# Application Study on Assistive Movement Training Using BP Neural Network

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**Abstract.**Here, the relevant special factors, training plans and the ultimate scores before the training of an outstanding athlete are studied as an example using artificial neural networks (ANNs). ANN models are developed to establish a supplementary system for training. This system is scientific and applicable, having crucial guiding significance to develop the creative thinking of coaches.

## Introduction

Artificial neural networks (ANNs) is a simulation of the neural networks of human brain, which mainly developed by simulating the neural structure and function of human brain[1]. It is made up of a large number of so-called "neurons" which interconnect with each other. Being able to operate the complex logical non-linear self-adaptive system, ANNs have a strong capacity to self-adapt, self-study, associative memorize and tolerate high false. It is suitable for dealing with complex information, incomplete data and the problems that are difficult to be described by mathematical models[2].

BP neural network is a kind of mature and widely-used ANN, which is made up of input, hidden and output layers. Units in different layers interconnect with each other and those in the same layer are independent. The basic principle of a BP neural network is: the information processing consists of the forward propagation and error back propagation. In terms of the forward propagation, information is inputted in the input layer, and then outputted by output layer after being processed by each hidden layer. If the outputted information in the output layer is not agreed with the desired information, the errors would be revised gradually. Because the BP neural network can precisely fit every continuous function, it has very good fitting effects in multi-factor and non-linear problems[3]. Therefore, in this study, we use BP neural network to build the supplementary system for sport training.

## Principle of BP Neural Network

1) Initialization, a certain reasonable structure of network is chosen and all the adjustable parameters (weights and thresholds) can be set as the minimal values evenly.
2) Calculate every sample as follows:

1 Calculate forward, for the jth neuron of the lth layer, it holds that:

 

$$v_j^{(l)}(n) = \sum_{i=0}^{T} \omega_{ji}^{(l)}(n) y_i^{(l-1)}(n) \tag{1}$$

where $y_i^{(l-1)}$ (n) is the signal from the ith neuron of the former layer (l-1th layer) (when $i$=0, $y_0^{(l-1)}(n) = -1$, $\omega_{j0}^{(l)}(n) = \theta_j^{(l)}(n)$ ). If the activated function of the jth neuron is the Sigmoid function, it holds that:

$$y_j^{(l)}(n) = \frac{1}{1+\exp(-v_j^{(l)}(n))} \quad \text{and} \quad \varphi(v_j(n)) = \frac{\partial y_j^l(n)}{\partial v_j(n)} = \frac{\exp(-v_j(n))}{(1+\exp(-v_j(n))^2} = y_j(n)[1-y_j(n)] \tag{2}$$

calculate $\delta$ oppositely

to the output unit it holds that:

$\delta_j^l(b) = e_j^L(n) o_j(n)[1-o_j(n)]$;

to the hidden unit it holds that:

$$\omega_{jk}^{(l)}(n+1) = \omega_{ji}^{(l)} + \eta \delta_j^{(l)}(n) y_i^{(l-1)}(n) \tag{3}$$

revise the weights according to the equation shown as follows:

$$\omega_{jk}^{(l)}(n+1) = \omega_{ji}^{(l)} + \eta \delta_j^{(l)}(n) y_i^{(l-1)}(n) \tag{4}$$

3) whenn=n+1, new sample (or new sample period) is inputted until $E_{AV}$ reach the defined requirements. Samples in different periods would be resequenced when training.

4) After training, the weights and thresholds have a defined function relationship between the input and output. Therefore, the network can start to work.

**Application of BP Neural Network to Assist Sport Training**

Training outstanding athletes with targeted training duties is of great complexity in systemic engineering. In terms of the training process, it includes the diagnosis of athletes' conditions, determination of training targets, accomplishments of training plans, evaluation during training processes and the achievement of targeted training (figure 1).

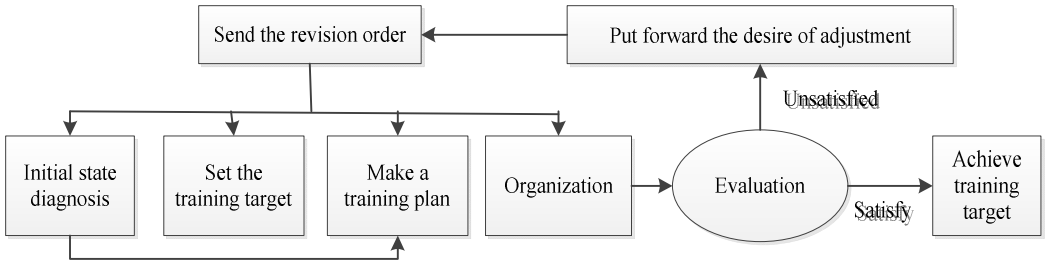


Fig.1 Basic structure of the sport training process.

Let's take the middle-distance race as an example to illustrate the application of ANN systems to the supplementary sport training. The scores of an athlete are mainly determined by the frequency of stride and the length of stride[4]. The biological factors that influence the frequency of stride and the length of stride are shown in Figure 2. Now combining the basic sections that develop the long-term training of middle-distance race can develop the ANN model. Here, we set the animal force, flexibility,consolidate degree of motor skill, ability of muscle relaxation, percentage of red muscle and the flexibility of neuron process as the input of the ANN. Indicators before training of 50 outstanding international famous sport players like Grace gini, Hicham Guerrouj, Haile Gebrselassie and Daniel, X=(xi，j)，i=1～50，j=1～7, are set as the input vector of the training network. 13 kinds of quantified methods of their successful training cases like leg lifts and bend standing are set as the targeted output vector Y=(yl)，l=1～13. We set 6 neurons in the hidden layer. The passing functions of the hidden and output layers are Sigmoid and Pureline functions respectively. After 1000 trails of training, the function relationship between the input and output layers is finally decided. The form of vector is shown as follows:

$$Y = \frac{W_2}{1+\exp(-(XW_1 + B_1))} + B_2 \tag{5}$$

where W1 and B1 W2 and $B_2$ are the weight and threshold between the final input and output layers respectively. Eq. (5) is the ANN model for deciding the suitable training plan. When inputting a new status of a athlete to the ANN model, we can quickly decide a scientific and efficient training plan Y. This plan can rationally control the training process of a athlete, simulating the growing process of the successful middle and long distance sport players. It also guide a new generation of players to follow previous successfully foot prints until they won the best price.

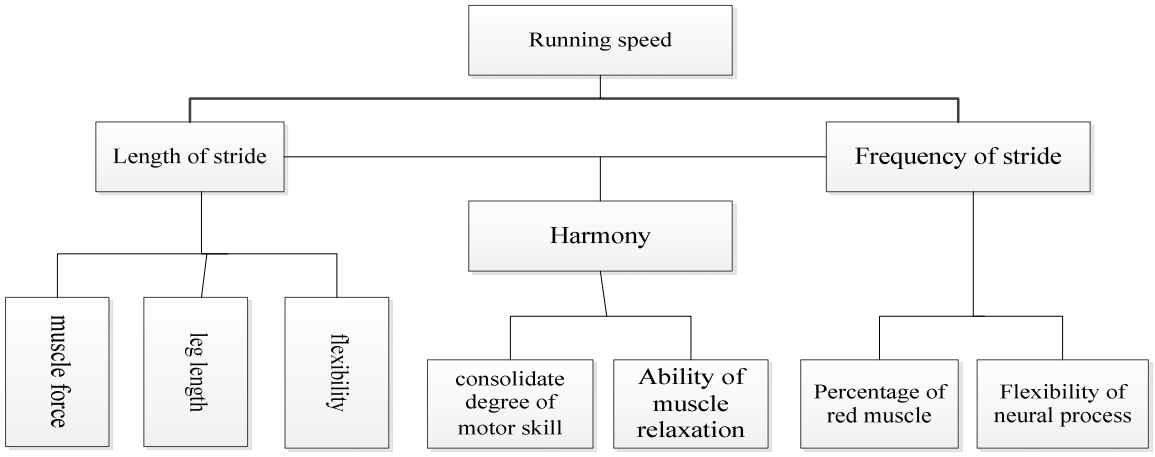


Fig.2 Biological factors that influence frequency of stride and length of stride.

**Attention Problems to Practical Applications when Developing ANNs**

**The Component of the Sample.** Training sample is crucial for model development of ANNs. In an ANN model, the adjustment of weights is highly relevant to the training samples. The basic principle of the adjustment is to minimize the errors between the actual and ideal outputs via adjusting the connected weights. The quality of training samples directly influence the performances of the ANN. Here, we use the successful sport players as the training sample of the ANN training.

**Structure of the ANN for the Evaluation of Athletes.** In a three-layer ANN model, there are input, hidden and output layers. The nodes in the hidden layer significantly influence the classification and generalization abilities. The effects of the nodes in the hidden layer is the extraction and store the inner regulation. Each node has several weights and each weight is the parameter that improve the reflection ability[5]. Therefore, too less number of nodes would lessen the ability of acquiring information, which cannot be used for the extraction of the regulation of samples; too many number of nodes also lead to the memory to the noise, leading to over-fitting and lower the generalization ability. In addition, it also waste too much training time. Generally speaking, the set of number of nodes is determined by the scale of training samples, scale of noises and the complexity of the sample regulation. However, it is not easy to decide the number of nodes. Scientists usually use the "cut-and-trial " method to find out the best number of nodes. However, it lacks a believable basis and requires a large number of experiments of networks, thus it is also difficult in practical applications.

## Conclusion

The developed training plan based on ANN model can rationally and scientifically avoid the kickback that generated by personal moods, lack of theoretical knowledge, impractical training plan and monotonous training.

Due to the generalization function of ANN, the model can be innovative and at the same time, based on the successful examples. Meanwhile, it can open coaches' insights and help finding the potential of coaches

ANN models are based on the congenital conditions of international outstanding athletes and it can rationally infer the scores after training. Therefore, it can save manpower and resources for the country.

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