An improved shuffled frog leaping algorithm and its application

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Abstract: In order to enhance the performance of shuffled frog leaping algorithm in solving optimization problem, this paper added the mutation operator to original shuffled frog leaping algorithm, an improved shuffled frog-leaping algorithm was proposed. Simulation results showed that the improved algorithm in the optimization accuracy, convergence speed and success rate had more improve.

1 Introduction

Shuffled frog leaping algorithm is proposed by Muzaffar Eusuff and Kevin Lansey on 2000 year, it is a swarm intelligence computation optimization algorithm [1]. It is used to solve discrete combinatorial optimization problem. As a new bionic intelligent optimization algorithm, it combined with memetic algorithms and particle swarm optimization algorithm, it has the advantages of two intelligence optimization algorithms. The features of the algorithm are concept simple, parameters is few, calculation speed is fast and global search ability is strong and easy to implement [2]. The main application of shuffled frog leaping algorithm is to solve multi objective optimization problems, such as water resources allocation, pier maintenance, workshop arranging flow engineering problem [3]. Domestic and foreign scholars have conducted a lot of research on it. Such as: Zhang joins "cognitive component" into the internal search strategy, improve the success rate of the algorithm for solving ability and jump out of local optimal solution; Zhao Pengjun joins the attraction repulsion mechanism into the internal search strategy, effectively avoid the algorithm premature convergence; Hatem E in the internal search strategy through the introduction of the "search accelerated factor", to improve the global searching ability of the algorithm.

Time-table Problem of Universities is a many factor of the global optimization problem, it is a NP- complete problem [4]. Since Time-table Problem of Universities involved in many information, the methods for Time-table Problem of Universities are the classical algorithm, structure algorithms and intelligent optimization algorithms. Among them, the classical algorithms, such as branch and bound method, dynamic programming method the exact solutions of problems can be obtained, but the classical algorithms are limited by the problem size and computing complexity, only suitable for solving small problems. Constructive algorithms, such as NEH method, Rajendran method, the methods can set up the problem of scheduling solution quickly, but the structure complex, and usually the solution quality is poor. Intelligent optimization algorithms, such as genetic algorithm [5], ant colony algorithm [6], particle swarm optimization algorithm, immune algorithmand a variety of hybrid algorithm etc. The intelligent algorithms have been paid more and more attention, they are used to solve combinatorial optimization and NP. In order to solve the above problems, this paper puts forward an improved Shuffled frog leaping algorithm to solve Time-table Problem of Universities.

2 The mathematical model of shuffled frog leaping algorithm

Shuffled frog leaping algorithm simulates the frog population when they are searching for food, according to ethnic classification of memes of information transfer. Shuffled frog leaping

algorithm mainly includes two parts: local search and global information exchange. The following is a brief introduction to the mathematical model of shuffled frog leaping algorithm.

A randomly generated F frog consists of initial population, each frog expresses a feasible solution of problem, $U = (U^1, U^2, ..., U^d)$, calculate the frog individual fitness $f(i)$, where d denotes the dimension of the solution space. After the random generation of initial population, the individuals frog according to the fitness $f(i)$ in descending order is stored in the $X = \{U(i), f(i), i = 1, ..., F\}$, then according to the specific principle to divide the whole frog population into m groups $Y^1, Y^2, ..., Y^m$, each group contains the n frogs, satisfy the following relations:

$$Y^K = \left[U(i)^k, f(i)^k, \left| U(i)^k = U(k + m(i-1)), f(i)^k = f(k + m(i-1)), i = 1, ..., n \right] k = 1, ..., m; F = mn \quad (1)$$

In the frog population, the aim of various group perform local search strategy is to search the local optima in the different search direction, after a certain number of iterations, making the local optimal individuals in the population tends to the global optimal individual.

First of all, the frog population is divided into a plurality of groups, local search is carried out for each ethnic group, in order to avoid the frog individual into a local optimum prematurely, while speeding up the convergence process, in each group, according to specific principles choose a certain number frogs constitute the ethnic sub family group. For the frog population, with global best fitness of the solution is expressed as U^g; for each sub groups, with the best fitness of the solution is expressed as UB, the worst fitness solutions expressed as UW. The local search is carried out for each sub population, update strategy as following:

$$S = \begin{cases} \min\{[rand(U_B - U_W)], S_{max}\}, & U_B - U_W \geq 0 \\ \max\{rand(U_B - U_W), S_{max}\}, & U_B - U_W < 0 \end{cases} \quad (2)$$

$$U_q = U_W + S \quad (3)$$

Among them, S expresses the adjustment vector of frog individual, S_{mac} represents the maximum step size of the frog allows to change.

Global information exchange helpful to collect local information of all kinds of group search, by meme transmission, obtain the search direction of new global optimal solution. After all populations conduct a certain number of local searches, various groups of frogs are mixed together, according to the fitness of $f(i)$ in descending order, the re division of population, which makes the meme information of the frog individual obtain the full transfer, then continue to conduct local search, so repeatedly until it is convergent, the algorithm stop.

3 Improvement shuffled frog leaping algorithm

This paper introduces the adjustment factor and the adjust order thought, at the same time, a mutation operation is added to the global information exchange process, so as to put forward an improved shuffled frog leaping algorithm for solving Time-table Problem of Universities.

2.1 Adjustment factor and adjustment of sequence

The solutions of d for $U = (U^i)$ $i = 1, 2, ..., d$, define the adjustment factor is $TO(i_1, i_2)$, before the U^{i_2} position insert U^{i_1}, then $U' = U = (i_1, i_2)$ is the new solution of U through the adjustment factor $TO(i_1, i_2)$ operating. For example, when U = (1, 3, 5, 2, 4), the adjustment factor for TO (4, 2), U = U+TO (4, 2) = (1, 2, 3, 5, 4).

Orderly arrangement of one or more adjustment factor is the adjust order, denoted as ST, $ST = (TO_1, TO_2, ..., TO_n)$, Where $(TO_1, TO_2, ..., TO_n)$ is the adjustment factor, the order between

them is meaningful.   UA, UB   are   two different   solutions, the   adjust sequence of $ST\left(U_B\Theta U_A\right)$ expresses the adjusting sequence of adjusting UA for UB.

$$U_A = U_B + ST\left(U_B\Theta U_A\right) = U_A + \left(TO_1, TO_2, ..., TO_n\right) = \left[\left(U_A + TO_1\right) + TO_2\right] + ... + TO_n$$

(4)

In   order   to make   the adjustment   factor more in   the   adjustment   sequence, increase the replacement diversity of frogs, thereby increasing the searching ability, avoid getting into local optimum, this paper does not require solution sequence preprocessing.

2.2 The selection of communication mode

The basic steps of improvement shuffled frog leaping algorithm for solving Time-table Problem of Universities are the following:

(1) The initialization parameter (the frog population number is m, the frog number is n in the population (total number of the frog F= (mn), the frog number is q in sub groups);

(2) Randomly generate F initial feasible solution, and calculate the fitness of the individual frogs;

(3) The frog individual is divided into m groups according to fitness in descending order, construct the sub groups;

(4) Local search. Update the frog individuals for each population group in the sub population groups in accordance with the method of this paper;

(5) Each frog individual mutation, such as the generation of new individuals better than original individual will replace the frog original individual into frog populations, re calculating the degree of adaptation;

(6) Determine whether the algorithm meets convergence conditions, if satisfied, output the optimal path sequence; otherwise, update the global optimal solution, return to step (3).

4 The experimental simulation

This paper selects Gansu Normal College for Nationalities (4grades, 240 classes, 700 teachers) as an example to test. Parameter settings: the total number of the frog population F = 10n, the number of population m = 10, the number of frog in the sub group q= 2 n/3, the iteration number IT=q, the biggest adjustment factor number l max= n/ 2. Figure 1 is the diagram of solution space. Figure 2 is Schedule scheme combination change chart.
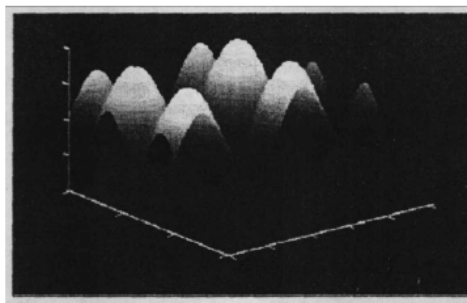

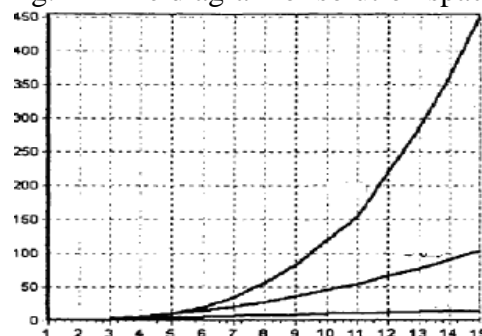Fig.1   The diagram of solution space

Fig.2   Schedule scheme combination change chart

5 Conclusions

This paper introduced the adjustment sequence of thought on the basis shuffled frog leaping algorithm, put forward an improved shuffled frog leaping algorithm for solving Time-table Problem of Universities. Simulation results show that improved shuffled frog leaping algorithm in solving Time-table Problem of Universities has better search performance and robustness.

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