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Research Article

Biomechanical Analysis of Martial Arts Movements Based on Improved PSO Optimized Neural Network

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Monitoring the development trend of martial arts biomechanics, which provides ideas for the scientific research of martial arts. It also proposes discussions and suggestions based on research results in related fields. As a traditional sport in China, martial arts have been around for a long time, and there is still a lot of research space. The biomechanical research of Wushu must be contemporary, forward-looking, and creative, and fully meet the needs of Wushu. This paper adopts the bibliometric method: it conducts statistical analysis on the research status and development trend of core journals and master and doctoral dissertations in the field of sports from 2011 to 2015. It aims to understand the latest developments in the biomechanical research of martial arts routines in the field of Chinese sports. The results show that the BP neural system model effectively improves the accuracy, recall, and F value of test classification. In the Naive Bayes method, the accuracy of the opening report is only 77.1%, the recall rate is 75.8%, and the F value is 76.3%. In the literature method, the accuracy of the opening report is 82.2%, the recall rate is 83.5%, and the F value is 82.8%. In the text method, the accuracy of the opening report is 86.5%, the recall rate is 88.3%, and the F value is 87.2%. In contrast, it outperforms simple Bayesian algorithms and methods in the literature.

1. Introduction

There must be a reason why Chinese martial arts are invincible. However, if it wants to continue to develop, it must be promoted and improved scientifically. This paper analyzes martial arts movements based on biomechanics so as to better promote the development of martial arts. In ancient times, there was Bodhidharma who used reeds to cross the river. In modern times, there is Tai Chi, which breaks the superstition for martial arts and justifies the name of martial arts. The concept of Wushu is the basis for people to understand and study Wushu. In the long historical process, the concept of martial arts has been expressed differently in different periods. Its connotation and extension develop and change with the development of social history and the development of martial arts itself.

Martial arts culture is broad and profound, with the essence of ancient Chinese culture, and has a long history. At the same time, martial arts are the same as traditional Chinese culture. It has accumulated thousands of years of Chinese history, established various schools, and established scientific and technological teachings. It is unforgettable in the inheritance and development of Chinese culture. Sports biomechanics is an important basis for physical education. It plays an important role in promoting the improvement of Wushu technical models and traditional Wushu training methods. At the same time, it is crucial to the development of competitive martial arts which combines technical research and comparative research using the basic beliefs of biomechanics and the research methods of biomechanics.

In today's increasingly prosperous competitive competitions, scientifically and rationally revealing the technical principles of its movements and making practical improvements to improve the competitive ability is the only way for Chinese martial arts. Sports biomechanics is a new discipline that applies the principles of human mechanics and anatomy to study the characteristics and laws of human mechanical movement in sports. The best way to solve the technical problems of martial arts is to optimize an element in the overall technical movement training.

2. Related Work

In this paper, some methods are studied based on the biomechanical analysis of martial arts movements based on the improved PSO optimized neural network. It is necessary to fully apply these methods to research in this field. Peng et al.'s study was for a class of uncertain nonlinear systems in strict feedback form. A predictor-based neural dynamic surface control (PNDSC) design method was proposed [1]. He et al. studied the robust state estimation problem of a class of uncertain neural networks with time-varying delays [2]. Zhao and Ding discussed Stochastic Cohen–Grossberg Neural Networks with Delay. By constructing a suitable Lyapunov function and using the semimartingale convergence theorem, he gave a sufficient condition to ensure that the network is almost definite exponentially stable [3]. Chen et al. believed that Eyeriss is an accelerator for state-of-the-art deep convolutional neural networks (CNN). It optimized the energy efficiency of the entire system, including accelerator chips and off-chip DRAM, for various CNN shapes by reconfiguring the architecture [4]. Goh studied the feasibility of using neural networks to simulate the complex relationship between earthquake and soil parameters and the possibility of liquefaction [5]. Gong et al. designed a deep neural network to achieve the detection of changing and invariant regions. This study provided a detailed analysis of neural networks. It was undeniable that this research has greatly promoted the development of the corresponding field. There was a lot to learn from, and it is necessary to fully apply these studies to the field [6]. Alanis introduced the use results of the recurrent neural network training algorithm based on the extended Kalman filter and its application in electricity price prediction, including two cases of one-step ahead and n-step ahead [7]. Kruthiventi et al. predicted that the human visual attention mechanism is an active area of research in neuroscience and computer vision [8]. Chen et al. neutralized uncertain nonlinear dynamics in agents by exploiting the approximation properties of Radial Basis Function Neural Networks (RBFNNs) [9]. Qian et al. believed that Convolutional Neural Networks (CNN) had been successfully applied to computer vision and speech recognition tasks. Based on previous work on ultra-deep CNNs, he further developed the architecture to improve recognition accuracy for noise-robust speech recognition [10]. Lee believed that two expressions are used in most martial arts, the two aspects of yin and yang. It was based on the balance between movement and stillness of the body and mind [11].

3. The Method and Method of Martial Arts Movement Biomechanics Based on Neural Network

3.1. Neural Networks. At present, neural network coordination research focuses on the integration and sequence of models, while the research on sequence, aggregation, and integration is limited, such as neural function, which links synchronization with the normal and abnormal physiological functions of the nervous system. Neural network systems have overall spatiotemporal dynamic behavior, information dissemination, and recognition problems [12]. The applications of neural networks (such as optimization, associative memory, signal processing, image processing, and pattern recognition) are all related to the dynamic characteristics of the network. The dynamic properties of neural networks also include control properties, functional efficiency, robustness, stability, spatiotemporal evolution models, and dynamic behavior. These are all worthy of further study.

Important factors that cannot be ignored in real biological neural networks are noise and time delay. Moreover, scholars often do not know where to start to theoretically analyze these two influencing factors. All of them are based on numerical simulation methods to illustrate and explain some problems. Whether a theoretical system can be established for analysis is an important research direction. It adopts a quantitative method to describe its dynamic characteristics. It is usually approximated as first-order inertia plus pure lag or second-order inertia plus pure lag.

The topology and statistical properties of neural network systems are closely related to neurocognitive functions. It should be noted that understanding the reality of the small world of brain networks is the first step in understanding how complex networks work and their evolving systems. It measures them experimentally and investigates new connections between them and the dynamic behavior of neural network systems.

3.1.1. Text Classification of Neural Network Learning Activities. It is usually divided into two categories: training and testing, with a total of four stages. After the text is prepared, it represents the text with a model; it builds a text classifier: feature extraction; it uses a trained classifier to classify tests [13]. The general process of text classification is shown in Figure 1:

3.1.2. Text Preparation. It uses lectures, conferences, presentations, and other academic activity content from university websites as training and testing corpora. To improve data quality, word processing is performed before the text is submitted. Chinese word processing often includes word segmentation, segment and deletion, word tagging, word recognition, and vector patterns [14]. Among them, Chinese word segmentation mainly divides each word into a word with independent meaning. Removing stop words means removing words that are not meaningful, such as "de, ah, ah". The preprocessing process of this paper is shown in Figure 2:

3.1.3. BP Neural Network Algorithm. BP network can learn and store a large number of input and output pattern mapping relationships without the need for mathematical equations of this mapping relationship. When solving the inverse kinematics, the simple BP neural network algorithm is prone to fall into the local extreme value, the output error

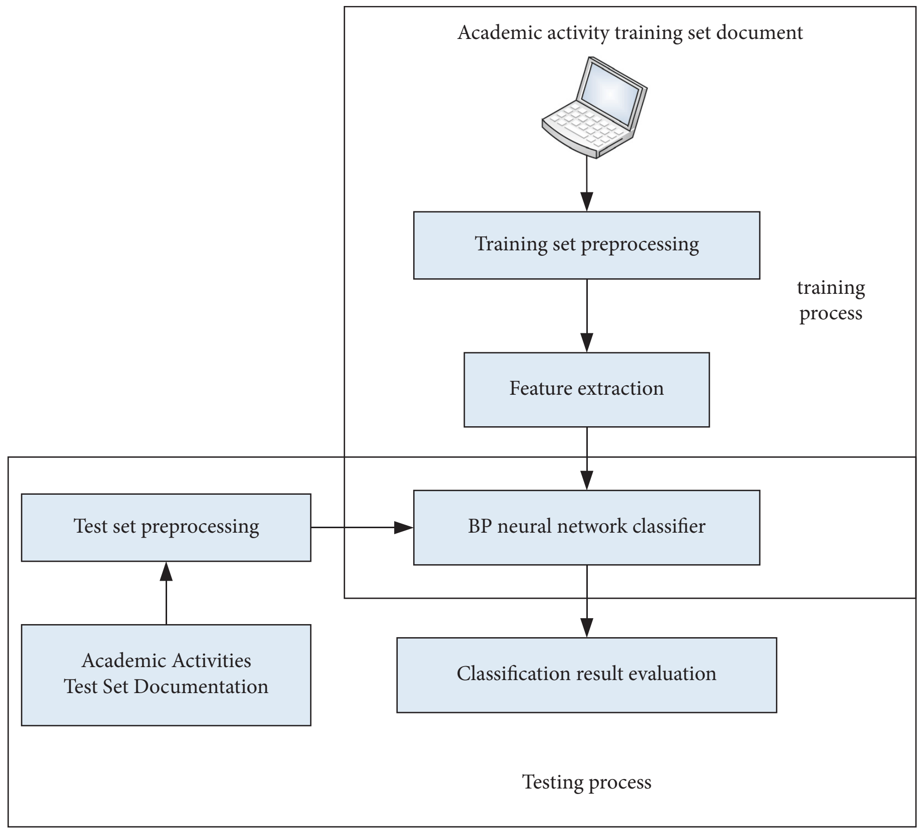


Figure 1: General process of text classification.

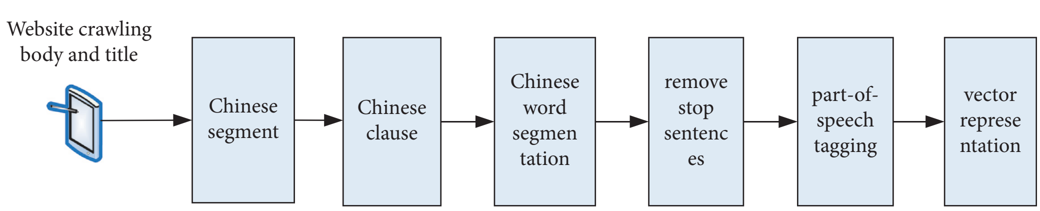


Figure 2: Text preprocessing process.

is too large, and the learning efficiency is not high [15]. In order to solve the above problems, it uses the PSO algorithm to optimize the parameters of the BP neural network so that the search is carried out in the entire solution space. The optimal network parameters obtained by optimization improve the network structure of BP neural network, thereby improving the generalization ability of BP neural network. The algorithm flow is shown in Figure 3:

It normalizes the sampled data. It determines the BP neural network structure and randomly generates initial weights and thresholds and takes the initial BP neural network parameters as the initial value of particles. It calculates the fitness of the corresponding particles and then iteratively finds the optimal solution.

The optimization genetic algorithm is used to optimize the vector output of the RBF neural network. According to the obtained optimal vector, the optimal orthogonalization is determined, and finally, the optimal function and the number of hidden layer nodes are obtained. It results in a better designed IGA-RBF neural network, thereby reducing the network training cost [16]. The algorithm flow of using IGA to optimize the orthogonal-based RBF neural network is shown in Figure 4:

During the training process of the IGA-RBF neural network, the IGA-RBF neural network algorithm is used to continuously optimize the column vector of the output matrix of the hidden layer. It finds the optimal orthogonalization order and determines the optimal activation function center and the number of hidden layer nodes. It designs predictive models of electronic component storage environments and optimal structures.

In this model, according to the IGA-RBF neural network algorithm, the nonlinear mapping relationship between the input and output electronic components storage environment is studied, and the structure of the electronic component prediction model based on the IGA-RBF network is obtained. The electronic component storage environment can monitor and shut down current production [17]. The

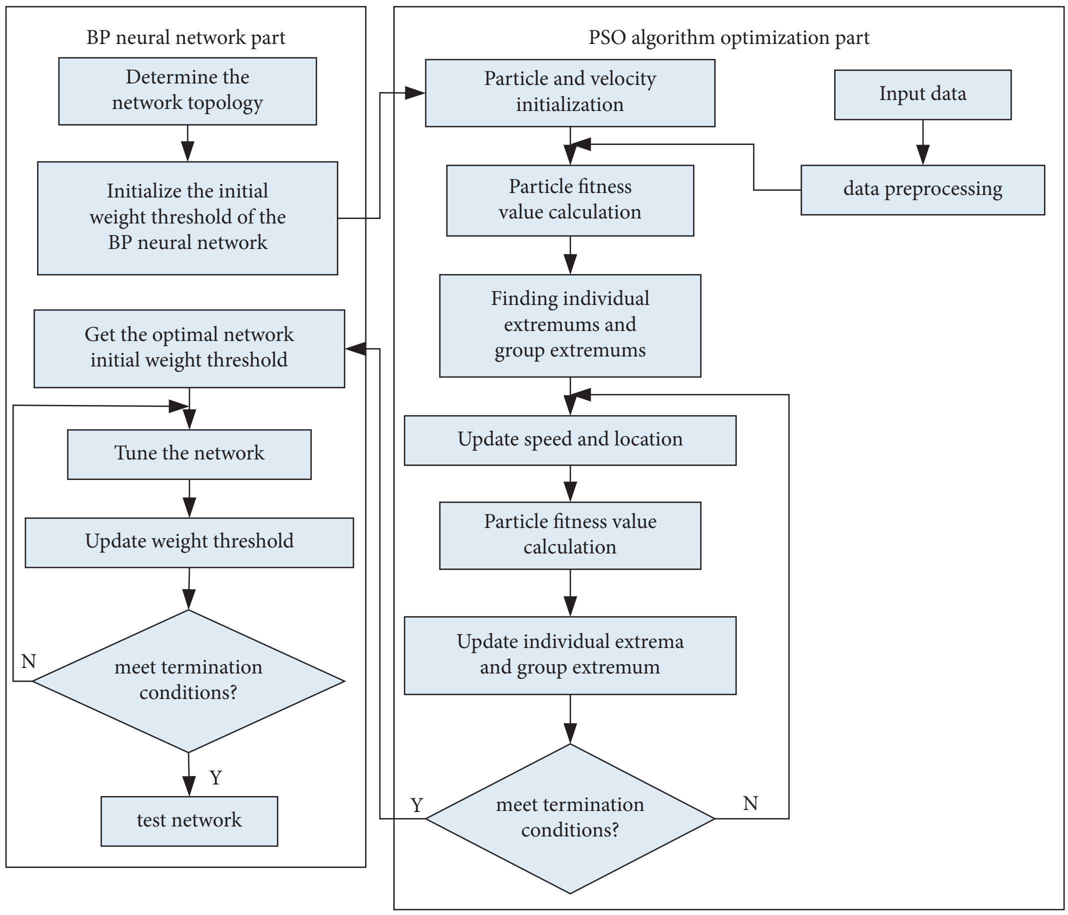


Figure 3: PSO optimization BP neural network algorithm flow.

structure of the electronic component prediction model based on the IGA-RBF network is shown in Figure 5:

3.2. Martial Arts Movement and Exercise Biomechanics. In martial arts, there are many movements that require a certain amount of stability such as jumping and landing, balancing. Equilibrium and stability measures directly affect the completion of the process [18]. According to the final data of male and female athletes of the 2000 Chinese Wushu Championships, 86.59% of the 167 contestants were deducted points for their movements that did not meet the requirements. Among them, the balance lost more points, reaching 129 people, and 50 people in the take-off and landing groups. In addition, each different project has its own special features. Changquan not only has balance problems but also has a high turnover rate. The main problem with the sword is the sweep and turn of the front legs. Due to the nature of Taijiquan, in the training plan and regular professional training, the main factors that cause different differences are the stability when landing and the height when swinging the legs. 158 athletes participating in the 8th Chinese Wushu Taolu Competition (men's team) were interviewed by researchers. The interview found that 35.42% of the 48 athletes who participated in the Changquan competition were deducted because the forefoot movement was not standard. 35.42% of cyclone foot deductions are due to the movement of the front foot during take-off. 56.25% of the sidekicks were deducted due to insufficient balance time. 34.29% of Taijiquan athletes deducted points because of insufficient subject degree. 28.94% of cyclone foot deductions are due to taking off and moving forward. These statistics show that in martial arts, movement stability and coordination are key points in determining an athlete's score.

According to the theory of biomechanics, the instability and stability of the human body are affected by factors such as stability angle, equilibrium angle, height of center of gravity, and supporting surface. Athletes must possess a high level of academic knowledge. Coaches must also analyze and study the stability of the athlete's movement to help the athlete achieve better performance and movement stability at the highest quality. When the researchers analyzed the frontal sweep, they looked at the center of gravity of the support. He believes that the successful completion of the front leg sweep can only be done under the premise of a stable center of gravity. Therefore, the difference in the center of gravity of the body during the rotation of the front leg is the key to resolve [19].

From a biomechanical point of view, three dimensions determine the control between the centers of gravity during a leg sweep. One is to reduce the impact of the rotary shaft.

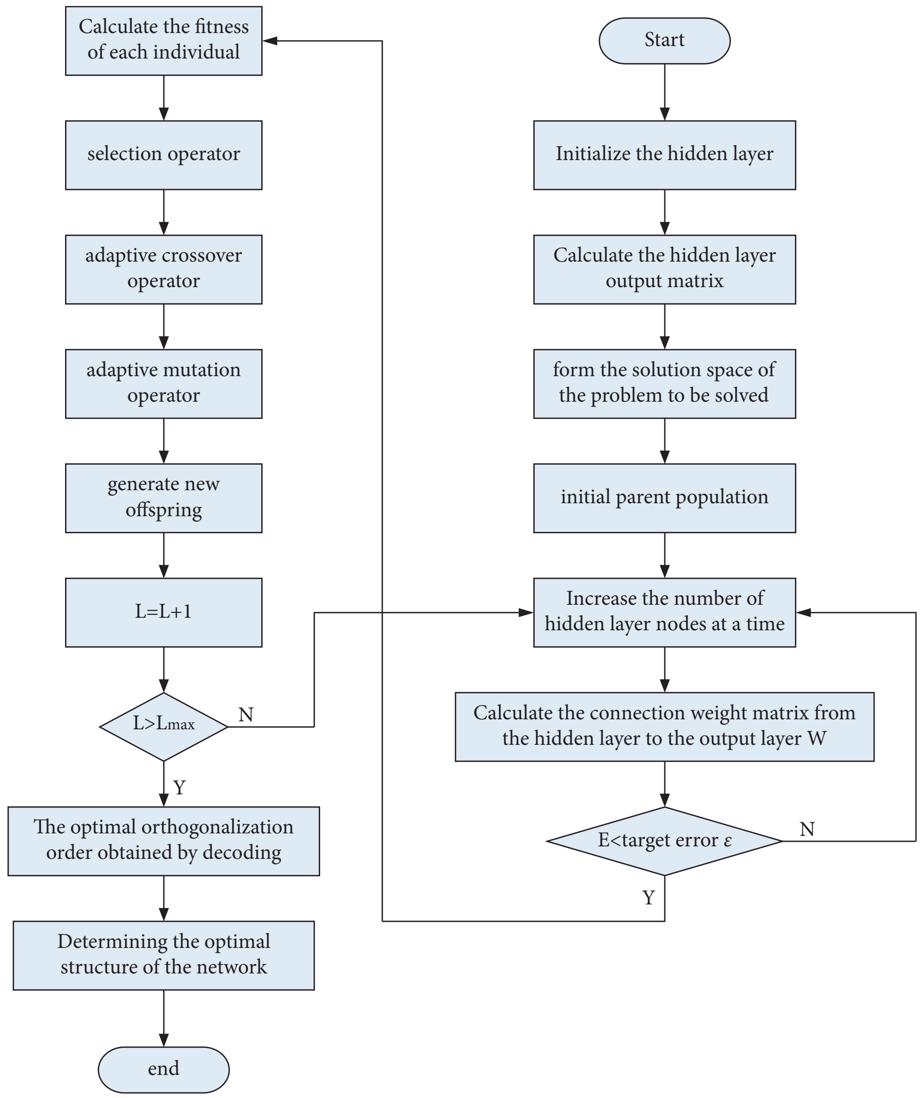


Figure 4: Flow chart of IGA-RBF algorithm.

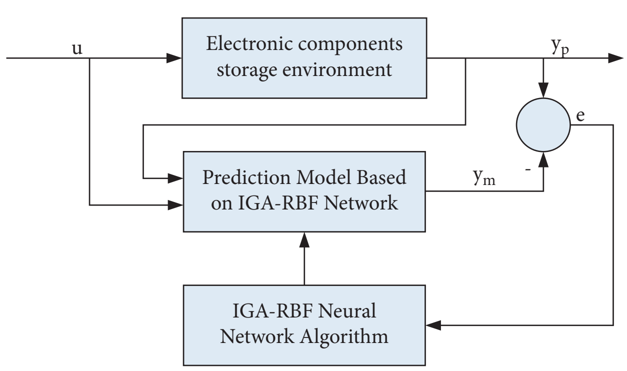


Figure 5: Structure of electronic components prediction model based on IGA-RBF network.

The rotating shaft is less stressed, and the rotating action is stable. To reduce pivot collisions, the front sweep leg should lift the heel each time the leg sweeps. Because when a person lifts their heels, they have less contact with the ground, which reduces traction. Second, the position of the torso must be adjusted. The size of an object depends on whether the object's center of gravity is within the support surface. If the center of gravity falls on the support surface, it may stabilize. The third is to squat down completely, try to lower the center of gravity, and increase the stability of the center of gravity. Research shows that coaches have reason and evidence to guide training when viewed from a biomechanical perspective. Team members use the concept to combine theory with practice to accelerate understanding of the action.

Sports biomechanical analysis not only plays an important role in human movement but is also a powerful tool for athletes and coaches to improve training and teaching [20]. It has developed rapidly in recent years. Many colleges and universities in China, such as science and engineering, medicine, and sports, have opened their own courses, and several universities have opened similar majors. Several scholars from different countries published several textbooks and corresponding textbooks at the same time and obtained different benefits from these studies. The result is up to a new world. Human and object motion analysis is an important factor in sports biomechanics research, and motion transfer trajectory analysis is an important part of defining motion.

Sports biomechanics is mainly studied through analytical application systems. Diagnostic methods such as motion detection method, motion imaging detection method, electromyography analysis method, and three-dimensional power analysis method were used to measure and analyze the content of this study. A report from the 23rd International Annual Conference on Sports Biomechanics found that global research on biomechanics and competitive sports competition remains popular. It simultaneously studies and tests its 3D and EMG. Later, universities also developed new experimental tools and research methods to advance their exercise biomechanics research.

3.3. Application of Biomechanical Principles and Diagnostic Measurement Methods in Martial Arts

3.3.1. Principle of Inertia. The inertia of an object describes how the object rotates. The higher the inertia, the longer the object will maintain its original rotational state. The rotation of the human body includes the rotation between the rotating limbs and the local rotation of the human body under the action of the muscles.

3.3.2. The principle of muscle activation sequence. The theory shows how the human body performs various functions.

When exercising, people usually open the large muscle groups first. It is usually a pinnate muscle attached to a muscle that contracts to generate force. It then moves the muscles in sequence, waiting until the activity of the fast muscles of the hands and feet ends.

3.3.3. Kinematic Principles. Kinesiology is the discipline that studies the changing laws of various parts of the human body. It provides qualitative and quantitative explanations based on the laws of human motion as well as no exposure to the mechanisms or causes of human motion. In martial arts, every part of the athlete's body is in motion, and the speed and form of movement are constantly changing.

3.3.4. Principles of Dynamics. Dynamics is the study of the relationship between the motion of an object and its forces.

3.3.5. Principles of Equilibrium Mechanics. Equilibrium mechanics is a branch of mechanics. It studies the properties and behavior of objects or systems of objects in equilibrium under the action of external forces. The balance mechanics of human motion is related to the mechanism of obtaining and maintaining the condition of balance when the human body is in action, that is, when the force of the human body becomes static or uniform.

The diagnosis of sports technology can be approached from three aspects: kinematics, dynamics, and muscle mechanics. These three aspects show the state of human behavior from three different levels. The development of sports diagnosis technology is mainly based on the development of measurement technology and research on sports training, sports anatomy, sports physiology, and sports biomechanics. In addition to knowledge research, advanced sports science research tools are used to investigate and analyze sports technology. As for the kinesiology index technology, dynamic index, and sports mechanics index, understanding the general laws of these women's technical movements can provide a basis for future scientific training.

3.3.6. Kinesiology Diagnostic Measurements. Kinesiology is the study of a series of events that occur in the human body or device over time. It includes the determination of kinematic spatial characteristics (trajectories of technical movements), temporal characteristics (start and end of technical movements, duration of movements, frequency of movements, rhythm of movements, etc.), and spatial characteristics of motion (angular velocity, angular acceleration).

3.3.7. Dynamic Diagnosis and Measurement. Strength Affects Changes in Human Motion. Therefore, health tests help to objectively and deeply analyze the laws of human behavior.

3.3.8. Diagnosis and Measurement of Muscle Mechanics. Dynamic diagnosis mainly discusses the causes of movement changes, that is, changes in physical activity caused by forces, while muscle mechanics mainly discusses the mechanical properties of the internal muscles of the human body.

3.4. Methods of Martial Arts Movement Biomechanics

3.4.1. Bibliometric Methods. It conducts statistical analysis on the research status and development trend of core journals and master's and doctoral dissertations in the field of physical education from 2011 to 2015, aiming to understand the latest trends in biomechanical research on martial arts routines in the field of Chinese physical education.

3.4.2. Text Classification. Under a certain classification system, the computer will automatically sort and annotate the text to be evaluated.

3.4.3. Technical Simulation and Simulation Research Methods. With the rapid development of computer software and hardware technology, computer technology has begun to be used for simulation and technical detection of motion.

A classification method for optimally correlated data: it uses heteroderivative functions for systematic classification.

4. Experiments on the Biomechanics of Martial Arts Movements Based on Neural Networks

4.1. Classification Distribution of Neural Networks. The test data set uses textual data from various academic activities on university websites. Among them, a total of 9680 school documents were selected for learning testing, 7252 documents were used as training corpus for model preparation, and 2420 documents were used as test corpus to verify the implementation of classification. The experimental data are shown in Table 1.

The test used three different classification algorithms to test the classification: the first time uses the naive Bayes algorithm in the machine learning algorithm, the second time uses the method in the literature, and the third time uses the improved BP algorithm. The experimental results of text classification using three methods are shown in Table 2:

The table shows the precision, recall, and F value of P, R, and F, respectively. As can be seen from Table 2, the neural system algorithm is significantly better than the machine learning algorithm in the classification effect. The proposed BP neural system model effectively improves the accuracy, recall, and F value of test classification. The effect is better than the simple Bayesian algorithms and methods in the literature.

Simulation experiments in optimal data classification: the combination of traditional data classification methods and improved linked data classification methods is considered in the classification method test. The optimal linked data extraction categories of traditional linked data classification methods are shown in Figure 6:

In Figure 6(a), x1–x5 represent the 5 experimental data extracted from the first round of experiment-related attributes. In Figure 6(b), x1–x7 represent the results of 7 experiments extracted from the second round of experiments related to the experimental correlation attribute. As can be seen from Figure 6 as a whole, the number of times of extracting results gradually increases and the accuracy of the data also increases gradually. The optimal linked data extraction category of the improved linked data classification method is shown in Figure 7:

In Figure 7(a), x1–x9 represent the nine experimental data extracted from the first round of experiments to improve the experimental association attributes. In Figure 7(b), x1–x13 represent the results of 13 experiments extracted from the second round of experiments to improve the experimental association attributes. It can be seen from the comparison of Figures 6 and 7 that the improved classification method of the optimal associated data in the motion data can perform various types of refined extraction for the optimal associated data. It guarantees the accuracy of the classification process.

Table 1: Distribution of experimental data sets.

Category	Number of training sets	Number of test sets
Conference	2316	773
Lecture class	2151	718
Public class	1573	526
Opening report	1212	403

Table 2: Classification results of academic activities based on different methods (%).

Category	Experimental method								
	Naive Bayes algorithm			Methods in the literature			Text method		
	P	R	F	P	R	F	P	R	F
Conference	82.5	80.6	81.3	88.2	86.5	87.1	92.2	90.3	91.1
Lecture class	80.1	79.2	79.5	86.8	85.3	86.0	87.7	89.5	88.3
Public class	78.3	76.2	77.3	84.2	85.5	84.7	87.3	88.7	88.2
Opening report	77.1	75.8	76.3	82.2	83.5	82.8	86.5	88.3	87.2

4.2. Distribution of Literature on Biomechanics of Martial Arts Movements. Extensive literature shows that many biomechanical studies on martial arts focus on qualitative analysis of movement techniques using basic theories. It involves the study of martial arts routines, Sanshou, Taijiquan, and so on. Several categories have been approved, and the best information is being obtained to ensure the accuracy of the classification process. From 2011 to 2015, a total of 34 papers were published on the biomechanical research of Wushu routine special movement techniques. The chronological distribution of biomechanical research literature on martial arts routines special movement techniques is shown in Table 3:

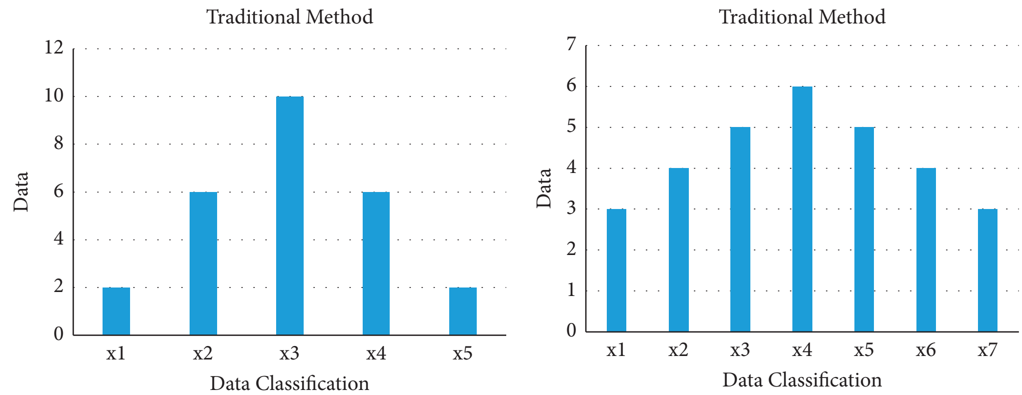
It can be seen from Table 3 that although the related researches decreased slightly in 2015, the biomechanical research on the special movement techniques of Wushu routines is still a continuous hot spot in the field of Wushu research. It maintains a stable research situation. Figure 8 shows the distribution of biomechanical research data on martial arts routines special action techniques:

From the combination of Table 3 and Figure 8, it can be seen that there are many literature published in the biomechanics research journals of Wushu routine special movement technology in the three years from 2012 to 2014, while the dissertations are mainly concentrated in 2011 and 2012. The papers published are mainly concentrated in three types of publications: "Journal of Shanghai Institute of Physical Education" (19.2%), Beijing Sports University Dissertation (15.4%), and "Fighting and Martial Arts Science" (11.5%).

5. Biomechanics of Martial Arts Movement Based on Neural Network

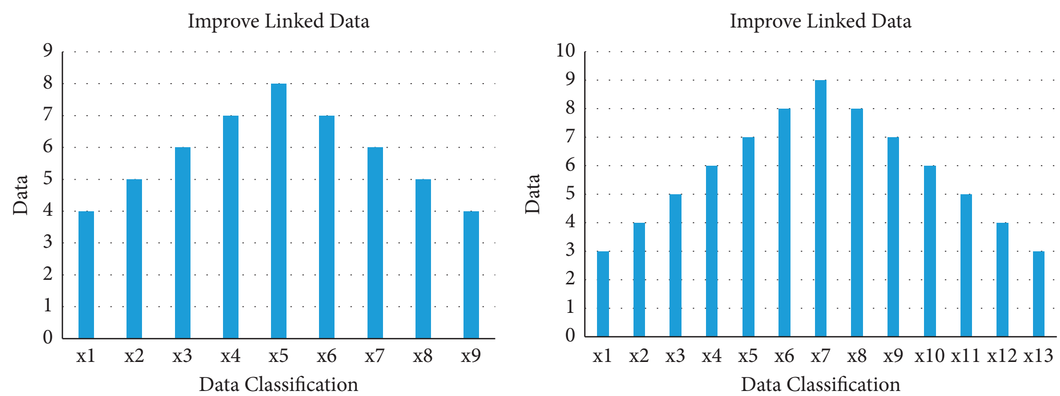
5.1. Algorithms of Neural Networks. Methods for identifying weighted nervous systems use formulas to adjust the weighted results and to add up to the accumulated value.

$$u_x = \frac{G(\mu_x)}{\varepsilon}, \qquad V_x = V_x + u_x. \tag{1}$$



(a) (b)

Figure 6: Experimental results of traditional methods.



(a) (b)

Figure 7: Experimental results of the improved method.

Then, the threshold value T_x is updated piece by piece, as shown in the following formula:

$$T_x = \begin{cases} T_x - 1y\dfrac{V_x}{c}, & u_x \leq 1, \\ T_x - \exp(u_x), & u_x > 1. \end{cases} \quad (2)$$

When $u_x \leq 1$, the strategy divides the accumulated value by the current accumulated frame number C as an average weight of V_x/c. It uses a modified threshold of V_x/c, and the average weight is low. It is greatly affected by the frame itself, and there is no way to obtain an accurate conclusion, so the critical value is increased, and the research will continue in the next frame. When $u_x > 1$, the high recognition level and effect on the results should be emphasized, and the threshold should be lowered to speed up the output. If there is more than one action that satisfies $T_x \leq 0$ after adding a certain frame, the smaller action of T_x is taken as the result.

The critical value of T_x can affect the output period of the recognition result. If the value of T_x is too large, the output period is relatively increased, and the real-time performance is poor. If the value of T_x is too small, the adjustable range of the production cycle is low, and the recognition degree is low. Setting $T_x = 0.69$, the flow chart of this method is shown in Figure 9:

Table 3: Age distribution of biomechanical research literature on martial arts routines.

Document type	2011	2012	2013	2014	2015	Total
Periodicals	2	4	5	5		16
Thesis	6	5		3	4	18
Total	8	9	5	8	4	34

Figure 9 can be roughly divided into four stages. If the current frame has a last frame, the stages are described as follows: (1) it determines the identification weight V_x of the five movements of running, jumping, walking, kicking, and squatting; (2) it uses the neural network model to identify the current single frame and obtains the recognition rate of the candidate action μ_x; (3) it uses a formula to accumulate weights; and (4) it uses formulas to set critical values.

5.1.1. Hopfield Neural Network. A class of artificial neural network models with associative memory function was

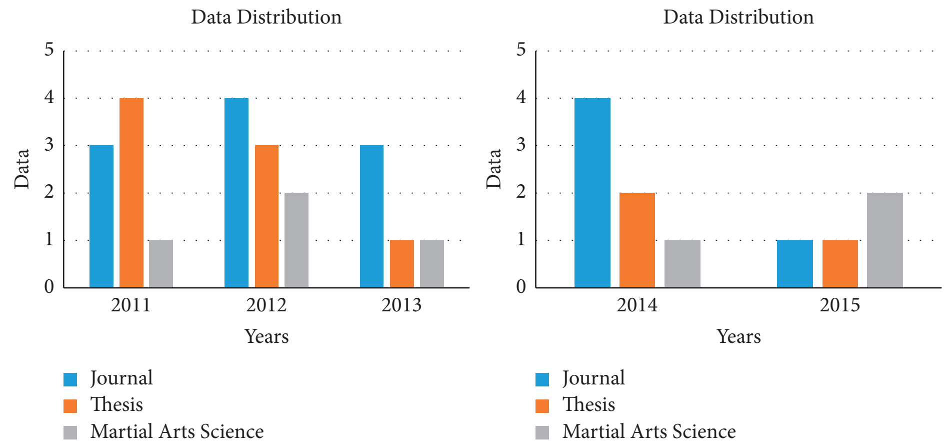


FIGURE 8: Data distribution of biomechanical research on martial arts routines.

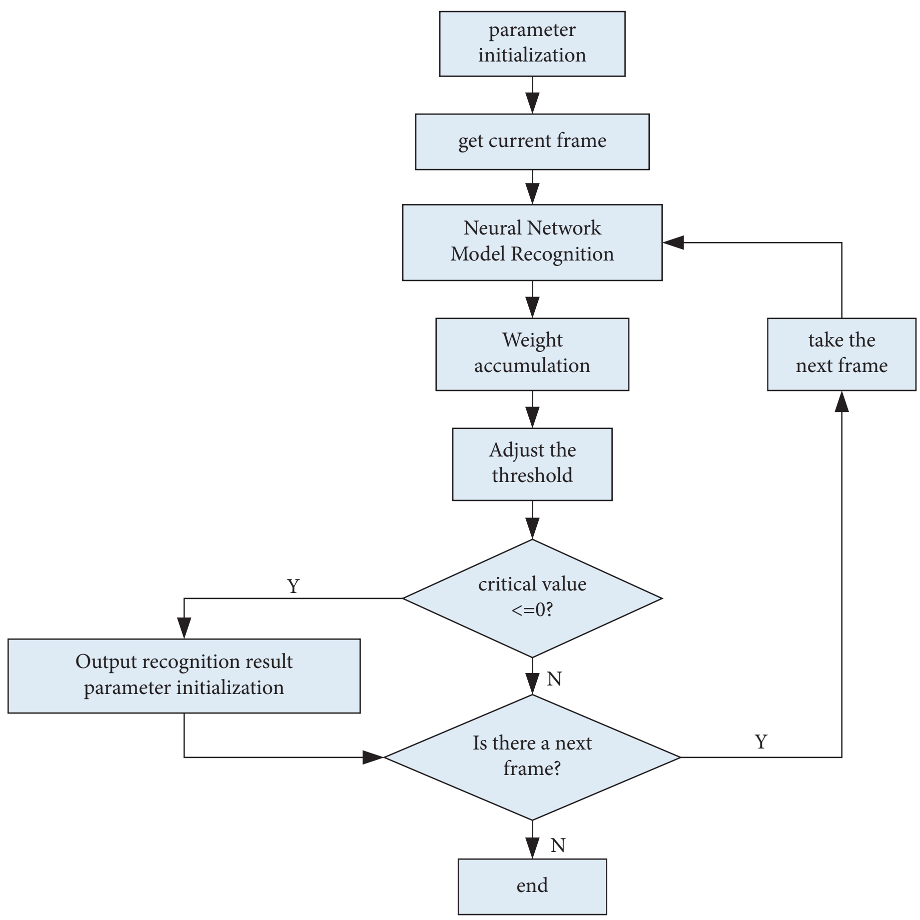


FIGURE 9: Flow chart of weighted recognition algorithm.

proposed by American physicists in 1984. It can be represented by the following system of differential equations:

$$C_m \frac{du_m(t)}{dt} = -\frac{u_m(t)}{R_m} + \sum_{n=1}^{i} T_{mn} g_n(u_n(t)) + M_m, \quad m = 1, \ldots, i, \tag{3}$$

where i represents the number of neurons in the network, $C_m > 0$ is the input capacitance of the mth neuron (amplifier), and u_m is the input voltage of neuron m. $R_m > 0$ represents the input resistance of the neuron, and T_{mn} represents the connection strength of neuron n to neuron m. g_n is the excitation function, and M_m is the applied current.

In the research, it is required that g_m is a Sigmoid function, the connection matrix $T = (T_{mn})$ is symmetric, and the physical parameters meet the constraints. The system of equations is as follows:

$$\begin{cases} \frac{1}{R_m} = \frac{1}{\rho_m} + \sum_{n=1}^{i} \frac{1}{R_{mn}}, \\ T_{mn} = \frac{1}{R_{mn}}, \end{cases} \quad (4)$$

where ρ_m is the internal resistance and R_{mn} is the connection resistance between neurons m and n.

5.1.2. Biassociative Memory Neural Network (BAM). In 1987, researchers proposed a neural system that combines memory. It can be expressed as a system of differential equations as follows:

$$\begin{cases} \frac{\mathrm{d}x_m(t)}{\mathrm{d}t} = -a_m x_m(t) + \sum_{n=1}^{p} \omega_{mn} g_n(y_n(t)) + M_m, \quad m = 1, \ldots, i, \\ \frac{\mathrm{d}y_n(t)}{\mathrm{d}t} = -b_n y_n(t) + \sum_{m=1}^{j} v_{nm} g_m(x_m(t)) + N_m, \quad n = 1, \ldots, p. \end{cases} \quad (5)$$

The BAM neural network changes the layer structure of the Hopfield neural network into a two-layer structure. Neurons are arranged in two layers, and neurons in the same layer are not connected. The neurons in different layers are connected to each other, and information is transmitted bidirectionally between the neurons in the two layers. Cellular Neural Network: the Cellular Neural Network (CNN) was first proposed in 1988. A two-dimensional structure of the CNN state formula can be represented by the following differential equations:

$$C\frac{\mathrm{d}V_{x_{mn}}(t)}{\mathrm{d}t} = \frac{V_{x_{mn}}(t)}{R_x} + \sum_{k,l\in I_r(m,n)} A(m,n;k,l)V_{ykl}(t) + \sum_{k,l\in I_r(m,n)} B(m,n;k,l)V_{ukl}(t) + M, \quad 1 \le m \le I,\ 1 \le n \le J. \quad (6)$$

Its output formula is

$$V_{ykl}(t) = \frac{1}{2}\left(\left|V_{xkl}(t) + 1\right| - \left|V_{xkl}(t) - 1\right|\right). \quad (7)$$

A neural cell network consists of many nonlinear circuit units called cells. Similar in structure to cellular automata, it is an analog circuit with a mesh-like structure. Each cell has connections only to its neighbors.

5.1.3. Cohen–Grossberg Neural Network. The Cohen–Grossberg Neural System was proposed in the literature in 1983 as a model of competition and cooperation. It aims to create a way to independently organize and adapt to the structure of the nervous system. The formula is as follows:

$$\frac{\mathrm{d}u_m(t)}{\mathrm{d}t} = -a_m(u_m(t))\left\{b_m(u_m(t)) - \sum_{n=1}^{j} a_{mn} g_n(u_n(t))\right\}, \quad m = 1, \ldots, j. \quad (8)$$

By combining models of such nervous systems, it can be seen that the Cohen–Grossberg nervous system is more common, such as the Hopfield nervous system, the dual associative nervous system, and the cellular nervous system. All these are special cases of the Cohen–Grossberg nervous system.

5.2. Wushu Movements. The purpose of practicing martial arts is the process of training one's own strength. The cover-hand humping is mainly divided into left-handed and right-handed humerus. It is divided into rubbing feet and arms, raising knees and legs, lunges and punches, and turning over and rotating arms.

5.2.1. Knee Lift and Leg Lift. The offensive and defensive strategy of raising the knee and closing the leg is that when the opponent presses the left wrist, the opponent should turn to the left. It changes the opponent's movement state and the stability of the center of gravity so as to crack the opponent's attack method.

The gradual development of the biomechanical movement system and the high requirements for the development of Wushu mean that Wushu education is no longer limited to a single discipline. It has caught the attention of scientists over the past 10 years. Compared with a sports major in a comprehensive university, the development of sports biomechanics in professional sports colleges is an important reason for the production of scientific research results. Overall, there is less research on health promotion and injury prevention and less research and development. Compared with the research results of other countries, its experimental equipment has certain limitations. An important factor in its development was the study of this biomechanics. Researchers should actively participate in the research of relevant departments in order to make the following recommendations:

(1) Research must be advanced, contemporary, and creative and pay attention to systematic, in-depth, and comprehensive research. From different perspectives, research can be more comparative. It can draw research experience from other aspects.
(2) It is necessary to expand the research on Wushu injury and rehabilitation. The study of sports biomechanics should not be underestimated in the aspects of athlete selection, sports technology innovation, and equipment and tool development. It is necessary to strengthen development-oriented research and improve the awareness of innovation and creativity.
(3) More advanced measurement tools should be mainly developed or introduced by scientific research institutions. Researchers should actively pursue research trends in the field and actively seek ways to learn advanced research methods.
(4) The biomechanical research of Wushu sports is carried out from two aspects of mechanics and physiology at the same time. Therefore, researchers must have multidisciplinary knowledge reserves and research capabilities.

5.3. Technical Analysis of Sports Biomechanics. In the analysis and research of motor skills, dividing motor skills is the main task phase. It determines the description of the motor skill characteristics. It determines the start and end times of the movement technique. Once the scope of the movement technique is determined, the various stages of the movement are divided to make them easier to analyze and study. For example, a single-step cycle is a running motion, and two supports and space make a single step.

5.3.1. The Basic Division of Action Phases. "Action" refers to the mode of coordinated movement of the muscles, bones, and joints of the limbs and torso under a certain time and space. It can either refer to a complete activity pattern composed of multiple parts, or it can refer to a specific activity pattern of a part. Various forms of simple basic actions can be combined into a complex action. In order to facilitate comprehensive learning and analysis of actions, they should be distinguished from each other. Due to certain circumstances, each component of the action is different. It can refer to the following situations and divide the action into several stages.

5.3.2. Anatomical Conditions and Forms of Working Muscles. For example, when a person jumps from a high jump, the buffer phase of the take-off movement needs to be completed by bending the knee joint. The initial stage of the take-off movement requires a process of knee extension.

5.3.3. The Nature of the Force. For example, when running, when the center of gravity of the human body falls on the end of the fulcrum, if the direction of human motion is opposite to the direction of action of the kicking force, it is considered as the resistance stage of running.

5.3.4. Action Direction. For example, when the arm swings forward relative to the human body during running, it is called the forward swing of the arm. When jumping high, the swinging leg mainly swings upward relative to the ground, which is called the upward swing of the swinging leg.

5.3.5. The Task and Nature of the Action. It is like a preswing when throwing a Frisbee. The phase division of the last effort action is named according to the specific task of the action.

5.3.6. Human Working Environment. According to the relationship between the human body or a part of its motion and the surrounding environment, it can be divided into parts and components of movements such as support, flight, and landing.

Athletes of different levels must follow the same rules when performing movement techniques. That is, the principle of action technique is the same. However, athletes of different levels have different levels of physical quality development. These differences are reflected in the technical characteristics of athletes during sports. The biomechanical characteristics of high-level athletes' action techniques can reflect the development prospects of sports techniques. A biomechanical understanding of high-level athlete's sports techniques can help improve sports technology theory and sports technology teaching.

When people jump, cartwheel, walk, etc., they find a set of equations of motion in space, which contains the biomechanics of human movement. The system of equations looks like this as follows:

$$
\begin{aligned}
& x\frac{\mathrm{d}V}{\mathrm{d}t} = P\cos\alpha - M - xg\sin\theta, \\
& xV\frac{\mathrm{d}\theta}{\mathrm{d}t} = P\sin\alpha + N - xg\cos\theta, \\
& J_z\frac{\mathrm{d}\omega_z}{\mathrm{d}t} + (J_n - J_m)\omega_n\omega_m + J_{mn}\left(\omega_n^2 - \omega_m^2\right) = M_z, \\
& \frac{\mathrm{d}m}{\mathrm{d}t} = V\cos\theta, \\
& \frac{\mathrm{d}n}{\mathrm{d}t} = V\sin\theta, \\
& \frac{\mathrm{d}\vartheta}{\mathrm{d}t} = w_z, \\
& \alpha = \vartheta - \theta, \\
& \delta_z = f(e_1),
\end{aligned}
\tag{9}
$$

where θ is the inclination angle when jumping in motion; ϑ is the forward inclination angle when pitching in running motion; α is the vertical offset data in the rollover movement; m and n are the vertical position and horizontal attitude in motion; ω_m and ω_n are the moment of the coordinate system Om_1 and axis On_1 in the nonaccelerated motion state; δ_z is the body declination at any posture; e_1 is the longitudinal motion error of the control; x is the mass of the human body; M and N are the airlift force and lateral force when running and jumping, respectively; X_z is the pitching moment; J_z means that the inertia in motion rotates with the transformation of the coordinate system; J_{mn} is the moment of inertia Oz_1 of the motion space model to the velocity coordinate system.

6. Conclusion

The principle of sports biomechanics runs through every martial arts movement technique, providing theoretical guidance for the rational and scientific completion of the movement. The technical movements of martial arts are all-encompassing and complicated, but they cannot exist independently of the essential structure of "force" anyway. Qualitative and quantitative analysis of the general principles of sports biomechanics in martial arts movement technology is the foothold and focus of the future development of martial arts technology. The principle of sports biomechanics can really and truly serve martial arts, and even, other sports technical movements are the direction of the efforts. The authors hope that this article will be able to draw some new ideas and also hope that the majority of sports biomechanics and physics workers can participate in the research of martial arts and jointly prepare for a new peak in the development of Chinese martial arts.

Data Availability

The data that support the findings of this study are available from the corresponding author upon reasonable request.

Conflicts of Interest

The authors declare that there are no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

References

[1] Z. Peng, D. Wang, and J. Wang, "Predictor-based neural dynamic surface control for uncertain nonlinear systems in strict-feedback form," *IEEE Transactions on Neural Networks and Learning Systems*, vol. 28, no. 9, pp. 2156–2167, 2017.

[2] H. He, F. Gang, and C. Jinde, "Robust state estimation for uncertain neural networks with time-varying delay," *Journal of Jishou University (Natural Sciences Edition)*, vol. 19, no. 8, pp. 1329–1339, 2019.

[3] H. Zhao and N. Ding, "Dynamic analysis of stochastic Cohen–Grossberg neural networks with time delays," *Applied Mathematics and Computation*, vol. 183, no. 1, pp. 464–470, 2006.

[4] Y. H. Chen, T. Krishna, J. S. Emer, and V. Sze, "Eyeriss: an energy-efficient reconfigurable accelerator for deep convolutional neural networks," *IEEE Journal of Solid-State Circuits*, vol. 52, no. 1, pp. 127–138, 2017.

[5] A. T. C. Goh, "Seismic liquefaction potential assessed by neural networks," *Journal of Geotechnical Engineering*, vol. 120, no. 9, pp. 1467–1480, 1994.

[6] M. Gong, J. Zhao, J. Liu, Q. Miao, and L. Jiao, "Change detection in synthetic aperture radar images based on deep neural networks," *IEEE Transactions on Neural Networks and Learning Systems*, vol. 27, no. 1, pp. 125–138, 2016.

[7] Alanis and Y. Alma, "Electricity prices forecasting using artificial neural networks," *IEEE Latin America Transactions*, vol. 16, no. 1, pp. 105–111, 2018.

[8] S. S. S. Kruthiventi, K. Ayush, and R. V. Babu, "DeepFix: a fully convolutional neural network for predicting human eye fixations," *IEEE Transactions on Image Processing*, vol. 26, no. 9, pp. 4446–4456, 2017.

[9] C. L. P. Chen, G. X. Wen, Y. J. Liu, and F. Y. Wang, "Adaptive consensus control for a class of nonlinear multiagent time-delay systems using neural networks," *IEEE Transactions on Neural Networks and Learning Systems*, vol. 25, no. 6, pp. 1217–1226, 2014.

[10] Y. Qian, M. Bi, T. Tan, and K. Yu, "Very deep convolutional neural networks for noise robust speech recognition," *IEEE/ACM Transactions on Audio, Speech, and Language Processing*, vol. 24, no. 12, pp. 2263–2276, 2016.

[11] A. C. Lee, "3. Practice through movement and practice through motionlessness," *Review of Artistic Education*, vol. 15, no. 1, pp. 151–154, 2018.

[12] B. Moore, D. Dudley, and S. Woodcock, "The effect of martial arts training on mental health outcomes: a systematic review and meta-analysis," *Journal of Bodywork and Movement Therapies*, vol. 24, no. 4, pp. 402–412, 2020.

[13] C. Hu, Z. Yi, and M. K. Kalra, "Low-dose CT with a residual encoder-decoder convolutional neural network (RED-CNN)," *IEEE Transactions on Medical Imaging*, vol. 36, no. 99, pp. 2524–2535, 2017.

[14] G. Singh, D. Kaushik, H. Handa, G. Kaur, S. K. Chawla, and A. Ahmed, "BioPay: a secure payment gateway through biometrics," *Journal of Cybersecurity and Information Management*, vol. 7, no. 2, pp. 65–76, 2021.

[15] H. Quan, D. Srinivasan, and A. Khosravi, "Short-term load and wind power forecasting using neural network-based prediction intervals," *IEEE Transactions on Neural Networks and Learning Systems*, vol. 25, no. 2, pp. 303–315, 2014.

[16] A. Mahmoud and M. M. El-Gayar, "A novel hybrid bio-inspiration technique for service composition," *Journal of Cybersecurity and Information Management*, vol. 0, no. 1, pp. 05–14, 2019.

[17] A. Lindsay, S. Carr, S. Cross, C. Petersen, J. G. Lewis, and S. P. Gieseg, "The physiological response to cold-water immersion following a mixed martial arts training session," *Applied Physiology Nutrition and Metabolism*, vol. 42, no. 5, pp. 529–536, 2017.

[18] G.-S. Lee, "A study on 1970s subculture through the reception of Hong Kong martial art films-focusing on the sentiments of discount theater audiences," *Journal of Popular Narrative*, vol. 23, no. 3, pp. 377–414, 2017.

[19] E. Mashkovskiy, A. Magomedova, and E. Achkasov, "Degree of vision impairment influence the fight outcomes in the Paralympic judo: a 10-year retrospective analysis," *The Journal of Sports Medicine and Physical Fitness*, vol. 59, no. 3, pp. 376–379, 2019.

[20] I. Loturco, L. A. Pereira, C. Winckler et al., "Performance changes of elite paralympic judo athletes during a paralympic games cycle: a case study with the Brazilian national team," *Journal of Human Kinetics*, vol. 60, no. 1, pp. 217–224, 2017.