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# Exploration Analysis Based on Improved BP Neural Network in Human Body Movement

Yongqiang Li

*(Software Technology Vocational College, North China University of Water Resources and Electric Power, Zhengzhou 450045, China)*
*1696450309@qq.com*

***Abstract***

*This paper fist gives common definition of human body movement data model and establishes human body movement model according to kinemaics of human body, and then adopts improved BP neural network to analyze and predict human body movement. Introducing genetic algorithm into BP neural network can better overcome problems caused by random preliminary value of BP neural network during the process of determining network structure, such as network vibration and it is easy for network to fall into local solution. In addition, generalization ability of neural network can be effectively improved. It can be obtained from analyzing and comparing simulation experiments that the accuracy of BP neural network algorithm in analyze and predict human body movement is slightly improved.*

***Keywords****: BP neural network; genetic algorithm; hurt in human body movement*

## 1. Introduction

As the application of data mining technology is playing a huge role in various industries, especially in recent years, certain progress has been made in hurt of human body movement [1]. Domestic and foreign scholars have made some researches into data mining in medicals, and it is proposed in literature [2] that data mining technology should be used to analyze previous data so as to obtain certain effect of guidance. Literature [3] based on the current relatively popular in the decision tree algorithm of data mining technology, and combining the students' sports test scores, and implement the related data mining to the school, better use of the teaching of physical education teachers to the students. Literature [4] put forward by collating data mining aspects of the sports science research literature, the use of sports statistics research methods, the literature according to the sports management, competition, training, application, teaching, review, and several other classified analysis. Literature [5] is proposed using the literature material method of data mining in the field of sports and related a further study on the status quo of the application, it is concluded that the data mining technique analysis in sports, body mass index and biochemical indicators monitoring application. Literature [6] is put forward in the sports industry informatization produced large amounts of data, in the data analysis and processing. Literature [7] technique analysis, data mining is put forward to the match the national physique monitoring and movement monitoring data give full play to their potential value, from the establishment of sports data platform, mining tools and cross with other technology integration is described.

Based on the above literature based on improved BP neural network to analysis and prediction of medical accidents. Genetic algorithms in the algorithm first, overcoming the initial weights of BP neural network randomness and network structure in the process of determining the network oscillations, as well as the network trapping in local solutions. Simulation analysis based on improved BP neural network in the prediction of accident of medical quality supervision higher accuracy.

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## 2. Description of Human Body Movement Model

Defined model to simulate the connections of each joint by kinematic chain, all joints are organized into a tree-like structure, all nodes except the root node has a parent node and turn in the coordinate system of the parent root node in addition to turning also to translation. Human movement can be described as:

$$V(t) = (T_{root}(t), R_{root}(t), R_1(t), R_2(t) \ldots R_n(t)) \tag{1}$$

In the formula, $T_{root}(t)$ and $R_{root}(t)$ refer to translation and rotation of human root node respectively, $R_{root}(t)$ refers to rotation of the node $i$ around parent node.

Define the energy of a certain node, and set the zero energy stance of local stance $i$ as $B_i^0$, and its elasticity coefficient of its movement is $k_i$. Driven by muscle and in the local coordinate, when the node rotates to $V_i^t$, its node energy is expressed as follows:

$$PE = k_i(\alpha \cos(\frac{B_i^0 \square V_i^t}{|B_i^0||V_i^t|}))^2 \tag{2}$$

Define the expression of joint kinetic energy with $N(i)$ referring to the aggregate of node $i$ and all the subsequent nodes; set $V_i^t$ as the direction of the body $i$ in local coordinate system at the moment $t$, and $M_i$ refers to the synthesis of all the nodes in $N(i)$, which are expressed as follows:

$$M_i = \frac{\sum_{j \in N(i)} m_j c_j}{\sum_{j \in N(i)} m_j} \tag{3}$$

Therefore, the expression of the energy of muscle towards the change of stance in node $i$, that is, the energy $KE$ of node, is as follows:

$$KE = \frac{1}{2} m_i v_i^{t2} + \frac{1}{2} (\sum_{j \in N(i)} I_i^t) w_i^{t2} \tag{4}$$

## 3. Introduction to Basic Algorithm

### 3.1. BP Neural Network

BP neural network is a one-way transmission networks, is usually determined by the input layers, hidden and output layer. It propagates the signal for forward and reverse transmission. When reverse Delta learning rule adjusting the weights. In turn in the forward pass (5) calculate the inputs and outputs of each layer until the output layer. When the output is not expected back-propagation of the output, the error between the desired and the actual output to adjust weights and thresholds. Weight adjustment formula see formula (6).

$$\begin{aligned} W_i &= \sum_j w_{ij} x_j + \theta \\ y_i &= f(W_i) \end{aligned} \tag{5}$$

In formula (5), $W_i$ is the active value of the node at level $i$, $\theta_i$ is the threshold, $x_j$ is the input signal, $w_{ij}$ is the connection weight between the node at level $i$ and the node at level $j$, $y_i$ is the output value of the node at level $i$.

 

$$w_{ij}(t+1) = w_{ij}(t) + \frac{\partial E}{\partial w_{ij}} \tag{6}$$

In formula (6), $\frac{\partial E}{\partial w_{ij}}$ is the error between the output of neural network expectations and the real output.

### 3.2. Neutral Network Training

Set input mode for $x_l^i$, k is the number of data input tuples in $i \in \{1, 2, \cdots k\}$, n is the dimension of input mode, $w_l^m$ is the connection weight between the l neuron in input level and the m neuron in hide level, then the active value of the m neuron in hide level is (7).

$$\partial^m = f(\sum_{l=1}^{n}(x_l^i w_l^m) - T^m) \tag{7}$$

In the formula, $f(x)$ is the active function of hide neuron, this paper takes $f(x)$ as Hyperbolic tangent function，$f(x) = 1 - \frac{2e^{-x}}{e^x + e^{-x}}$, $T^m$ is the bias of the m neuron in hide level, it maps larger activation values to a smaller range [-1，1], once, the active value of neuron in hide level is calculated，the output value of the p neuron in output level can be obtained. The formula is:

$$S_p^i = \sigma(\sum_{m=1}^{h} \partial v_p^m) \tag{8}$$

In the formula, $\sigma(x)$ is the activation function of neurons at the output level, select $\sigma(x) = \frac{1}{1+e^{-x}}$, which will reflect the larger activation value into the relatively smaller interval [0, 1]. $v_p^m$ is the linking right of $p$ neuron at the output level from neuron $m$ at the hidden level.

### 3.3. Description of Genetic Algorithm

Genetic algorithm (GA) is based on biological evolution principle of a robustness of since adapted optimization method. Genetic algorithm followed through based on problem sample adapted degrees function on initial groups select, and cross and variation operation, to guide learning and determine search of direction. due to used population of way organization search, so it can in global solutions space within of multiple regional within sought optimal solutions, and special for mass parallel processing.

## 4. Mining Algorithm based on Improved BP Neutral Network

### 4.1. Proposition of Problems

Due to genetic algorithm of search not rely on gradient information, also not need solution function can micro-, only need solution adapted degrees function in constraints conditions Xia can solutions. and genetic algorithm has global search of characteristics, with genetic algorithm optimization optimization neural network of connection right and network structure, can better to overcome BP neural network of initial right value of randomness and network structure determine process in the by brings of network oscillation, and network very easy into local solutions problem, and effective improve neural network of generalization capacity. Therefore, using genetic algorithm for global search feature, look for the most suitable

network connection power and network structure to change BP algorithm of gradient-dependent instructions, so as to achieve the network structure and network optimal allocation of the initial connection weights and thresholds. In the switching coefficient is introduced in this article, used $k$ to represent the neural connections between network nodes evaluate to 1 or 0, to say there is any connection between the two nodes, respectively. Mathematical description of genetic-neural network for optimization problems are as follows:

$$E_1 = \sum_{k=1}^{N_1} \sum_{t=1}^{n} [y_k(t) - \hat{y}_k(t)] \tag{9}$$

Herein, $E_1$ is the total error of network, $y_k(t)$ is the theoretical output of network, and $\hat{y}_k(t)$ is the actual output of network. Herein, $\hat{y}_k(t)$ is as follows:

$$\hat{y}_k(t) = \sum_{i=1}^{m} w_{ij} x_i(t) + \theta_j \tag{10}$$

Suppose $E_2 = \dfrac{\sum_{k=1}^{N_1} \sum_{t=1}^{n} [y_k(t) - \hat{y}_k(t)]}{N - N_1}$ is the test sample average mean square error for network output data reliability estimates. The value $E_2$ is small, represents the reliability of the network output, on the other hand, the network output is less reliable.

During the application process of neural network, due to the approximate nature of samples cannot be accurately known, even in conditions of network error $E_1$ is zero, $E_2$ may not be able to guarantee to meet the requirement. $E_1$ will often appear very small, and does not meet the requirements, the network ultimately loses value. So the algorithm's design should make $E_2$ less than a given error $\varepsilon$, and meet output reliability.

### 4.2. Design of Algorithm

Algorithm in this paper by using the genetic algorithm is determined primarily by the BP network in basic solution space (network connection power and neuron threshold value range), by means of gene selection, crossover mutation operation. On the sample individual merit evolution constantly, until the evolution (the general evolution algebra by initial given) generation, selection of individual fitness in the largest individual to determine the network structure and initial weights and thresholds.

(1) Genetic Code

Code string encoded in this article by the switching coefficient coding, weighting coefficient coding consists of two parts. Switch coding hidden layer neurons and neurons in input and output connection status, switch coding string length $l_1$ can be determined implicitly by the initial number of neurons. Actually the number of hidden layer neurons determined by switching the number of coefficients in the 1. Weighting coefficients represent network connections right, float-encoding, string length $l_2 = (m+n) \times l_1$, where m is the number of input nodes and n is the number of output nodes. Coding according to a certain order of cascading into a long string, each string corresponds to a set of network structure and connection weights.

(2) Determine Space of Basic Solutions

Three levels of BP network is used to preliminarily determine the space of basic solutions (the range of network connection weights and neuron thresholds). First of all set up a network of training and network training error $\varepsilon_1$, enter the training samples for training, then enter test sample are error $\varepsilon_2$, error $\varepsilon_1$ and $\varepsilon_2$ are more satisfactory, weights the maximum connections

 

value and the minimum value is denoted as $u_{\max}$ and $u_{\min}$, respectively, to the interval $[u_{\min}, u_{\max}]$ as a connection of the right solution space.

(3) Fitness function computation

In genetic algorithms, the fitness function is only required for inputting can be calculated to compare the non-negative result, so this network error function is used as a fitness function, and that error the individual adaptation of small, concrete expressed as

$$F(x) = \sqrt{\sum_{k=1}^{N_1} \sum_{t=1}^{n} [y_k(t) - \hat{y}_k(t)]^2} \tag{11}$$

Calculate the fitness of each individual in the group, by switching coefficients are the number of hidden nodes of the network, by the weight of the digital network connections right, enter the training samples, calculate the fitness of each individual according to the (11).

(4) Crossing and variation factor

Crossing is by larger of probability from groups in the, random select two individuals. Exchange these two individuals of some bit, exchange of purpose is produced new of gene combination, to limit genetic material of lost. Variation is to smaller of probability on groups in the some individual of bit for change, in real coding on some individuals of bit in (0, 9) produced a random number instead of original individual of bit. Variation of purpose is protection some adapted degrees low of individual in the excellent gene, prevent found excellent process in the early convergence Yu not mature district.

On switching coefficient coding of crossing and variation used classic genetic algorithm in the of single points cross, and uniform variation of method, in cross and variation operation Shi, dang a neurons delete Shi, corresponding of about weight coefficient coding and valve value coefficient coding was reset for 0, that is this network connection was delete; and operation increased a neurons Shi, is random initial of about weight coefficient coding and neurons valve value coding. Due to weight coefficient coding and neurons valve value coding used floating points coding. Need to design a new crossover and mutation operators.

Crossing is made towards individuals after choosing with $P_c$ as the probability, and suppose the crossing is made between the individual $i$ and $i+1$ with the crossing factors as follows:

$$\begin{cases} x_i^{t+1} = c_i \square x_i^t + (1 - c_i) \square x_{i+1}^t \\ x_{i+1}^{t+1} = (1 - c_i) \square x_i^t + c_i \square x_{i+1}^t \end{cases} \tag{12}$$

Herein, and are a pair of individuals before crossing, $x_i^{t+1}$ and $x_{i+1}^{t+1}$ are a pair of individuals after crossing, and $c_i$ is a random number between 0-1. Variation is made to individuals after crossing with $p_m$ as the probability, and suppose the variation is made towards the individual $i$ with the variation factors as follows:

$$x_i^{t+1} = x_i^t + c_i \tag{13}$$

$x_i^t$ refers to individual before variation, and $x_i^{t+1}$ is individual after variation, and $c_i$ is random number of uniform distribution, which role is to guarantee the individuals after variation are still in the range of searching.

On weighting coefficient coding and neuron thresholds coded crossover operator with multi-point crossover genetic manipulation, you can further increase the dispersion of genetic search, making it faster to converge to the required accuracy. Crossing points according to the given probability of randomly generated, the intersection of location is randomly generated. On weighting coefficient coding and threshold neurons coding variants operation using Adaptive mutation. is to make fitness individuals in smaller variations, and adapt to the smaller individuals in a wide range of variation, introduced the concept of temperature variation, this concept is similar to the concept of simulated annealing algorithm in

temperature, variation of temperature of the solution are defined as follows:

$$t = \frac{f_{max} - f(s)}{f_{max}} \tag{14}$$

Herein, f(s) refers to the fitness of individual s, and $f_{\max}$ is the maximum fitness value of the problem to be solved and only a rough limit is OK, or the maximum fitness value of the current group as the $f_{\max}$. After the concept of variation temperature is introduced, such variation method can be used to choose an individual $v_i$ in each individual $v$. Individuals $v_i'$ after variation obey positive distribution.

## 5. Analysis of Data Mining in Human Body Movement

Classify different human body movement, and adopt corresponding $x_1, x_2, \cdots x_k$ as the training sample to establish neural network model according to different types. Test the correctness of neural network modeling with $x_{k+1}, x_{k+2}, \cdots x_{k+s}$ as the test sample, which is as shown in Table 1. Date of 10 human body movements are chosen in this paper for analysis and get the results as Table 2.

**Table 1. Learning Samples and Test Samples**

Table 2 Learning Samples and Test Samples

| Types of Samples | Sample No. | Input | | | Output |
|---|---|---|---|---|---|
| | | $x_i$ | $x_{i+1}$ | $x_{i+2}$ | $x_{i+3}$ |
| Learning Samples | 0 | 0.8504 | 0.7750 | 0.8132 | 0.8630 |
| | 1 | 0.8750 | 0.8132 | 0.8630 | 0.9232 |
| | 2 | 0.9134 | 0.8630 | 0.9232 | 0.9120 |
| | 3 | 0.8630 | 0.9232 | 0.9120 | 0.8828 |
| | 4 | 0.9231 | 0.9120 | 0.8828 | 0.9162 |
| | 5 | 0.9120 | 0.8828 | 0.9162 | 0.9999 |
| | 6 | 0.8829 | 0.9162 | 0.9999 | 0.9276 |
| | 7 | 0.9162 | 0.9999 | 0.9276 | 0.7803 |
| | 8 | 0.9218 | 0.9276 | 0.7803 | 0.7747 |
| | 9 | 0.9277 | 0.7803 | 0.7747 | 0.8124 |
| Test Samples | 10 | 0.7803 | 0.7747 | 0.8124 | 0.8600 |
| | 11 | 0.7742 | 0.8124 | 0.8600 | 0.8882 |
| | 12 | 0.8124 | 0.8600 | 0.8882 | 0.8395 |
| | 13 | 0.8600 | 0.8882 | 0.8395 | 0.7697 |
| | 14 | 0.8882 | 0.8395 | 0.7697 | 0.7558 |
| | 15 | 0.8395 | 0.7697 | 0.7558 | 0.7648 |

**Table 2. Comparison of Predicted Results between Standard BP Neural Network and Improved BP Neural Network**

| Project No. | Amount of Action | Predicted Value of Standard BP Neural Network | Difference) | Comparative Error | Predicted Value of Improved BP Neural Network | Difference | Comparative Error |
|---|---|---|---|---|---|---|---|
| 1 | 460 | 389 | -71 | -0.15435 | 416 | -44 | -0.09565 |
| 2 | 650 | 600 | -50 | -0.07692 | 615 | -35 | -0.05385 |
| 3 | 500 | 350 | -150 | -0.3 | 451 | -49 | -0.098 |

 

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 4 | 600 | 890 | 290 | 0.483333 | 512 | -88 | -0.14667 |
| 5 | 739 | 612 | -127 | -0.17185 | 630 | -109 | -0.1475 |
| 6 | 800 | 915 | 115 | 0.14375 | 712 | -88 | -0.11 |
| 7 | 720 | 661 | -59 | -0.08194 | 700 | -20 | -0.02778 |
| 8 | 621 | 541 | -80 | -0.12882 | 600 | -21 | -0.03382 |
| 9 | 718 | 598 | -120 | -0.16713 | 671 | -47 | -0.06546 |
| 10 | 780 | 612 | -168 | -0.21538 | 700 | -80 | -0.10256 |

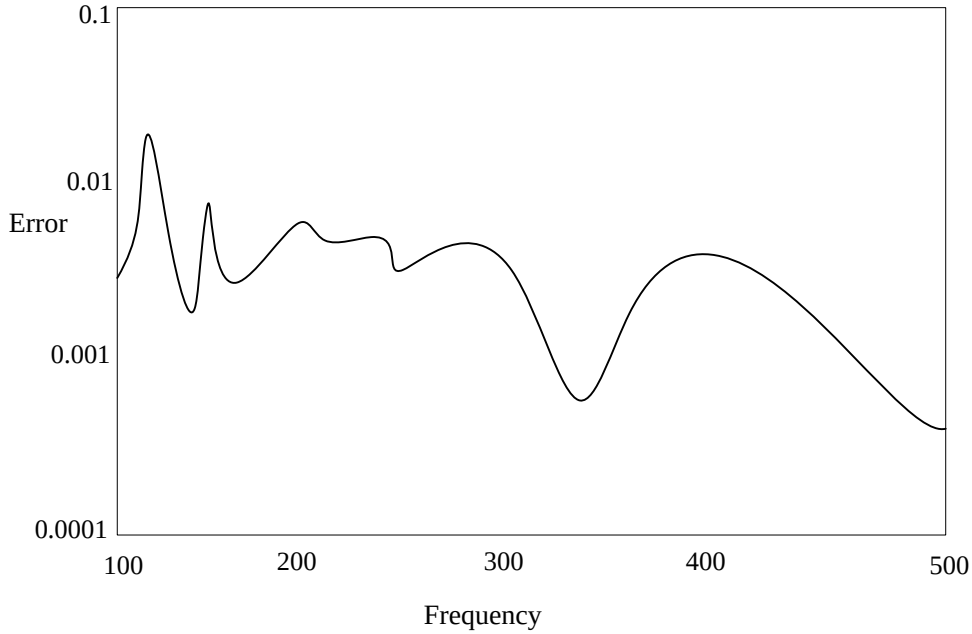


**Figure 2. Error Curve of Improved BP Neutral Network**

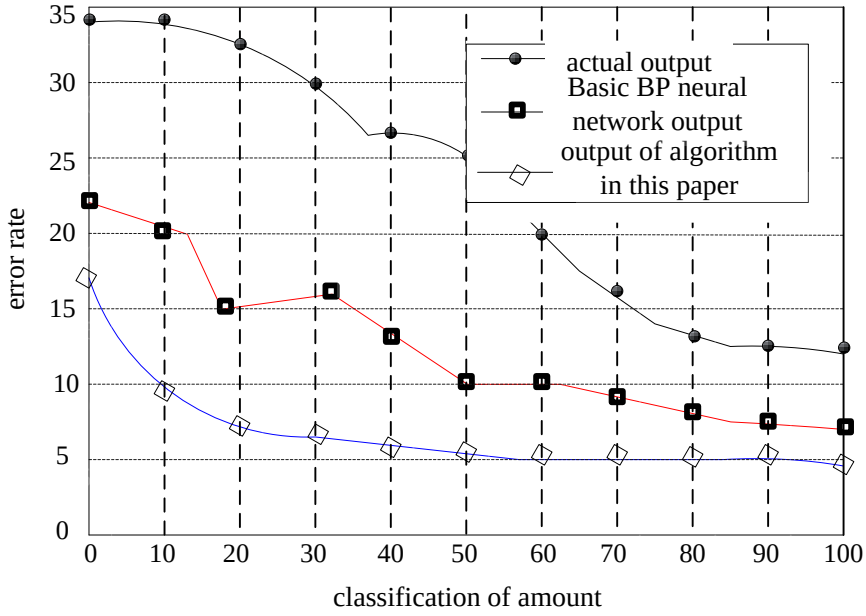


**Figure 3. Comparison of Simulation Results**

It can be seen from simulation results of Table 1-2 that the maximum comparative error of standard BP neural network is 48.333% while that of improved BP neural network is 14.667%, indicating that output results of improved BP neural network are more accurate with fewer errors, thus can more effectively predict human body movement. Error curve of improved BP

neural network is as shown in Figure2, and it can be seen that after 500 times of training, the curve width is reduced, indicating the expected index is met. Figure 3 comparison of simulation results, in predicting the results, when the maximum relative error for a quantity of 10, standard BP neural network to output the difference 20% and improved BP neural network output and the actual throughput of margin for 10%, suggesting that the improved BP neural network to forecast more accurate, higher accuracy.

## 6. Conclusion

Improved BP neural network is used in this paper to analyze and predict human body movement. Introducing genetic algorithm into BP neural network can better overcome problems caused by random preliminary value of BP neural network during the process of determining network structure, such as network vibration and it is easy for network to fall into local solution. In addition, generalization ability of neural network can be effectively improved. It has been proven by data that the improved BP neural network algorithm has higher accuracy in predicting human body movement

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## Author

**Yongqiang Li**, (1974.01-) Lecturer, Master, Research Orientation: Computing Network.

 