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The Application of Particle Immune Algorithm in Soccer Equipment Training

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ABSTRACT: With the increase of information obtained by human, the processing of such a huge amount of data information has become a focus of current researches. Intelligent processing methods are featured by fast speed and conciseness and will certainly become the mainstream of the future development. First, this paper gives a brief introduction on specific implementation steps of particle swarm algorithm and particle immune algorithm, draws implementation flow charts and studies the mechanism. Then this paper carries out a comparative analysis on the shortest path problem of particle swarm algorithm and particle immune algorithm and finally concludes that the particle immune algorithm features higher convergence, which is then applied in soccer equipment training. It proves the superiority of the method and provides a certain theoretical support for future studies on this method.

Keywords: particle swarm; particle immune algorithm; soccer; the shortest path

1 INTRODUCTION

Researches have started to solve practical problems through hints from natural phenomena since 1940s. Optimized bionic algorithms are produced gradually. Validity and feasibility of this method are also verified in practical applications. At present, bionic algorithms mainly include bacterial foraging algorithm, immune algorithm, fish swarm algorithm, ant colony algorithm and so on. Although bionic algorithms have things in common, biological behaviors have insurmountable difficulties like singleness due to their own special structural features. However, the particle immune algorithm has overcome the shortcoming and been applied in various fields.

Lots of studies have been carried out on particle immune algorithm with certain achievements. For example, Jun Cheng has applied particle swarm algorithm to the mechanism of biological behaviors in the aspect of its improvement. As for the phenomenon of parasites immune escape in the natural world, the immune escape mechanism of bacteria has evolved into the immune particle swarm optimization algorithm based on the study on the mechanism. The optimization model of immune escape is formed in the simulation process of parasites variation and escape, which is also tested with simulations. Researches indicate that the particle immune algorithm has a better effect on the application of parasites escape. Hongliang Wang analyzed the mechanism of particle swarm immune algorithm, applied it to the design of the soccer robot system, and finally verified the reliability and practicability of particle immune algorithm through simulation experiment.

Based on previous studies, this paper carries out further explorations and analyses on particle immune algorithm with several methods like documentary method and mathematical statistics. And in the end, it conducts a simulated verification through soccer equipment training and concludes that this model has certain practical values

2 THE STUDY BASED ON IMMUNE PARTICLE SWARM ALGORITHM

The particle swarm algorithm is an algorithm with fast convergence speed and high precision that can be easily realized. However, the evolution will lead to an obvious decline of the diversity and eventually the local optimum affects the whole path planning and fails to meet the requirement. The immune particle swarm algorithm increases the population diversity and improves the optimal performance of particle swarm optimization algorithm by simulating the regulating mechanism of the biological immune system.

Major steps are:

1) Determination of parameters. Suppose inertia factors are $\omega_{\max}$ and $\omega_{\min}$; the evolutional generation is $D_{\max}$; learning factors are c_1 and c_2; the population size is N.

2) Initialization. The number of particles x_i produced in the space s^n is M and the velocity is v_i. The initial position of particles is regarded as the current optimal point of particles, where the initial particle swarm t_0 is produced correspondingly.

3) The judgment of constraint conditions. An evaluation criterion is assumed to be the optimal con-

strained solution. The solution will be directly output if it is within the constraint. Otherwise, it will be turned to step4).

4) The evaluation of population. Calculate the fitness of the particle swarm and update the global optimal position G_{best}.

5) The new generation of particles. *M* new particles are generated through update formulas of the position and the velocity of the particle swarm. Half of the new particles are generated subsequently.

The inertia weight decreases gradually with the increase of the number of iterations of the above-mentioned process. The global convergence ability of particle swarm algorithm is realized thusly. The inertia weight ω of the global convergence ability is improved in the end:

$$\omega = \omega_{\max} - \frac{\omega_{\max} - \omega_{\min}}{D_{\max}} \times d \tag{1}$$

$$V_i = \omega \times V_i + c_1 \times rand() \times (P_{best_i} - X_i) + c_2 \times rand() \times (G_{best_i} - X_i) \tag{2}$$

$$X_i = X_i + V_i \tag{3}$$

6) The immune process will select particles. 3/2 *M* new particles are generated through the above formula, *M* of which are selected randomly so as to form a new population *t*:

$$Density(\mathrm{X_i}) = \frac{\sum_{j=1}^{M+N} \left| f(\mathrm{X_i}) - f(\mathrm{X}_j) \right|}{\sum_{i=1}^{M+N} \sum_{j=1}^{M+N} \left| f(\mathrm{X_i}) - f(\mathrm{X}_j) \right|} \tag{4}$$

7) The selection of immune. If the affinity value of the immune particle swarm t_1 is inferior to the last generation, the system will abandon automatically. Otherwise, a new particle swarm t_2 will be formed.

8) The termination of conditions. If the maximum number of iterations is ultimately achieved, conditions will be terminated. Otherwise, go back to step4) automatically.

The main process is shown in Figure 1.

3 COMPARATIVE ANALYSIS ON IMMUNE PARTICLE SWARM ALGORITHM AND PARTICLE SWARM ALGORITHM

Advantages of immune particle algorithm can be analyzed through the comparison between the simple and fast convergence algorithm of particle swarm and immune algorithm that processes information rapidly. This paper carries out a study on the shortest path problem.

The immune particle swarm algorithm is introduced in this paper to solve the problem. The path coding is indispensable, which is shown in Figure 2.

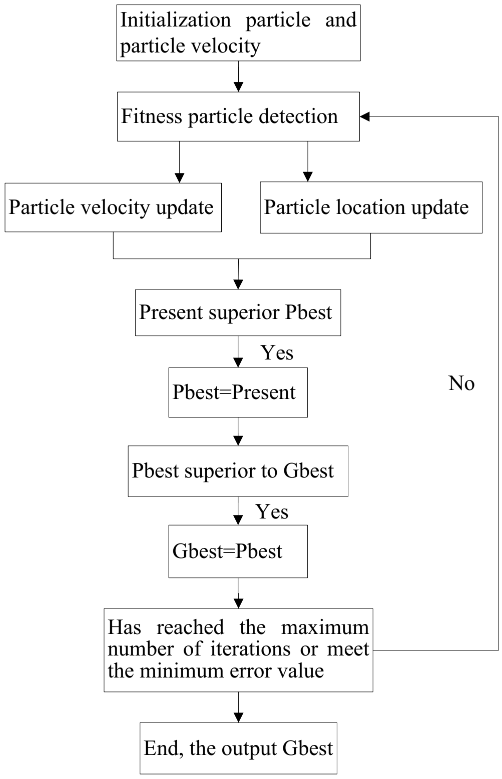

Figure 1. Particle swarm optimization in progress

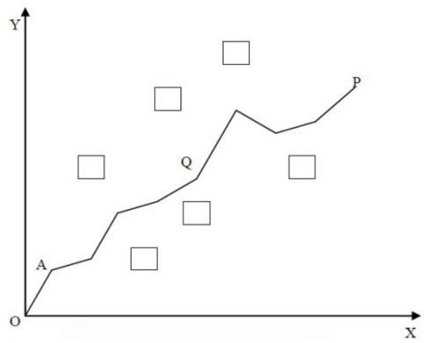

Figure 2. Schematic path coding

In the searchable path region, it can be expressed as:

$$L_j = \left\{ A_{j0}, A_{j1}, A_{j2}, \cdots, A_{ji,}\ldots A_{jn-1} A_{jn} \right\} \tag{5}$$

Here, the x-coordinate is divided into *n* parts. After all points are connected together, the terminal point and the starting point of A_j are respectively A_{jn} and A_{j0}. Besides, $j = 1, 2, \cdots, m$, $i = 0, 1, 2, \cdots, n$. Thus all these points can be expressed in the coordinate system to get:

$$L_j = \begin{Bmatrix} (x_{j0}, y_{j0}), (x_{j1}, y_{j1}), (x_{j2}, y_{j2}), \cdots, \\ (x_{ji}, y_{ji}), \cdots, (x_{jn-1}, y_{jn-1}), (x_{jn}, y_{jn}) \end{Bmatrix} \quad (6)$$

When coordinates of the terminal point and the starting point are already known, the point of (x_{ji}, y_{ji}) in the coordinate system is A_{ji}. Therefore, we can get an arithmetic progression about $\{x_{j0}, x_{j1}, x_{j2}, \cdots, x_{ji}, \cdots, x_{jn-1}, x_{jn}\}$. In this formula, $i = 0,1,2,\cdots,n$ $b = DIST / n$, $DIST$ and $x_{ji} = i \cdot b$. Besides, the length of the segment OD is the distance between the terminal point and the starting point on the x-coordinate. So the path coding can be simplified as:

$$L_j = \{0, y_{j1}, y_{j2}, \cdots, y_{ji}, \cdots, y_{jn-1}, a\} \quad (7)$$

In the above formula, the coordinate of the target point on the y-coordinate is a and $i = 0,1,2,\cdots,n-1$.

Through the above process, we can not only obtain the calculation that is beneficial to the function after two-dimension is converted into one-dimension but also simplify the path coding.

3.1 *Optimization model of the algorithm*

Various factors will be involved in order to realize the shortest path. Therefore, to some extent, the particle swarm algorithm fails to meet the requirements and might cause the problem that the result is the local optimum. Aiming at making up for the deficiency, this paper introduces the immune algorithm of concentration regulation so as to optimize the structure and functions of the algorithm.

3.2 *Optimization standardization of particle swarm algorithm*

In the standard particle swarm optimization algorithm with the particle velocity of $V_i = (v_{i1}, v_{i2}, \cdots, v_{in})$, $X_i = (x_{i1}, x_{i2}, x_{i3}, \cdots x_{in})$ represents the location of particles and $P_{best_i} = (P_{best_{i1}}, P_{best_{i2}}, \cdots, P_{best_{in}})$ represents the best location of the current i[th] particle. The best location of the whole particle swarm can be expressed as:

$$G_{best_i} = (G_{best_{i1}}, G_{best_{i2}}, \cdots, G_{best_{in}}) \quad (8)$$

So the evolutionary formula of the particle swarm is:

$$\begin{aligned} V_i &= \omega \times V_i + c_1 \times rand() \times (P_{best_i} - X_i) \\ &+ c_2 \times rand() \times (G_{best_i} - X_i) \end{aligned} \quad (9)$$

3.3 *The study on correlation parameters of the algorithm*

In order to balance the speed and the precision of the convergence, it is necessary to select a suitable inertia factor, which is an impact factor of the original speed on the current speed. According to features in this paper, this factor can be expressed as formula 2.

The largest number of iterations is represented by $D_{\max}$. Based on the previous experience, $\omega_{\max}$ =0.9 and $\omega_{\min}$ =0.4. Now the number of iterations is represented by d and the maximum weight is expressed as $\omega_{\max}$. So the corresponding minimum weight can be expressed as $\omega_{\min}$. In addition, weights of each item used for acceleration statistics can be expressed as c_1 and c_2. According to previous experience and features in this paper, it can be ordered that:

$c_1 = 1.4$, $c_2 = 1.4$

The length of the shortest path of the objective function can be expressed as:

$$fit_1 = \sum_{i=1}^{n} \sqrt{(x_{ji} - x_{ji-1})^2 + (y_{ji} - y_{ji-1})^2} \quad (10)$$

In the above formula, (x_{ji}, y_{ji}) refers to the coordinate of the i[th] point on path j.

A corresponding model can be established so that soccer robots are able to avoid obstacles in the game process. The formula is:

$$OB_S^-(i) = \min\left\{0, \left[\sqrt{(x_{ji} - x_k)^2 + (y_{ji} - y_k)^2} - 2r\right]\right\} \quad (11)$$

In the above formula, values of k are $1, 2, 3, \cdots, q$.

3.4 *Parameters and results of two algorithms*

According to the above-mentioned content, this algorithm is combined with matlab. It concerns the selection problem of parameters. Suppose $n = 22$ is the dimension of the searched space and $m = 250$ is the number of particle swarms at the beginning. The starting point starts from the original point. The largest number of iterations is represented by $D_{\max} = 600$ and the last point is represented by $(100,100)$. Besides, $b = 5$, so we can get data in Table 1.

It can be obtained through the calculation that the average value of particle swarm algorithm is 198.99 whereas the operational result of particle swarm immune algorithm is 151.09. So compared with the particle swarm algorithm, the immune particle swarm algorithm has greater advantages.

Table 1. Results of two different algorithms

Number of operations	1	2	3	4	5	6	7	8	9	10
Particle swarm algorithm	241.97	193.05	158.34	174.62	165.54	189.58	161.56	164.44	178.47	206.29
Particle swarm immune algorithm	151.20	151.41	151.28	155.94	151.74	149.76	151.14	151.16	152.20	151.58

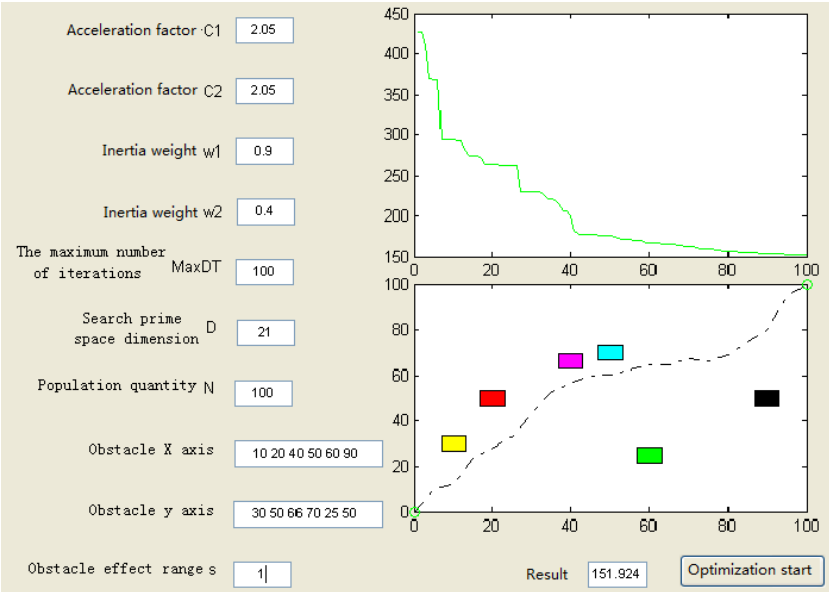

Figure 4. Simulation and analysis of the application of particle immune algorithm in soccer equipment training

4 APPLICATION OF PARTICLE IMMUNE ALGORITHM IN SOCCER EQUIPMENT TRAINING

In this paper, the particle immune algorithm is applied in soccer equipment training. The path planning and analysis software is first designed and realized with the MATLAB software. The flow chart is shown in Figure 3.

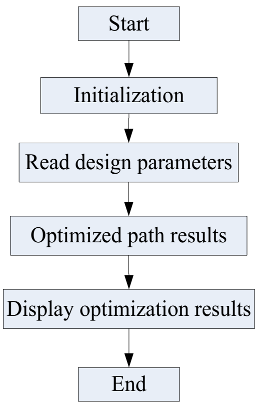

Figure 3. Program flow chart

The software program is then edited. The path planning interface and the path planning simulation diagram are drawn with determined parameters that are shown in Figure 4. The interface is convenient, concise and easy to achieve.

It can be clearly concluded from the above figure that the particle immune algorithm has a higher convergence speed and greater advantages in the application of soccer equipment training.

5 CONCLUSION

This paper carries out a study on the particle swarm algorithm and the immune particle algorithm, describes implementation steps of the two algorithms in detail and makes a comparison between the two algorithms on the shortest path problem, concluding that immune particle algorithm features conciseness, fast speed, and fast convergence and so on. In the end, it applies the immune particle algorithm in soccer equipment training and provides a kind of convenient and concise visual analysis software.

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