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Athlete's gait tactics analysis system based on tactile sensor

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Abstract. Deficiencies of tactical information acquisition and analysis of existing methods hinder the correct judgment of coaches, athletes and researchers on the ability of the athletes, which seriously restricts the improvement of the training level and the competition quality. In order to solve this problem, this paper first of all takes tactile sensor as the basis, gives gait analysis model, and then, based on the model, designs and implements the athletes gait tactics analysis system. In addition, the paper tests the accuracy of the system acquisition of plantar pressure data and reflection of footwork technique information. The test results showed that the system can accurately collect the data and reflect the footwork technique information technique, and meet the requirements of coach, scientific research personnel and so on for tactic quantitative analysis, conductive for coach and scientific research personnel making a correct judgment on the athletic ability of athletes. In this way, it can provide effective basis for coaches and athletes making a scheme for daily trains and competitions.

Key words. Tactile sensor, athletes, gait analysis.

1. Introduction

At present, the combination of sports, science and technology has become an irresistible trend of development. The development level of sports to a large extent depends on the level of scientific and modern sports. Deficiencies of the existing tactics information acquisition method hinder the coaches, athletes and researchers to make the correct interpretation and judgment of athletic ability of athletes, which seriously restricts the improvement of the training level and the competition quality [1]. Data acquisition is restricted by environmental change parameters calibration, only obtaining local static information. As a result, in order to fully improve the competitive ability, it is urgent to develop stronger real-time, adaptable, and special tactical ability analysis system.

And the acquisition of gait tactile information in human motion based on tactile sensing technology not only achieves access to relevant kinematic information, also can complete the relevant dynamic information acquisition, so as to realize the real-

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time monitoring of sports information feedback. This is an important breakthrough of the modern science and technology in research methods in sports science.

2. Gait analysis model

In order to design the athletes gait tactics analysis system, we should first of all analyze the gait of the athlete in the designed gait analysis model. In this paper, the flexible sensor array based on tactile sensor and its data processing system are used to obtain the pressure distribution of the foot, the curvature and the acceleration of the foot in the movement. Through the original data, it is difficult to complete the tactics ability analysis of athletes within a time window [2]. As a result, we need to preprocess the original data, and extract the parameters of gait characteristics during exercise, so as to facilitate further analysis and processing.

2.1. Multi-characteristics parameters extraction used for gait analysis

Set a rectangle on the insole, inner vertex of the heel set as the origin, set the two adjacent edges of the origin to X axis and Y axis, and set the vertical direction to the rectangle as Z axis, consisting of the coordinates.

In the coordinate system XOY, first of all, measure and obtain the position coordinates of 8 flexible pressure sensors, recorded respectively as $\{(x_1, y_1), (x_2, y_2), \cdots, (x_8, y_8)\}$. Symbols $(x_i,\ y_i)$, $i = 1, 2...8$ refers to the position coordinate of the ith flexible pressure sensors, respectively [3]. We make use of 8 flexible pressure sensors to obtain the pressure value of the 8 pressure sensors at the moment t, recorded as $\{F_1,\ F_2,\ ...,\ F_8\}$. After determining the distribution position of the pressure sensors, we measure the pressure of 8 pressure sensors at the moment t, using pressure center method. We also use the following equations to obtain the center point information $(x_c,\ y_c)$ of the pressure distribution.

$$x_c = \frac{\sum_{i=1}^{8}(x_i \times F_i)}{\sum_{i=1}^{8} F_i}\,, \tag{1}$$

$$y_c = \frac{\sum_{i=1}^{8}(y_i \times F_i)}{\sum_{i=1}^{8} F_i}\,, \tag{2}$$

The bending C_t at the t moment is obtained by the flexible tension sensor.

The accelerations a_x^t, a_y^t, and a_z^t in the X, Y, Z directions at the t moment are obtained by the inertial sensor, and the scalar value S_t of the acceleration at the t moment is obtained by using the formula

$$S_t = \sqrt{(a_x^t)^2 + (a_y^t)^2 + (a_z^t)^2}\,. \tag{3}$$

For gait analysis within a time window, we first of all select the characteristics parameters of gait information within the window. In the previous part, we get 7

kinds of gait sensing information within the window, and calculate four features values of the 7 kinds of sensing information discrete data within the window, including the maximum and minimum value, mean and variance [4]. These 28 parameters are used as the characteristic parameters of gait analysis within the window.

2.2. Gait analysis model

We make use of the neural network toolbox in MATLAB software, and establish the mapping relationship between the 28 kinds of characteristic parameters and gait, so as to determine the gait of athletes.

(1) Selection of neural network algorithm

In this paper, the feed-forward neural network is used to classify and recognize the gait model of athletes. The most commonly seen in feed-forward neural network are BP (Back Propagation) neural network and RBF (radial basis function) neural network. About 80 % to 90 % of the neural network model use BP neural network and its change form.

The BP algorithm is used for network training.The network consists of an input layer, a hidden layer and an output layer. The results showed that the increase of hidden layer number or unit number is not positively related to the precision of the network and the ability to express. A hidden layer can also produce high accuracy, and a number of hidden layers will lead to the increase of the amount of calculation andslowing down the speed. Therefore, only one hidden layer is selected in this paper.

In the case of the n input units X_1, X_2, ..., X_n of the input layer of BP neural network, the input of the hidden layer neural unit is

$$I_j = \sum_{i=1}^{n} W_{ji} X_i = T_j,\ j = 1, 2, ..., n\,. \tag{4}$$

In (4), W_{ji} refers to the connection weights between the hidden layer neural unit J and input layer neural unit I, while T_j represents the threshold value of the hidden layer neural unit J.

The output of the hidden layer neural unit is

$$O_j = f(I_j)\,. \tag{5}$$

In (5), the activation function f always takes continuous and differentiable S-type function. The input calculation of the output layer neural unit is similar to (4).

The output of the output layer neural unit is

$$O_k = f\left(\sum_{i=1}^{m} W_{kj} O_j + T_k\right),\ k = 1, 2, ..., q\,. \tag{6}$$

BP neural network algorithm is a supervised learning algorithm. The main rule

of this supervision method is, for a plurality of input samples $(P_1, P_2, ..., P_q)$ and the corresponding output samples $(T_1, T_2, ..., T_q)$, through training, to make the squared error between the actual output of the network and the target vector achieve the minimum.

(2) BP neural network training

BP neural network can, through artificially prepared input and output sample data with corresponding relationship, analyze the potential rules between the input samples and output samples [5].

In this paper, the author selected the neural network toolbox in MATLAB software to create a three-layer feed-forward BP network as shown in Fig. 1: the first layer is the input layer containing 28 input nodes; the second layer is the hidden layer, and the number of nodes in the hidden layer is determined in the training process; the third layer is the output layer with 2 nodes. The components of two-dimensional output vector $(Y_1, Y_2)^{\mathrm{T}}$ are used for the representation of the gait analysis results.

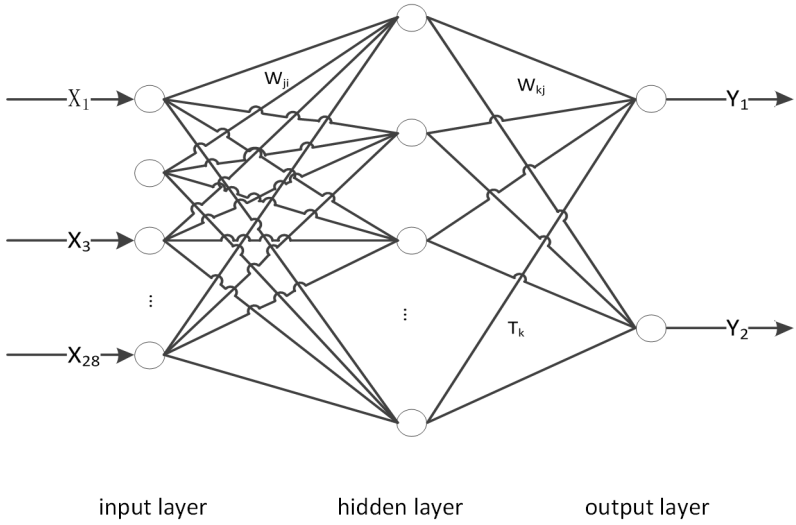

Fig. 1. Three-layer BP network structure for gait analysis

In the BP neural network, we are supposed to select the appropriate number of hidden layer nodes on the premise of ensuring the gait discrimination rate. According to these weight coefficients and thresholds, we can obtain the gait analysis model.

3. Design of athlete's gait tactics analysis system

According to the purpose of the gait tactics analysis system, the system can be divided into three modules, which are system management, data acquisition and management module, and tactical analysis and report module. Its functional structure is shown in Fig. 2.

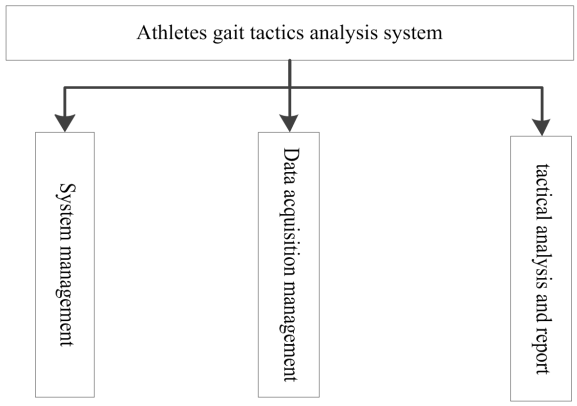

Fig. 2. System functional structure

3.1. System management

The system management mainly includes parameter setting, parameter script code processing and analysis, and system setting function. The script interpreter realizes tactical information statistics and analysis. The delimiter uses "&" to represent the connection of two movements, "#" represents the end of the turn, followed by the tactics used in the turn.

After the system reading into the script code group, the word is divided by the delimiter, and then the word rules and the semantic rules are used to explain the technique and tactics. According to this project, we need to design a special interpreter. The main function of the interpreter is to input the script code group and to explain and output the natural language.

3.2. Data acquisition management

Data acquisition management can be divided into video editing, digital site acquisition, synchronous acquisition and data validation of storage. Video editing mainly realizes video capture and playback, and video analysis. Clicking on the corresponding button can classify and store the corresponding tactics analysis information along with the corresponding video clips; video analysis means that the operator can refer to the competition video clips according to the query conditions of the athletes, the technology, the tactics, the round and so on, and can also classify and store again after editing.

The data confirmation storage module mainly completes the modification of error data and data storage in the data acquisition process.

3.3. Tactics analysis and report

Tactics analysis and report can be divided into analysis function and reporting function. In the tactics analysis and report module, the analysis function serves the

on-site guidance and preparations, and training summary these two aspects; report function mainly relies on the crystal report to realize, which can realize the report presentation and print.

4. System test results

For testing the system acquisition plantar pressure data and reflecting the accuracy and effectiveness of gait technology information, this paper selects 50 badminton players as the test samples, so these athletes play badminton at the same site. In the test samples, 10 athletes defense samples, first of all use first guaranteeing and later defensing tactics; 25 athletes attacking samples, use attack-after-service tactics; 15 athletes normal walking samples, without using any tactics. If the data information collected by the system and the gait technology information reflected by the method are consistent with the test samples classification, the test is normal. The final test results are shown in Table 1.

Table 1. Test results

Test samples	System analysis results			Accuracy
	First defensing and later attacking tactics	Attack-after-service tactics	No tactics	
Sample of players in defense	10	0	0	100 %
Sample of players in attack	0	25	0	0 %
Sample of players in normal walking	0	0	15	0 %

It can be seen from the test results that the system can correctly identify all the test samples, and prove the accuracy and validity of the data collected by the system.

5. Conclusion

The gait analysis system designed in this paper made use of script decoding technology of digital encoding technology with strong operability, and realized data automatic acquisition when the athletes are exercising. This paper designed the actual tests to test the accuracy of the system data acquisition of plantar pressure and reflection of gait technology information. The test results showed that the gait tactical analysis system based on tactile sensor designed in the paper not only can collect the plantar pressure data, but also can accurately reflect the gait technical information and tactical information. At the same time, the system can well meet

the needs of coaches, athletes, and researchers for the tactics quantitative analysis, providing an effective basis for the coaches and athletes to do the daily training and pre-competition strategies.

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