a business actually conducts marketing activities, advertising and promotional expenses make up the bulk of the marketing budget and have a direct impact on sales. In business, advertising and promotional activities are equally effective. In terms of cost, physical resources, financial resources, and human resources for marketing are the major cost expenditures. Since enterprises are mostly represented by dealers for sales, the cost required for maintaining the dealer network and expanding the market is also one of the major costs of marketing activities. After-sales service is also one of the major expenditures. After-sales service includes the cost of setting up after-sales service stations and the cost of after-sales service personnel's salary.

Human resource cost, H, consists mainly of marketing staff salary cost h, travel cost b, and annual training cost x. The quantitative relationship among them is $x = \alpha h (0.1 \le \alpha \le 0.4)$. Thus there is:

$$\begin{cases} H = h + b + x \\ x = \alpha h \quad 0.1 \le \alpha \le 0.2 \end{cases} \tag{1}$$

The cost of physical resources, M, consists mainly of the cost of office hardware and equipment for marketing staff, $m_1$, and the cost of office space, $m_2$, with the constraint relationship being the average depreciation rate of hardware and equipment, $0.1 \le \beta \le 0.2$. There are:

$$\begin{cases} M = \beta m_1 + m_2 \\ 0.1 \le \beta \le 0.2 \end{cases} \tag{2}$$

The cost of financial resources, F, consists mainly of, advertising costs, A, market development costs, G, office supplies costs, $d$, and business hospitality costs, $e$. Get:

$$F = A + G + d + e \tag{3}$$

Dealer maintenance costs J, mainly including dealer rebates $j_1$, marketing network management costs $j_2$, where the quantitative relationship is the ratio of dealer rebates to sales revenues $0.01 \le \theta \le 0.02$, and the dealer rebates are counted as the cost of maintaining dealer relationships:

$$\begin{cases} J = j_1 + j_2 \\ J_1 = \theta Q \\ 0.005 \le \theta \le 0.01 \end{cases} \tag{4}$$

After-sales service cost S, including service station laying cost $s_1$, after-sales service personnel salary cost $s_2$. After-sales service cost can be scaled down within certain limits, but after-sales service is an important experience process after the customer purchases the product, through after-sales service can improve the credibility, expand the market share of the product, improve the efficiency and effectiveness of sales promotion work, and maintain customer loyalty, so after-sales service cost should be maintained as a percentage of the sales ratio $0.05 \le \gamma \le 0.1$. That is:

$$\begin{cases} S = s_1 + s_2 \\ S = \gamma Q \\ 0.05 \le \gamma \le 0.1 \end{cases} \tag{5}$$

The final marketing cost function was determined to be:

$$C = f(H, M, F, J, S) = H + M + F + J + S \tag{6}$$

After analyzing the marketing costs, we now analyze the cost factors that have a direct impact on sales in marketing activities. For most manufacturers, the sales response function single present horizontal line or diagonal straight line or parabolic is unreasonable, combined with the sales response function, the resulting functional form: power exponential functional form, according to the change of its index can simulate a variety of graphical structure [24]. Thus, the use of power exponential function form more accurately reflect the actual situation of the sales reaction function under the conditions of the market economy. Cobb-Douglas form is:

$$Y = A(t) L^{\alpha} K^{\beta} \mu \tag{7}$$

where Y is the total industrial output value, A (t) is the integrated technology level, L is the number of input labor force, K is the input capital, generally refers to the net fixed assets, $\alpha$ is the elasticity coefficient of the output of the labor force, \ is the elasticity coefficient of the output of the capital, $\mu$ indicates the effect of random interference, $\mu \le 1$.

The main factors affecting the sales volume include: price, investment in advertising costs, market development costs three Therefore, the product demand function is derived as:

$$Q = f(P, A, G) = kP^{\delta} A^{\varepsilon} G^{\varphi} \tag{8}$$

where: $k, \delta, \varepsilon, \varphi$ is a constant, need to determine the range of values based on the statistical analysis of the historical data of the specific enterprise.

After the market sales are determined, the sales function can be described according to the actual product type and different types of sales as:

$$PQ = p_1 q_1 + p_2 q_2 + \ldots\ldots + p_n q_n \tag{9}$$

where $n$ is the number of specific major products.

Summarization leads to the final profit function $\Pi = PQ - C$.

Therefore the model constructed by the many elements of marketing resources is:

$$\begin{cases} \Pi = PQ - C \\ PQ = p_1 q_1 + p_2 q_2 + \ldots\ldots + p_n q_n \\ Q = f(P, A, G) = kP^{\delta} A^{\varepsilon} G^{\varphi} \\ C = f(H, M, F, J, S) = H + M + F + J + S \\ H = h + b + x \\ x = \alpha h \quad 0.1 \le \alpha \le 0.2 \\ M = \beta m_1 + m_2 \quad 0.1 \le \beta \le 0.2 \\ F = A + G + d + e \\ J = j_1 + j_2 \\ J_1 = \theta Q \quad 0.005 \le \theta \le 0.01 \\ S = s_1 + s_2 \\ S = \gamma Q \quad 0.05 \le \gamma \le 0.1 \end{cases} \tag{10}$$

### *2.3. Design and implementation of improved hybrid genetic algorithm*

In this section, the hybrid genetic algorithm is improved to solve the marketing resource allocation model, which increases the adaptive crossover probability and mutation probability, and after generating the initial population, it protects the excellent individuals, and performs simulated annealing and Levy flight operation on the underperforming individuals, which overcomes the problems of the traditional genetic algorithms, such as the “precocity” and the susceptibility to fall into the local optimal solution. It overcomes the problems of “early maturity” and easy to fall into local optimization solution of traditional genetic algorithms.

2.3.1. Chromosome coding. The encoding method of the chromosome directly affects the computing speed of the algorithm and the optimization results. For the flexible job shop scheduling problem, a multi-layer coding method is used, in which the process layer is the first layer, the equipment layer is the second layer, the process number is the process layer gene, and the equipment number is the equipment layer gene. The chromosome coding diagram is shown in Figure 1. In the figure, the process code is the sequence of workpiece processing, and the equipment code is the number of the processing equipment selected for the process processing.

| Procedure code | | | | | | | | | Device coding | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 2 | 1 | 2 | 3 | 2 | 3 | 2 | 3 | 2 | 4 | 3 | 2 | 5 | 1 | 3 |
| $O_{11}$ | $O_{21}$ | $O_{31}$ | $O_{22}$ | $O_{12}$ | $O_{23}$ | $O_{32}$ | $O_{24}$ | $O_{33}$ | $M_2$ | $M_3$ | $M_2$ | $M_4$ | $M_3$ | $M_2$ | $M_5$ | $M_1$ | $M_3$ |

**Fig. 1.** Chromosome coding diagram

2.3.2. Adaptation function. The fitness function is utilized to assess the quality of individuals, also known as a screening program, i.e., the determination of the best individuals in the population. The fitness of an individual is generally determined as the reciprocal of the value of the objective function.

The fitness function is:

$$f_v = \frac{1}{\max\{c_i\}} \tag{11}$$

where $f_v$ is the adaptation value. $\max\{c_i\}$ is the maximum completion time.

2.3.3. Adaptive strategies. Since traditional genetic algorithms do not consider the advantages and disadvantages of crossover and mutation operators, they can only operate on them according to specific crossover and mutation probabilities, thus greatly limiting their convergence. For this reason, adaptive crossover probability $P_c$ and mutation probability $P_m$ solution formulas are introduced, i.e.:

$$P_c = \begin{cases} \dfrac{k_1(f_{\max} - f')}{f_{\max} - f_{\min}} & f' \geq f_{\arg} \\ k_2 & f' < f_{\arg} \end{cases} \tag{12}$$

$$P_m = \begin{cases} \dfrac{k_3(f_{\max} - f)}{f_{\max} - f_{\min}} & f \geq f_{\arg} \\ k_4 & f < f_{\arg} \end{cases} \tag{13}$$

where: $f_{\max}$ is the maximum fitness value in the population. $f_{\min}$ is the minimum fitness value in the population. $f_{avg}$ is the average fitness value in the population. $f'$ is the larger fitness value of the 2 individuals crossed. $f$ is the fitness value of the individual to be mutated [25]. $k_1 \sim k_4$ are constants in the interval (0, 1).

2.3.4. Selection operations. The selection probability of selecting offspring from a population using roulette selection is positively correlated with the value of its fitness function, i.e., the greater the fitness of an individual, the greater the probability of being selected for the crossover operation $P_a$.

The formula for $P_a$ is:

$$P_a = \frac{f_a}{F} \tag{14}$$

where $f_a$ is the fitness value for each individual in the population. $F$ is the total fitness value of the population.

2.3.5. Cross-operation. Uniform crossover is used to select a number of gene loci with average probability, each of which is selected with arbitrary probability and independently of the others, and then the 2 individuals whose gene loci are drawn are exchanged, thus constituting 2 new individuals. A schematic diagram of the chromosome crossover operation is shown in Figure 2.

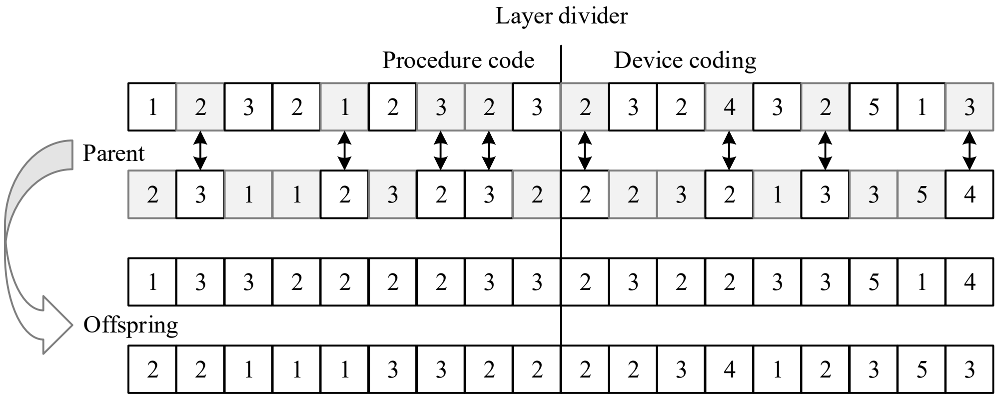



**Fig. 2.** Schematic diagram of chromosome crossing operation

For example, the shaded portion of Figure 2 shows the loci that were selected for the crossover operation, and the probability of each locus being selected is random and not specific.

2.3.6. Variant operations. The schematic diagram of chromosome mutation operation is shown in Fig. 3, where the 1st, 3rd, 5th and 8th loci encoded by the device are randomly selected, and the exchange of loci is randomly chosen, e.g. the 1st locus is exchanged with the 5th locus, and the 3rd locus is exchanged with the 8th locus, and the process-encoded portion of the process is mutated together with it to obtain the progeny.

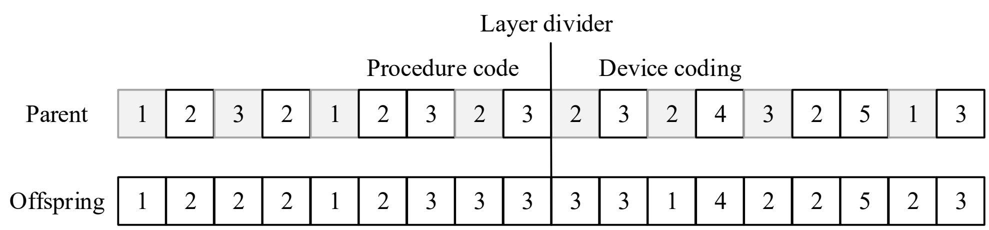



**Fig. 3.** Schematic diagram of chromosome variation operation

2.3.7. Improved hybrid genetic algorithm (IGA). Genetic algorithm is easy to fall into local optimal solution after crossover operation and mutation operation, so simulated annealing algorithm is added and Lévy flight strategy is introduced to improve the efficiency of solution search.

1) Improved simulated annealing algorithm. Simulated annealing algorithm is an optimal solution search method based on combinatorial optimization, the principle of this method is similar to the thermal annealing treatment of solid materials. Using heating to warm the solid to the melting point, the melted crystals will realize the lattice reorganization due to the thermal movement, so as to repair the crystal defects in the original solid in the process of cooling.

The algorithm in this paper is improved as follows:

(1) Initial solution selection i.e., selecting the individual that does not satisfy the termination condition as the initial solution from the traditional genetic algorithm, randomly generating an initial solution individual $x_0$ and calculating the corresponding objective function value $E(x_0)$ at this time.

(2)Select a new solution to randomly perturb the current solution to generate a new solution individual $x_1$ and calculate the corresponding objective function value $E(x_1)$ at this point.

(3) Calculate the difference between the new solution and the old solution for the above objective function value, with the result $\Delta E = E(x_1) - E(x_0)$

(4) Adopt the Metropolis criterion to decide whether to accept new solutions, retain good gene fragments, and ensure the quality and diversity of solutions. The Metropolis criterion is defined as for the previous generation of individuals $x_1$ and the next generation of individuals $x_2$, the corresponding fitness functions are $f(x_1)$ and $f(x_2)$, respectively, and the difference of fitness functions is $df = f(x_1) - f(x_2)$. Then the Metropolis criterion can be expressed as:

$$P = \begin{cases} 1 & df < 0 \\ \exp(\frac{-df}{k_B} gr) & df \geq 0 \end{cases} \tag{15}$$

where: $P$ is the probability of accepting a new solution. $k_B$ is the Boltzmann constant.

Temperature decay function of the cooling law. Newton's cooling law is calculated for the law of temperature change of the target with time considering the constant temperature of the surrounding environment, which is given by:

(5) Annealing strategy. In order to improve the global optimization seeking ability of simulated annealing, this paper cites Eq:

$$T(t) = T_c + \left[T(t_0) - T_c\right] \cdot e^{-k(t-t_0)} \tag{16}$$

where: $t_0$ is the initial number of iterations. $T(t_0)$ is the initial temperature of the object. $T(t)$ is the object temperature for the current iteration number $t$. $T_c$ is the ambient temperature. Is the temperature decay coefficient, which is a constant.

2) Introducing the Lévy flight strategy. $Levy(\lambda)$ is a randomized search path with a randomized step size conforming to the Levy distribution, denoted as $levy \sim u$, i.e.

$$levy \sim u = g - \lambda \quad 1 < \lambda \leq 3 \tag{17}$$

The position update formula for the Levy flight is:

$$x_b^{g+1} = x_b^g + \delta \oplus Levy(\lambda) \tag{18}$$

where $x_b^g$ is the position of the $b$ th solution in the $g$ th generation. $\oplus$ is the pairwise pointwise multiplication. $\delta$ is the step size, usually set to $\delta = 1$.

Currently it is common to use a Lévy-distributed randomized step size $s$ to update the solution, i.e:

$$S = \frac{u}{|v|^{1/\beta}} \tag{19}$$

where: $u, v$ are random variables satisfying normal distribution, denoted as $u \sim N(0, \sigma_u^2), v \sim N(0, \sigma_v^2)$ respectively.

where:

$$\sigma_a = \frac{\Gamma(1+\beta)\sin(\beta \times \frac{\pi}{2})}{\Gamma(\frac{1+\beta}{2}) \times \beta \times 2^{(\beta-1)/2}} \tag{20}$$

$$\sigma_v = 1 \tag{21}$$

where: $\beta$ is a constant, taking the value in the interval [0, 2], this paper takes the value of 1.5. $\Gamma(\cdot)$ is the gamma function.

3) Improve the hybrid genetic algorithm steps. The flow chart of the improved hybrid genetic algorithm is shown in Figure 4.

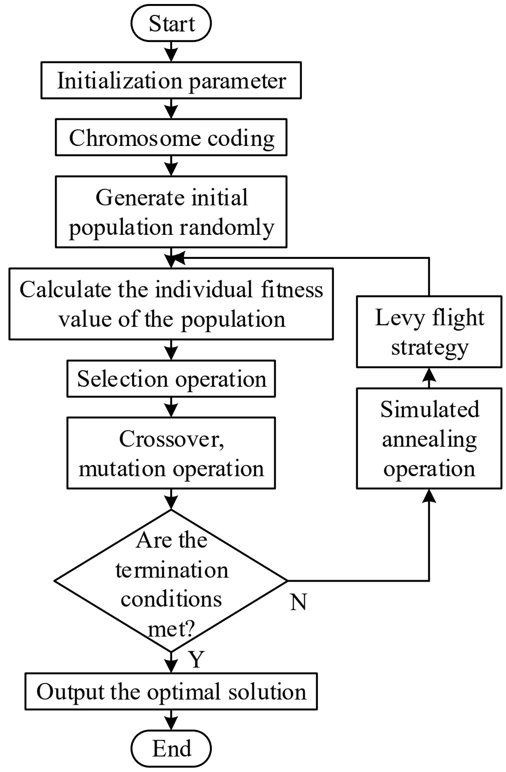



**Fig. 4.** Flow chart of improved hybrid genetic algorithm

The specific steps to improve the hybrid genetic algorithm are as follows.

Step 1: Parameter initialization to generate the initial population.

Step 2: Chromosome coding of the population.

Step 3: Calculate the population individual fitness value.

Step 4: Selection operation is performed and roulette method is used to select excellent individuals.

Step 5: Crossover and mutation operations, in which the population after uniform crossover and local mutation operations are used, is then screened by adaptive crossover probability and mutation probability as a means of accelerating convergence of the algorithm.

Step 6: The populations that have not reached the termination condition after crossover and mutation are subjected to simulated annealing operation and Lévy flight perturbation to avoid falling into a local optimum.

Step 7: The simulated annealing and Lévy flight perturbation will be excellent individuals to re-carry out the calculation of fitness value.

Step 8: Determine whether the termination condition is satisfied, if so, end and output the optimal solution. Otherwise return to step 3 [26].

## 3. Experiments and discussions

### *3.1. Algorithm Performance Testing*

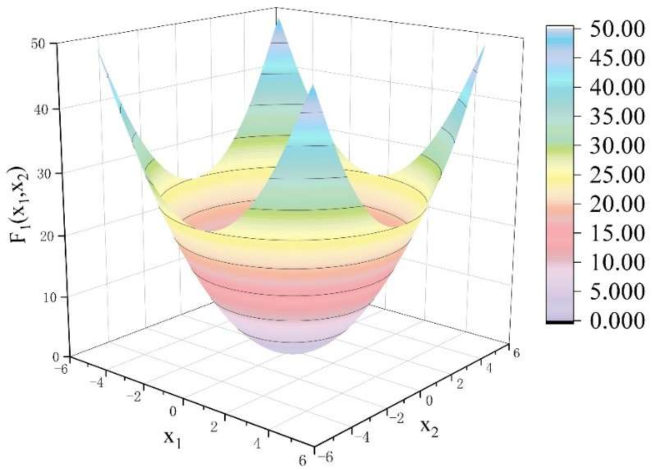
In order to verify the performance of the improved hybrid genetic algorithm (IGA) proposed in this paper, three test functions, Sphere function, Rastrigin function and Shubert function, are selected for testing. The test function expressions are shown in Table 1.

**Table 1.** Test function expression

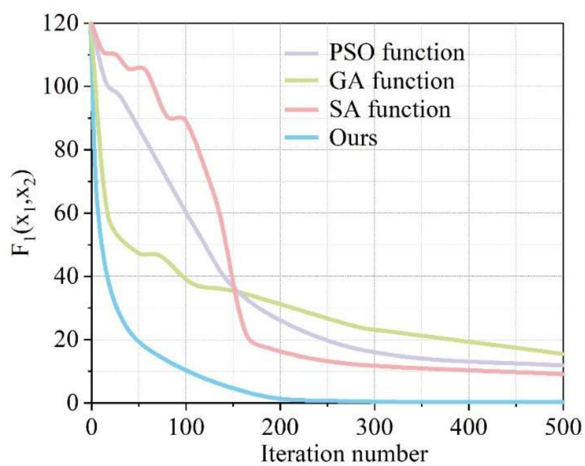
| Function name | Function expression |
|---|---|
| Sphere function | $f(x)=\sum_{i=1}^{D} x_i^2$ |
| Rastrigin function | $f(x)=\sum_{i=1}^{D}\left[x_i^2-10\cos(2\pi x_i)+10\right]$ |
| Shubert function | $f(x)=\left[\sum_{i=1}^{5} i\cos((i+1)x_1+i)\right]\bullet\left[\sum_{i=1}^{5} i\cos((i+1)x_2+i)\right]$ |

Sphere function is a single-peak function, Rastrigin function and Shubert function are multi-peak functions, single-peak function can test the convergence accuracy of the algorithm, and multi-peak function can test the algorithm optimization ability. Three kinds of test functions are used to test PSO, SA, GA and this paper's algorithm for a total of four algorithms, and the test results are obtained as shown in Fig. 5~Fig. 6, respectively (Fig. a indicates the Sphere function, the Rastrigin function and the Shubert function, and Fig. b indicates the different algorithms' adaptability curves). As can be seen from Fig. 5, the Sphere function has a unique global minimum $f(x^*)=0$, and in the test results, all the algorithms except the GA algorithm are able to find the global optimum. the SA algorithm is able to find the global optimum but the convergence speed is slower, while the algorithm in this paper is able to find the global optimum at the fastest speed. As can be seen from Figure 6, the Rastrigin function is a typical nonlinear multi-peak function, in addition to a global minimum $f(x^*)=0$, there are a large number of local minima, which can detect the ability of the algorithm to jump out of the local extremes. The algorithms in the test results except for the algorithm in this paper all fall into different local extremes and fail to find the global optimum. As can be seen from Figure 7, Shubert function has multiple global minima $f(x^*)=$ -185.6592 and multiple local minima, in the test results, the SA algorithm and this paper's algorithm have found the global optimum, but in the speed of the search for the optimum, the SA algorithm is at a significant disadvantage.

Combining the results of the three test functions, this paper's algorithm has the advantage of high optimization accuracy and improves the defect of easy to fall into the local optimum. Compared with the traditional PSO, GA and SA algorithms, this paper's algorithm improves both the optimization accuracy and optimization speed, which shows that this paper's algorithm is scientific and effective.

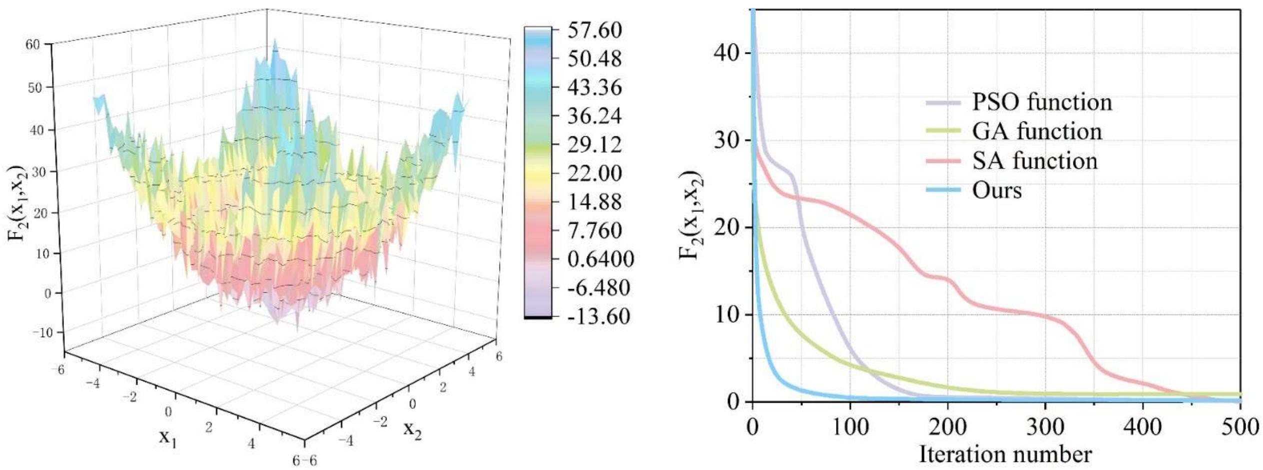



(a) Sphere function



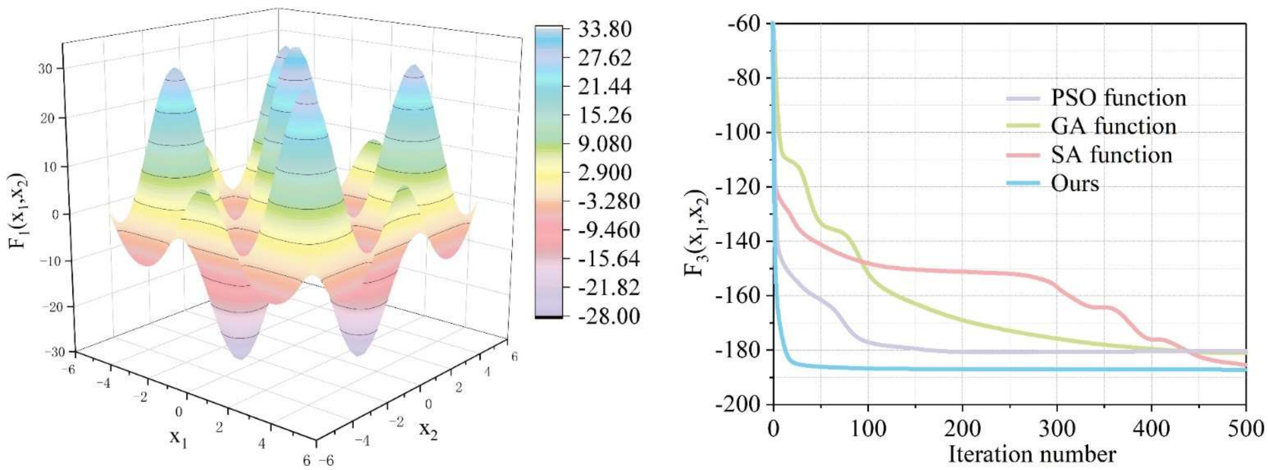

(b) Different algorithm fitness curve

**Fig. 5.** Test results of Sphere function




(a) Rastrigin function (b) Different algorithm fitness curve

**Fig. 6.** Test results of Rastrigin function




(a) Shubert function (b) Different algorithm fitness curve

**Fig. 7.** Test results of Shubert function

### *3.2. Model Application and Analysis*

This section takes an electrical appliance company as the object of empirical research, and uses the marketing resource allocation model in this paper to solve the company's production and sales decisions. In 2024, an electrical appliance company plans to produce 10 products in 3 categories, including hot water kettles, soymilk makers, and rice cookers, with a maximum annual production capacity of 60,000 hot water kettles, 65,000 soymilk makers, and 63,000 rice cookers, respectively. In order to maximize the company's profits and take into account the interests of both the company and the marketing department, respectively, for the electrical appliances company to develop the corresponding production and sales plan.

3.2.1. Company profit-maximizing production and marketing programs. Using the marketing resource allocation model designed in this paper to fit a function to the data on the relationship between production cost and production volume, $A_\alpha(i)$, $A_\beta(i)$, $A_\gamma(i)$ denote the cost function, the sales product funding function, and the sales function, respectively. The cost function coefficients are shown in Table 2.

**Table 2.** Cost function coefficient

| | $A_\alpha(i)$ | $B_\alpha(i)$ | $C_\alpha(i)$ | $D_\alpha(i)$ | Fitting precision index | |
|---|---|---|---|---|---|---|
| | | | | | SSE | R-square |
| 1 | 0.1801 | -8.052 | 80.1 | 1.873 | 5.62 | 0.9999 |
| 2 | 0.4673 | -8.688 | 86.19 | 1.413 | 3.01 | 0.9999 |
| 3 | 0.2409 | -9.038 | 87.41 | 2.091 | 6.87 | 0.9999 |
| 4 | 0.3528 | -25.26 | 207.8 | 5.71 | 71.24 | 0.9997 |
| 5 | -0.0856 | -17.7 | 227.4 | 8.027 | 166.01 | 0.9995 |
| 6 | 0.4795 | -24.76 | 239.5 | 6.224 | 102.53 | 0.9998 |
| 7 | 6.484 | -65.39 | 292.8 | -3.456 | 264.85 | 0.9991 |
| 8 | 6.9442 | -66.04 | 311.1 | -3.702 | 309.64 | 0.9992 |
| 9 | 7.3733 | -72.1 | 328.8 | -3.908 | 339.71 | 0.9993 |
| 10 | 7.5377 | -75.89 | 339.4 | -4.308 | 359.5 | 0.9992 |

A function was fitted to the data on the relationship between sales and sales volume, and the coefficients of the sales function are shown in Table 3.

**Table 3.** Sales function coefficient

| | $A_\gamma(i)$ | $B_\gamma(i)$ | $C_\gamma(i)$ | $D_\gamma(i)$ | Fitting precision index | |
|---|---|---|---|---|---|---|
| | | | | | SSE | R-square |
| 1 | 0.2467 | -30.8 | 115.2 | 1.412 | 5.62 | 0.9999 |
| 2 | 7.7633 | -42.29 | 128.3 | 1.218 | 3.01 | 0.9999 |
| 3 | 16.5247 | -60.13 | 139.4 | 0.7928 | 6.87 | 0.9999 |
| 4 | 68.213 | -199.7 | 359.7 | -2.045 | 71.24 | 0.9997 |
| 5 | 58.3673 | -186.4 | 397.2 | -0.6005 | 166.01 | 0.9995 |
| 6 | 78.2826 | -224.5 | 420.7 | -1.601 | 102.53 | 0.9998 |
| 7 | 104.5021 | -276.5 | 447 | -3.15 | 264.85 | 0.9991 |
| 8 | 98.5614 | -272.2 | 471.1 | -2.688 | 309.64 | 0.9992 |
| 9 | 187.0106 | -433.3 | 557.9 | -9.044 | 339.71 | 0.9993 |
| 10 | 104.8145 | -289.2 | 509.1 | -2.787 | 359.5 | 0.9992 |

A function was fitted to the sales funding and sales volume data, and the coefficients of the funding function for sales products are shown in Table 4.

**Table 4.** The cost of selling products

| | $A_\beta(i)$ | $B_\beta(i)$ | $C_\beta(i)$ | $D_\beta(i)$ | Fitting precision index | |
|---|---|---|---|---|---|---|
| | | | | | SSE | R-square |
| 1 | 0.1492 | -1.346 | 7.723 | -0.834 | 0.521 | 0.9945 |
| 2 | 0.1661 | -1.632 | 10.888 | 5.363 | 1.165 | 0.9929 |
| 3 | 0.1382 | -1.521 | 8.537 | 0.365 | 2.823 | 0.9939 |
| 4 | 0.3304 | -3.671 | 19.274 | 8.65 | 18.84 | 0.994 |
| 5 | 0.313 | -3.858 | 26.625 | 6.488 | 27.5 | 0.9913 |
| 6 | 0.3823 | -4.374 | 26.469 | 6.622 | 25.401 | 0.993 |
| 7 | 1.003 | -8.445 | 34.856 | 5.224 | 26.524 | 0.996 |
| 8 | 1.071 | -9.062 | 33.039 | 6.624 | 20.376 | 0.9906 |
| 9 | 1.139 | -9.522 | 31.083 | 5.57 | 29.34 | 0.9919 |
| 10 | 1.212 | -9.808 | 36.099 | 3.708 | 31.644 | 0.9947 |

A function was fitted to the data of profit and sales volume paid by the marketing department, and the coefficients of the function of profit and sales volume paid by the marketing department are shown in Table 5.

**Table 5.** The profit and sales function of the Marketing Department

| | $A_\beta(i)$ | $B_\beta(i)$ | $C_\beta(i)$ | $D_\beta(i)$ | Fitting precision index | |
|---|---|---|---|---|---|---|
| | | | | | SSE | R-square |
| 1 | 8.105 | -21.44 | 22.31 | 0.0242 | 0.0607 | 0.9697 |
| 2 | 9.42 | -24.53 | 25.27 | -0.0404 | 0.0961 | 0.9784 |
| 3 | 21.69 | -39.82 | 36.63 | -0.5333 | 0.2837 | 1.002 |
| 4 | 29.52 | -73.98 | 71.75 | -0.8724 | 0.8155 | 0.9956 |
| 5 | 33.54 | -85.62 | 80.11 | -0.8529 | 0.5675 | 0.9745 |
| 6 | 36.36 | -85.87 | 80.59 | -0.545 | 1.0379 | 0.9884 |
| 7 | 35.78 | -90.84 | 86.42 | -0.8904 | 0.11484 | 1.0345 |
| 8 | 44.33 | -102.52 | 95.24 | -1.3512 | 0.8708 | 0.9964 |
| 9 | 45 | -109.28 | 97.18 | -1.4424 | 0.5572 | 1.0009 |
| 10 | 52.18 | -117.23 | 105.5 | -1.6338 | 0.9952 | 0.9871 |

According to the company's profit maximization model that has been established, and the relevant fitting function, the marketing resource allocation model is used to solve the production and marketing plan when the company's profit is maximized, and the production and marketing plan when the company's profit is maximized is shown in Table 6.

**Table 6.** The production and marketing plan of the company's profits

| Product type | | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Production plan | Planned production | | 1.1 | 2.5 | 1.3 | 1.6 | 2.8 | 1.9 | 1.5 | 2.8 | 1.5 | 0.6 | 17.6 |
| | Planned output | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Sales scheme | Signed quantity | Customer 1 | 0.49 | 0.75 | 0.1 | 0 | 0 | 0 | 0.38 | 0.5 | 0.25 | 0.085 | 2.56 |
| | | Customer 2 | 0 | 0.66 | 0.31 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.97 |
| | | Customer 3 | 0.32 | 0.54 | 0.23 | 0 | 0 | 0 | 0.25 | 0.55 | 0.38 | 0.077 | 2.35 |
| | | Customer 4 | 0 | 0.34 | 0.37 | 0.22 | 0 | 0 | 0 | 0 | 0 | 0 | 0.93 |
| | | Customer 5 | 0 | 0 | 0 | 0.37 | 0 | 0.34 | 0.3 | 0.35 | 0.13 | 0.18 | 1.67 |
| | | Customer 6 | 0 | 0 | 0 | 0.49 | 0.42 | 0.29 | 0 | 0.4 | 0.3 | 0.2 | 2.10 |
| | | Customer 7 | 0 | 0 | 0 | 0 | 0.67 | 0.39 | 0 | 0 | 0 | 0 | 1.06 |
| | | Customer 8 | 0 | 0 | 0 | 0 | 0.91 | 0.25 | 0 | 0 | 0 | 0 | 1.16 |
| | Intention contract | Customer 1 | 0.16 | 0.2 | 0.2 | 0 | 0 | 0 | 0.1 | 0.29 | 0.22 | 0 | 1.17 |
| | | Customer 2 | 0.16 | 0.3 | 0.3 | 0 | 0 | 0 | 0.1 | 0.34 | 0.13 | 0 | 1.33 |
| | | Customer 3 | 0 | 0 | 0 | 0.33 | 0.17 | 0.1 | 0 | 0 | 0 | 0 | 0.60 |
| | | Customer 4 | 0 | 0 | 0 | 0.24 | 0.31 | 0.1 | 0 | 0 | 0 | 0 | 0.65 |
| | | Customer 5 | 0 | 0 | 0 | 0 | 0 | 0 | 0.2 | 0.35 | 0 | 0 | 0.55 |
| | unplanned | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Company profit (10,000 yuan) | | | 191.26 | 565.63 | 802.65 | 1554.6 | | | | | | | |

Analysis of program results:

1) When the company's profits are at their maximum, the amount of unplanned contracting is zero, which indicates that unplanned sales do not increase the company's profits, and the profits from their sales flow to the marketing department. Further analysis shows that with the expansion of production and sales scale, the company will gradually gain profit from the products sold out of plan. These patterns can also be crystallized in Table 2, Table 4 and Table 5.

2) The planned part, the company is not all kinds of products according to the maximum production capacity for production, which indicates that some products in a certain scale of production, the

company there is a "loss" of money. The company and the marketing department's interest in balancing the production and marketing program.

3.2.2. Equalization of production and marketing programs between the company and the marketing department's interests. Using the marketing resource allocation model to fit a function to the data on the relationship between promotional expenses and sales volume, the coefficients of the promotional expense function are shown in Table 7.

**Table 7.** The function of the publicity fee

| | $A_\eta(i)$ | $B_\eta(i)$ | $C_\eta(i)$ | $D_\eta(i)$ | Fitting precision index | |
|---|---|---|---|---|---|---|
| | | | | | SSE | R-square |
| 1 | 0.02288 | -0.6703 | 5.524 | 0.3691 | 0.0713 | 0.9996 |
| 2 | 0.05665 | -0.9073 | 4.607 | 0.3696 | 0.0711 | 0.9999 |
| 3 | 0.03461 | -0.7915 | 10.476 | 0.4308 | 0.1003 | 0.9997 |
| 4 | 0.07128 | -1.8897 | 15.92 | 1.0811 | 1.121 | 0.9993 |
| 5 | 0.03486 | -1.9295 | 19.99 | 1.3757 | 2.2229 | 0.9991 |
| 6 | 0.08882 | -1.2865 | 22.41 | 1.2394 | 1.4475 | 0.9995 |
| 7 | 0.59024 | -5.6049 | 23.56 | 0.4092 | 2.222 | 0.9991 |
| 8 | 0.63243 | -6.0019 | 27.98 | 0.4527 | 2.5137 | 0.9992 |
| 9 | 0.6659 | -6.346 | 27.18 | 0.4542 | 2.7597 | 0.9992 |
| 10 | 0.68509 | -6.5308 | 25.44 | 0.4554 | 2.859 | 0.9991 |

Using the marketing resource allocation model for solving, we get the production and marketing scheme when the profit of marketing department accounts for 15% of the product profit, and the production and marketing scheme when the profit of sales department accounts for 15% of the total product profit as shown in Table 8.

**Table 8.** Trading case

| Product type | | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Production plan | Planned production | | 1.2 | 2.3 | 1.4 | 1.5 | 2.43 | 2.22 | 1.4 | 2.55 | 1.36 | 0.59 | 16.95 |
| | Planned output | | 0 | 0.2 | 0 | 0 | 0.2 | 0 | 0 | 0.2 | 0.1 | 0 | 0.7 |
| Sales scheme | Signed quantity | Customer 1 | 0.49 | 0.85 | 0.12 | 0 | 0 | 0 | 0.39 | 0.55 | 0.27 | 0.08 | 2.75 |
| | | Customer 2 | 0 | 0.52 | 0.35 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.87 |
| | | Customer 3 | 0.33 | 0.47 | 0.2 | 0 | 0 | 0 | 0.49 | 0.49 | 0.35 | 0.05 | 2.38 |
| | | Customer 4 | 0 | 0.28 | 0.39 | 0.2 | 0 | 0 | 0 | 0 | 0 | 0 | 0.87 |
| | | Customer 5 | 0 | 0 | 0 | 0.35 | 0 | 0.43 | 0.23 | 0.36 | 0.12 | 0.16 | 1.65 |
| | | Customer 6 | 0 | 0 | 0 | 0.47 | 0.4 | 0.27 | 0 | 0.4 | 0.3 | 0.2 | 2.04 |
| | | Customer 7 | 0 | 0 | 0 | 0 | 0.68 | 0.38 | 0 | 0 | 0 | 0 | 1.06 |
| | | Customer 8 | 0 | 0 | 0 | 0 | 0.91 | 0.65 | 0 | 0 | 0 | 0 | 1.56 |
| | Intention contract | Customer 1 | 0.16 | 0.2 | 0.2 | 0 | 0 | 0 | 0.1 | 0.29 | 0.22 | 0 | 1.17 |
| | | Customer 2 | 0.16 | 0.3 | 0.3 | 0 | 0 | 0 | 0.1 | 0.34 | 0.13 | 0 | 1.33 |
| | | Customer 3 | 0 | 0 | 0 | 0.33 | 0.17 | 0.1 | 0 | 0 | 0 | 0 | 0.60 |
| | | Customer 4 | 0 | 0 | 0 | 0.24 | 0.31 | 0.1 | 0 | 0 | 0 | 0 | 0.65 |
| | | Customer 5 | 0 | 0 | 0 | 0 | 0 | 0 | 0.2 | 0.35 | 0 | 0 | 0.55 |
| | Unplanned | | 0 | 0.5 | 0 | 0 | 0.3 | 0 | 0 | 0.1 | 0.2 | 0 | 0.09 |
| Company profit (10,000 yuan) | | | 216.65 | | | 633.98 | | | 845.98 | | | | 1696.61 |

The use of marketing resource allocation model to solve, get the marketing department profit accounted for 25% of the product profit of the production and marketing program, the sales department profit accounted for 25% of the total profit of the product when the as shown in Table 9.

**Table 9.** Production and marketing plan

| Product type | | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Production plan | Planned production | | 1 | 2.6 | 1.4 | 1.5 | 2.9 | 1.6 | 1.4 | 2.49 | 1.5 | 0.7 | 17.09 |
| | Planned output | | 0 | 0.3 | 0.25 | 0.1 | 0.4 | 0.2 | 0.1 | 0.5 | 0.3 | 0 | 2.15 |
| Sales scheme | Signed quantity | Customer 1 | 0.4 | 0.78 | 0.22 | 0 | 0 | 0 | 0.35 | 0.55 | 0.25 | 0.08 | 2.63 |
| | | Customer 2 | 0 | 0.5 | 0.35 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.85 |
| | | Customer 3 | 0.26 | 0.45 | 0.2 | 0 | 0 | 0 | 0.45 | 0.47 | 0.35 | 0.07 | 2.25 |
| | | Customer 4 | 0 | 0.27 | 0.36 | 0.2 | 0 | 0 | 0 | 0 | 0 | 0 | 0.83 |
| | | Customer 5 | 0 | 0 | 0 | 0.35 | 0 | 0.4 | 0.36 | 0.37 | 0.2 | 0.15 | 1.83 |
| | | Customer 6 | 0 | 0 | 0 | 0.45 | 0.5 | 0.25 | 0 | 0.4 | 0.3 | 0.2 | 2.1 |
| | | Customer 7 | 0 | 0 | 0 | 0 | 0.75 | 0.45 | 0 | 0 | 0 | 0 | 1.2 |
| | | Customer 8 | 0 | 0 | 0 | 0 | 0.95 | 0.5 | 0 | 0 | 0 | 0 | 1.45 |
| | Intention contract | Customer 1 | 0.1 | 0.3 | 0.1 | 0 | 0 | 0 | 0.1 | 0.35 | 0.2 | 0 | 1.15 |
| | | Customer 2 | 0.1 | 0.2 | 0.1 | 0 | 0 | 0 | 0.1 | 0.35 | 0.1 | 0 | 0.95 |
| | | Customer 3 | 0 | 0 | 0 | 0.35 | 0.25 | 0.1 | 0 | 0 | 0 | 0 | 0.7 |
| | | Customer 4 | 0 | 0 | 0 | 0.2 | 0.45 | 0.1 | 0 | 0 | 0 | 0 | 0.75 |
| | | Customer 5 | 0 | 0 | 0 | 0 | 0 | 0 | 0.1 | 0.3 | 0 | 0 | 0.4 |
| | Unplanned | | 0 | 0.5 | 0.2 | 0.2 | 0.4 | 0.1 | 0.1 | 0.43 | 0.3 | 0 | 2.23 |
| Company profit (10,000 yuan) | | | 222.96 | | | 695.45 | | | 846.95 | | | | 1765.36 |

Analysis of program results:

1) As the proportion of the profit of the marketing department set in the model rises from 10% to 25%, the total profit of the product is increasing.

2) In the case of not setting the profit of the marketing department to account for the total profit of the product and only pursuing the maximum profit of the product sales, we can get the total profit of about 17,956,500 yuan, and at this time the profit ratio of the marketing department and the company is about 3:7.

3.2.3. Analysis of the effect of algorithmic solution. To confirm that the hybrid genetic algorithm (IGA) designed in this paper can converge to the global optimal solution in the solution space, the algorithm is tested here with a total budget of 100 as an example. When the total budget is 100, the running results of the hybrid genetic algorithm are shown in Fig. 8. The figure gives the optimal fitness value, maximum, minimum and average fitness values for each generation in the evolutionary process, when the genetic algorithm iterates to 1455 generations, the algorithm converges, thus finding a satisfactory solution to the problem X=[2.99986,4.99996,24.75692,31.8365,22.6503, 2.99972,3.00015] and the net gain of 85.36, and then this point as the initial search point, began to use the pattern search for local focus optimization, through a number of iterative tests, the results were obtained as X = [2.9999,5.0026,24.7587,31.8395,22.6503,2.99932,0.99983], at this time, the marketing expenditures of 912,651,000 yuan, the total net gain,935.6 thousand dollars. From the analysis, it can be seen that the optimal solution obtained from the two optimizations is in line with the actual situation, thus confirming the feasibility and practicality of the algorithm in this paper.

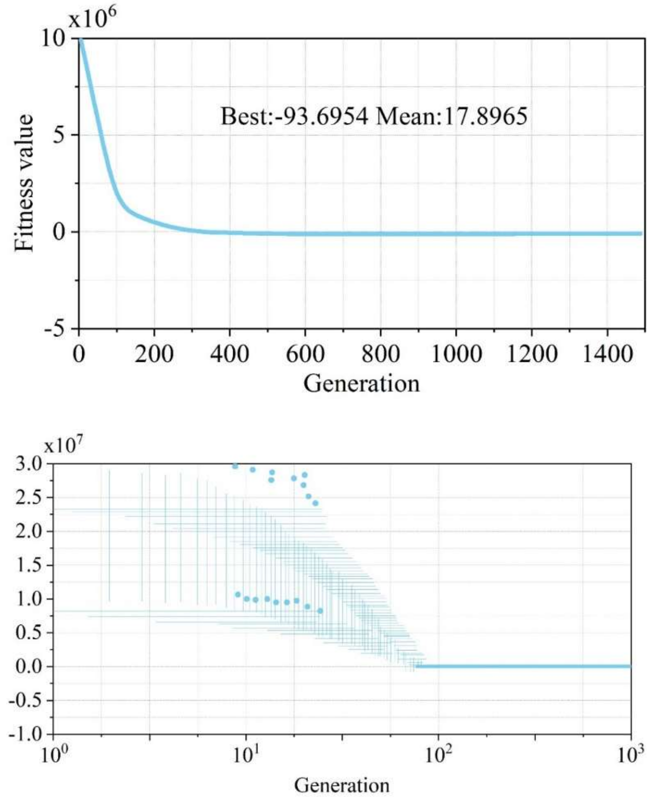



**Fig. 8.** The results of the genetic algorithm

## 4. Conclusion

Marketing activities throughout the whole process of business operations, marketing resources as the core of marketing activities, can regulate the whole society unlimited market business activities, so as to achieve the optimal allocation of resources and sustainable development of enterprises.

After using the method of this paper to design the marketing program for an electrical company, it is found that the company's profit is maximum when the unplanned contracted volume is zero, unplanned sales of products can not increase the company's profit, the profit will flow to the marketing department, which can be obtained with the expansion of the production and sales scale, the company will gradually gain profit from the unplanned sales of products.

In the analysis of the operation results of the improved genetic algorithm, when the genetic algorithm iterates to 1455 generations, the satisfactory solution X=[2.99986,4.99996,24.75692, 31.8365,22.6503,2.99972,3.00015], the net gain is 85.36, and through many iterations of the test, the result is obtained as X=[2.9999,5.0026,24.7587,31.8395,22.6503,2.99932,0.99983], with a marketing expenditure of 912,651,000 yuan and a total net benefit of 935,600 yuan. It can be concluded that the optimal solution obtained from the two optimizations is in line with the actual situation, which confirms the feasibility and practicality of the algorithm in this paper.

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