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Fuzzy Integration Monitoring Method in a Regional Economic System Based on PSO Algorithm and its Simulation

Shi Zheng
School of Economics and Management, Dalian Nationalities University

Abstract: The purpose of this paper is to enhance the efficiency of monitoring a regional economic system by the optimization of the fuzzy membership function in the fuzzy controller. The paper improves the membership function by PSO algorithm and made a comparison with our prior research. The simulation results show that the improved controller has many advantages, such as accuracy, self adaptive, robustness and real-time. The method has more applying prospect that it can monitor and control a regional economic system effectively.

Keywords: PSO Algorithm; Fuzzy Controller; Membership Function; Fuzzy Monitor Optimization Method; Regional Economic System

I. INTRODUCTION

Actual data in a regional economic system is characterized by time delay, time-varying. Meanwhile, a regional economic system is a typical non-linear one. Thus establishing a set of precise mathematical model is very difficult. The computational task is very heavy. To solve this problem, Chinese scholars[1-3] have done a lot of research work, which mainly include fuzzy control and real-time monitoring. Moreover, genetic algorithm was also employed to optimize membership functions in fuzzy neural controller so as to realize more accurate real-time monitoring and further improvement of fuzzy rule extraction.

In recent years, the emergence of particle swarm optimization provides a new method for membership function optimization in fuzzy control model of a regional economic system. PSO (Particle Swarm Optimization, PSO) is a kind of swarm intelligence algorithm. Swarm intelligence algorithm (Swarm Intelligence Algorithm, SIA) was proposed in the 1990s. The basic idea is to simulate the natural behavior of biological communities to construct stochastic optimization algorithm[4][5]. A single creature is not intelligent in nature. However the whole group of organisms when working together, produce complex emergent behavior. Swarm intelligence algorithms that mimic the behavior of these groups of organisms and apply it in artificial intelligence. PSO algorithm developed by American social psychologist James Kennedy and electrical engineer Russell Eberhart in 1995. The basic idea is to simulate birds, fish feeding behavior during migration and aggregation. It employs biological population model of biologist Frank Heppner [6-8]. It is a family of stochastic optimization techniques based on swarm intelligence. Comparing with the genetic algorithm, both the two groups are based on iterative search, but PSO algorithm has no crossover and mutation operators. Particle swarm optimization search for the optimal solution by collaboration between individuals. The concept which takes advantage of biological information sharing groups thought is simple, easy to implement. Meanwhile it has profound intelligence background. It is suitable for scientific research, as well as engineering applications. Thus, when PSO algorithm emerged, it caused many scholars' the attention. The extensive achievements of theory and engineering applications has been made[9] [10], the advantage of convergence speed of the algorithm is quickly attracted researchers' attention in various fields. Some scholars apply it to optimize the S-type fuzzy membership function in practice, and good results were obtained[4]. However PSO has not yet been applied in researches about regional economy. Whether it can improve the efficiency of optimization of the membership function is the focus of this article.

This article will apply PSO algorithm to optimize Gaussian membership function, in order to achieve efficient regional economic Fuzzy integration monitoring.

II. FUZZY INTEGRATION MONITORING METHOD

2.1. Fuzzy Integration monitoring System of a regional economy

The fuzzy integration monitoring system is as follows (see Fig. 1),

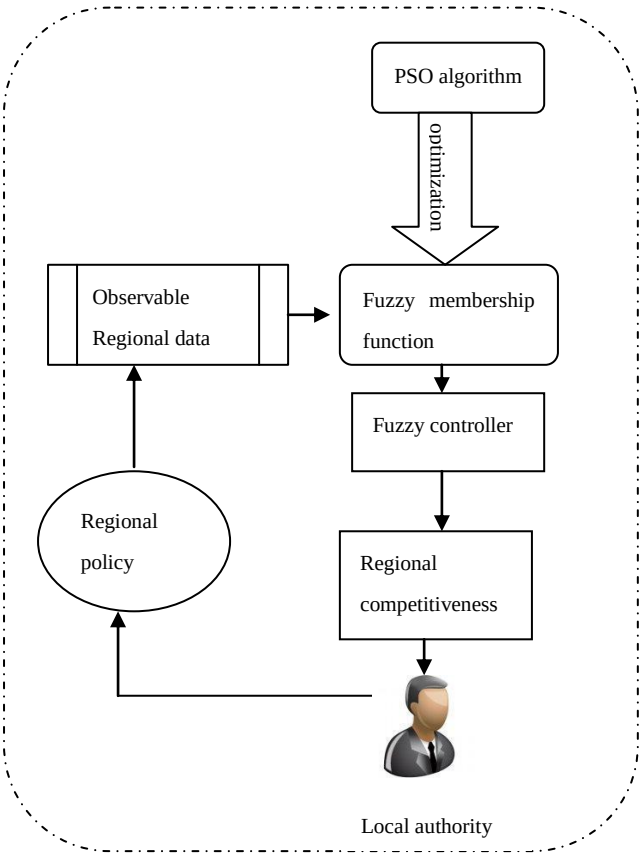

Fig. 1 Fuzzy Integration monitoring System

Among them, a regional economic system is a fuzzy system model which has two inputs and a single output. The two inputs are regional competitiveness core-elements and auxiliary elements. The output is overall competitiveness of a regional economic system.

2.2. Regional economic integration monitoring model based on PSO Algorithm

Regional economic integration monitoring model is mainly achieved effectively monitoring the regional economy through the extraction of the membership function of the input signal. Compared with the optimization of the fuzzy control rules, the optimization of the membership function is more valuable for obtaining accurate input signal in the regional economic monitoring process. The selection of fitness function is the key points in evolutionary algorithms such as PSO algorithm. Literature [11] regards optimal solution of fuzzy membership function as a genetic algorithm fitness function. Fuzzy membership function in this article is employed the one similar to the former fitness function of the optimal solution. We use Gaussian membership function $\mu(x) = e^{-\left(\frac{x-a}{\sigma}\right)^2}$, and set it to the one has two parameters, i.e. a , σ . Then we use PSO algorithm to adjust the two parameters a , σ . The optimization process is the one minimize parameters of fitness function. The steps are as follows[12]:

A. Initialize a group of random particles, each particle is set initial position and initial velocity.

B. From the initial position and velocity of the particle generating new position.

C. Calculate the fitness value of each particle.

D. For each particle, compare its fitness value and the value which its best position p_{id} ever experienced. If can be better, the value will be updated.

E. For each particle, compare the value of his fitness and the best fitness value of the group experienced position p_{gd} . If can be better, the value will be updated.

F. According to the Equation (1) and Equation (2), adjust the particle velocity and position.

$$v_{id}(t+1) = \omega v_{id}(t) + \eta_1 rand(\,)(p_{id} - z_{id}(t)) + \eta_2 rand(\,)(p_{gd} - z_{id}(t)) \quad (1)$$

$$z_{id}(t+1) = z_{id}(t) + v_{id}(t+1) \quad (2)$$

Among them, $v_{id}(t+1)$ denotes the first iteration of particles in the speed of d dimension, ω denotes the inertia weight, η_1, η_2 denotes accelerate constant respectively. $rand(\,)$ is a random number between $0 \sim 1$.

G. If the shelter conditions (good enough location or maximum number of iterations) is reached, then go to the end, otherwise go to step C., and continue iteration.

III. EXPERIMENTS

PSOt toolbox in MATLAB soft package is employed. Optimization of the parameters of the Gaussian fuzzy membership functions to fuzzy control the regional economy is compared. The normal fuzzy sets are shown in Table 1:

Table1. fuzzy sets of Gaussian fuzzy membership functions

Parameters / types	σ	a	$\mu(x)$
fuzzy membership function of type ① core competiveness of a regional economy is low	0.06	0	$\mu(x)=e^{-\left(\frac{x}{0.06}\right)^2}$
fuzzy membership function of type ② core competiveness of a regional economy is medium	0.01	0.0995	$\mu(x)=e^{-\left(\frac{x-0.0995}{0.01}\right)^2}$
fuzzy membership function of type ③ core competiveness of a regional economy is high	0.02	0.2	$\mu(x)=e^{-\left(\frac{x-0.2}{0.02}\right)^2}$

M file is developed as follows,

```
function f=c7mpso1(x)
a=[0.01:0.2]';
b=[0.01:0.3]';
a(:,1)=a;b(:,1)=b;
f=exp(-1)*(((a(:,1)-x(:,1))/b(:,1)).^2);
x1=x(:,1);
ii=find(x1>0.21);x=-100;x=x(:);
```

Input the following command in the command window *x=pso_Trelea_vectorized('c7mpso3',1);x(1:1)*

The optimal solution of parameters a is obtained. As PSO has no crossover and mutation operators, algorithm is simple, fast. The optimal solution 0 of parameters a in the core competitiveness of regional economies with low membership function of is obtained, after 277 iterations. Its iterative process is shown in Fig. 1.

The optimal solution 0.0995of parameters a in the core competitiveness of regional economies medium membership function, after 931 iterations are obtained. Its iterative process is shown in Fig. 2.

The optimal solution 0.2 of parameters a in the core competitiveness of regional economies with high membership function is obtained, after 927 iterations. Its iterative process is shown in Fig. 3.

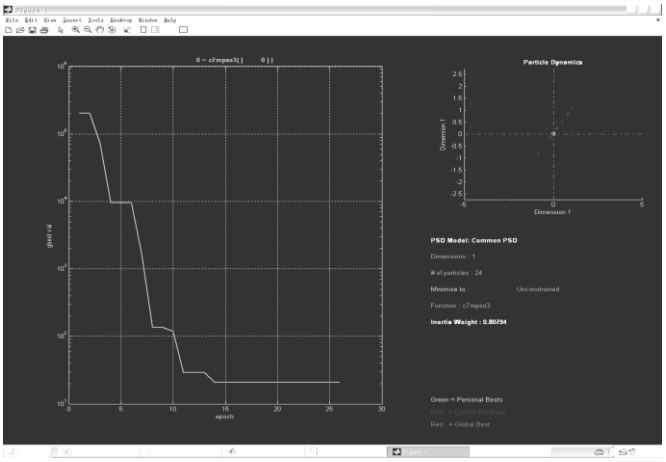

Fig. 1 Group average particle distance and optimal fitness value curve in optimizing fuzzy membership function process with pair ①

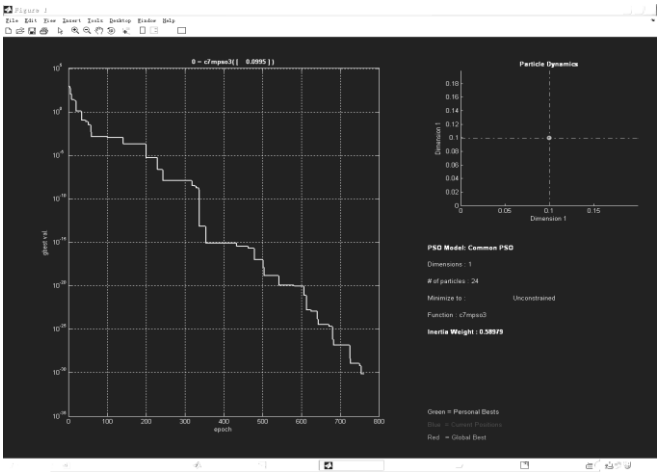

Fig. 2 Group average particle distance and optimal fitness value curve in optimizing fuzzy membership function process with pair②

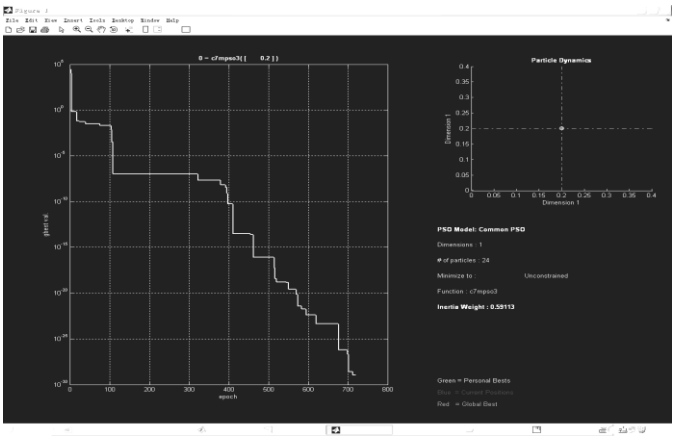

Fig. 3 Group average particle distance and optimal fitness value curve in optimizing fuzzy membership function process with pair③

The fuzzy membership function of regional economic auxiliary competitiveness and comprehensive competitiveness is also optimized. It can be found that the control effect is significantly improved in the redesigned fuzzy controller (see Fig. 4).

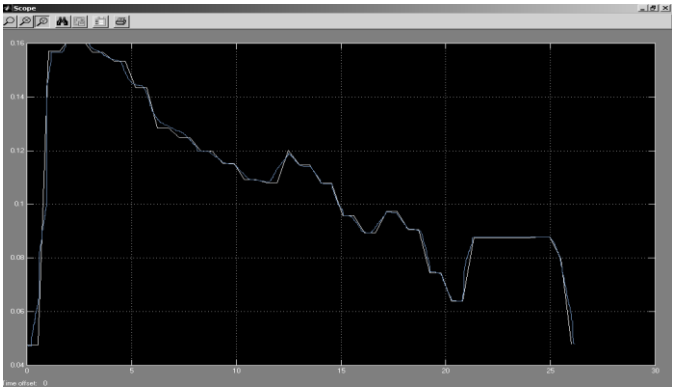

Fig. 4 Comparison between output curves of the fuzzy controller based on PSO algorithm and GA algorithm (White line for GA algorithm and blue line for PSO algorithm)

IV. CONCLUSIONS

This paper attempts to apply PSO algorithm to the regional economy monitoring process. It is another attempt besides the application of GA algorithm in optimizing fuzzy membership function in a regional economic monitoring system. It seeks the optimal parameters of the membership function in a regional economic monitoring system rather than that only be determined empirically. Meanwhile optimization efficient and result of dynamic monitoring is superior to the genetic algorithm. Simulation results show that the designed fitness function effectively avoids both adverse circumstances in data mining. It can provide additional information to the user. In the future, we will continue to strengthen the PSO algorithm in the application of fuzzy rule extraction to adapt more complex regional economic solutions to problems.

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