

A Mathematical Modelling Evaluation of Wushu Training using Multi-Agent System and Wavelet Particle Swarm Optimization

Yuanhai Gui

Yunnan University of Finance and Economics, Yunnan, China

Abstract — In this paper we carry out a mathematical modelling and optimization study to measure the effectiveness of the Wushu training system. In general, Wushu system can be divided into two parts: Wushu theory system and Wushu technology system. The theoretical system includes the theory of humanities and social sciences, the theory of human movement science and the theory of education and training. Wushu technology system can be divided into two categories: drilling technique and counter-measure technology. The martial arts development assessment can promote the popularization of Wushu system. As a typical representative of Chinese traditional sports, Wushu adapts to enrich and renewing its own system. To measure the development level of Wushu, in this paper we establish a comprehensive and specific evaluation index system for it.

Keywords — *Wushu; Index system; evaluation criterion; Multi-Agent System; Wavelet Particle Swarm Optimization*

I. INTRODUCTION

Modernization refers to the process of social evolution from the traditional society to the modern society. This reform has penetrated into various fields, such as social economy, politics, culture and so on. Under the background of the modernization of society and the modernization of sports, Wushu is the representative of Chinese traditional sports. Wushu, as an outstanding cultural heritage of the Chinese nation, during the long process of development, has formed its own unique and sophisticated methods. However, due to various historical reasons, there is no comprehensive exposition of the basic theory of Wushu system. Obviously, it is imperative to establish the framework of Wushu system.

The fundamental purpose of the construction of Wushu system is to study the essential characteristics of Wushu, and to discuss the forming process, content, changing rule and developing trend of Wushu theory and technology. We need to analyze the structure of the whole martial arts system, the whole and the branch disciplines, as well as the interaction between the various branches of science, the study of the law of the development of various disciplines and the evolving principles of classification. The martial arts is the sports, but is far higher than the sports, which has absorbed the essence of the times unceasingly during thousands of years, gradually becoming a kind of outstanding national culture, therefore Wushu is rich and more complex. The modernization of Wushu is a developing concept and its modernization development is not only the modernization of Wushu itself, but also the modernization of all concerned aspects.

This study mainly focuses on the modernization, sports modernization, social culture and other related theories, and combined with the modernization of modern martial arts research results. Chinese Wushu is profound, which is not only a sport, but also a traditional cultural phenomenon. Literature survey is a research method based on literature. According to the needs of the subject, we have access to the

martial arts theory and martial arts techniques related information, including historical data, papers, monographs, etc.

We investigate the process of the development of Wushu, and then make an objective system according to the information obtained by the description, explanation and analysis, so as to obtain the general system of martial arts. The theoretical method takes dialectical materialism as the thought and uses the theory of system. The Wushu system is divided into two parts, theoretical system and technology system of Wushu. According to the classification of physical education, Wushu theory system is divided into three parts: the theory of Humanities and social science, the theory of sports human science, the theory of education and training.

The introduction of Wushu is a discipline that studies the basic characteristics and development rules of Wushu from the macroscopic aspect. The contents include: the concept of martial arts; the nature of Wushu; the characteristics of Wushu; the value function of Wushu; the classification of Wushu; the introduction of Wushu schools; the principles and policies of Wushu; the development strategy of Wushu; the frame of Wushu system [1-3].

Wushu historiography is a discipline that studies the process of Wushu development and its law. The martial arts philosophy is based on the traditional Chinese philosophy, and is based on the practice of martial arts, revealing the essence of Wushu and its dialectical development. Wushu aesthetics is a discipline that studies the laws, essence and characteristics.

Wushu ethics reveals the essence and development trend. Sports modernization theory is the product of social modernization theory. The modernization of sports is the level and state of the development of sports, and it is also the ideal goal and future trend of sports' development. The measurement index system is not only the subjective

abstraction and simulation of the real system, but also the reflection of the concept of the evaluation objects.

II. MULTI-AGENT SYSTEMS

In the research field of multi Agent system, the emergence of the phenomenon is attracting more attention, and the research on the emergence of multi Agent system is becoming a hot topic in the research of multi Agent system. Multi Agent system is a hot research topic in distributed artificial intelligence, and the cooperation and coordination among them are the key issues. Multi Agent system is a packaged computer system in a specific environment. It has the ability of autonomy and flexibility. Agent technology is a kind of social computing paradigm, theory of Sociology of technology is the inevitable trend of its development. It focuses on the macro level of multi Agent system and the macro and micro level of the system. The problems and the future directions in this field are discussed in this paper [4-5].

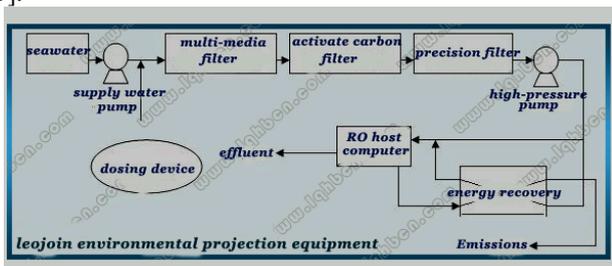


Fig. 1. Multi Agent System.

A. Application

MAS is widely applied in large scale system. Agent is a computing entity that has the characteristics of autonomy, sociality, reactivity, initiative and so on, including robots, expert systems, processes, modules, or solving units. A kind of complex and extremely important macroscopic characteristic also gradually emerges. In these systems, MAS is usually a centralized control system, which is composed of interacting autonomous Agent, and is a kind of artificial complex adaptive system. On the other hand, in the field of CAS, people use MAS as a natural tool to study natural CAS. MAS and CAS are the same class of systems described by some researchers.

The difference is that CAS is related to the phenomenon and structure of high level, and MAS is related to the underlying components and elements of the system. Therefore, in order to study the overall nature of MAS, some researchers regard to MAS as CAS, and use the research results of CAS to promote the emergence of MAS.

Traditional MAS research focuses on micro level issues, such as Agent theory, Agent architecture, etc. In the macro aspect, we only focus on the interaction and cooperation between Agent and other local behavior problems. MAS research is concerned with the emergence of the macro level

of the MAS and the macro and micro level contact mechanism of the system, and we ultimately hope to develop a sound design and control methods.

Emergence is an important feature of CAS system. When we consider MAS as CAS, we need to have a clear understanding of MAS when it comes into being. Expert system is one of the important artificial intelligence technologies, with a specialized knowledge of the program system. Expert system can be based on one or more experts to provide a domain of knowledge reasoning, simulation expert decision-making to solve the problem. The key of expert system is how to acquire, express and use expert knowledge. The reasoning mechanism is similar in solving problems. MAS and expert systems need to interact with each other.

The expert system is separated from the reality, that is, they are not directly linked to the environment, but regard the user as the middleman. People cannot explain the target or the state in detail. MAS can directly interact with the environment, and make decision according to the environment information. In general, the expert system does not take reactive action. MAS can respond quickly to the changes in the environment. MAS has strong problem solving ability, computational ability, flexibility, reliability, scalability, adaptability and so on. With the development of computer network, many practical systems become very complex, so MAS becomes the focus of research.

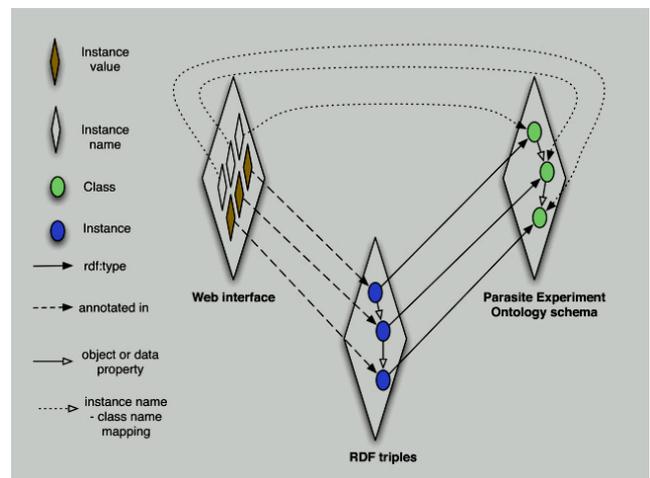


Fig. 2. Expert System.

B. Cooperation problem of MAS

Collaboration, that is, cooperation, is a manifestation of social Agent. For example, moving a heavy object together, playing music together, compiling complex programs together, building a house together, etc. The purpose of establishing MAS is to solve the problem that single Agent can't solve. With the development of science and technology, the system becomes more and more complex and distributed and uncertain. A single Agent cannot solve these problems, so we need multiple Agent system to complete the task. In

addition, collaboration can be divided into organized collaboration and spontaneous collaboration [6-9].

C. Contract net

The contract net method is the method of negotiation in MAS collaboration, which is based on contract mechanism. The contract net method is the most widely known and widely used method in all cooperative methods.

All Agents are divided into two roles, managers and workers. Formal method is based on mathematical logic, which includes three stages: system specification, system implementation and system verification. At present, the most successful framework is the specification of temporal modal logic. System validation is used to determine whether the computing system is properly implemented. System verification can be divided into two methods: axiomatic verification and model checking [10-12].

Formal methods use graphs, tables, texts as model language. Compared with the formal method, the research of non-formal method is more active. MAS represent a social computing paradigm. Therefore, the research based on sociological perspective is the inevitable trend of the development of Agent technology. Non formal methods are based on the concepts of human society, social organization and social role to establish Agent model.

To sum up, the main problems faced by formal methods are consistent with the cognitive problems in the research work of MAS. That is, the complexity and difficulty of logical proof, symbolic operation and implementation. To simulate the autonomy and flexibility of human beings, and construct a Agent model with autonomy and flexibility. From the perspective of social operation, according to the formation of social roles, we need to establish the role of human society based on paradigm. This paper is based on the formation and role theory of sociology social role.

D. The social paradigm based on roles

Sociology is a comprehensive science which studies the factors of human society. The main factors that determine the benign operation of society include: population, natural ecological environment, economy, politics, culture and psychology. Society is the community of human life. Broadly speaking, society refers to the whole human society. In a narrow sense, society refers to a community or unit. Sociology analyzes the social operation mechanism from two perspectives of micro and macro.

Micro analysis pays attention to the individual structure of society, such as people's socialization, social role, social interaction social group and so on. Social role refers to some kind of social status and identity. Social interaction is sort of the interaction between roles.

Macro analysis focuses on the overall structure of society, such as social organizations. Social organization is a set of interdependent and interrelated roles which constitute the social organization, and each person will live in different social organizations. From the perspective of micro analysis

and macro analysis, social role is the main line of sociological research. The social relationship between people is the relation of role and social interaction.

The role is not innate, but is the result of the human socialization. The roles cannot exist in isolation and they must be interdependent with other characters.

E. Multi Agent conflict resolution

In the MAS system, considering the dynamic nature of the environment and the complexity of the task, as well as the limitations of each individual ability, knowledge and resources of Agent, it is necessary to cooperate effectively. Conflict resolution can make MAS cooperation smoothly. Try to avoid conflict, or at least ignore it. Such as contract nets or planning methods, at the beginning of the assignment, try to avoid the emergence of conflict. Resolve conflicts through negotiation. A buffer degradation system is established in the presence of inconsistency.

Negotiation is the key link of cooperation. Negotiation is a process which interests parties exchange information and reach a compromise. Negotiation is a process in which the two sides of the collaboration reducing the inconsistency or uncertainty in order to reach a consensus. Negotiation protocol is a structured process of automatic negotiation. It details the possibilities of initializing a negotiation loop and responding to messages. The content of the message includes the sending of the message, the message number, and the sending time of the message. In the course of negotiation, the strategy adopted is unknown. Negotiation processing includes negotiation algorithm and system analysis.

Synergy is the social performance of MAS, which can improve the overall performance of the system. The overall performance of MAS collaboration system depends on the system environment, and the overall goal of the system. We are looking for a way to make the overall performance of the system to give full play. The essence of the coordination problem is how to manage the dependencies within the system.

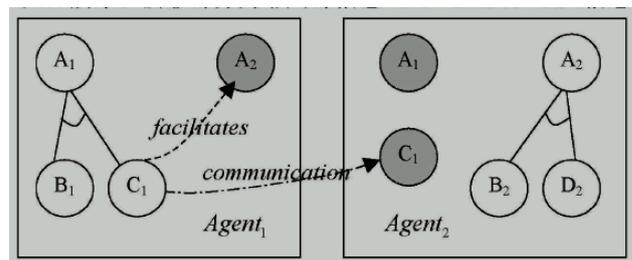


Fig. 3. Internal relationship of MAS system.

Each Agent determines its own objectives, and to achieve the goal of short-term planning. Agent through the exchange of information to determine the interaction of planning and objectives and in order to better coordinate their actions, Agent needs to modify the local planning [13-15].

Before the start of the coordination process, each Agent must establish its own local planning to solve their respective objectives. Each local plan should contain an overall structure. The target information includes the information about the final goal and the importance of each sub target. The activity diagram represents the work stage of each node, such as the main planning and cost of the node, and the expected results, etc. The state information records the information received from other nodes, the time of receipt, etc.

F. Task Analysis, Environment Modeling and Simulation

TASMS refers to task analysis, environment modeling and simulation language, which was proposed by Massachusetts in America. Professor Decker and Lesser put forward this theory when conduction research of GPGP, in order to analyze and predict the system performance.

In MAS system, Agent is able to conduct information reasoning according to environmental information. When Agent finds that it is in a complex environment, its various possible behaviors are interrelated, and each Agent is not isolated.

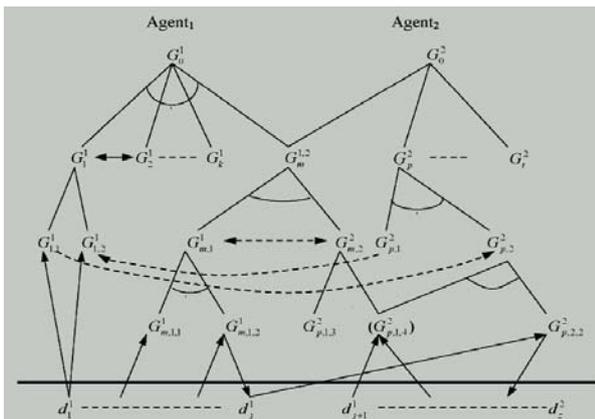


Fig. 4. Distributed object search tree of MAS system.

TAEMS is a tree structure that includes tasks, subtasks, methods, resources, and interrelationship between nodes that means the completion of a goal can affect the performance of other tasks.

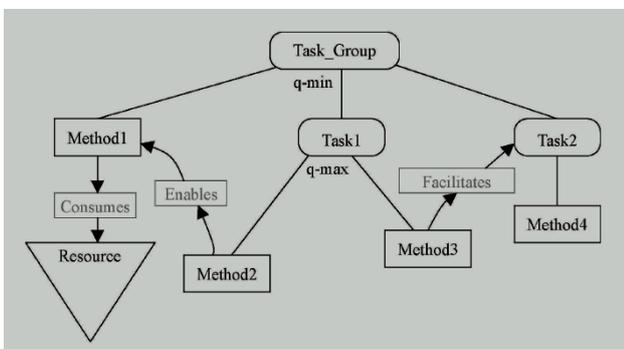


Fig. 5. Task Analysis and Environment Modeling and Simulation.

III. PARTICLE SWARM OPTIMIZATION ALGORITHM

On the basis of wavelet neural networks, a learning algorithm based on particle swarm optimization is proposed in this paper in order to optimize the parameters. Wavelet neural network is a kind of network model based on the combination of wavelet transform and neural network. It inherits the advantages of both of them, which not only has the characteristics of time and frequency, but also has the ability of self-learning, adaptive, robustness, fault tolerance and generalization. However, the construction of wavelet neural network is complex and the computation is very large.

Particle swarm optimization (PSO) is an evolutionary algorithm based on population. Its basic concept is derived from the study of artificial life and predation by bird, which is an optimal algorithm for searching the global optimal solution through interaction and cooperation among individuals. The main feature of PSO is that the concept is simple and the convergence speed is fast, which has become a hot topic in the field of evolutionary computation.

In this paper, the PSO algorithm is further improved, which can improve the local convergence ability and avoid the local extremum. Finally, it is tested by a function simulation experiment, and compared with BP algorithm. The experimental results show that the proposed algorithm not only reduces the number of iterations, but also improves the accuracy greatly.

A. Theoretical Basis

Assume we have a wavelet mother function, denoted as:

$$f(x) \in L^2(R), \psi : R \rightarrow R \tag{1}$$

$$f(x) = \frac{1}{C_\psi} \int_R \int_R W_f(a,b) \psi\left(\frac{x-b}{a}\right) da db \tag{2}$$

Discrete equation is as follows:

$$f(x) = \sum_i w_i \psi\left(\frac{x-b_i}{a_i}\right) \tag{3}$$

Finite term approximate expression of $f(x)$ is:

$$f(x) \approx g(x) = \sum_{i=1}^N w_i \psi\left(\frac{x-b_i}{a_i}\right) + g \tag{4}$$

We can establish a three layer neural network with only one input and one output node, shown in Fig.6.

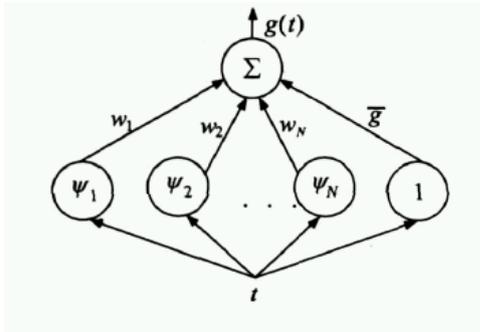


Fig. 6. The Structure of WNN

$$E = \frac{1}{2} \sum_{m=1}^M [f(x_m) - g(x_m)]^2 \tag{5}$$

Where x_m is data sampling point.

B. Wavelet neural network learning algorithm based on particle swarm optimization

In traditional wavelet neural network, the network training method is gradient descent method, which is a local search algorithm. Nevertheless, this method is easy to make the network fall into local extremum, and the network training error is larger. Particle swarm optimization wavelet neural network avoids this shortcoming. The local extremum can be calculated more effectively by adjusting the parameters in the iteration formula.

Particle swarm optimization wavelet neural network training algorithm is as follows:

Determine the particle position vector, velocity vector and dimension.

Determine the number of particles m , and randomly generate particle swarm matrix:

$$\begin{bmatrix} x_{11}, x_{12}, \dots, x_{1D}, v_{11}, v_{12}, \dots, v_{1D} \\ x_{21}, x_{22}, \dots, x_{2D}, v_{21}, v_{22}, \dots, v_{2D} \\ \vdots \\ x_{m1}, x_{m1}, \dots, x_{mD}, v_{m1}, v_{m1}, v_{m2}, \dots, v_{mD} \end{bmatrix} \tag{6}$$

Initialize the parameters of the particle swarm.

Particle swarm optimization (PSO) is an evolutionary computation technique based on swarm intelligence which is inspired by the behavior of birds, fish and human beings. The algorithm simulates the foraging behavior of birds, and makes the group to achieve the best by the collective cooperation among birds, which is similar to the genetic algorithm.

Particle swarm optimization (PSO) is usually regarded as an important branch of swarm intelligence. It is a new evolutionary computation method, and can also be regarded as a form of artificial life. Wavelet analysis has been widely used in the field of image processing, including image

denoising, image fusion and so on. If the problem is considered as a parameter optimization problem, the advantages of PSO can be fully utilized.

The theory of wavelet analysis was developed in the middle of 1980s, which contains abundant mathematical theories, and is the perfect crystallization of functional analysis, such as Fourier analysis, harmonic analysis and numerical analysis. Wavelet neural network is a kind of feedforward neural network based on wavelet multi-resolution analysis and artificial neural network. With the continuous improvement of the theory, wavelet analysis and wavelet neural network have been widely used in the field of image processing.

C. PSO algorithm flow

Set parameters to initialize particle swarm, including random position and speed.

Evaluate the fitness of each particle.

For each particle, compare its current fitness value with the best location $pbest$ it has ever visited. If the current value is better, update the $pbest$ with the current location.

Update particle according to velocity and position update formula.

According to the specific problem, the iterative termination condition is generally chosen as the maximum number of iterations or the optimal position of the particle swarm search to meet the predetermined accuracy threshold.

The inertia weighting factor is introduced, and the modified velocity update formula is as follows:

$$v_{id}^{n+1} = \omega v_{id}^n + c_1 r_1^n (p_{id}^n - x_{id}^n) + c_2 r_2^n (p_{gd}^n - x_{id}^n) \tag{7}$$

Local PSO algorithm without information sharing can be calculated as follows:

$$v_{id}^{n+1} = \omega v_{id}^n + c_2 r_2^n (p_{gd}^n - x_{id}^n) \tag{8}$$

The inertia weight is changed according to the following rules:

$$\omega = \omega_{start} - \frac{\omega_{start} - \omega_{end}}{MaxEpochs} \times Epochs \tag{9}$$

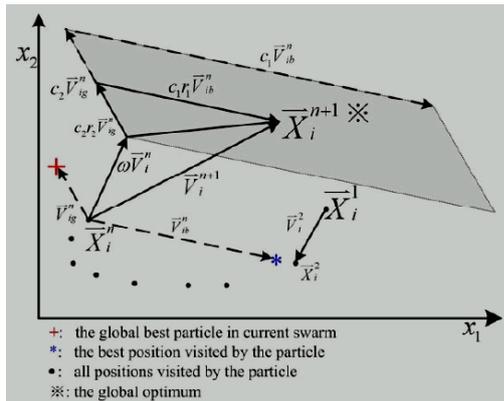


Fig. 7. Particle motion diagram in optimization.

In the practical application of particle swarm optimization, the standard particle swarm optimization algorithm is often not ideal, because of the loss of population diversity. When the particle swarm is about to converge, the attractor of the whole group may be very close to the optimal position. Here the so-called attractor, refers to those with higher fitness of the particles, may be more than one, and they have an important impact on the direction of movement of the entire population.

The particle swarm is randomly generated in the search space and searched in the whole search space. The particles have the ability to remember, and the previously searched information is not lost while the population changing. Particle swarm optimization does not require gradient information of the objective function. Particle swarm optimization's concept is simple, and is easy to implement.

D. Dynamic changes of r- subgroup and K- subgroup

The following Figure 8 shows the schematic diagram of state transition.

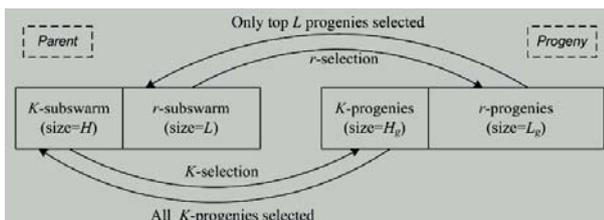


Fig. 8. Schematic diagram of state transition of r- subgroup and K- subgroup.

At present, the method of wavelet neural network based on particle swarm optimization plays an important role in improving the convergence speed and accuracy. In this paper, an improved method based on particle swarm optimization algorithm is proposed. We can see that wavelet analysis and perfect integrated with the network, making the wavelet neural network has the advantages of both, which has a stronger fault tolerance and approximation capabilities. Nothing is perfect, so is the wavelet neural network. With the deep study and improvement of wavelet neural network by

experts and scholars, the method of training wavelet network is enriched.

At present, the wavelet neural network has been applied to various industries at home and abroad, which has achieved good results. Wavelet neural network is a new network structure, which not only has the video localization properties of wavelet transform, but also has the ability of self-learning neural network.

One dimensional wavelet neural network theory can also be used for two-dimensional, three-dimensional, and even multi-dimensional. The wavelet neural network replaces the excitation function of the corresponding hidden layer node with wavelet basis function. Gradient descent method is a first-order optimization algorithm this method can be used to find a function of local extrema.

There are four general conditions of convergence: first, the initial temperature is high enough; second, the equilibrium time should be long enough; third, the low enough termination temperature; fourth, the slow cooling process. In practical applications, it is difficult to meet these four factors. The algorithm is composed of three modules, namely, the genetic operation module, the individual fitness evaluation module and the decoding module. In recent years, particle swarm optimization has been used in many kinds of constrained optimization problems. At present, the theory of PSO dealing with multi-constrained target optimization problem needs to be further studied. The search performance of particle swarm optimization is determined by the balance between global and local search capability. The velocity of the particle in the search for the optimal value is random.

E. Particle Swarm Optimization Based on Hybridization

This algorithm combines the genetic algorithm with particle swarm optimization algorithm. The basic idea is that in each training according to the current value of the probability of hybridization, selecting a certain number of particles, and then all of these particles are selected into the hybrid pool.

The position and velocity of the new particle can be calculated by the following formula:

$$child(x) = r \bullet parent_1(x) + (1 - r) \bullet parent_2(x) \tag{10}$$

$$child(v) = \frac{parent_1(v) + parent_2(v)}{|parent_1(v) + parent_2(v)|} |parent_1(v)| \tag{11}$$

The improved methods mentioned above are more commonly used methods, which are not only easy to understand, but also easy to implement. However, due to the diversity of the algorithm parameters and the corresponding operators, there are still many variants.

IV. CONCLUSION

On the basis of the dialectical materialism methodology, we use the method of literature research to discuss the

construction of Wushu system framework. In this paper, Wushu system can be divided into two parts, Wushu theory system and Wushu technology system. In our research, we mainly use the method of literature, investigation and mathematical statistics. In the research field of multi Agent system, the emergence of the phenomenon is attracting more attention, and the research on the emergence of multi Agent system is becoming a hot topic. Based on wavelet neural networks, a learning algorithm based on particle swarm optimization is proposed in this paper in order to optimize the parameters. We combine PSO and MAS in this paper in order to better evaluate the effect of material arts.

REFERENCES

- [1] Azad, A. "The effect of two weeks morning and afternoon special training program on performance and plasma levels of IL-17 and cortisol in wushu athletes." *Armaghane danesh* 20.11 (2016): 947-961.
- [2] Chang, Erik Chih-Hung, et al. "Relationship between mode of sport training and general cognitive performance." *Journal of Sport and Health Science* (2015).
- [3] Fong, Shirley SM, et al. "Shoulder mobility, muscular strength, and quality of life in breast cancer survivors with and without Tai Chi Qigong training." *Evidence-based complementary and alternative medicine* 2013 (2013).
- [4] Bin, Y. A. N. G. "A Study on the Rehabilitation Training of Sprinters Knee Isokinetic." *Journal of Shangluo University* 4 (2013): 019.
- [5] Guang, S. H. I. "The Rhythm Transform Research in the Teaching and Training of Aerobics." *Journal of Hubei University of Education* 4 (2013): 036.
- [6] Yanxia, Wang, and Zhao Jingguo. "Experimental Study on the Effects of Swiss Ball Core Stability Training on Cardiopulmonary and Its Regulatory Function." *Journal of Jilin Institute of Physical Education* 2 (2013): 023.
- [7] Timm, Ingo J., et al. "Flexible Mass Customisation: Managing Its Information Logistics Using Adaptive Cooperative Multi-agent Systems." *Developments in Logistics and Supply Chain Management*. Palgrave Macmillan UK, 2016. 203-211.
- [8] Fan, Yuan, et al. "Distributed event-triggered control of multi-agent systems with combinational measurements." *Automatica* 49.2 (2013): 671-675.
- [9] Cao, Yongcan, et al. "An overview of recent progress in the study of distributed multi-agent coordination." *IEEE Transactions on Industrial Informatics* 9.1 (2013): 427-438.
- [10] Wen, Guanghui, et al. "Containment of higher-order multi-leader multi-agent systems: a dynamic output approach." *IEEE Transactions on Automatic Control* 61.4 (2016): 1135-1140.
- [11] Kabysch, Anton, Vladimir Golovko, and Arunas Lipnickas. "Influence learning for multi-agent system based on reinforcement learning." *International Journal of Computing* 11.1 (2014): 39-44.
- [12] Chen, Yao, et al. "Multi-agent systems with dynamical topologies: Consensus and applications." *IEEE circuits and systems magazine* 13.3 (2013): 21-34.
- [13] Osório, G. J., J. C. O. Matias, and J. P. S. Catalão. "Short-term wind power forecasting using adaptive neuro-fuzzy inference system combined with evolutionary particle swarm optimization, wavelet transform and mutual information." *Renewable Energy* 75 (2015): 301-307.
- [14] Mandal, Durbadal, Sakti Prasad Ghoshal, and Anup Kumar Bhattacharjee. "Optimized radii and excitations with concentric circular antenna array for maximum sidelobe level reduction using wavelet mutation based particle swarm optimization techniques." *Telecommunication Systems* 52.4 (2013): 2015-2025.
- [15] Bagheri, Ahmad, Hamed Mohammadi Peyhani, and Mohsen Akbari. "Financial forecasting using ANFIS networks with quantum-behaved particle swarm optimization." *Expert Systems with Applications* 41.14 (2014): 6235-6250.