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Establishment and Analysis of Assembly Sequence Planning Model of Construction Machinery Components Based on Ant Colony Algorithm

Yu Han*

Shenyang Jinbei Vehicle Manufacturing Co., LTD, Shenyang, Liaoning, China

84869006@qq.com

**corresponding author*

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Abstract: Taking the assembly sequence of construction machinery as the research object, this paper analyzes the application of traditional heuristic algorithm in the path optimization problem based on ant colony, and the simulation results show that the method has good performance. This paper mainly aims at establishing the assembly sequence planning model of engineering mechanical components based on ant colony algorithm. First, the principle of genetic operation and basic operators are introduced, and then the genetic evolution process is simulated using Matlab software. After it is converted into the optimal solution, the desired number of solving parameters and time minimum characteristic curves are finally obtained to analyze the nature of the problem. Finally, the simulation results show that the data processing time and the shortest path planning time of the construction machinery assembly sequence planning model based on ant colony algorithm are within 10 seconds. This shows that the model meets the needs of users.

1. Introduction

In modern life, construction machinery products have become the necessities of people's daily life. Because of the complex working environment and low production efficiency, it is very important to study the assembly sequence of construction machinery. Although the traditional design method based on artificial ant colony algorithm can effectively solve the global minimization problem in the design process [1-2]. However, because this method is based on heuristic optimization and does not take into account the interaction between parameter variables, there are a lot of complex and uncertain factors in practical application. Therefore, a more efficient and convenient tool is needed to solve this problem. This paper designs the optimal path planning scheme based on ant colony algorithm and verifies its feasibility and applicability through experiments [3-4].

Many scholars have done some research on ant colony algorithm. In foreign countries, the research on assembly sequence planning of construction machinery has been quite mature, mainly represented by Japan, the United States and other developed countries. China started this aspect late. At present, most of the programs based on the ant colony algorithm distribution model and ant colony optimization method are used to solve the simulation calculation under multiple constraint conditions in China. The system can achieve optimal control without changing the parameters in the current process of assembly sequence diagram [5-6]. Some scholars and others use ant colony optimization algorithm to solve TSP problem. This method is a heuristic calculation method to improve the model design with ant search ability as the evaluation index. Some scholars have conducted simulation experiments with the "ant moving" model to verify that the algorithm has good global and high controllability, and has fast stability and convergence speed, but at the same time, it lacks flexibility and is easy to fall into the local optimal solution. The above research has laid the research foundation for this paper.

In this paper, the assembly sequence planning problem of construction machinery is studied. Based on the basic principle of ant colony algorithm, the traditional simulation process is improved and optimized. The assembly path planning model of engineering mechanical components is established. Through the relevant parameters and program files in the MATLAB software simulation toolbox. After getting the optimal solution, the comparison with the actual situation verifies that the method has certain practicability and applicability in solving large-scale production. The final results prove that the method in this paper can effectively improve product quality, reduce enterprise costs and other aspects have a positive role.

2. Research on Assembly Sequence Planning Model of Construction Machinery Components Based on Ant Colony Algorithm

2.1. Assembly of Engineering Machinery Components

The assembly of construction machinery components is to arrange the processes of each workpiece in a certain order. In this process, it is necessary to ensure that each part has sufficient size, and also take into account the mutual position relationship between components [7-8]. In order to enable the products to go online from the lower end of the production line smoothly and complete the predetermined task indicators, the manufacturing plant and production batch can be designed for assembly. At the same time, the assembly can be realized by adjusting the distance between parts. The assembly of construction machinery components is to place each workpiece in the designated area at the specified location according to the process requirements and processing sequence. In the assembly of construction machinery, it mainly includes the preparation, processing and packaging of raw materials [9-10]. Materials are an integral part of the whole production process, and their quality is directly related to whether the products can achieve the quality and efficiency on time. Therefore, it is necessary to strictly control the purchase quantity and quantity to reduce waste for management and storage, and develop corresponding systems to ensure the adequacy and stability of material supply. Construction machinery and equipment must be tested and inspected before assembly. In the production process of construction machinery, assembly is generally carried out in the way of assembly line. According to the requirements and actual conditions, the engineering machinery components are divided into different varieties according to the process flow, required quantity, specifications and other factors given by the designer, and then different parts are configured for each category. The manufacturing of engineering machinery components usually adopts modular design method, which can simplify the complex, huge and numerous problems, reduce the production cycle and cost, and realize the automatic operation of the system. All components have their own independent characteristics, functional requirements and special performance requirements. During the assembly process, computer technology is used to automatically classify the parts and calculate the required size, and then select appropriate specifications, models and specifications according to the design drawings.

2.2. Sequence Planning

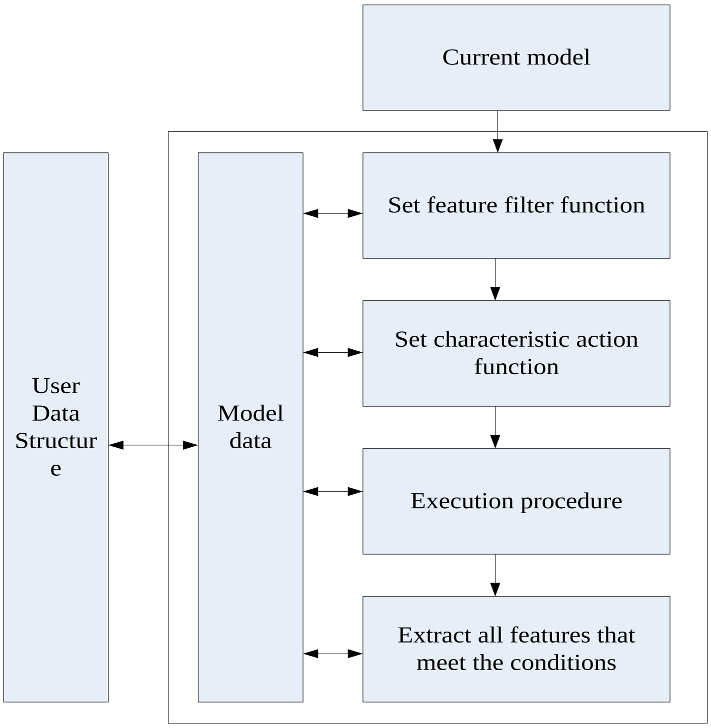

Figure 1. Sequence planning program

In real projects, there are many kinds of problems, and these complex factors often lead to the system being unable to determine its optimality. The most important thing is how to transform the problem into an optimal solution [11-12]. However, we can solve these problems by establishing a solution sequence planning model. We need to constrain the objective function. When the objective function is determined, we can start to set the initial point, starting point and termination conditions. Then, according to the constraints and heuristic algorithm, the final required results are obtained and the corresponding scheme is given (Figure 1 is the sequence planning process). In this process, it is also necessary to consider the following iteration problems, that is, whether there is an optimal solution or the best answer. Therefore, it is necessary to combine the real process with the optimization algorithm. To some extent, information leakage and asymmetry exist when solving the target group. When a new problem arises after the algorithm operates on the object, the local optimal solution or the global minimum solution, or the local optimal solution may appear, and the feasibility of these solutions depends on whether the initial conditions are appropriate, whether the requirements of the entire system operating environment and constraints can be met. In the actual production process of construction machinery, many problems can be solved through the model to achieve the optimal solution. Due to the complexity, randomness, unpredictability and other characteristics under the influence of many uncertain factors in the system, it is impossible to accurately describe its characteristics. Therefore, it is necessary to integrate multiple individuals with different characteristic attributes or independent structures to solve these problems, so as to obtain optimization results. In practical applications, the optimal solution can be achieved by setting parameters of the model. Therefore, in order to achieve the optimal effect of research, it is necessary to control the interaction between external conditions and internal variables and the regularity of size change, which is one of the most important and widely used characteristics in sequence optimization problems, namely, stochastic process characteristics [13-14].

2.3. Ant Colony Algorithm

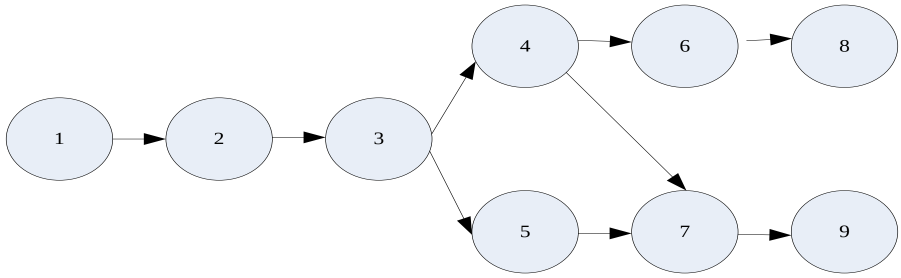

Figure 2. Ant colony algorithm optimal path

Ant colony algorithm is formed by ants through the buoy and foraging process in the food chain. Its basic idea is to find an optimal solution first, and then continuously find the optimal path according to this optimization (Figure 2 is the optimal path of ant colony algorithm). It is a stochastic optimization method with strong global search ability and good robustness. It realizes individual optimal solution by studying the mutual cooperation and synergistic effect between pheromones. In nature, many populations have strong adaptability to environmental changes (such as natural dormancy). When the system is subject to external interference, there will be some local minimization problems. Ant colony algorithm can overcome these shortcomings, making the solution process simple and easy to control, easy to understand, and has good global optimization ability, so it is widely used in various intelligent fields and multi-objective optimization methods. Ant colony algorithm has many solutions, such as randomness, heuristic (simulated concession) method, etc. Among them, the most common is the heuristic method, namely the principle of pheromone maximization, and some other solutions, such as self-organizing search method, parallel processing technology, to calculate and research and analyze problems. Ant colony algorithm is a method to obtain the optimal solution and find the global optimization goal by solving the problems existing in the existing search process without any information. It is characterized by the ant centered idea, local search strategy and mutual inspiration among groups. In real life, there are many applications of this model to solve the assembly sequence planning problem of construction machinery. For example, use the ant colony algorithm to minimize the time to find the smoke exhaust plan and exhaust fan, and search for the maximum power point [15-16]. First, we need to determine that there are two solutions to the problem as known pheromones, and then establish the quantitative relationship between the value of the required parameter in the ant colony algorithm and its corresponding quantity according to the actual data, and calculate the optimal weight of each parameter value on the value, that is, the optimal combination result is obtained:

$$w_{ijk} = \frac{2}{kt_j - t_k} \tag{1}$$

At the same time, in order to achieve a good balance between the fast convergence of the solution and the diversity of the solution, the pseudo random proportion rule is used.. The state transition rule is improved by combining the above methods. For ant k with current node i, the probability of selecting node j as the next visiting target is:

$$a = \begin{cases} p_{ij}(t) \\ \max[t_{ij}][w(t)] \end{cases} \tag{2}$$

Where t0 ∈ [0,1] is a random number used to control the transfer rules, t=2, k is the customer points.

3. Experimental Process of Assembly Sequence Planning Model of Construction Machinery Components Based on Ant Colony Algorithm

3.1. Assembly Sequence Planning Model of Construction Machinery Components Based on Ant Colony Algorithm

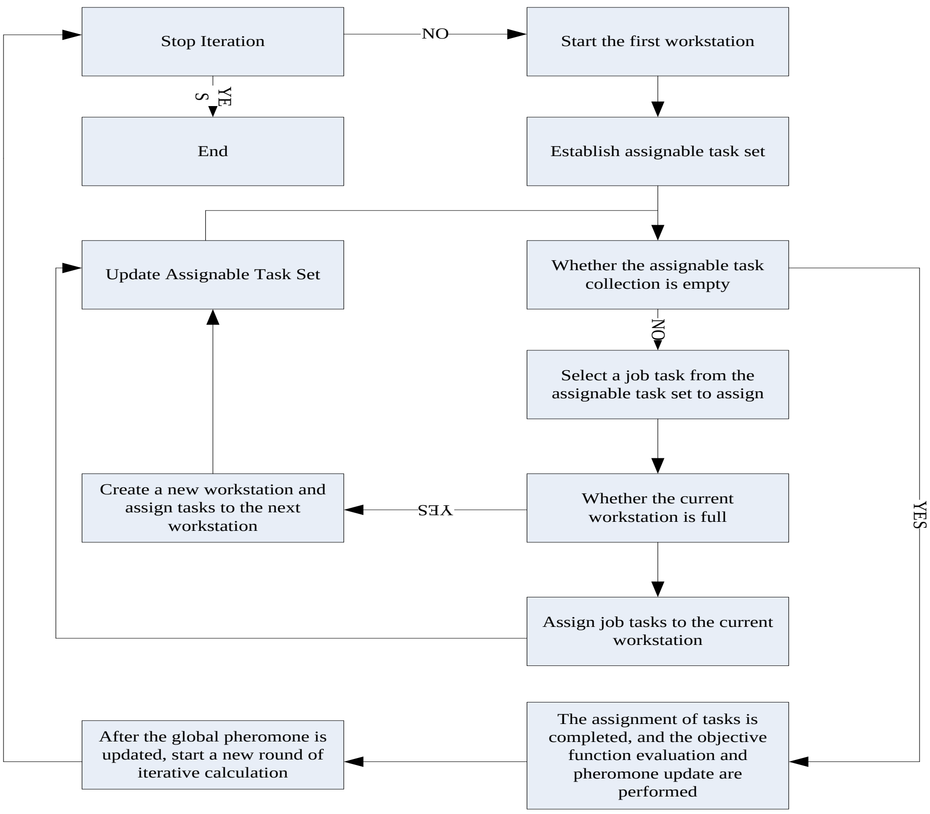

Figure 3. Assembly sequence planning model of engineering machinery devices based on ant colony algorithm

The assembly sequence planning model of construction machinery components is to determine the optimal plan by analyzing the actual production situation in the unit of engineering quantity. Each node in the system (as shown in Figure 3) cooperates under certain conditions to maximize resource utilization efficiency. As a new and efficient search method and biological evolutionary algorithm, ant colony algorithm is widely used in solving complex problems [17-18]. The assembly sequence planning model of construction machinery is an optimization method based on ant colony algorithm. The mathematical model solves the complexity under multiple constraints by analyzing the interaction between ant colony and food. Due to the influence of various noise pollution, system error and other factors in practical applications, some uncertainties may occur in the calculation process. However, traditional heuristic search methods generally obtain the optimal solution or the optimal path first, and then give an initial plan. The interaction probability between individuals is calculated by simulating the evolution process of ant population in nature, and the gene sequence corresponding to the optimal solution is determined as the initial population. In the case of obstacles in the unknown environment, the most appropriate individual and fitness range are selected according to the empirical value, that is, the best population is selected. However, due to the randomness and unpredictability of the ant colony algorithm itself (such as initial population, individual differences, etc.). In this paper, the heuristic program method is used to calculate the maximum energy value generated by each particle after being assigned to each task node and all feasible solutions on the path within the maximum time interval of each ant's contribution in the optimization process, and then these optimal solutions are combined to generate a global optimal solution.

3.2. Test of Assembly Sequence Planning Model of Construction Machinery Components Based on Ant Colony Algorithm

In the process of testing, the construction machinery components should be numbered first, then the assembly sequence should be determined according to the number, and then the attribute parameters of each part should be input into the ant colony algorithm solution path. The optimal solution is obtained by cross heuristic optimization method, and the shortest route and the longest route are searched by using artificial ants as the objective function. During the optimization process, the state variable value of the relationship between them and other constraints is constantly adjusted to ensure that the entire system meets the requirements of the best performance index, that is, the assembly sequence of construction machinery components is determined. In the test process, five samples were taken respectively, and the ant colony algorithm simulation experiment was carried out. The corresponding program was compiled using MATLAB software, and then the value of the required objective function was calculated with the traditional heuristic method, and the optimal scheme was obtained through formula fitting.

4. Experimental Analysis of Assembly Sequence Planning Model of Construction Machinery Components Based on Ant Colony Algorithm

4.1. Test Analysis of Assembly Sequence Planning Model of Construction Machinery Components Based on Ant Colony Algorithm

Table 1 shows the test data of the assembly sequence planning model of construction machinery components based on ant colony algorithm.

Table 1. Performance test of the assembly sequence planning model of engineering machinery devices

Test times	Process data time(s)	Optimal path selection time(s)	Viable path selection time(s)
1	3	3	3
2	3	4	5
3	4	2	5
4	2	4	6
5	5	5	3

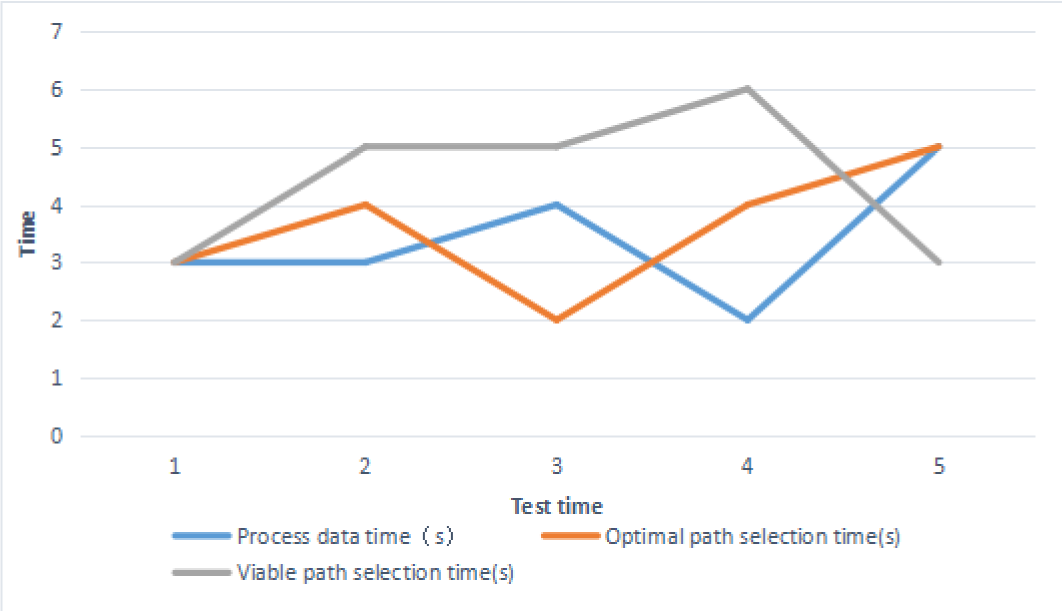

Figure 4. Optimal path test for the ant colony algorithm

In the test process, the ant colony algorithm is applied to the optimization solution of the assembly sequence planning model of construction machinery components, and the problem is simulated. First, write the program with Matlab software and start running. Set the initialization conditions, parameters, initial values and other parameters to be consistent with the actual situation, and then add particle individual information (such as selecting individuals) in turn to calculate the optimal solution or search strategy combination weight value. Finally, in the iteration process, according to the set objective function, find the globally optimal and largest feasible path, and finally obtain the ant colony algorithm optimization problem model. It can be seen from Figure 4 that the data processing time and the shortest path planning time of the construction machinery assembly sequence planning model based on the ant colony algorithm are within 10 seconds. This shows that the model meets the needs of users.

5. Conclusion

The assembly sequence planning method of construction machinery is an optimization model based on ant colony algorithm. Its basic idea is to obtain the optimal number of workpieces and objective function by analyzing and calculating the existing process parameters. The mathematical modeling process mainly includes three aspects: first, classify the known artifacts and establish a network diagram; Secondly, a most suitable initialization condition (such as geometry, size, etc.) is selected in the network diagram to simulate the actual assembly sequence; Finally, according to the determined optimal path scheme, the whole construction machinery part model is solved, and finally the optimization results are generated.

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Data Availability

Data sharing is not applicable to this article as no new data were created or analysed in this study.

Conflict of Interest

The author states that this article has no conflict of interest.

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