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Research Article

Optimization and Design of General Machinery Production Line Management Process Based on Intelligent Computing Model

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Machinery is the most important basic tool for modern times, and it is also an indispensable sharp weapon for creating big country projects. The production line management of general machinery is particularly important. Traditional production line management causes a lot of labor waste, time waste, and low production efficiency, so the efficiency of production line management also determines the quality and output of general machinery. Therefore, it has become an industry consensus to realize intelligent management in the manufacturing process of general machinery. General machinery is not only a complex industrial structure but also has a series of preconditions that are not conducive to production, such as the diversity of parts and the low precision of preparation in the early stage. Therefore, to realize automation in the field of construction machinery manufacturing, it usually faces more challenges. Whether it is traditional production process or automatic production process, the realization of intelligent production line is the primary problem, because both production efficiency and product quality are determined by the efficient production line management efficiency and exquisite process. The workload of production line management is heavy, which is time-consuming, labor-consuming, and expensive. Adhere to the goal of quality first, and how to improve the efficiency of the production line has become the biggest problem at present. Based on the above problems, this paper adopts intelligent computing model to improve the efficiency of production line management and optimize the process. A series of tedious processes from product adoption to final shipment of production lines need intelligent technology to simplify the process, which can effectively improve the production efficiency of general machinery, reduce production costs, and improve the production quality of machinery. Supply chain management theory is used to manage suppliers' production behavior, so as to reduce costs and improve quality and service, thus improving the competitiveness of batch production lines and enterprises. Advanced manufacturing technology is used to realize automation and flexible production of batch production lines, thus improving the rapid response ability of production lines to market demand.

1. Introduction

In the production process of general machinery, before the intelligent technology of mechanical engineering is applied to the production process of mechanical engineering, most mechanical production is completed by assembly line operation, which has high labor cost and cannot guarantee the product quality. Towards intelligence, the symbols on 5G system are detected through deep echo state network [1]. This paper expounds five principles of using intelligent application in medical imaging [2] and expounds that the whole enterprise should develop intelligently, which is proved that the methodology of scientific cognition is the foundation of intelligent management of enterprise overall development. This paper introduces the strategic target complex of intelligent management for the overall development of industrial enterprises. It introduces the influence of risk on the intelligent management process of the overall development of railway tank machinery manufacturing industrial enterprises [3]. The problem of constructing

knowledge base of scheduling decision support system based on empirical data obtained from system diagram calculation experiment is solved, and the proposed method and the actual efficiency of the developed model are determined by research [4]. This paper summarizes the current research status of intelligent body and especially pays attention to the detection and expression of emotions in virtual environment [5]. This paper expounds the intelligent application of fecal immunochemical detection in population screening [6]. This paper introduces the transition from agriculture to digitalization, intelligence, and robot technology [7]. It provides a new idea for the automatic production line of automobile control arm [8]. Considering man-machine cooperation and task allocation, the performance of the production line is evaluated and optimized [9]. This paper introduces the development technology and realization method of intelligent production line based on C language of single chip microcomputer [10]. The literature expounds that using facility location redescription and single commodity flow constraint to eliminate subsequences, effective formulas that can provide high-quality solutions for large-scale instances can be obtained from classical models by making binary production variables explicit [11]. Literature research puts forward a reference practice system for practical training of key progress of SM and systematically constructs a mobile robot-based production line (MRPL) to improve participants' interest in theoretical study and professional skills [12]. A numerical example based on the information collected from the engine crankshaft leasing batch production line shows that the R and OM policy can effectively maximize the leasing profit, reduce the complexity of joint decision-making, and extend the OM theory [13]. The literature analyzes the shortage of the production line, puts forward the optimization method, and simulates the results by using genetic algorithm [14]. The solution proposed in the literature considers the energy availability and energy price of renewable energy and uses genetic algorithm with multiple constraints to optimize the production line scheduling [15]. The intelligent manufacturing process is studied, and the automatic production line based on multiple industrial robots is introduced [16]. By implementing three different line balancing technologies to improve the production line efficiency of the edging unit, a simulation verification platform for data interaction with the control system is proposed, which can verify the control system at low cost [17]. The purpose of this study is to analyze the market demand of jelly beverages in the eastern region in the next five years, select the best place to increase the factory capacity, and conduct a feasibility study on building additional production lines [18]. The literature introduces the replacement of rigid production line with flexible box [19]: production line balance analysis using genetic algorithm [20]. The literature introduces the design and application research of automatic production line of mechanical parts [21] and the application of position weight ranking method in spring production line balance [22]. The optimization and design method of general mechanical production line management flow [23, 24] based on intelligent computing model proposed in this paper can improve the traditional production mode and improve the working efficiency of the production line, and the intelligent method can realize the optimal method and the global optimal scheme in the global design. From the production line of enterprises, the production efficiency of enterprises can be improved, the production cost of enterprises can be reduced, and the production efficiency can be improved.

2. Production System Structure

The production system of machinery industry is the goal of enterprise's own production, management, and long-term development. It is an organic whole that combines various production parts and engages in certain production activities according to the development goal and demand. The production factors input by the production system include people, machines, materials, methods, environment, and energy. The manufacturing process is the process of producing the products that meet the requirements according to the production flow. The essence is the organic combination of the logistics process, the information flow process, and the capital flow process. The management process is the effective management of personnel, equipment, inventory, and other elements. The output of production system is mainly products and services. The general machinery production system takes the enterprise's own development and the market demand as the ultimate goal, increases the product value, satisfies the customer's expectation product, and realizes the enterprise profit. The structural diagram of general machinery production system is shown in Figure 1.

2.1. Content and Optimization. The study of the project of the productive evaluation of production system: firstly, the productive evaluation system of production system is established from three dimensions: task demand response ability, production resource management ability, and job fatigue degree. Secondly, taking the company's engine assembly line as the research object, based on system simulation technology, different levels of simulation models are constructed from macro to micro, and the productivity of the assembly line is comprehensively evaluated, and the evaluation results are verified by the system dynamics model. Finally, according to the evaluation results, the assembly line is optimized, as shown in Figure 2.

2.2. Improvement Ideas of Machining Production Line. Optimized processing efficiency: The traditional production line consumes a long time in the processing of parts and components, and the manufacturing efficiency is low. The commonly used optimization scheme is double production line setting or double station setting. Under the background of public welfare development of machining production line and continuous optimization of production equipment, the operation efficiency and production quality of production work can be improved to a certain extent by improving production equipment, optimizing production links, and applying advanced technologies, such as applying electronic control hydraulic drive devices.

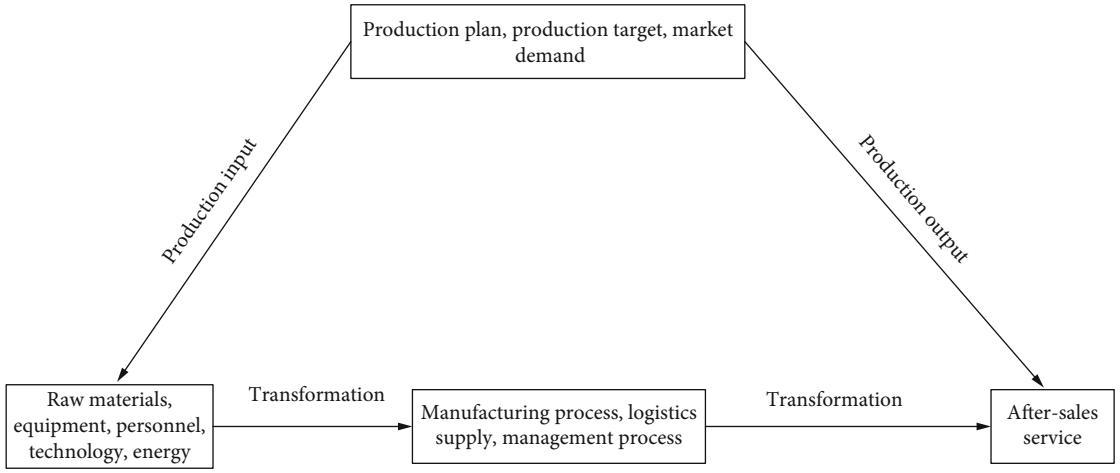

Figure 1: Production system structure.

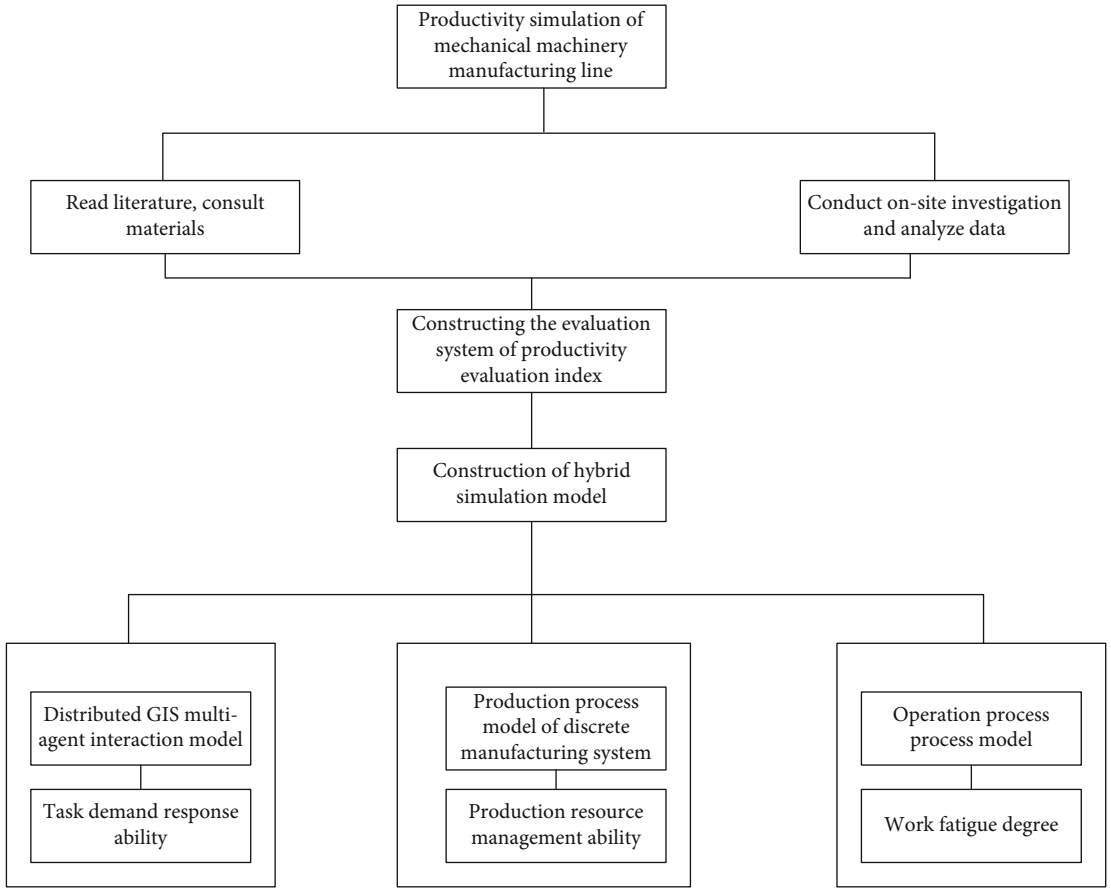

Figure 2: Production line optimization.

Change the operation mode of flexible manufacturing system: the control system of traditional machining production line is mainly relay circuit type. Under the background of the development and popularization of NC machine tools, the production structure of previous production machine tools has changed to some extent, and at the same time, the structure of parts has also changed, such as the change of design standards and production standards. Compared with previous production systems, flexible manufacturing system can coordinate with numerical control technology, enhance the connection between multiple links in the production process, and make it meet the basic requirements of expected manufacturing in terms of production quality and process control. The application of flexible manufacturing system can adjust the form of production and processing according to different production tasks, so that the

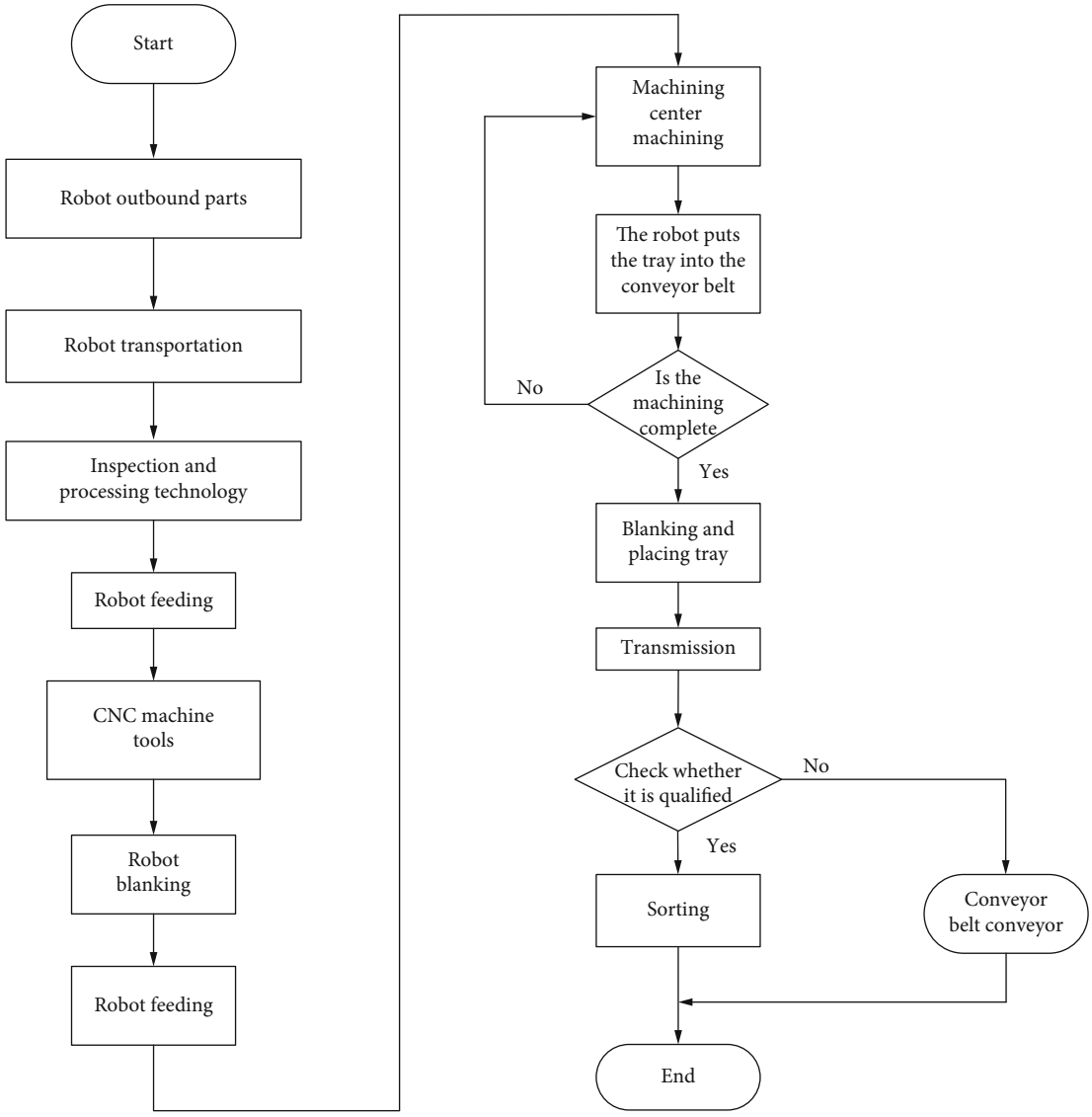

Figure 3: Process flow chart.

Table 1: Comparison of solution values.

Algorithm	Optimal solution	Average solution	Standard solution
Whale algorithm [25]	0.01231	0.01197	0.035
Improved whale algorithm [26]	0.03804	0.03195	0.031
Genetic algorithm [27]	0.02371	0.02762	0.027
Particle swarm optimization [28]	0.03196	0.02474	0.028

The best results after increasing the number of iteration steps of the above four algorithms are compared with, for example, Figure 4.

production efficiency of enterprises can be guaranteed to a certain extent and then meet the requirements of users for production components.

2.3. Improve Machining Quality and Precision. With the development and maturity of machining industry system, the intensity of market competition continues to rise. In order to stand out in the competition, relevant machining enterprises need to firmly grasp the customer dynamics and make the finished products meet the customer's needs through the production and application of new production lines according to their processing and production needs, so as to adapt to the development of market environment through the optimization of production management and production process. With the development of small machinery manufacturing, the fine requirements between its components are becoming more and stricter. In this regard, the first step for general machining enterprises to compete with other enterprises is to improve the precision of parts and to carry out fine machining through high-tech technologies and tools in the manufacturing process, so as to improve the cutting quality of parts and make them reach the desired height in terms of size and observation. Secondly, in the

Table 2: Data comparison table.

Model	1	2	3	4	5	6	7
Whale algorithm	0.291	0.263	0.242	0.263	0.253	0.272	0.211
Improved whale algorithm	0.411	0.392	0.383	0.381	0.393	0.374	0.374
Genetic algorithm	0.312	0.246	0.253	0.274	0.282	0.227	0.245
Particle swarm optimization	0.336	0.224	0.258	0.281	0.254	0.239	0.239

A bar chart of the statistics of the data in the above table is shown in Figure 5.

Table 3: Data comparison table.

Model	1	2	3	4	5	6	7
Whale algorithm	0.292	0.251	0.249	0.254	0.272	0.272	0.283
Improved whale algorithm	0.403	0.373	0.377	0.384	0.391	0.393	0.391
Genetic algorithm	0.323	0.255	0.253	0.242	0.245	0.253	0.255
Particle swarm optimization	0.330	0.232	0.251	0.273	0.277	0.237	0.321

A bar chart of the statistic of the data in the above table is shown in Figure 6.

Table 4: Data comparison table.

Model	1	2	3	4	5	6	7
Whale algorithm	0.282	0.243	0.245	0.255	0.266	0.269	0.287
Improved whale algorithm	0.411	0.363	0.367	0.366	0.371	0.377	0.388
Genetic algorithm	0.223	0.244	0.252	0.244	0.240	0.247	0.253
Particle swarm optimization	0.330	0.233	0.250	0.268	0.273	0.277	0.278

A bar chart of the statistic of the data in the above table is shown in Figure 7.

Table 5: Data comparison table.

Model	1	2	3	4	5	6	7
Whale algorithm	28.4%	23.1%	24.8%	25.2%	26.3%	26.7%	27.8%
Improved whale algorithm	40.02%	36.1%	36.7%	36.8%	37.2%	37.5%	38.3%
Genetic algorithm	23.3%	24.2%	25.1%	25.4%	25.6%	27.2%	27.3%
Particle swarm optimization	33.1%	33.3%	32.4%	33.4%	37.1%	31.5%	28.2%

A bar chart of the statistics of the data in the above table is in Figure 8.

Table 6: Comparison of experimental data of each algorithm.

Algorithm	Construction period	Cost	Quality	Safety	Environmental protection
Whale algorithm	0.4	0.6	0.4	0.4	0.2
Improved whale algorithm	0.3	0.2	0.8	0.8	0.65
Genetic algorithm	0.3	0.4	0.6	0.6	0.3
Particle swarm optimization	0.4	0.5	0.6	0.5	0.2

A bar chart of the statistic of the data in the above table is shown in Figure 9.

process of measurement, it is necessary to control the thermal effect of cutting parts, and the parts are easy to deform in the cutting process because of the high knife edge temperature. According to the characteristics of thermodynamic effect, machining enterprises can implement axial and radial dual control through production precision monitoring, automatic observation equipment, and hollow tool cone, so as to improve the machining quality and fineness of parts.

3. Production Line Optimization Algorithm

Every element in the general machinery production line must be assigned to the corresponding process. The mathematical expression is

$$\sum_{k=1}^{k} X_{ik} = 1 ; (i = 1, 2, 3, \cdots, m). \quad (1)$$

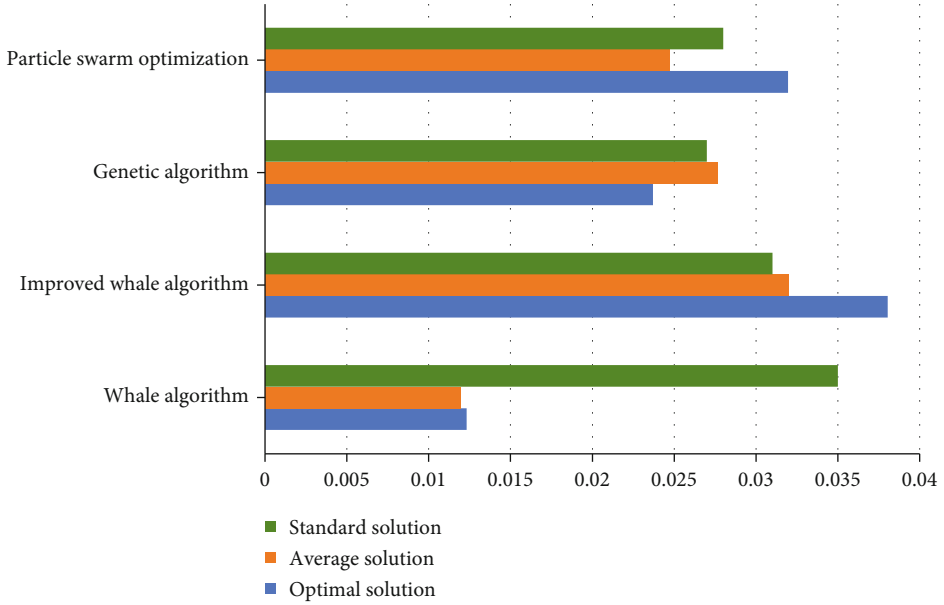

Figure 4: Comparison diagram of optimal values of algorithms.

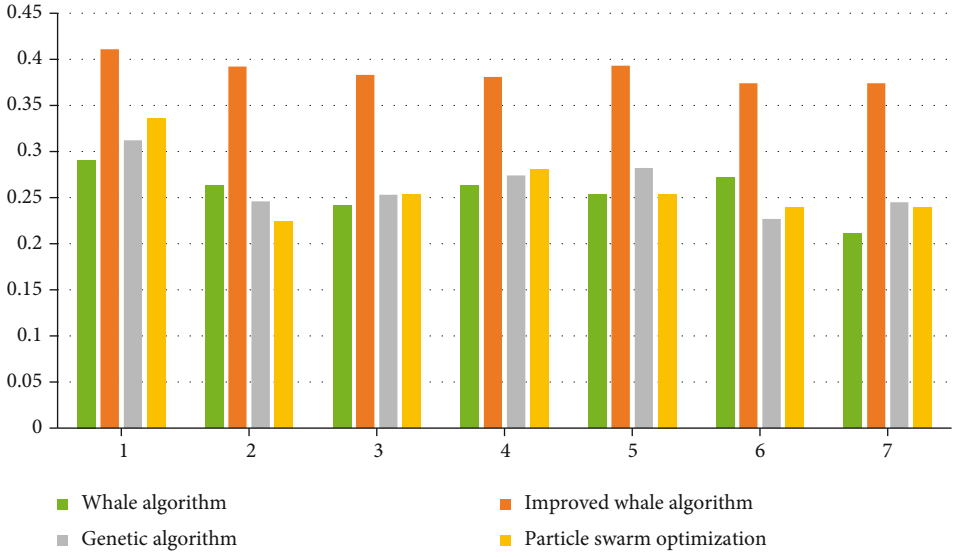

Figure 5: Comparison of algorithm accuracy.

Its expansion is

$$\begin{cases} X_{11+}X_{12} + X_{13}+\cdots+X_{1k} = 1, \\ X_{21+}X_{22} + X_{23}+\cdots+X_{2k} = 1, \\ \cdots \\ X_{m1+}X_{m2} + X_{m3}+\cdots+X_{mk} = 1. \end{cases} \tag{2}$$

In a general machinery production line, the operation where element i is j, when j is assigned to operation k, then element i must be manufactured before element j. The mathematical expression is

$$\sum_{k=1}^{K} k\left(X_{jk} - X_{ik}\right) \geq 0\,; (i, j) \in Pread. \tag{3}$$

Its expansion is

$$\left(X_{j1} - X_{i1}\right) + 2\left(X_{j2} - X_{i2}\right) + 3\left(X_{j3} - X_{i3}\right) + k\left(X_{jk} - X_{ik}\right) \geq 0. \tag{4}$$

The total manufacturing time of each process must be less than the production beat (CT). Production beat is an

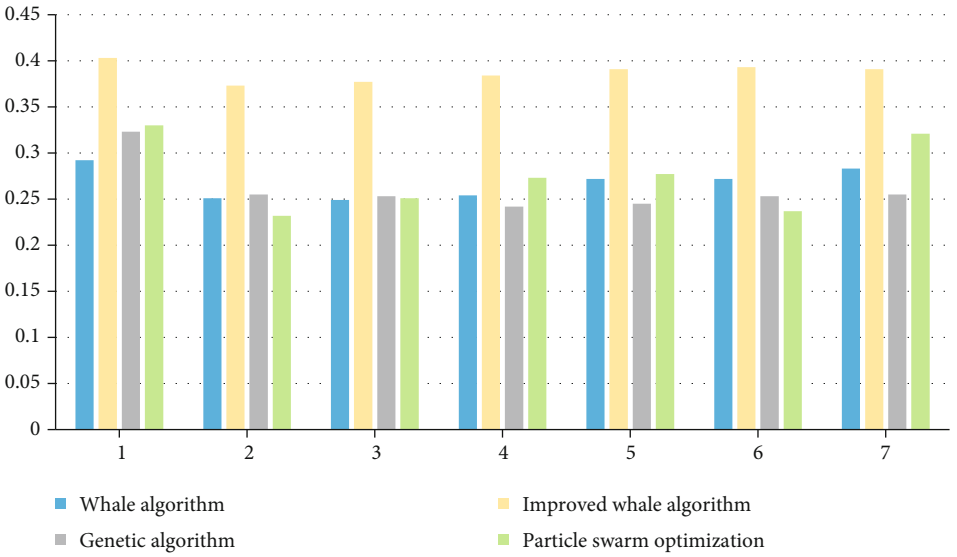

Figure 6: Comparison chart of algorithm recall rate.

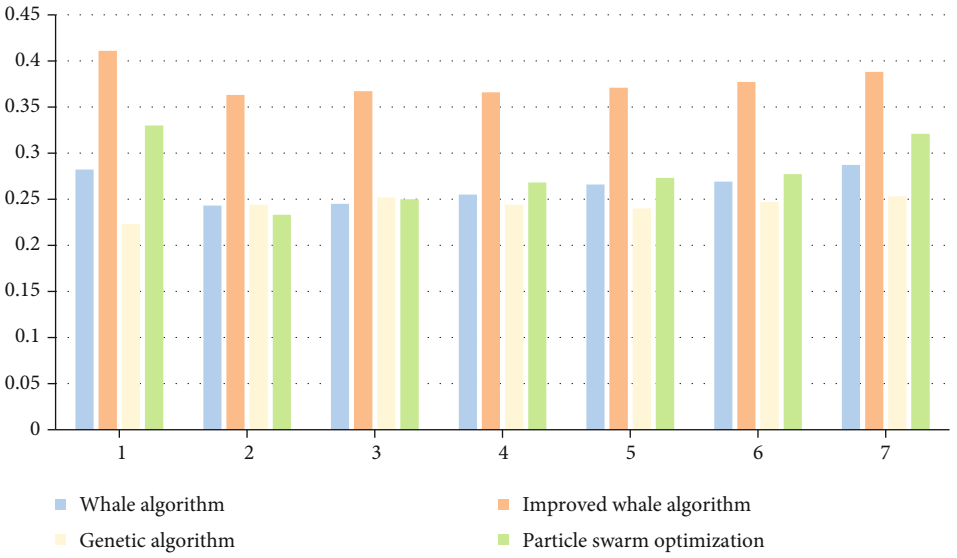

Figure 7: Comparison diagram of algorithm F value.

index used to measure the efficiency of production line. CT $= T_a/T_d$, and its mathematical expression is

$$\sum_{i=1}^{m} X_{ik} t_i \le \mathrm{CT}\,;\,(k = 1, 2, 3.., K). \tag{5}$$

Its expansion is

$$\begin{cases} X_{11}t_1 + X_{21}t_2 + X_{31}t_3 + \cdots + X_{m1}t_m \le \mathrm{CT}, \\ X_{12}t_1 + X_{22}t_2 + X_{32}t_3 + \cdots + X_{m2}t_m \le \mathrm{CT}, \\ \cdots \\ X_{1K}t_1 + X_{2K}t_2 + X_{3K}t_3 + \cdots + X_{mK}t_m \le \mathrm{CT}. \end{cases} \tag{6}$$

If a workstation in the production line has a job element assigned to it, the indication value of the workstation is 1, and its mathematical expression is

$$\sum_{k=1}^{K} X_{ik} \le mA_k, \tag{7}$$

$$\begin{cases} X_{11+}X_{12} + X_{13} + \cdots + X_{1k} \le mA_k, \\ X_{21+}X_{22} + X_{23} + \cdots + X_{2k} \le mA_k, \\ \cdots \\ X_{m1+}X_{m2} + X_{m3} + \cdots + X_{mk} \le mA_k. \end{cases} \tag{8}$$

3.1. Improved Unbalanced Programming Model of

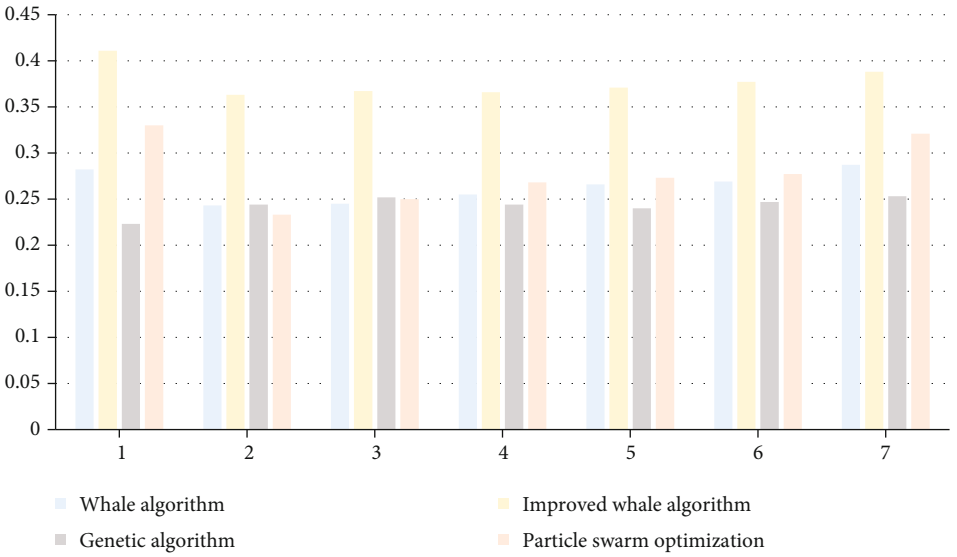

Figure 8: Comparison diagram of algorithm convergence.

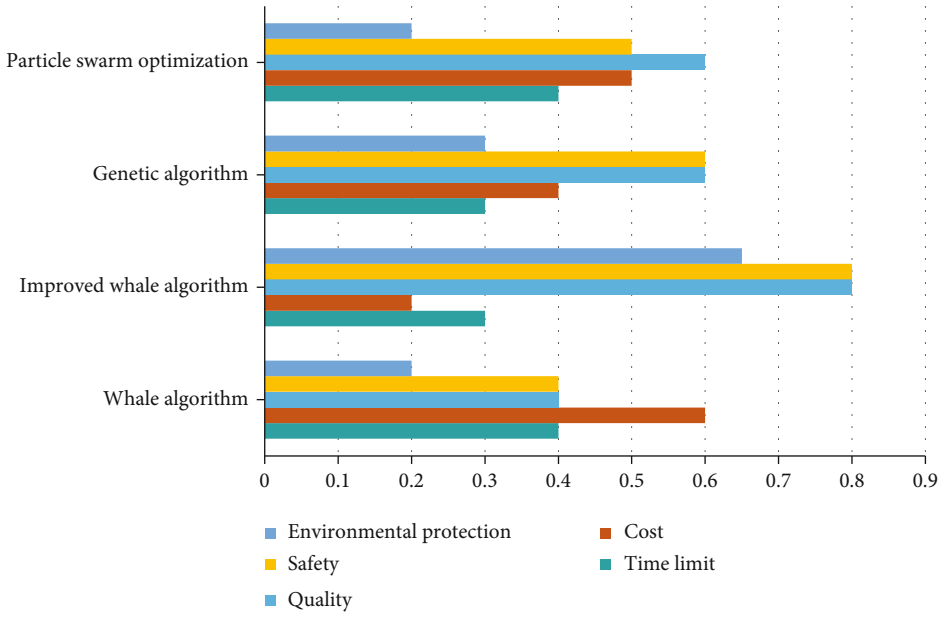

Figure 9: Comparison chart of various elements.

Production Line. Objective function:

$$\min = \sum_{k=1}^{K} A_k. \tag{9}$$

Constraint condition:

$$\sum_{k=1}^{K} X_{ik} = 1\,;\,(i = 1, 2, 3, 4, .., m), \tag{10}$$

$$\sum_{k=1}^{K} k\left(X_{jk} - X_{ik}\right) \geq 0\,;\,(i, j) \in Pread, \tag{11}$$

$$\sum_{i=1}^{m} X_{ik} t_i \leq CT\,;\,(k = 1, 2, 3, .., k), \tag{12}$$

$$\sum_{k=1}^{k} X_{ik} \leq mA_k\,;\,(k = 1, 2, 3, .., k), \tag{13}$$

where the value of the first row in the A_k matrix and X_{ik} represents the values of the i rows and k columns of the matrix X. Formula (9) is the target value requirement, and formulas (10)-(13) are for the constraints in Formula (9). Under the condition of satisfying Formula (10) to Formula (13), find the minimum value of Formula (9). The minimum value in Equation (9) is the target value for implementing the objective function.

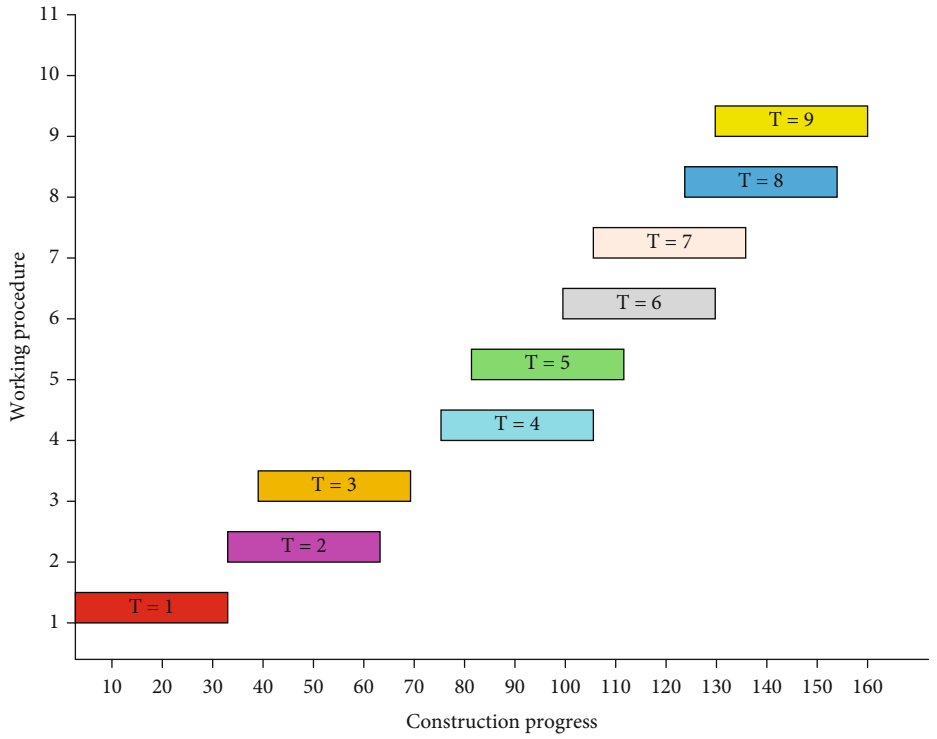

Figure 10: Process management diagram.

3.2. Evaluation Index of Production Line. The production line balance rate of its general machinery:

$$W = \frac{\sum_{i=1}^{N} T_i}{N * T}. \tag{14}$$

Equipment utilization, expressed in JPH:

$$\text{JPH} = \frac{\text{Output}}{\text{time}}. \tag{15}$$

Enterprise production capacity:

$$P = \frac{T}{\text{CT}}, \tag{16}$$

where T_i represents the value of each production line, and $N * T$ represents the total value. JPH represents the ratio of utilization, output, and time. P denotes production capacity, and T denotes production.

3.3. Whale Algorithm

3.3.1. Basic Whale Optimization Algorithm. Whales kill prey and approach the prey position and update their position by different mechanisms. There are three mechanisms for updating the position of whales in whale optimization algorithm:

The first:

$$X_i^{t+1} = X_p^t - A * D, D = \left| C * X_p^t - X_i^t \right|. \tag{17}$$

The second:

$$X_i^{t+1} = D * e^{bl} * \cos(2\pi l) + X_p^t, \tag{18}$$

$$X_i^{t+1} = \begin{cases} X_p^t - A * D, pr < 0.5, \\ D * e^{bl} * \cos(2\pi l) + X_p^t, pr \geq 0.5, \\ D = \left| X_p^t - X_i^t \right|. \end{cases} \tag{19}$$

The third:

$$X_i^{t+1} = X_R^t - A * D, D = \left| C * X_R^T - X_i^T \right|, \tag{20}$$

where X_p^t represents the global optimal position, then $X_i^t = (X_{i,1}, X_{i,2}, .., X_{i,d})$ represents the whale's position in the D-dimensional search space.

3.3.2. Improved Whale Algorithm. Elite reverse solution definition:

$$\overline{X_{i,j}^e} = K * \left(d_{a_j} + d_{b_j} \right) - X_{i,j}^e. \tag{21}$$

Reset method:

$$\overline{X_{i,j}^e} = \text{rand}\left(d_{a_j}, d_{b_j} \right). \tag{22}$$

The purpose of the improved whale algorithm is to achieve the problem of local trapped optimum and to

improve the convergence effect of the algorithm by adding the whole algorithm in the global query time.

3.3.3. Golden Sinusoidal Mechanism. The sinusoidal mechanism is equal to a new metaheuristic optimization algorithm proposed in 2017. Its inspiration comes from the scanning in the unit circle of sine function, which is similar to the spatial search of the solution of the problem to be optimized, and the search space is reduced by the golden section ratio to approach the optimal solution of the algorithm. Compared with traditional metaheuristic optimization algorithm, Gold-SA algorithm has the characteristics of simple principle, few parameters, and strong optimization ability.

The position update formula of the ith individual is as follows:

$$X_i^{t+1} = X_i^t * |\sin(R_1)| + R_2 * \sin(R_1) * \left|x_1 * P_i^t - x_2 * X_i^t\right|. \tag{23}$$

The golden section number is a definition:

$$x_1 = -\pi + (1-\tau) * 2\pi, \tag{24}$$

$$x_2 = -\pi + \tau * 2\pi. \tag{25}$$

Divide a line segment into two parts so that the ratio of one part to the total length is equal to the ratio of the other part to this part. Its ratio is an irrational number, and the approximation of its first three digits is 0.618. Because the shape designed according to this proportion is very beautiful, it is called the golden section, also known as the ratio between China and foreign countries. The function of this value is not only reflected in the art fields, such as painting, sculpture, music, and architecture, but also plays an important role in management and engineering design.

4. Experiment Analysis

The automatic production line used in general machining is mainly to realize the intelligentization of machinery in the processing and production process. On this basis, digital technology is added. The production process flow of each stage is shown in Figure 3.

4.1. Simulation Experiment. Intelligent algorithms are used to optimize the production process of general machinery. The results of the two algorithms are compared with the data of the optimal solution, the average solution, and the standard solution, as shown in Table 1.

4.2. Model Comparison. Traditional production lines consume a long time in the processing of parts, and the production and manufacturing efficiency is low. In order to improve the traditional mode of the general mechanical production line and improve the management efficiency and work efficiency, an intelligent and efficient production and operation model is adopted, and the accuracy, recall rate, F value, and convergence of the seven processes of the production line are compared in an intelligent way, as shown in the following table.

The accuracy of general machinery in different production processes is compared, such as Table 2.

The recall rate of general machinery in different production processes is compared, such as Table 3.

General machinery performs F value pairs in different production processes, such as Table 4.

Convergence of general machinery in different production processes is shown in Table 5.

It can be seen from the chart of model comparison that the accuracy, recall, F value, and convergence of the improved whale algorithm are always higher than the other three algorithm models in different processes of the production line.

4.3. Contrast Experiment. In order to further explore whether the improved whale algorithm is effective for general machinery production line management optimization, the influence degree of enterprise stakeholders is different, so the influence degree of different goals on enterprises is also different. Compare the statistical data of experimental results with four algorithms as shown in Table 6.

In order to show the decision schemes given by these four optimization schemes more intuitively, the Gantt chart corresponding to the improved whale algorithm is given, as shown in Figure 10.

5. Conclusion

Aiming at the optimization of production line management of general machinery, this paper optimizes each process by improving whale algorithm method, which takes the factors of production schedule, such as construction period, safety, cost, and quality as evaluation indexes. In this paper, some achievements have been made in the research of general machinery production line optimization, and the conclusions are as follows:

(1) Through the comparison diagram of simulation experiment, it can be seen that although it is not the optimal solution, the optimal value of the improved whale algorithm is more stable than that of the other three algorithms

(2) Through model comparison, the comprehensive indexes of all production processes of the four algorithms are compared, and the improved whale algorithm is about 10% higher than the other three algorithms

(3) The effectiveness of the algorithm is further tested in the comparative experiment. By comparing the factors such as construction period, cost, quality, safety, and environmental protection of the production line, and using Gantt chart, it is fully proved that the improved whale algorithm is more effective and fast in job sequencing

Data Availability

The experimental data used to support the findings of this study are available from the corresponding author upon request.

Conflicts of Interest

The authors declared that they have no conflicts of interest regarding this work.

Acknowledgments

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