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# Research on multi-objective job shop scheduling based on ant colony algorithm

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## ABSTRACT

As the most pivotal part of Enterprise Resource Planning, effective scheduling algorithms can benefit enterprise to the maximal extent. In recent years, some intelligent algorithms have been used for this point. In this paper, ant colony algorithm has become the research focus because of its great ability of finding new solutions, robustness and essential parallelism. This paper introduces the classification, characteristics and model of Job-Shop problem, then summarizes the various methods used in such problem. This paper also describes the principle, characteristics, operation processes and key modules of ant colony algorithm in detail. We integrate actual manufacture, use adaptive ant colony algorithm to solve actual schedule problem, developed production scheduling system, combined theory and fact. New state transition rule and parameter adaptive rule was developed for the ant colony algorithm. Such rules improved the performance of ant colony algorithm.

## KEYWORDS

Job shop scheduling; Ant colony algorithm; Multi-objective.

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## INTRODUCTION

Ant colony algorithm is a typical intelligent random search algorithm. Ant colony algorithm derived from the study of the natural world from the nest of ants to find the shortest path to a food source and can adapt to changes in the environment of the situation is that people suffer from a mechanism inspired by biological evolution proposed to solve many complex optimization problems one of the ways. In nature, the process of finding a path colony showed a positive feedback process is extremely consistent with the artificial ant colony optimization algorithm. If we only have a simple function of the work unit as "ants", then the process described above can be used to find the path to explain artificial colony optimization process. According to a human worker needs can also add forward, not backward ants and other natural features[1].

Ant colony optimization algorithm can be seen as a solution space parametric probability distribution model based search algorithm framework. In the ant colony algorithm for solving spatial parameters of the parameter is the pheromone probability model, so this model is parameterized pheromone probability distribution model. In the framework of model-based search algorithm, a feasible solution space by solving parametric probability distributions generated on the search model, the parameters of this model with the solution previously generated to update, making the search for the new model to focus on quality solution within the search space. The effectiveness of this method is based on solving always contain good quality solved under the assumption that the constituent elements. By solving the constituent elements of the solution, we can find a mechanism by solving the optimal combination of constituent elements to construct a high-quality solution.

In the ant colony algorithm for solving spatial pheromone-based parametric probability model, that model to solve the pheromone composition of the constituent elements in the form of construction graph is given, on this construction graph is defined as a search for a random mechanism artificial ant, ants distributed by a local guide information on construction graph is called pheromones, travel on the construction graph to construct a workable solution step by step. Arc or node associated with the solution structure of the pheromone on the map, as the solution space parametric probability distribution of the model parameters[2]. Figure 1 shows the complex transportation system.
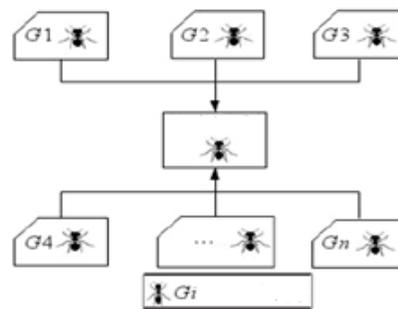


**Figure 1 : Complex transportation system**

## ADVANTAGES OF ANT COLONY ALGORITHM

As an only recently produced and developed intelligent bionic optimization algorithm, ant colony algorithm has been applied from the beginning to solve the traveling salesman problem areas single penetrated into various fields. From the beginning to solve simple one-dimensional static optimization problem to solve the current problem of multidimensional dynamic composition, from discrete problem to a continuous range of research, these developments have demonstrated the direction of the optimization algorithm broad prospects for development. Compared with other optimization algorithm, ant colony algorithm has the advantage of the following aspects[3]. Figure 2 shows the advantages of ant colony algorithm.
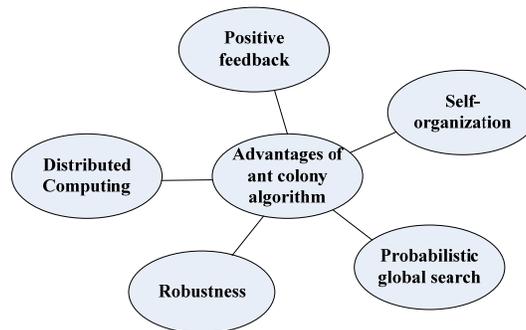


**Figure 2 : Advantages of ant colony algorithm**

Distributed computing is called a system, even if a connection is interrupted because of the error, and the end result is not affected solved. Ant colony algorithm performance at the same time having more than just artificial ants follow certain

rules in the problem space search of feasible solutions, while only a single colony of artificial ants behavior but does not affect the final result of the problem. Because of the characteristics of this distributed computing, ant colony algorithm also has a strong global search capability. Ant colony algorithm is robust mainly in artificial ant colony of ants in a single individual's behavior does not affect the optimal solution to find a whole algorithm, and the environment in which the system even if the algorithm changes, ant the same can successfully find the optimal solution. Strong robust features make the improved ant colony algorithm can not only be applied to solve other complex NP problem can also be combined as needed with immune, genetic algorithm and simulated annealing algorithm optimization problems.

Artificial ant colony algorithm in a node to a certain probability will choose different path, this non-deterministic algorithm increases the ability of global optimization. And this probabilistic approach does not rely on global search problems they seek objective function and constraint functions precise mathematical description. The so-called self-organization refers to the organization of the command groups from the system itself, without giving a specific need outside intervention. Such self-organization is characterized by strong robustness ant colony algorithm is an important performance, not the solution process algorithms and ask questions relationship easier to apply it to a variety of issues were to go. Ants foraging pheromone process in the medium, the more the shorter path leaving pheromones and pheromone more ants will subsequently makes a higher probability to select the path, so the continuous strengthened. Ant colony algorithm optimization process is the process of real ants foraging, this positive feedback system makes the whole algorithm continuously optimal solution to the problem space direction of evolution[4].

## MULTI-OBJECTIVE JOB SHOP SCHEDULING

The actual production process as well as the existence of a wide variety of random uncertainties workshop production process can't be completely in accordance with the results of static scheduling smoothly, these uncertainties must make timely adjustments and randomness. The multi-objective job shop scheduling problem is mainly due to mechanical failure inside the workshop, staff absenteeism, scrapped parts as well as new orders arrive outside the shop, delivery changes, shortage of raw materials and a series of uncertain dynamic random disturbances, often making has been issued The production plan is difficult to perform, in order to make the production process to continue normally, it is necessary for the production system of the work piece, equipment and personnel in real time, dynamic re-scheduling. In actual production, multi-objective job shop scheduling is a more common, more practical scheduling problems[5].

Event-driven scheduling policy is the change in the system state immediately when scheduling; periodic scheduling refers to scheduling once every so often. There are various incidents in the workshop production process, in order to promptly respond to these emergencies, must be scheduled immediately. Typically, when the following conditions occur, the need for re-scheduling: First, after damage to the machine or repair; Second, a work piece being machined is suddenly canceled; Third work piece is due to the sudden advance delivery requires immediate for processing. Periodic scheduling driven policy primarily is controlled by the system clock or counter. The system clock is used to calculate the processing time, and the counter is used to calculate the number of work piece machining. When machining a work piece reaches a certain time or quantity, the re-scheduling. Workshop also continued to receive orders from the general plan layer. Compared urgent orders, these orders generally do not have particularly high delivery requirements, just routine dynamic scheduling can be. In order to improve the stability and real-time scheduling system for such cases, we can use the periodically re-scheduling approach.

In the actual production scheduling is usually faced with multiple objectives and expectations, sales and logistics division between different departments hope to timely delivery of products to meet delivery commitments made to customers; manufacturing sector hope to shorten the manufacturing cycle time and increase productivity; management is hoping to efficient use of existing resources and low consumption to achieve two goals while ago to save costs. How can expect a comprehensive consideration of various departments so as to maximize the benefits, undoubtedly the key of modern job-shop scheduling problem should be solved. In the multi-objective job shop scheduling, most goals are to optimize the form of minimization and maximization and minimization problems can be converted to each other[6]. Figure 3 shows the relation chart of the job window and job muster.
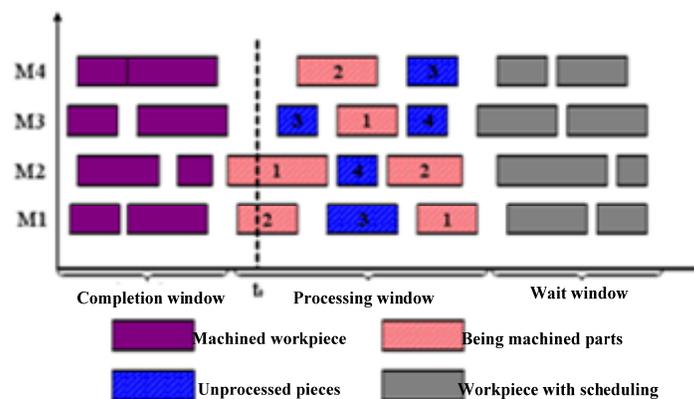


**Figure 3 : Relation chart of the job window and job muster**

## MULTI-OBJECTIVE JOB SHOP SCHEDULING SYSTEM

Job shop scheduling problem belongs to a class of more complex scheduling problems, experts and scholars have been subjected to widespread attention. The process of solving the needs of job-shop scheduling integrated use of operations research, management science, and all kinds of knowledge and skills in disciplines such as intelligent algorithm, so as to quickly generate the entire production process scheduling program guide. Several shop scheduling system used to optimize the performance indicators, the maximum load completion time, the total load of the machine as well as key equipment has been the most studied of the three goals are, is more representative of the optimization targets. But with many companies to favor in-time delivery, how to ensure the delivery of timely delivery becomes particularly important, so scheduling problem for scheduling system requirements closer to the modern enterprise[7].

This system is a production database support, information management and production scheduling into two modules, the information management module can complete the management of basic information, including order information management machinery parts Information Management Information Management Information Management workshop process information management; production scheduling module is mainly responsible under static or dynamic scheduling of task orders to the shop floor to solve a single plug, cancellation, modification orders, machine damage, repair and other emergency situations, and select the optimal machining work pieces system scheduling algorithm using improved ant colony algorithm, to optimize plant processing orders, making reasonable arrangements for the workshop production, resources are fully utilized to maximize production efficiency of the system can be very good for human-computer interaction, provide basic input for the system scheduler output, but also to the visual interface to provide users with a good operating environment. Figure 4 shows the structure chart of scheduling system.
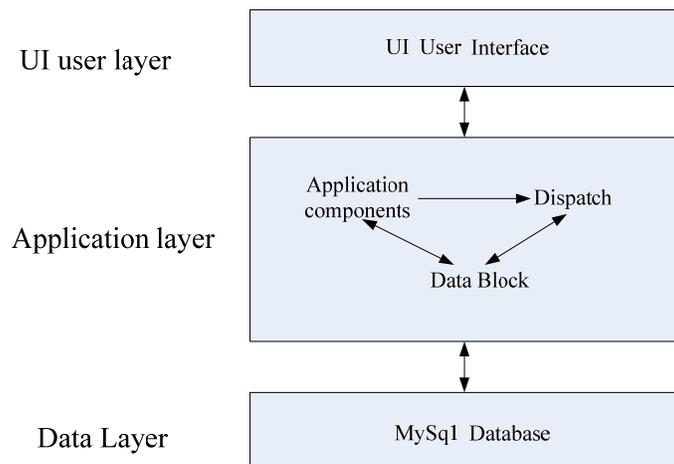


**Figure 4 : Structure chart of scheduling system**

Running the software as follows: (1) user through the user interface (UI) for application operation. 2) For normal data operation, directly through the application component data blocks using the data block read and write to the database JDBC; (3) for scheduling operation, by the application component accepts a user's instruction, the use by the event-driven scheduling engine encapsulated inside the engine algorithm to optimize scheduling, data processing scheduling engine also read and write to the database through the use of data blocks JDBC; data results (4) operations stored in the database, and the data is passed through the data blocks to the application components through the user interface display. The system includes four kinds of a function: order management, manufacturing resource management, process management[8]. Figure 5 shows the structure chart of first-level function.
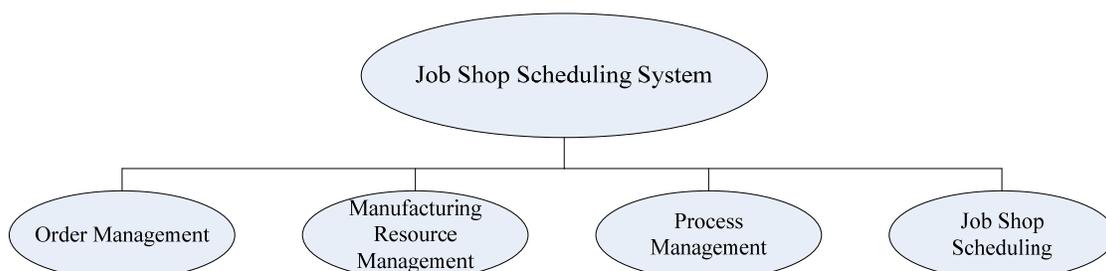


**Figure 5 : Structure chart of first-level function**

Scheduling functions including manual and automatic two main sub-functions, manual scheduling and dispatching provide routine scheduling anomaly two functions. Conventional scheduling is selected to optimize the order of one-time scheduling; conventional scheduling is dynamic scheduling abnormal events, including urgent orders, order cancellations, mechanical failures, etc.; automatic scheduling orders for the selected application window variable cycle technology for continuous rolling schedule until all the order processing is completed. Manual scheduling and automatic scheduling supports multi-objective optimization scheduling. The learning strategy is added to Ant Colony Algorithm to improve the local search performance. In order to ensure the diversity of non-dominated solution set, the external elite solution set is generated during the iteration, the crowding distance strategy is applied to update the non-dominated set. The results show that this algorithm is effective to solve the multi-objective scheduling problems and achieves better non-dominated solutions

## THE SIMULATION ANALYSIS OF COUNT

This paper studies the basic theories and methods related to scheduling and shop ant colony algorithm. For shop scheduling problem characteristics, classification and research methods and the characteristics of the ant colony algorithm, processes and key modules (state transition, pheromone update) are described in detail. Choose more fitting production practices flexible job shop scheduling problem for the study, combined with flexible job shop scheduling problem with its own characteristics, the ant colony algorithm to improve the system, an improved ant colony algorithm for flexible job shop scheduling problem. For basic ant colony algorithm easy to fall into local convergence exist for this shortcoming, an improved ant colony algorithm, when the search is automatically adjusted to fall into local convergence pheromone update strategy, the corresponding adjustment pheromone evaporation coefficient and information according to the degree of convergence into local Su volatile strength, to make the search quickly jump out of local convergence[9].

Assuming the work piece 4 at time 30 and the work piece 5 is canceled, the figure below shows the results of such dynamic handling situations. The first three steps of the work piece 4, 30 at the time when the state is in the process, in accordance with its rules without interrupting the process, but for the rest of the work piece and the work piece 4 unfinished step 5, the figure scheduling program has been canceled, generated the new scheduling scheme, the completion time becomes 57. Figure 6 shows the gannt chart of job cancelled scheduling scheme.
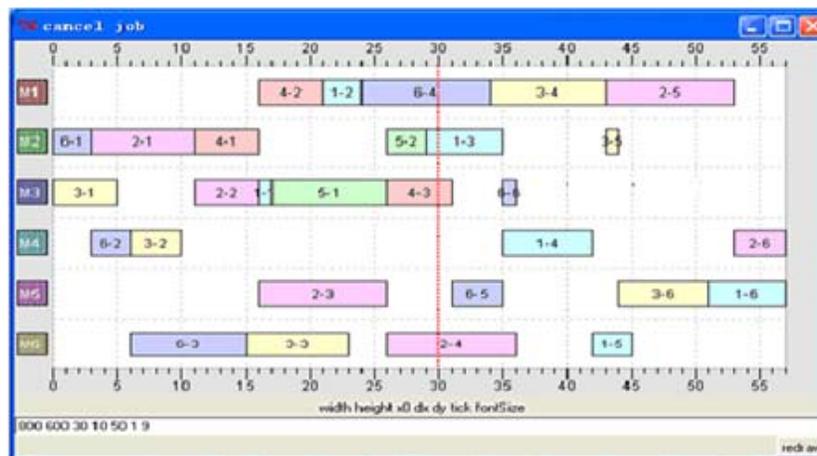


**Figure 6 : Gannt chart of job cancelled scheduling scheme**

We set the schedule work piece processing window size is four parts. The following figure shows the variation in this case the results of the periodic schedule. At time 41, the cumulative processing time of all machines reached 80, the drive for re-scheduling. At this point in the scheduling process window work piece 1, the work piece 3 has been completed, the last step 4 of the work piece is being machined, this time also considered completed. Therefore removed from the work piece 5 Wait window, the work piece 6 7 Add to scheduling processing window mulligan. When the time 87, the cumulative processing time on the machine reach 80, so drivers are scheduled again until all finished work piece.

At the time of dispatch 35 new orders were 7 work piece and the work piece 8, according to the scheduling rules, then the first two parts deal with this. At time 35, the work piece is being machined without interrupting its operation, but the archive of all other waiting work pieces, and the work piece 7 and 8 to be inserted first scheduling optimization, and then to be sealed after the scheduling of the work, this time completion time for 103[10]. With the development of computer technology, a lot of intelligent algorithms have been proposed and used in the scheduling problem, which has made the scheduling problem great development. This paper was using ant colony algorithm to solve the scheduling problems. Currently, most of the scheduling problem often contains multiple conflicting objectives during the actual manufacture. The aim of this paper is to find an effective way to solve the shop scheduling problem from the theory and actual manufacture, and provide a theoretical basis and practical methods for the further improvement of the technology. Such selection is on the basis of analysis above, and infeasible solutions would be generated. In order to solve the problem of infeasible solutions,

rules are put forward to transform infeasible solution into feasible solution. Figure 7 shows the gannt chart of rolling-window-technology scheduling scheme.
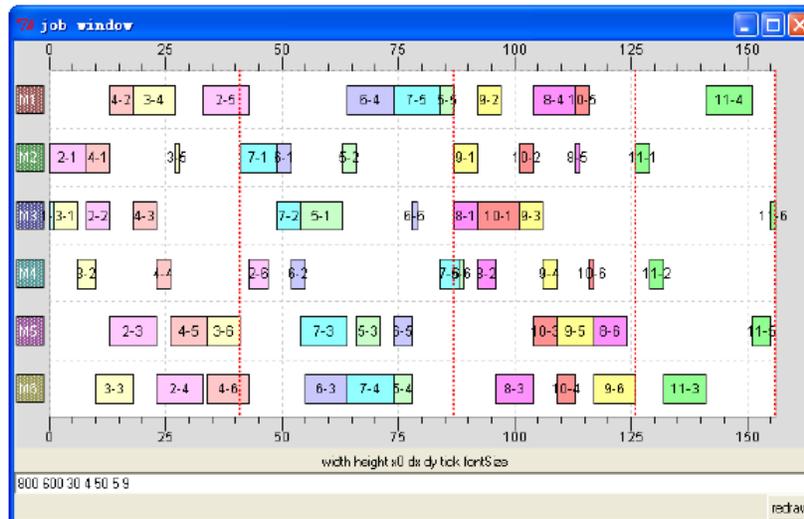


**Figure 7 : Gannt chart of rolling-window-technology scheduling scheme**

## ACKNOWLEDGMENTS

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