A Plant Growth Simulation Algorithm for Permutation Flow Shop Scheduling Problem

Zhenhong He[1,a] Yueguang Li [2,b]
[1]Gansu Normal University for Nationalities, Hezuo, gansu, 747000, China
[2]Gansu Normal University for Nationalities, Hezuo, gansu, 747000, China
[a]Yueguangli7@163.com, [b]Yueguangli7@sohu.com

Abstract

Permutation flow shop scheduling problem is a complicated global optimum problem. A number of intelligent algorithms have been used for this problem. In this paper, a plant growth simulation algorithm was used to solve permutation flow shop scheduling problem. The algorithm was experimented and the experimental results show that the Plant Growth Simulation Algorithm (PGSA)has better feasibility and validity for solving permutation flow shop scheduling problem.

Keywords: Plant Growth Simulation Algorithm(PGSA); Permutation flow shop scheduling problem; speed-up; heuristics

0. Introduction

The permutation flow shop scheduling problem has been widely studied in the recent decades. An flow shop system consists of m machines in a serial layout where a set of n jobs has to go through first machine one, then machine two, and so on until machine m. That is, all the jobs have identical routes. Each job requires an operation with uninterrupted processing time on each of the machines. Each job can be preceded at most one machine at the same time. The processing of a job on a machine cannot be interrupted. All jobs are independent and are available for processing at time 0; and etc. The aim is to find a sequence for processing all jobs on all machines so that the given criterion is minimized. Although the process constraint of the model is relatively simple, but it has proven more than 3 machine of permutation flow shop scheduling problem is NP problem[1].

Methods for permutation flow shop scheduling problem are traditional algorithms and evolutionary algorithms. The traditional methods mainly have enumeration method, branch and bound method, dynamic programming. The traditional method has high accuracy, but because permutation flow shop scheduling problem is a NP problem, they only suitable for small scale problems. Evolutionary algorithms such as simulated annealing algorithm [2], ant colony algorithm [3], PSO algorithm[4] etc.

1. Mathematical description of permutation flow shop scheduling problem

Permutation flow shop scheduling problem studies the flow process of n work pieces on m machines. If the scheduling objective is the maximum completion time, the case of Permutation flow shop scheduling problem mathematics is described as follows: n represents the number of jobs, m represents the machine number, *prmu* shows that all the workpiece after each machine processing consistency, C_{max} represents the maximum completion time of the work pieces, t_{ij} denotes the processing time of workpiece i on machine j, $C(j_i, k)$ represents the completion time of workpiece j_i on machine k, π represents a sort of all jobs, T is collection of all sort. Assume that the workpieces are processed according to machine 1 to m , then the completion time of n work pieces on m machines can be obtained by formula(1) to formula(5) .

$$c(j_1,1) = t_{j_1,i} \tag{1}$$

$$c(j_i,1) = c(j_{i-1},1) + t_{j_i,i} \quad i = 2....n \tag{2}$$

$$c(j_1,k) = c(j_1,k-1) + t_{j_1,k} \quad k = 2....m \tag{3}$$

$$c(j_i,k) = \max\{c(j_i,k-1), c(j_{i-1},k)\} + t_{j_i,k} \quad i = 2...n, k = 2....m$$

$$c_{\max}(\pi) = c(j_n, m) \tag{4}$$

$$\pi' = \arg\{c_{\max}(\pi) = c(j_n, m)\} \to \min, \forall \pi \in T \tag{5}$$

(6)

Which formula (5) is the maximum completion time, formula (6) represents the corresponding scheduling scheme of minimize the maximum completion time.

2. The plant growth simulation algorithm

Plant growth simulation algorithm(PGSA) is an evolutionary computation technique through simulating the growth processes in plants, which is based on the principles of plant phototropism growth [5]. The algorithm has a good prospect in the application due to requiring a simple on the parameters. It has gradually been applied in the field of engineering by many scholars [6].

Plants can be viewed as a system, which composes of a large number of branches and nodes. It must be as soon as possible to strive for breeding more branches and leaves for earning more surface areas, which can obtain the greatest possible sunlight. The form of grammar that simulates the plant description analysis and development had been established since linguistics was introduced into the biological, which based on a simple rewrite rules and branching rules, this is called L-system. Formal description of plant growth can be carried out as the following:

1. The section of the site grow new branches which first emerged in a number of stems is called the growth node.

2. Most of the new branches have grown updated branches, and the process repeated on the old and new branches.

3. Different branches in the tree have similarities with each other, and the entire plant has self-similar structure.

The Branching model of plant growth is improved according to L-system combined with computer graphics and fractal theory, the plant, as the form of plant growth characteristics, can be described as follow: Supposed branches of plant growth occurred in the two-dimensional plane, Each branch growing in units length every time, or rotating a certain angle α , Starting from the node of trunk or branches, The growth process were repeated through rewriting the rules of branches of plant growth in the two dimensional plane.

It was proved by biological experiments that a new branch that is able to grow depends on its morphactin concentration when the plant has more than one node. The node which has larger value of morpheme concentration has more growth opportunities than the smaller one, morphactin concentration are not pre-assigned to the nodes, but formed according to their location information which we call that plant showed the feature of plant's Phototropism. After the node has been formed, morphactin concentration will be readjusted according to changing in the environment of a new growth node else.

We could describe the characteristics of plant growth in term of the mathematical view basis on plant growth analysis of the above. Suppose the length of tree trunk is T, the length of branch is L, there are W growing nodes $S_T = (S_{T1}, S_{T2}, ..., S_{TW})$ in the trunk, morphactin concentration of those nodes is $P_T = (P_{T1}, P_{T2}, ..., P_{TW})$ respectively. There are q growth nodes $S_T = (S_{T1}, S_{T2}, ..., S_{Tq})$ in the branch. Morphactin concentration of those nodes is $P_T = (P_{T1}, P_{T2}, ..., Pq)$ respectively. The morphactin concentration which grown in the trunk and branch is calculated as follows:

$$P_{Ti} = \frac{f(x_0) - f(S_{Ti})}{\sum_i^W (f(x_0) - f(S_{Ti})) + \sum_j^q (f(x_0) - f(x_{Tq}))} \tag{7}$$

Where x_0 represents the root of plant (the initial node), $f(*)$ is the information function of the node in the environment, The smaller value of the function as possible shows the better environment where the node located, it will help to grow new branch.

From formula (7), the value of morphactin concentration in every node depends on relative position of the relative to the initial root and the location of the environmental information, the mechanism consistent with the formation of the morphactin concentration in the plant cell. We can deduced from formula (7) as follows:

$$\sum_{i=1}^{T}\sum_{j=1}^{q}\left(P_{Ti}+P_{Tj}\right)=1 \tag{8}$$

We can produce random number in the interval [0, 1]. The random number must fall within one of the state space $\left(P_1, P_2, ..., P_{T+q}\right)$, where the corresponding node will have a prior right to grow new branch. A simple example of morphactin concentration state space displays in the fig. 1.The value of morphactin concentration in all nodes will change after the new branch has grown up. Computation formula of the value of morphactin concentration in other nodes will add the relevant node on the new branch, and remove the grown node, which basis on formula (7). The process will be repeated until there is no new branches growing.

4. The analysis of simulation

Run environment of algorithm is *MATLAB (R2010b)* under *Win7* operating system. In order to investigate the feasibility and effectiveness of plant growth simulation algorithm(PGSA), This paper chose the Liao[9] benchmark problems tested, and compared with the other intelligent algorithms. The test results are shown in table 1.

Table 1 The test results of Car benchmark problems

problem	PSO			IA			PGSA		
	AVE	MIN	SD	AVE	MIN	SD	AVE	MIN	SD
J30C3e1	561.6	557	5.1	559.6	554	2.4	552.7	549	2.7
J30C3e2	720.0	701	4.4	716.3	701	3.2	700.7	697	2.7
J30C3e3	747.5	739	6.0	743.0	736	4.5	723.3	712	4.6
J30C3e4	702.2	696	7.5	697.5	688	5.9	685.3	674	5.9
J30C3e5	733.7	726	8.7	731.5	726	5.9	725.1	709	3.8
J30C3e6	737.1	730	3.6	730.7	718	3.1	718.1	708	8.8
J30C3e7	752.2	745	4.3	747.9	741	3.8	732.1	723	4.7
J30C3e8	836.7	802	10.4	826.4	790	9.5	786.8	771	6.7
J30C3e9	799.4	791	6.8	793.6	788	5.9	766.9	760	4.8
J30C3e10	748.9	740	3.2	738.1	712	9.3	718.5	710	8.7

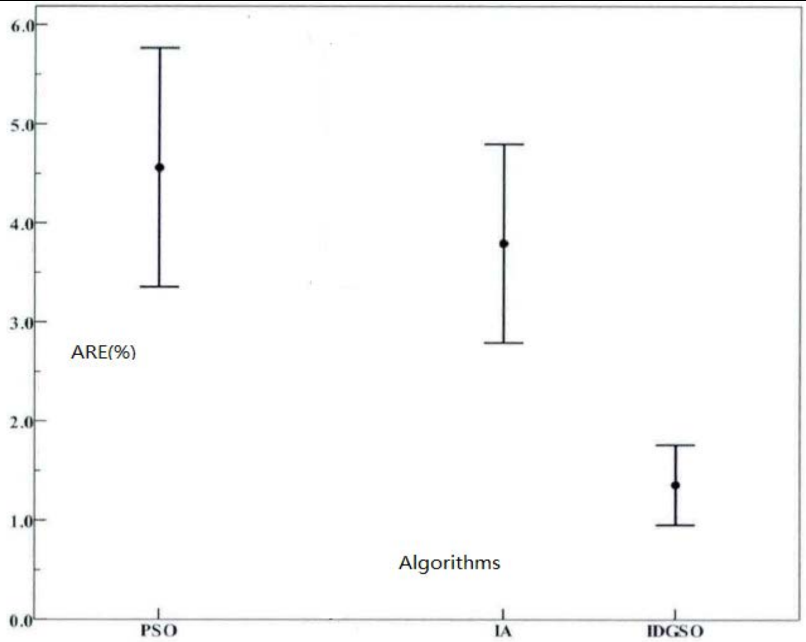

Fig1. Means plot of ARI for different algorithms

From the test data can be seen, for the selected Liao problems, the algorithm has good optimization performance in the field of combinatorial optimization, and it is an effective tool for solving the permutation flow shop scheduling problem.

5. Conclusions

This paper proposes an plant growth simulation algorithm(PGSA)，it is applied to solve the permutation flow shop scheduling problem, the performance has been improved obviously, and as the problem size increases, the improvement is more obvious.

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