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Firefly Algorithm on Multi-Objective Optimization of Production Scheduling System

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Abstract –In the business of manufacturing process, production scheduling problems act as a very strong foundation, meanwhile they are the most important, most difficult and complex issues. In the actual social production process, we consider several different scheduling objectives for almost all or most of the situations ,rather than single scheduling objective which is rarely encountered. This is so-called multi-objective scheduling problem. This article paper is in this context, based on inspired by Xin-She Yang's work in 2008 and proposed a novel algorithm is proposed to solve the production scheduling firefly such complex combinatorial optimization problems.

Keywords –Firefly algorithm, Multi-objective optimization, Scheduling System

1. Introduction

Multi-objective optimization scheduling problem is a theory and practice of production scheduling hot research topic, also is the actual manufacturing work which is urgent need to address the problem.

Various aspects of the different areas in our daily lives are actually a load system design, modeling and planning, common transport, for example, the capital budget, the city layout, and industrial manufacturing and the allocation of resources what will be involved in this article, the solving of these problems is no longer a single goal can meet the demand, usually requires a lot of different indicators together, considering, according to actual needs, and some of the strategies, or some limited constraints this is the so-called multi-objective optimization problem (MOP) to a relatively optimal solution.

Historically, the multi-objective optimization problems is the earliest by Franklin put it in 1772, multi-objective contradiction between the problem of how to coordinate. The French economist Pareto internationally recognized multi-objective optimization problem in 1896, when he was starting from the perspective of the professional political economy, the target of many general bad comparison, organize and grouped into a multi-objective optimization problem. Later in World War II in 1944, von Neumann and Morgenstern introduced knowledge of game theory in multi-objective decision making about conflicting policy makers. Also in the same year, based on mathematical programming point of view, Kuhn and Tucker specializes Research on Vector Extremum problems, and eventually combined with research theories and concepts of Pareto-optimal solution, and further study the Pareto-mostsufficient conditions and necessary conditions of the optimal solution.

Although from Pareto formally put forward this problem to Johnsen system summary, multi-objective optimization problem up and down have experienced sixty or seventy years, at present as people of the 21st century, information to growth, the geometry of the knowledge explosion, the multi-objective optimization problem is it may be said is in the period of prosperity, and from the last century 70 s it has formally as a branch of mathematics is the scholars all over the world to study the system The representative is in 1975 by Zeleny published a memoir, detailed expounds the multi-objective optimization problem. Up to now, the multi-objective optimization not only has a lot of important achievements in theory, but also in the application fields of the also more and more shows its strong vitality.

The multi-objective optimization can be simply summed up as the following methods: classical multi-objective optimization method (weighting method, constraint method, target programming and minimax method [3] is common classical methods), based on evolutionary algorithm based on multi-objective optimization algorithm, particle swarm multiple objective optimization algorithm, based on collaborative evolutionary multi-objective optimization method, based on particle swarm multiple objective optimization method, based on collaborative evolutionary multi-objective optimization method, based on artificial immune system based on multi-objective optimization method and the distribution of the estimated multi-objective optimization method, etc.

This paper tries to research demonstrates that the Firefly Algorithm (FA) is the latest a yuan heuristic intelligent swarm optimization algorithm., it is Getting from biology background, by the Firefly luminescence behavior inspiration, , from biology knowledge we know, fireflies glow the main purpose of fireflies to glow is to play a kind of signal system to attract other fireflies. Xin - She Yang [4] in 2008 invented introduced this algorithm, the use of this algorithm is less application applicable, especially on the research of the algorithm in the application of production scheduling is even less. Therefore this paper is to introduce this algorithm to multi-objective production scheduling field, and a specific application research area, so as to in order to find a better solution method of production scheduling problem.

2. Fireflies algorithm profile

In order to research the firefly algorithm, we put the fireflies glow behavior idealized, and abstracted. First using the following three ideal hypothesis rules:

All the firefly is not distinguish between sex, so that each fireflies can all be attracted by other fireflies.

Attraction is luminosity in certain proportion to luminosity, meaning that luminous weak fireflies are attracted by luminous strong firefly, and to the mobile. Attraction is proportional to luminous intensity, and with the increase of distance, it’s reducing. If in a firefly around there's no fireflies' attraction is more than it , that the fireflies will do free flight.

The luminous intensity of fireflies depends on the environment of the objective function. For example, in maximization problem, luminosity can simple directly with the objective function value composition proportion. For other situation, luminosity can be defined into similar genetic algorithm of adaptive value function.

Based on the above three rule, firefly algorithm of the basic steps can use the following pseudo code said out.

Define the objective function f(X), among them $X=(x_1,\cdots,x_d)^T$

Random generation of fireflies initial position X_i (i=1, 2, ⋯, n)

Define light intensity calculation formula, such as for maximization problem can be defined as $I_i \propto f(X_i)$, or simple use $I_i=f(X_i)$

Definition absorption parameters

Iterative

WHILE the current algebra (t < maximum iterating times)

FOR I = 1: n (cycle variable population of all fireflies)

FOR j = 1: n (cycle variable population of all fireflies)

IF $(I_j>I_i)$

If the light intensity of the firefly i fly to light intensity strong firefly j

End if

According to the distance r use $e^{(-\gamma r^2)}$formula update attract degree

Evaluate new results, and updates the light intensity

END FOR j

END FOR I

For all the firefly to sort and find out the best fireflies

END WHILE

Deal with the final result, and graphical display.

In a certain sense, the firefly Algorithm and bacteria Foraging Algorithm (BFA) have many similar concepts. In BFA , bacteria mutual attract is partially based on fitness, in part based on the relative distance between them, firefly algorithm is also similar, in addition to the objective function and the outside, but also the distance of the monotone decreasing function. However, as the instance of firefly algorithms having adjustable visibility and diverse attractive, these factors make the individual having the higher mobility of the firefly algorithm, therefore, in the search space is also more efficient.

3. Multi-objective optimization problem described

The multi-objective optimization problem can usually adopt type mathematical language to describe:

$$\min f(x)= (f_1(x),\cdots,f_N(x)),x\in X \tag{2-1}$$

Among them, f_1, ⋯, $f_N$for N objective function, x said decision variable, X said solution space.

Consider the following two solution x_1 and x_2, if they meet the following two conditions:

$$\begin{cases}\forall j\in\{1,2,\cdots,N\}, f_j(x_1)\le f_j(x_2)\\ \exists k\in\{1,2,\cdots,N\}, f_k(x_1)<f_k(x_2)\end{cases} \tag{2-2}$$

Are we can call solutionx_1 control solutionx_2, denoted $x_1 \succ x_2$.

If given a solution x^*, in the solution space X can't find out any solution x^* can dominate, the solution x^* is called for Pareto optimal solution, or call not dominate the solution, or is anon-dominated solution. By all the solution space within the non control solution set of composition is the sense of multi-objective optimal solution set, and the optimal solution concentration of solution in target space constitute the multi-objective problem of Pareto Front [5].

If the two goals, for example, Figure 2.1 depicts dominated solutions and non-dominated solutions in the distribution of the target space.

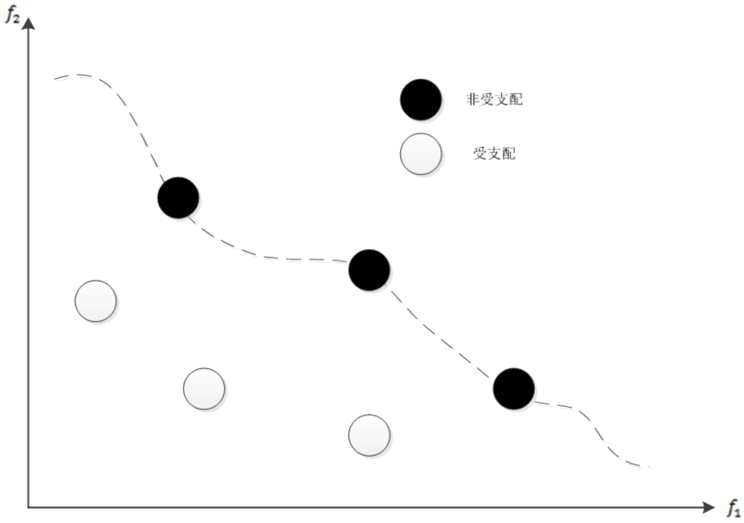


Figure 2.1 ominated solutions with non-dominated solutions.

How to evaluate multi-objective problems in a solution quality, it will directly affect the optimization algorithm search direction and its search process. Usually used three evaluation way [6] are as follows:

(1) target integration: simplely speaking it's integrate multiple targets to a comprehensive abstract goal up by some reasonable and effective mechanism integration, thus achieve that the multi-objective optimization problem is transformed into single objective optimization problem. The most common should be weighted method, it is separately for every one goal according to the importance of target respectively, and gives the corresponding a permission value, and then multiple targets integration into a single objective problem, thus using the single objective optimization method to solve the problem.

(2) sequential optimization: according to some sort rules, in order to multiple targets, and then again to them in turn optimization, in every optimization is only considered in dealing with a optimization goal, at the same time, it has been optimized target put some constraint, the purpose is to avoid the performance decline.

(3) based on the Pareto dominant evaluation: in evaluating the quality of solution, using the concept of Pareto domination, with their advantages and disadvantages between the relationship to decide the search process.

In reality, the multi-objective optimization between the various objectives of the problem, there are varying degrees of conflict and constraints often encounter improvement on a target at the same time lead to the deterioration of another goal. Actual production activities in the vast majority of cases, multi-objective optimization problem doesn't exist what can make all goals are the best solution. Therefore, the goal of multi-objective optimization algorithm is not to seek a global optimal solution, it should be effectively search the solution set of multiple non-inferior solutions, and these solutions should have a better proximity and diversity. Among them, the proximity refers to these non-inferior solution as far as possible near the boundary of first theoretical optimal Pareto, the closer the better; Diversity is refers to the income non-inferior solution to hash in Pareto boundary, the bigger the homogeneous dispersion, the better.

4. Multi-objective firefly algorithm (MOFA)

This article learn MOPSO algorithm to solve the problem of multi-objective thinking, and its application to the firefly algorithm multi-objective problem solving.

Algorithm based on the external file NP to realize Pareto of multi-objective optimization problem. Below is a basic steps of the algorithm.

The population initialization parameters and fireflies position.

Initialize external file NP, and find out all the non-dominated solutions from the initial position of the fireflies filled to the NP.

Iteration of the loop

WHILE (current algebra t <maximum number of iterations)

FOR i = 1: n (the loop variable populations firefly)

FOR j = 1: n (loop variable populations fireflies)

The IF (Firefly j domination fireflies i)

Fireflies light intensity if i fly to the light intensity of firefly j

END IF

Based on the distance r calculated using the formula e ^ ((-γr ^ 2)) updated attract degrees

To evaluating new results and update the light intensity

END FOR j

END FOR i

To updated external file NP

END WHILE

Deal with the final results, the Pareto optimal set

The update of the external file NP using the MOPSO external file update strategy. Ie, the largest preset file (the maximum number of files to retain non-inferior solutions), in an iterative process, when the number of non-inferior solutions file reaches the specified value, external file must be maintained the size of the file, to ensure always does not exceed a fixed value in advance.

Non-inferior solutions for the generation, perform the following steps:

When external file size is less than the predetermined value, the external file is not filled, non-inferior solutions can be added directly into the external file.

External file size is greater than or equal to the specified value, that is, an external file has been filled, and the new solution can dominate some individuals in the external file, then it can be directly replaced, which means you can adopt new solutions to replace by those who file individual disposable; otherwise, it will be based on the size of the density values, individual out of the worst of a density value, while the new solution is added to the file.

5. MOFA apply in pipeline scheduling problem

In order to verify the validity of the MOFA algorithm used here the typical the FSSP problems do simulation experiment. In addition to the objective function to minimize make span obtained min (C_max) to add an objective function, the machine total vacancy rate that all the machines in the vacant time, the proportion of the total running time. Therefore, the mathematical model of the type of problems are as follows:

$$\min F(x) = (F_1(x), F_2(x)), x \in X$$
$$F_1(x) = \min(C_{max})$$
$$F_2(x) = \frac{\sum_{j=1}^{m}(m_{end,j} - m_{start,j}) - \sum_{i=1}^{n}\sum_{j=1}^{m} p_{ij}}{\sum_{j=1}^{m}(m_{end,j} - m_{start,j})}$$

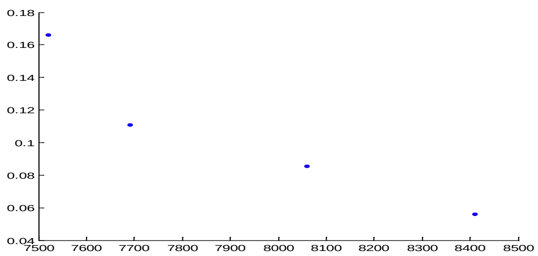
F_1 make span objective function, F_2machines vacancy rate target function, $m_{start,j}$is the boot time machine j start processing, $m_{end,j}$ is the machine j after the completion of the processing downtime, $p_{ij}$the job i on the machine j machining time.

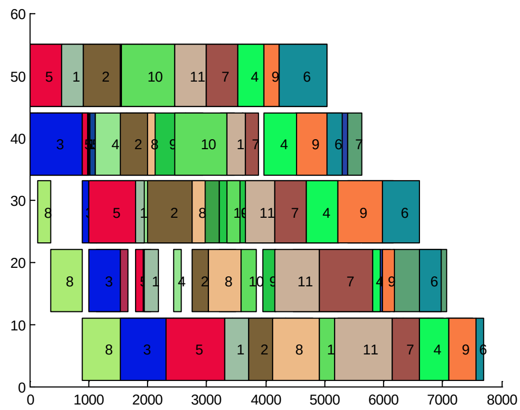
Follows Pareto optimal solution set for the famous Car1 problem solving

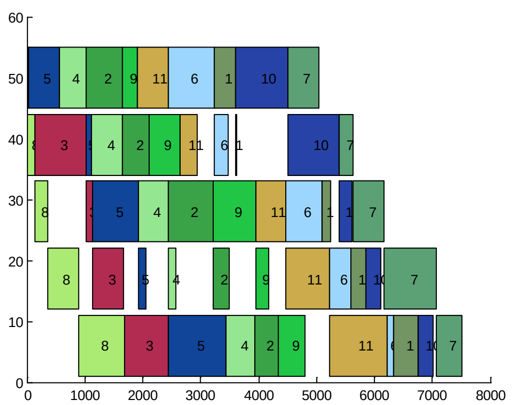
Table4 – 1 Car1 problems Pareto optimal solution set

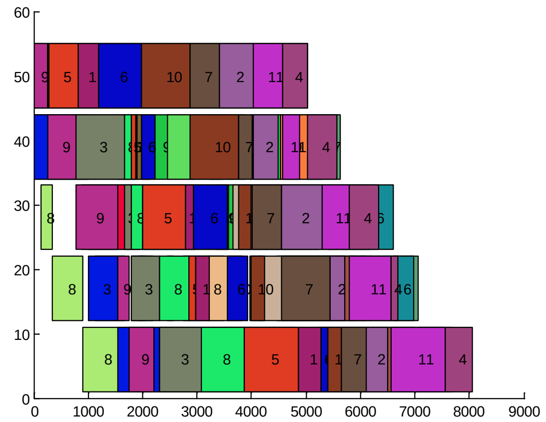
Pareto Optimal solution	F_1 (Makespan)	F_2 (Machine vacancy rate)	π^* (The scheduling Sort program)
1	7519	0.16639	8 3 5 4 2 9 11 6 1 10 7
2	7689	0.11098	3 5 1 2 8 10 11 7 4 9 6
3	8058	0.085444	9 3 8 5 1 6 10 7 2 11 4
4	8408	0.056123	2 8 5 3 4 7 10 6 1 11 9

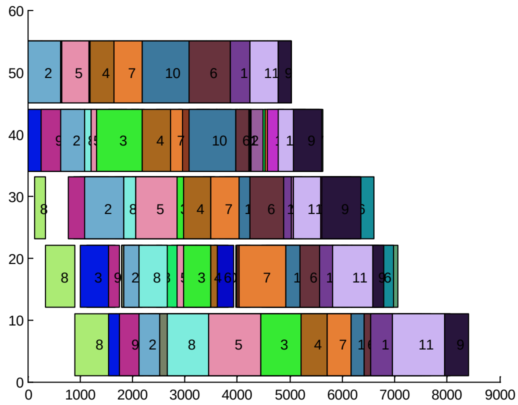
Corresponding the Pareto front end image is











Follows Pareto optimal solution set for the famous Car6 problem solving.

Pareto Optimal solution	F_1 (Makespan)	F_2 (Machine vacancy rate)	π^* (The scheduling Sort program)
1	8906	0.23367	6 8 1 5 7 4 3 2
2	9476	0.22494	7 8 3 1 5 6 2 4
3	9758	0.21894	6 7 2 5 8 4 3 1
4	10002	0.21589	7 4 6 5 8 2 3 1
5	10079	0.20295	7 6 2 5 8 3 4 1

6. Conclusions

In this paper, a new algorithm was proposed to solve the multi-objective optimization of production scheduling problems in the production practice, and as well as improve the performance of existing firefly algorithm performance improvements, and apply it to multi-objective problem solving to get better results., but the newer algorithm, the problem is relatively complex, so all aspects of the research work also requires further in-depth.

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