Teaching Management System Based on Particle Swarm Algorithm

Wei Xie*

Mudanjiang Normal University, Mudanjiang, Heilongjiang, 157011, China

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Abstract

The core of school teaching management is comprehensive utilization of human, material and time resources. The work aims at building an optimization model of the above resources and solving scheduling problems of teaching management system based on particle swarm algorithm. This method is proved effectively by simulation, thus providing technical means for informatization of school teaching management.

Keywords: Particle Swarm Algorithm, Teaching Management System, Human Resource, Time Resource

1 Introduction

The optimization of teaching management system is reflected in maximizing the utilization of human, material and time resources by computer according to the relation of them.

Particle swarm algorithm has advantages such as few controlling parameters and rapid convergence. The work applies particle swarm algorithm to the optimization of teaching management system. After building mathematical model of teaching management system, the work analyzes and solves scheduling problems of system in terms of particle swarm algorithm. Simulation indicates the priority of this method in accuracy and operation time.

2 Particle swarm algorithm

2.1 PRINCIPLE OF PARTICLE SWARM ALGORITHM

Particle swarm algorithm, proposed by Kennedy, is used to analyze cooperation and competition between groups for the optimal results by simulating flight foraging behavior of bird flock. In particle swarm algorithm, each alternative solution is a "particle". At first, the initial population is generated, and each particle can be seen as a feasible solution. The fitness is determined by objective function. The direction and distance of the movement of each particle in solution space are determined by speed.

The common particle moves along with the movement of the optimal particle and derives the optimal solution after generational search. In each iteration process, the particle will follow extremes including the optimal solutions of itself (*pbest*) and the whole swarm (*gbest*).

2.2 MATHEMATICAL MODEL

Global optimization problem:

$$(\mathrm{P})\min\left\{f(x): x\in\Omega\subseteq R^n\right\},\ f:\Omega\subseteq R^n\to R^l \qquad (1)$$

The set of feasible solutions of Problem (p) is called a population, where each feasible solution is a particle, and the number of particle is population size.

Position of the ith particle is expressed as:

n-dimensional vector $X_i=(x_{i1},x_{i2},...,x_{in})^T\in\Omega$; ;
speed of the ith particle as $V_i=(v_{i1},v_{i2},...,v_{in})^T\in\Omega$;
optimal position of the particle in searching space flight as
$P_{pi}=(p_{pi1},p_{pi2,},...,p_{pin})^T$;
optimal position of the whole particles as P_g.

Therefore, speed and position of the particle in each generation can be calculated by:

$$v_{id}(t+1)=v_{id}(t)+c_1rand_1*(p_{pid}-x_{id}(t))+c_2rand_2*(p_{gd}-x_{id}(t)) \qquad (2)$$

$$x_{id}(t+1)=x_{id}(t)+v_{id}(t+1) \qquad (3)$$

where $i=1,2,...,m$; $d=1,2,...,n$; $rand_1$ and $rand_2$ obey $U(0,1)$ distribution;

learning factors c_1 and c_2 are non-negative constants ($c_1=c_2=2$); $v_{id}=[-v_{\max},v_{\max}]$,

and $v_{\max}$ is the upper speed limit set by the user.

* ***Corresponding author's*** e-mail: weixie163@126.com

The iterative procedure is as follows:

Initialize population: random X_i

repeat:

for each particle $i \in [1, S]$

if $f\ X_i\ < f\ P_i$

$P_i = X_i$

end

if $f\ P_i\ < f\ P_g$

$P_g = P_i$

end

update the position and velocity of particle using equation (6) and equation (7)

end

until termination criterion is satisfied

3 Design flow of teaching management system

To achieve design flow of teaching management system, teacher, teaching and time resources of schools should be designed rationally. Fig. 1 shows the specific design procedure.

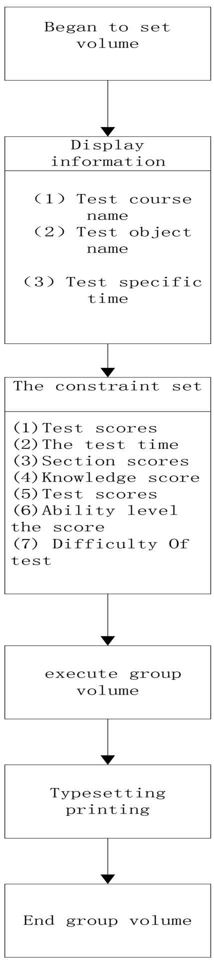


FIGURE 1 Design flow chart of teaching management system

4 Constraint condition of teaching management system

4.1 HARD CONSTRAINT MATHEMATICAL MODEL

Teaching management system is to design course arrangement and intelligent combination. Actually, the problem, meeting the constraints at the same time, is selected from item bank in teaching system design. An examination paper contains m test questions, and each test question meets n indexes. An objective matrix is built, where n-dimensional vector contains factors such as difficulty a_1, question type a_2, section a_3, teaching requirement a_4, test time a_5, and test score of each question a_6; a_i is the ith index; m the question number of the examination paper. The matrix is expressed as:

$$s = \begin{bmatrix} a_{11} & a_{12} & \dots & a_{1n} \\ a_{21} & a_{22} & \dots & a_{2n} \\ \dots & \dots & \dots & \dots \\ a_{m1} & a_{m2} & \dots & a_{mn} \end{bmatrix},$$

where each row is the question of the item bank, and each column the attribute of each question. The objective matrix should satisfy the following constraint conditions.

(1) $\sum a_{i1} * a_{i6} / 100 = ND$
(ND is constraint of test difficulty, namely the difficulty of the whole paper is determined by test users). In addition, the difficulty of each question is determined by:
Scoring Rate (d)=1−(Average Score/Full Score of Question)

(2) $\sum a_{1i} * a_{i2} = m_d$
(m_d is the score of the dth question type),
where $C_{1i} = \begin{cases} 1 \\ 0 \end{cases}$ (if $a_{i2}=d$, $C_{1i}=1$; else if $a_{i2} \neq d$, $C_{1i}=0$).

(3) $\sum c_{2i} * a_{i3} = Z_h$
(Z_h is the score of the hth section), where $C_{2i} = \begin{cases} 1 \\ 0 \end{cases}$
(if $a_{i3}=h$, $C_{2i}=1$; else if $a_{i3} \neq h$, $C_{2i}=0$).

(4) $\sum c_{3i} * a_{i4} = p_k$ (P_k is the score of the kth teaching requirement), where $C_{3i} = \begin{cases} 1 \\ 0 \end{cases}$ (if a_{i2}=k, $C_{3i}=1$; else if $a_{i2} \neq k$, $C_{3i}=0$).

(5) $\sum a_{i5} = t$ (t is the test time).

(6) $\sum a_{i6} = G$ (G is the whole test score).

4.2 SOFT CONSTRAINT MATHEMATICAL MODEL

In the process of organizing test paper, the papers which can completely and partially achieve the objective value are called "hard constraint" and "soft constraint", respectively. In actual process, the above six objective functions cannot completely be satisfied. Therefore, to minimize the deviation between each objective function and value, the whole objects are sequenced according to the importance priority of each object.

The positive and negative deviation variables are the sections beyond and below objective value, respectively. So, the organizing process can be solution of soft constraint object value. The multi-objective optimization model based on soft constraint is built as follows:

$$\min z = p_1\left|\sum_{i=1}^{p}(da_i^- + da_i^+)\right| + \ldots + p_2\left|\sum_{j=1}^{q}(db_j^- + db_j^+)\right|$$

Constraint conditions are expressed as:

$$\sum_{j=1}^{q}\sum_{k}^{n} f_k x_{ijk} + da_i^- + da_i^+ = a_i \cdots\cdots i = 1,2\ldots,p$$

$$\sum_{i=1}^{p}\sum_{k}^{n} f_k x_{ijk} + db_j^- + db_j^+ = b_j \cdots\cdots j = 1,2\ldots,q$$

$$\sum_{i=1}^{p}\sum_{j=1}^{q} x_{ijk} = S_k \cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots k = 1,2\ldots,n$$

where p_i, the priority factor indicating the relative importance of each object, is prior to p_{i+1} for the whole i (i=1,2,3,…); x_{ijk} test number of the ith difficulty, jth range and kth type; d_{ai-} and d_{ai+} are positive and negative deviation variables of ratio between sum of scores of the questions with the ith difficulty and difficulty demand a_i; db_{j-} and db_{j+} positive and negative deviation variables of ratio between sum of scores of the questions with the jth range and range demand b_j.

5 Algorithm simulation

MATLAB is used to simulate mathematical model designned by algorithm procedure and teaching management system. To verify the effectiveness of the algorithm in the work, the population size is denoted as 20; c_1 and c_2 as 2; v_{max} as 5; v_{min} as -5. Figure 2 shows the result after 100 iterations and derives that particle swarm algorithm has good convergence.

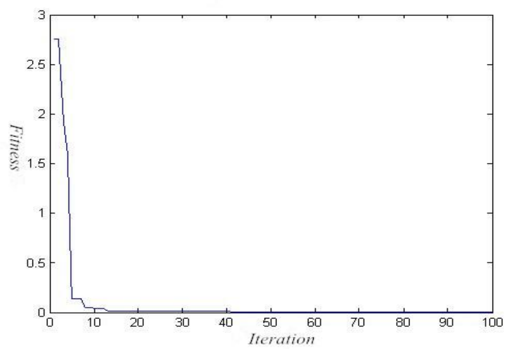


FIGURE 2 Convergence graph of particle swarm algorithm

To verify the effectiveness and priority of the algorithm in the work, particle swarm algorithm and random sampling method are contrasted in accuracy of test and elapsed time. Figure 3 and 4 show the contrast results.

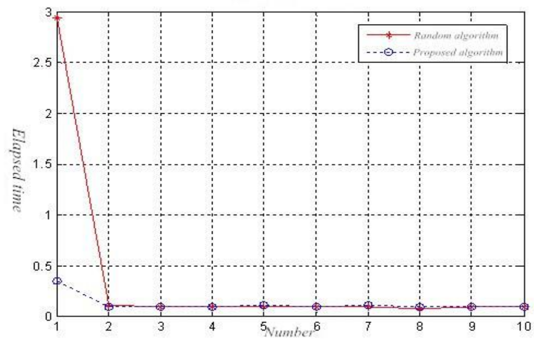


FIGURE 3 Contrast of elapsed time

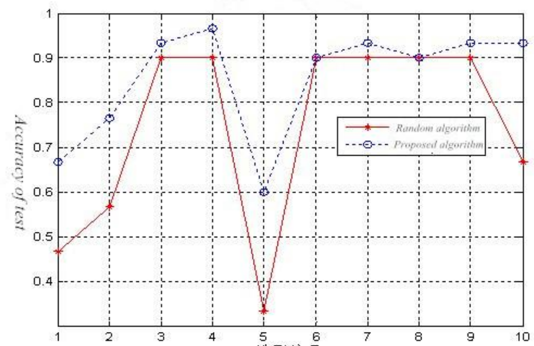
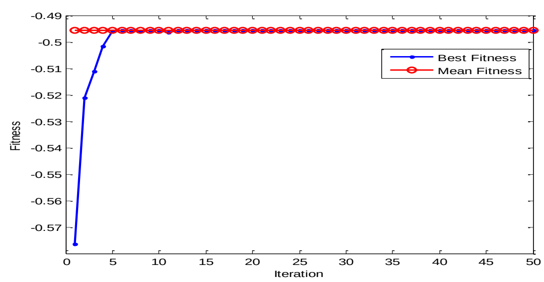


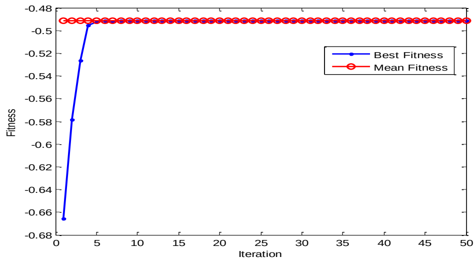
FIGURE 4 Contrast of accuracy of test

Compared with the algorithm in the reference, particle swarm algorithm is used for simulation by MATLAB. The results of the two algorithms are verified from accuracy of test and elapsed time. Figure 3 and 4 show that the accuracy and elapsed time of particle swarm algorithm are higher than random algorithm, respectively.

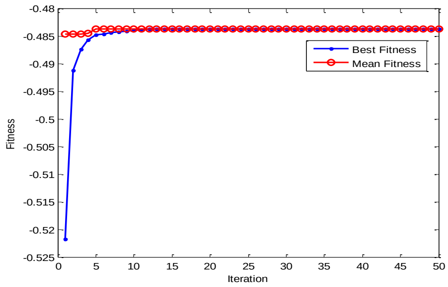
Figure 5 indicates fitness function contrast diagrams of different population sizes.



(a) Convergence curve when population size $popsize = 5$



(b) Convergence curve when population size $popsize = 10$



(c) Convergence curve when population size $popsize = 15$

FIGURE 5 Convergence curves of different population sizes

6 Conclusions

Particle swarm algorithm has advantages such as few controlling parameters and rapid convergence. The work aims at building an optimization model and solving scheduling problems of teaching management system based on particle swarm algorithm. Simulation shows that the method proposed in the work has superiority in accuracy and elapsed time, thus bringing certain theory and application value.

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Authors

Wei Xie, 1981. 09, Liaoning Province, China

Current position, grades: Lecturer, Master
University studies: Financial Mathematics
Scientific interest: Financial Mathematics, Computational Mathematics
Publications: 12 papers published in the international or national journals
Experience: associate professor in Mudanjiang Normal University, Mudanjiang, China.