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Design of remote injury diagnosis system for Wushu competition based on wireless sensor network

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Abstract

INTRODUCTION: In this paper, a remote injury diagnosis system for Wushu competition based on wireless sensor network is designed to improve the safety of athletes in the process of Wushu competition.
OBJECTIVES: Improve the safety of athletes during martial arts competitions.
METHODS: On the basis of clarifying the overall architecture of the system, the hardware is equipped with pulse sensor, temperature sensor and ECG sensor as the terminal node of the injury diagnosis system of long-distance Wushu competition. The sensor is used to collect the physiological parameters of athletes in Wushu competition, and the collected parameters are transmitted to the wireless RF module. The radio frequency module uses the wireless sensor network to realize the wireless communication of various parameter data through the routing node and terminal node, and transmits the data to the remote diagnosis module. In the software part, the athletes' physiological parameters collected by the remote diagnosis module are used to realize the remote diagnosis of injury in remote Wushu competition through particle swarm optimization support vector machine diagnosis model.
RESULTS: The experimental results show that the designed system can remotely collect the physiological parameters of athletes in Wushu competition, and remotely diagnose the injury of Wushu competition according to the collected data, and the diagnosis accuracy is as high as 99%.
CONCLUSION: It has good safety performance and is of practical significance

Keywords: Wireless sensor network; Remote Wushu competition; Injury diagnosis system; Support vector machine; ECG sensor; Temperature sensor.

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1. Introduction

Today's Wushu is mainly characterized by its antagonism, entertainment and nationality. It is more and more loved by people for its functions of strengthening body and self-defense, exercising will, developing the mind and cultivating competitive consciousness. Wushu can not only strengthen body [1], shape the body and exercise will, but also promote physical development and improve physical and psychological endurance. However, due to the characteristics of this sport, sports injuries will inevitably occur. Because Wushu is a direct confrontation between two people, fists and feet are used together, and physical contact is frequent, the incidence of sports injuries is also high. If proper precautions are not taken, minor injuries can prevent athletes from participating in normal training and competition, and serious injuries may end an athlete's sports career. Therefore, how to prevent and reduce the occurrence of sports injury has become an important topic in teaching and training. The characteristics of Wushu determine the location of sports injury [2]. Because the attack parts of Wushu are mainly the head, trunk, thigh and calf, the injured parts are generally in the head, neck, shoulder, arm, knee and ankle.

Compared with common wireless networks such as mobile communication network and wireless LAN, wireless transmitter network has a larger network scale. Wireless sensor network is based on a large number of sensor nodes in the monitoring area [3], which has high monitoring accuracy as a whole, and the monitoring range of sensor network is relatively large. The existence of a large number of nodes increases the fault tolerance of wireless sensor networks, reduces the accuracy requirements of a single node and reduces the cost of network construction. Wireless transmitter network has the ability of network self-organization. A large number of sensor nodes are distributed in the monitoring area [4], so it is impossible to preset the location of each node and determine the relationship between nodes in advance. Therefore, the self-organization ability of nodes is particularly important in sensor networks, and has the function of automatic configuration and management. In the case of sensor network node failure, the topology of wireless network can change according to this situation [5], so as to realize the dynamic network topology characteristics. Wireless transmitter networks are data centric. If the application system is based on wireless sensor network, it needs to manage and process the sensing information. Each node in the application system has the functions of end node and router at the same time.

In the traditional medical monitoring system, every physical index needs medical staff to check the patients in person, which greatly increases the workload of medical staff, but it is still unable to achieve efficient rescue. As a new subject with rapid development in recent years, wireless sensor network has the characteristics of low power consumption, low cost, distributed and self-organization [6], which has gradually become a research hotspot in the field of medical monitoring. Based on the wireless sensor network, different sensors are used to collect the human physiological signals and state information of Wushu athletes through remote means, obtain the athletes' pulse and other information, use the obtained information to diagnose the injuries of Wushu athletes in the process of competition, and process these information and send them to the medical staff wirelessly through the wireless RF module [7]. Through these data, medical staff can take timely and efficient remote assistance to the monitored Wushu athletes. Since its application in the United States in the 20th century, telemedicine has been highly praised by medical workers and patients for its convenience, real-time and many other advantages. Telemedicine breaks through the limitations of time and space. Through the telemedicine system, doctors and patients can communicate in real time, which not only reduces patients' medical expenses, but also makes the whole medical process more convenient. As a part of telemedicine, telemedicine monitoring system can realize the real-time transmission and analysis of important physiological parameters of patients [8]. Doctors can diagnose patients for the first time according to such information. In case of abnormal parameters or emergencies, they can notify the emergency contact person and the patient himself to ensure that the patient can see a doctor on time in case of emergencies. In the implementation process of telemedicine monitoring, real-time monitoring is carried out for Wushu athletes in the competition process, which can timely and remotely diagnose the athletes' injury in Wushu competition, determine the health status of Wushu athletes, and timely deal with the sports injury in the competition process, so as to avoid more serious harm.

At present, there are many scholars studying wireless sensor networks. Vijayalakshmi et al. applied the random waypoint movement model to wireless sensor networks in order to improve the communication performance of wireless sensor networks [9] and avoid errors in communication routes in the application of wireless sensor networks; In order to improve the coverage performance of wireless sensor networks [10], Shi et al. studied and solved the coverage problem of battery free wireless sensor networks; Xu et al. applied leapfrog algorithm to node redeployment in wireless sensor networks [11]. The above three methods effectively improve the communication performance of wireless sensor networks, but they have not been studied for the application performance of wireless communication networks.

In order to reduce the injury rate of Wushu competition and improve the safety of Wushu competition, this paper applies wireless sensor network to the software and hardware design of remote Wushu competition injury diagnosis system. Through the results of systematic diagnosis, we can understand the causes of Wushu sports injury, improve athletes' awareness of prevention of Wushu sports injury, reduce the sports injury caused by Wushu sports, and promote Wushu Sports in order to promote the development of sports.

2. Design of injury diagnosis system for long-distance Wushu Competition

2.1. Overall system structure

The overall structure of the remote injury diagnosis system for Wushu competition based on wireless sensor network is shown in Figure 1.

As can be seen from the overall structure diagram of the system in Figure 1, the remote injury diagnosis system of Wushu competition based on wireless sensor network mainly includes terminal node, wireless RF module, routing node, gateway node, PC terminal and other modules.

The terminal node of the system is mainly responsible for the collection, processing and transmission of athletes' physiological parameters and other data in the process of Wushu competition. The wireless RF module uses the wireless sensor network to realize the transmission of various data, that is, the sensor node is used to collect the data of the sensing object, and the collected data is transmitted to the remote diagnosis terminal through the wireless communication network. The routing node is mainly responsible for data transmission and location. The gateway node is mainly responsible for wireless data transmission and serial communication with PC. The remote diagnosis terminal uses the support vector machine optimized by particle swarm optimization algorithm to diagnose athletes' Wushu competition injury remotely. The sensing data of the sensor includes heartbeat, blood pressure, body temperature and other indicators.

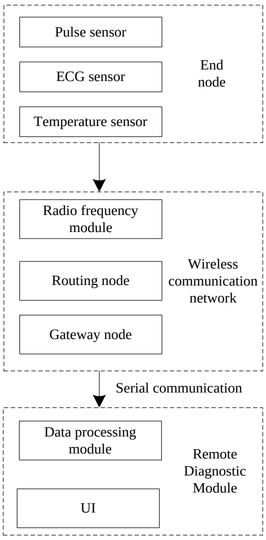

Figure 1. Overall structure of the system

2.2 System hardware design

The hardware part of the system is equipped with pulse sensor, temperature sensor and ECG sensor are set as the terminal nodes of the remote injury diagnosis system of Wushu competition. The physiological parameters of athletes in Wushu competition are collected by various sensors. The collected parameters are completed. The wireless communication of data is realized through the wireless RF module, the wireless sensor network and the routing node and the terminal node [12], and the data is transmitted to the remote diagnosis module. Through the optimization of the physiological parameters of Wushu athletes, the remote diagnosis of the injury is realized by using the particle swarm optimization-support vector machine.

2.2.1 Wireless sensor network terminal / routing node

The terminal node of wireless sensor network realizes the functions of data acquisition, processing and transmission. The transmission process of the terminal / routing node of the wireless sensor network used in the remote injury diagnosis system of Wushu competition is shown in Figure 2.

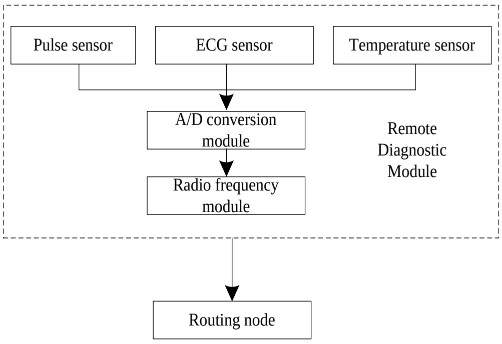

Figure 2. Wireless sensor network terminal/routing node communication process

After the system receives the acquisition command, the terminal node collects data and performs corresponding operations to judge whether there is any abnormality. In case of abnormality, it can broadcast the positioning request signal to all routing nodes for 2s. After receiving the positioning request information, the routing node will be timed for 1s and reply to the confirmation request information. After the timing time of the terminal node expires, it sends the routing request information.

The routing node is mainly responsible for data transmission and positioning. When the terminal node moves or there is data to be sent, the routing node is responsible for receiving the positioning request information sent by the terminal node, sending the confirmation request and receiving the routing request [13]. The routing node receives the routing request, calls the CTP protocol, and sends the data packet up the tree to the root node in a multi hop manner. In this system, the gateway node is the root node.

2.2.2 ECG sensor

The heart is the driving force of blood circulation in organisms. Relying on the rhythmic beat of the heart, the blood circulates continuously in the body to maintain normal life activities. Its working principle and steps are generally that before the heart beats, the myocardium is excited first and generates a weak current in the process. The generated current is transmitted to each functional part through the human body tissue. Due to the different tissue functions and distances of each part of the body, there are different potentials in each functional part of the human body surface. These potential changes are sent to a special recording device to form a dynamic real-time curve. Finally, ECG is formed. ECG is of great value in analyzing the injury of Wushu competition. It can reflect the electrical activity excited by the heart of Wushu athletes [14]. ECG sensor HKD-10A is an analog signal output module, which adopts single lead ECG signal and outputs voltage signal. The ECG sensor is characterized by high-precision amplifier and weak signal conditioning, so it has the characteristics of high output precision and high signal-to-noise ratio. It is suitable for ECG monitoring of related equipment.

The system uses HKD-10A ECG sensor as a wireless sensor to collect athletes' ECG signals in Wushu competitions. The structure diagram of HKD-10A ECG sensor is shown in Figure 3.

The performance parameters of HKD-10A ECG sensor are as follows: ± 5VDC power supply; < 4mA current; The measuring range is 0-4mV; The signal gain is 300 times; The accuracy is 5 UV; The frequency is 200; The baud rate is 9600.

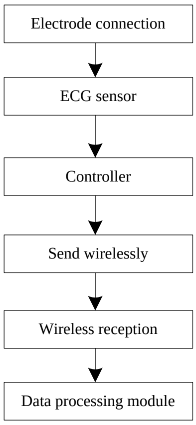

Figure 3. Structure diagram of ECG sensor

2.2.4 Temperature sensor

DSl8B20 is a kind of temperature sensor, which can directly read the measured temperature and reach the digital value reading mode of 9 ~ 12 bits. Temperature sensor and analog-to-digital conversion unit are integrated in the chip, which is suitable for places with low power consumption requirements. The current in standby state is generally less than 1 μA. The DSl8B20 sensor has a sleep state and is in a sleep state when it does not need to collect signals, further realizing low power consumption [15]. Based on the above characteristics and human body temperature range and accuracy requirements, we choose DSl8B20 as the sensor to detect human body temperature. The system adopts 5V independent power supply. DSl8B20 is also suitable for multi-channel and multi-point testing, so it is more suitable for application in this system. The single line bus connection mode is adopted in the system. The bus mode is that the data line, address line and control line of the controller share a signal line for two-way data transmission.

The basic characteristics of DS18B20 temperature sensor are as follows:

(1) The applicable voltage range is wider. The voltage range is 3.0V ~ 5.5V. Under the parasitic power supply mode, it can be powered by the data line.

(2) Dsl8b20 has an original single line interface mode. When connecting with microprocessor, only one line is needed to realize the two-way communication between DS18B20 and microprocessor.

(3) When used, it does not need any peripheral components and has high-performance integration.

(4) The temperature measurement range is - 55 ℃ ~ + 125 ℃, and the accuracy is ± 0.5 ℃ at - 10 ℃ ~ + 85 ℃.

(5) High precision temperature measurement can be realized.

(6) Super-fast.

(7) Multiple DSl8B20 can be connected in parallel on the only three lines to realize networking and multi-point temperature measurement.

2.2.4 Radio frequency module

The CC2430 chip of TI company is used as the RF chip of the wireless sensor network in the remote injury diagnosis system of Wushu competition. The chip integrates the enhanced 8051 microcontroller core and the 2.4GHz RF wireless RF transceiver in accordance with IEEE 802.15.4 standard, which can handle the transmission of sensor node data and data between nodes [16]. In addition, the system adopts the fully open source TinyOS operating system, which reduces the memory demand, saves energy consumption and improves the utilization rate of node CPU. The structure diagram of CC2430 chip is shown in Figure 4.

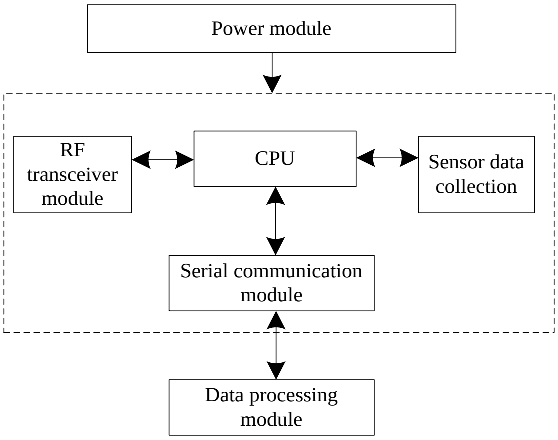

Figure 4. Diagram of CC2430 chip structure

It can be seen from the diagram of CC2430 chip structure in Figure 4 that CC2430 chip can effectively collect the data of the sensor, and use CC2430 chip to realize data acquisition, RF transceiver and serial communication [17]. Through this chip, various physiological parameters collected by the sensor in the process of athletes' Wushu competition can be transmitted to the host computer, so as to provide data basis for the host computer to diagnose the injury of Wushu competition.

2.3 System software design

Support vector machine can accurately classify the injury types of athletes in Wushu competition, but the sample data are often difficult to be linearly separable in the application of this method. Therefore, this paper optimizes the support vector machine diagnosis model with the advantage of particle swarm optimization algorithm, which is more intelligent and flexible. On the basis of hardware design, it can better diagnose athletes' Wushu competition injury remotely.

2.3.1 Support vector machine classification model

The essence of support vector machine classification model is to find a hyperplane to separate two types of data. The position of the hyperplane must be equal to and the maximum interval between the two categories. The hyperplane is usually expressed by the following formula:

$$f(x) = sign\left(xw^{\mathrm{T}} + b\right) \tag{1}$$

In formula (1), x represents the sample, and the parameters w and b are the normal vector and intercept of the hyperplane respectively. The above formula is also called discriminant function model. Assuming that there is data sample $\left\{\left(x_i, y_i\right), x_i \in R^n, y_i \in R^n, y_i \in \{+1, -1\}\right\}$, there are:

$$\begin{cases} xw^{\mathrm{T}} + b > 0, y_i = +1 \\ xw^{\mathrm{T}} + b < 0, y_i = -1 \end{cases} \tag{2}$$

The discriminant function of the above formula is normalized, that is:

$$y_i\left(x_i w^{\mathrm{T}} + b\right) > 0,\ for \forall i = 1, 2, \cdots, N \tag{3}$$

The core of SVM follows the idea of optimal classification surface. Let W be the classification line of sample points. Assuming that we find two parallel lines W_1 and W_2 with the largest and equal distance from W, the "fat degree" between W_1 and W_2 is the classification interval, and the points on W_1 and W_2 are the support vector. Therefore, the maximum classification interval we need to find in SVM is:

$$\min_{w,b} \frac{1}{2} ww^{\mathrm{T}} \tag{4}$$

$$s.t.\left(x_i w^{\mathrm{T}} + b\right) \geq 0 \quad i = 1, 2, \cdots, N \tag{5}$$

The support vector machine classification problem is transformed into finding the minimum value of function (4) under the constraint of formula (5), which is also the original problem of our derivation and calculation.

We transform the above problem into an unconstrained problem through Lagrange function as follows:

$$L(w, b, \lambda) = \frac{1}{2} ww^{\mathrm{T}} + \sum_{i=1}^{N} \lambda_i \left(1 - \lambda_i y_i \left(ww^{\mathrm{T}} x_i + b\right)\right) \tag{6}$$

$$\begin{cases} \min\limits_{w,b} \max\limits_{\lambda} L(w, b, \lambda) \\ s.t.\ \lambda_i \geq 0 \end{cases} \tag{7}$$

Since the function $L(w, b, \lambda)$ is a convex QP problem, the constraint is a linear factor [18], and the objective function is quadratic, the function satisfies the property of strong duality, then:

$$\max \min L(w, b, \lambda) = \min \max L(w, b, \lambda) \tag{8}$$

According to KKT conditions, $L(w, b, \lambda)$ is converted to:

$$L(\lambda) = -\frac{1}{2} \sum_{i=1}^{N} \sum_{k=1}^{N} \lambda_k y_i y_k x_i^{\mathrm{T}} x_k + \sum_{i=1}^{N} \lambda_i \tag{9}$$

By solving the minimization problem of $L(w, b, \lambda)$, the values of w and b are:

$$w^* = \sum_{i=1}^{N} \lambda_i^2 y_i x_i \tag{10}$$

$$b^* = y_k - \sum_{i=1}^{N} \lambda_i^2 y_i x_i^{\mathrm{T}} x_k \tag{11}$$

When the support vector machine cannot train a hard interval to accurately classify all the data, we introduce the relaxation variable ξ_i into the objective function to represent the error, allowing the wrong classification at a distance near the model boundary [19], and most of the data can be correctly classified at this time. Then the original problem will be transformed into the following objective function:

$$\begin{cases} \min\limits_{w,b} \frac{1}{2} ww^{\mathrm{T}} x_i + C \sum\limits_{i=1}^{N} \xi_i \\ s.t. y_i\left(x_i w^{\mathrm{T}} + b \geq 1 - \xi_i\right) \\ \xi_i \geq 0 \end{cases} \tag{12}$$

Where C is the regularization parameter, which is also solved by the above dual function method.

In the actual process, the sample data is often difficult to be linearly separable in the original input space. Using kernel function in SVM can transform the original samples into high-dimensional space, also known as kernel space. Using a linear hyperplane in kernel space can realize the classification of data. The form of kernel function is:

$$K(x, u) = \sum_{i=1}^{N} \varphi_i(x) \varphi_i(u) \tag{13}$$

The Gaussian radial basis function is selected as the kernel function of remote injury diagnosis in Wushu competition, and its expression is as follows:

$$K(x,u)=\exp\left(-\frac{\|x-u\|^2}{\sigma^2}\right) \tag{14}$$

According to the calculation results of kernel function, a support vector machine classification model is constructed to diagnose the injury of Wushu competition. However, because the injury data of Wushu competition can not be divided linearly effectively, this paper introduces particle swarm optimization algorithm to optimize it.

2.3.2 Diagnosis model based on particle swarm optimization-support vector machine

Particle swarm optimization is a global random search algorithm based on swarm intelligence. The principle is that each example adjusts its own best state according to its own characteristics to achieve the overall best state of the whole group. The core significance of particle swarm optimization algorithm is to find the best for group mutual assistance and resource information sharing [20]. It has high flexibility, does not need many parameters, and is simple to implement. Therefore, this paper uses particle swarm optimization algorithm to optimize the support vector machine diagnosis model.

Suppose there is a particle swarm $X_i\{x_1,x_2,\cdots,x_n\}$ composed of n particles in the D-dimensional search space, and each x_i represents a D-dimensional vector, indicating the position of the i-th particle in the D-dimensional solution space, that is, the solution representing an optimal value. The velocity vector of the third particle i is represented by $V_i=[v_{i1},\cdots,v_{id}]$. At this time, the position vector corresponding to the historical optimal fitness value P_{best} of particle i is represented by $P_i=[p_{i1},\cdots,p_{id}]$, and the position vector corresponding to the global historical optimal value G_{best} of all particles is represented by $P_g=[p_{g1},\cdots,p_{gd}]$.

Each time the particle moves, it indicates the iterative solution process, and then its indicators at the single optimal position and the optimal value of the group are updated. After adjustment, it is as follows:

$$v_{id}^{t+1}=v_{id}^{t}+c_1r_1\left(p_{id}^{t}-x_{id}^{t}\right)+c_2r_2\left(p_{gd}^{t}-x_{id}^{t}\right) \tag{15}$$

$$x_{id}^{t+1}=x_{id}^{t}+v_{id}^{t+1} \tag{16}$$

Where, c_1 and c_2 are acceleration factors, which are random numbers between [0,1]. They all depend on the information sharing between particle groups. Each movement keeps searching and tracking to achieve an optimal.

Particle swarm heuristic optimization algorithm plays a good role in parameter optimization of SVM. The structure of particle swarm optimization for parameter optimization of SVM is shown in Figure 5.

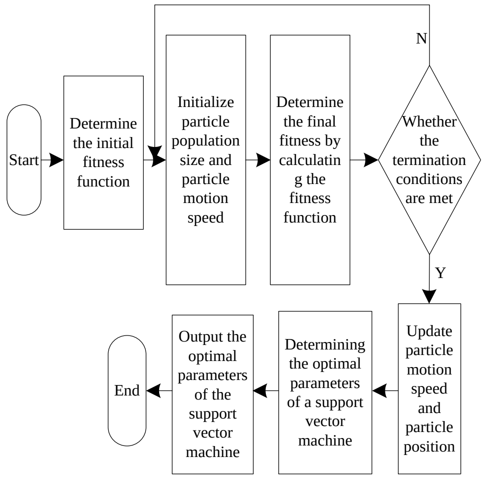

Figure 5. PSO optimizes support vector machine parameters

The optimization ability of PSO algorithm is used to optimize the super parameters of SVM, and then PSO algorithm is used to classify the remote injury data set of Wushu competition, so as to obtain the remote injury diagnosis results of Wushu competition.

3. Experimental test and result analysis

In order to verify the effect of the designed remote injury diagnosis system for Wushu competition based on wireless sensor network on the remote injury diagnosis of athletes in Wushu competition, the designed system is applied to the Wushu major of a sports college, and the system is used to remotely diagnose the injury of Wushu athletes in Wushu competition. The competition time of each martial arts competition is 80s.

3.1 Experimental preparation

System test software environment: Ubuntu 112 4 LTS; Puthon2. 7; MySQL 5.7; Redis; Beanstalk; Jetty 9.20. Client machine, CPU: Intel (R) core (TM) i3-2130, memory: 2G DDR, hard disk: 500G SATA. Hardware environment: server computer with CPU frequency above 1GHz, memory no less than 512MB and hard disk capacity no less than 40GB.

In the above test environment, the particle swarm optimization algorithm parameters in the test process are as follows: the number of population particles is 1400, the maximum allowable number of iterations is 300, the inertia weight has a linear negative correlation with the number of iterations, and the value range is [0,1].

3.2 Result analysis

Table 1. Pulse changes of martial arts athletes in martial arts competitions

Detection time/s	Athlete 1/N	Athlete 2/N	Athlete 3/N
0	67	71	63
10	71	79	75
20	78	81	91
30	85	89	94
40	89	92	112
50	91	97	125
60	115	105	129
70	124	116	131
80	135	124	137

The system in this paper is used to detect the pulse changes of athletes in the process of Wushu competition. The statistical results are shown in Table 1.

Through the experimental results in Table 1, it can be seen that the system can effectively monitor the pulse changes of Wushu athletes in the process of Wushu competition. The pulse of athletes in the process of Wushu competition shows an upward state. When athletes have sports injuries, the pulse shows an obvious linear upward state. This paper systematically collects the pulse data of Wushu athletes in the process of Wushu competition as an important parameter to diagnose injury in Wushu competition, so as to improve the injury diagnosis accuracy of Wushu competition.

The temperature sensor of the system in this paper is used to collect the temperature changes of different parts of the Wushu athletes' body during Wushu competition. The collection results are shown in Table 2.

Table 2. Temperature collection results of martial arts athletes

Body parts	20/s	40/s	60/s	80/s
Head/℃	36.2	36.4	36.7	36.8
Neck/℃	35.8	35.9	36.1	36.4
Shoulder/℃	35.6	35.8	36.2	36.4
Arm/℃	35.7	35.9	36.4	36.6
Trunk/℃	35.9	36.2	36.5	36.7
Knee joint/℃	35.6	35.8	36.1	36.3
Ankle joint/℃	35.7	36.1	36.3	36.5
Legs/℃	35.6	36.2	36.4	36.7

According to the experimental results in Table 2, the system can effectively collect the body temperature changes of different parts of the human body at different times in Wushu competition, and the body temperature changes of athletes during the competition can be used as an important basis for remote injuries diagnosis of Wushu competition. When the human body is injured in the Wushu competition, the injured part will be significantly improved. The remote diagnosis personnel can diagnose the injury of athletes according to the temperature changes of different parts of the human body.

The ECG sensor of this system is used to collect the changes of blood oxygen saturation of Wushu athletes during Wushu competition. The statistical results are shown in Table 3.

It can be seen from the experimental results in Table 3 that the system in this paper can use the ECG sensor to collect the blood oxygen saturation of human body during Wushu competition, and the blood oxygen saturation results collected by the system fluctuate according to the change of time. The experimental results verify that the system can effectively collect various physiological parameters such as blood oxygen saturation of human body, and can take the collected physiological parameters in the process of Wushu competition as an important basis to judge whether there is injury in human body.

Table 3. Changes in blood oxygen saturation

Detection time/s	Athlete 1/%	Athlete 2/%	Athlete 3/%
0	95.1	96.2	95.4
10	95.2	96.4	96.1
20	95.3	96.5	96.5
30	95.6	96.5	96.3
40	96.4	96.4	95.7
50	96.8	96.8	95.4
60	96.5	96.7	95.3
70	96.4	96.4	95.6
80	95.7	97.1	96.4

The above experimental results verify that the system in this paper can effectively collect the physiological parameters of athletes in the process of Wushu competition, and the collected physiological parameters can diagnose the injury of athletes in Wushu competition. When counting different acceleration factors, the system in this paper is used to diagnose the diagnosis accuracy of athletes' injury in Wushu competition. The statistical results are shown in Figure 6.

Through the experimental results in Figure 6, it can be seen that the acceleration factor in particle swarm optimization algorithm has a great impact on the injury diagnosis accuracy of Wushu competition. When the acceleration factor 1 is 0.4 and the acceleration factor 2 is 0.5, the injury diagnosis accuracy of Wushu competition diagnosed by the system in this paper is significantly higher than that when the acceleration factor is other values. According to the experimental results in Figure 6, the acceleration factors of particle swarm optimization algorithm are 0.4 and 0.5 respectively.

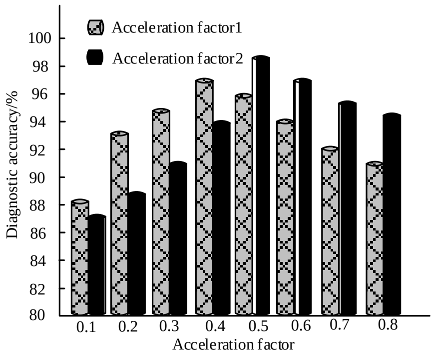

Figure 6. Influence of different acceleration factors on diagnostic accuracy

Considering that in the process of Wushu competition, the main injured parts of athletes mainly include head, neck, shoulder, arm, trunk, knee, ankle and leg, this paper uses this system to diagnose Wushu competition injury. The diagnosis results of remote injuries diagnosis in Wushu competition of 100 Wushu athletes are counted. The statistical results are shown in Table 4.

Table 4. Temperature collection results of martial arts athletes

Injury site	System Diagnostic Results/N		Actual results/N	
	Damaged	No damage	Damaged	No damage
Head	2	98	2	98
Neck	3	97	3	97
Shoulder	2	98	2	98
Arm	3	97	3	97
Trunk	4	96	5	95
Knee joint	8	92	8	92
Ankle joint	9	91	9	91
Legs	3	97	3	97

It can be seen from the experimental results in Table 4 that the system in this paper can effectively diagnose athletes' injuries in Wushu competition. There is only one difference between the remote injuries diagnosis results and the actual injury results in Wushu competition, and the diagnosis accuracy is as high as 99%. The experimental results in Table 4 show that the system can not only realize the remote injury diagnosis of Wushu competition, but also has high diagnosis accuracy.

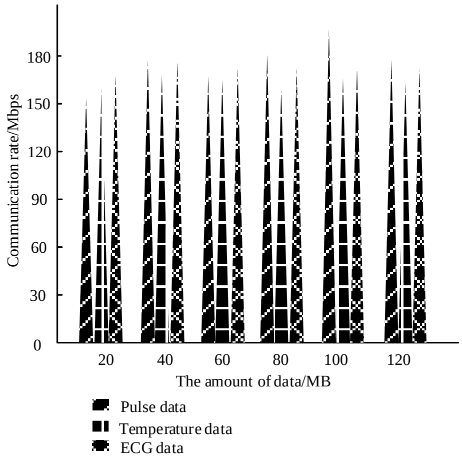

Figure 7. System communication rate

In this paper, the wireless sensor network is used as the communication network of the remote injury diagnosis system of Wushu competition. The communication quality of the network has a great impact on the effect of remote diagnosis. The system in this paper is used for remote injury diagnosis of Wushu competition. In the process of communication, the communication rate when transmitting different types of data is counted. The statistical results are shown in Figure 7.

Through the experimental results in Figure 7, it can be seen that when using the system in this paper to remotely diagnose injuries in Wushu competition and transmit different types of data, the transmission rate of the wireless communication network is higher than 150Mbps. The experimental results verify that the wireless communication network used in this system has good communication performance. When transmitting different types of data, this system can realize efficient data communication and improve the application effect of remote diagnosis of injury in Wushu competition.

The pulse data, temperature data and ECG data obtained by the sensor are transmitted, and the bit error rate in the communication process of remote diagnosis of Wushu competition injury is counted by using the system in this paper. The three types of data transmission capacity are 20MB, 40MB, 60MB, 80MB, 100MB and 120MB respectively. The statistical results are shown in Figure 8.

As can be seen from the experimental results in Figure 8, when using the system in this paper to remotely diagnose the injury of Wushu competition, when the wireless sensor network transmits different types of data, the bit error rate of communication is less than 0.4%, which verifies that the wireless sensor network used in this system has good communication performance. In this paper, the system uses wireless sensor network as the communication mode of system transmission, which can ensure that different types of data can be effectively transmitted to the remote diagnosis module. The communication performance is good, which provides a good communication basis for accurate injury diagnosis of Wushu competition.

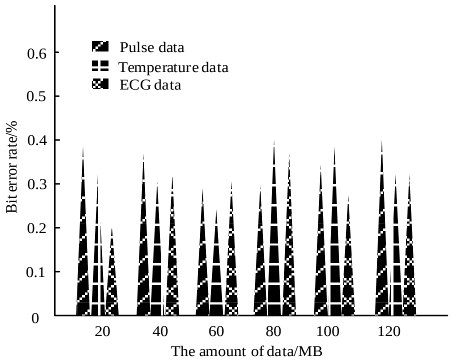

Figure 8. Statistical result of bit error rate

4. Discussion

A remote injury diagnosis system for Wushu competition is designed based on wireless sensor network. Through the designed system, we can effectively diagnose the competition injury of Wushu athletes. In order to avoid injury to Wushu athletes, the following preventive measures are proposed:

(1) To strengthen athletes' efforts to learn sports injury knowledge and traditional Wushu ethics education

Only by learning the preventive measures of sports injury can athletes reduce sports injury in training and competition. In Wushu, it is necessary to carry out theoretical courses on Wushu sports injury for Wushu athletes, as well as necessary traditional Wushu ethics education. Arranging the study of sports injury prevention course can effectively enable Wushu athletes to correctly understand the prevention knowledge of Wushu sports injury. The education of Wushu ethics can strengthen the code of conduct of athletes in the process of training, reduce sports injuries, and let athletes fully understand the adverse consequences of sports injury, so as to avoid the occurrence of injury accidents, and let athletes cultivate the fine quality of unity, friendship, mutual help and mutual protection in training.

(2) To strengthen physical and psychological quality training

Good physical quality is the basic ability that a Wushu athlete must have. It allows athletes to play a normal level of sports in the competition. Good psychological quality can make an athlete's performance extraordinary. Therefore, we should strengthen the training of athletes' physical and psychological qualities, which is also the key to preventing athletes from sports injury in actual competition and simulated actual combat. Athletes should strengthen physical fitness training and practice more sensitivity, flexibility and physical confrontation ability on the basis of speed, strength and endurance. Good physical quality can ensure that athletes master technical movements faster, and can effectively prevent sports injuries and strengthen their ability to resist. In addition, we should strengthen the training of athletes' sports psychological qualities in school, cultivate the ability of athletes' self-psychological adjustment and control of psychological state, and avoid adverse psychological states in the process of confrontation and affecting the competition.

(3) To strengthen self-protection awareness and training of vulnerable parts

The main techniques of Wushu competition are kicking, hitting and falling, using both fists and feet, and taking each other's body as the object of attack. In particular, if the athletes' awareness of self-protection is poor or their self-protection actions are not in place, they are easily injured. Colleges and universities can learn from some protective actions of gymnastics for the usual training methods. When practicing the falling method, we can first carry out technical training such as rolling, jumping and falling to the ground, which can reduce sports injuries and increase the awareness of self-protection. In the process of practice, the easily injured parts can be protected with bandages or protective equipment, as well as the fight against the easily injured parts such as hands, feet, waist, abdomen and head, which can reduce unnecessary sports injuries.

(4) To fully grasp the correct technical action

In the ordinary learning process, athletes should listen carefully and carefully observe the explanation of the actions demonstrated by the teacher and the actions easy to make mistakes, which is very key for athletes. In the process of training, we should constantly strengthen the practice of basic skills, so that we can correctly apply the basic technical movements. On the basis of fully mastering the technology, we can flexibly apply it and accurately attack each other's hitting points, so as to avoid damage.

(5) To strengthen the construction of site facilities

From the perspective of psychology, it is easier to stimulate the interests of athletes to exercise in a place with advanced and sound equipment, beautiful surrounding environment and fresh and smooth air. In the process of Wushu training or competition, we should try our best to improve the venues and facilities. Schools should provide a special sports ground or hall for Wushu, which is more conducive to the enthusiasm of athletes to learn martial arts and reduce unnecessary sports injuries.

(6) To strengthen medical supervision

Medical supervision is an effective measure to prevent sports injury, over training and ensure the smooth progress of sports training. In the process of Wushu training, athletes need to learn the method of self-examination. If they are injured, they must be treated on time to avoid delaying their condition. We also need to cooperate with and follow the advice of doctors to avoid and reduce the occurrence of sports injuries.

5. Conclusion

This paper designs a remote injury diagnosis system for Wushu competition based on wireless sensor network. The physiological parameters of athletes in the process of Wushu competition collected by monitoring nodes are transmitted to the remote diagnosis terminal through wireless sensor network. The remote diagnosis terminal uses particle swarm optimization-support vector machine to diagnose athletes' remote competition injury. The experimental results show that the system can accurately collect the athletes' pulse, body temperature and other information in Wushu competition, realize the accurate remote diagnosis of athletes' injury in Wushu competition, and provide a theoretical basis for the reliable, accurate and real-time wireless monitoring of Wushu Athletes in the process of competition. In the next step, the specific injury in Wushu competition will be clarified, and the corresponding data will be collected to further optimize the diagnosis performance of the injury diagnosis system in distance Wushu competition.

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